Joint UNDP/World Bank
Energy Sector Management Assistance Program

Activity Completion Report

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Country: BANGLADESH

Activity: POWER SYSTEM EFFICIENCY STUDY

FEBRUARY 1985

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

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

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BANGLADESH

POWER SYSTEM EFFICIENCY STUDY

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I. SUMMARY

Introduction

1.1 This report presents the main findings and recommendations from a review of the Bangladesh Power Development Board's (BPDB) power loss reduction program, on-site inspection and discussions of the overall management of the utility. 1/ The major objective of this activity is to present a series of practical steps for reducing transmission and distribution losses and generation costs. The total cost of the recommended programs, which will be implemented in two phases, is about US$50 million. The first phase will extend over a period of nine months and cost US$6 million. The second phase, lasting about three years, will complete the implementation of these projects at a cost of US$44 million. At the end of the project implementation the economic benefits are expected to be about US$36 million per year. Additional financial benefits of US$31 million per year will also accrue from the reduction of non-technical losses. At the same time, the BPDB would substantially improve its operating, organizational and service efficiency, the benefits of which have not been quantified.

1.2 The present level of losses in the system is about 31% of net generation, which is quite high. Technical losses are around 14%, while non-technical losses are around 17%. 2/ The value of losses to the economy is considerable: technical losses represent about US$19 million per year, while non-technical losses represent a financial burden to the BPDB of about US$39 million per year. 3/ These high non-technical losses explain much of BPDB's current financial difficulties and affect directly the level of electricity tariffs required to cover the financial cost of power supply. Unless immediate and thorough actions are taken, both types of losses will grow at least at the rate of the system's growth. The mission believes that implementing the recommended actions would reduce technical losses to about 10%, and non-technical losses,

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1/ The review was carried out by a mission comprising Messrs: Alfred Gulstone (Power Engineer, Mission Leader), Miguel Bachrach (Economist), Alfred Banks (Generation Specialist, Consultant), Alexander Csida (Distribution Engineer, Consultant), which visited Bangladesh in July 1984.

2/ Technical losses are related to the design of the system and comprise losses in lines, transformers, etc. Non-technical losses are losses due to unmetered supplies, inaccurate metering, theft, fraud, etc.

3/ These figures pertain to FY83, when net generation was estimated at 3,780 GWh.

initially, to about 7%. The latter could then be gradually brought down to about 1%.

1.3 Another area that needs urgent attention is system dispatch and operating procedures in generation stations. Considerable savings -- at least US$10 million per year -- can be achieved by implementing an integrated package of changes in plant operations and dispatch, estimated to cost US$12 million. At the same time, the mission has identified a series of measures that would increase energy efficiency at the generating stations and recover derated capacity. These measures are estimated to cost about US$6.0 million and yield savings of about US$6.1 million per year. 4/

Action Programs

1.4 While most of the causes for the high losses are known at various levels of the BPDB, the major barrier for improvement has been the lack of an integrated approach and continuity in the efforts to reduce losses. Accordingly, the mission believes that the most important prerequisite for effectively reducing losses and improving system efficiency is a commitment on the part of the BPDB to tackle the problems in a thorough and integrated fashion. To this end, the mission recommends six action programs consisting of specific measures that should be implemented in a comprehensive and coordinated fashion. To ensure the success of a program all of its component measures must be fully implemented, particularly in the case of the programs to reduce non-technical losses and to reduce generation cost by applying economic dispatch practices. Partial implementation of these two programs is doomed to failure since the various measures are interdependent and all are required to attain the final objectives. The recommended set of programs consists of:

(1) Technical loss reduction.

(2) Improvement of distribution operations.

(3) Non-Technical loss reduction.

(4) Economic operation of generation system.

4/ In the case of dispatch and plant efficiency improvements, savings are based on the displacement of oil by the less expensive natural gas as a fuel, or by the more efficient use of fuel. In the case of the recovery of derated generating plant capacity, savings are based on the long-run marginal cost of capacity. Details of costs and savings are included in the Annexes referring to each project. In all cases annual savings are the savings generated during the year when the project is fully underway, and are calculated in 1984 US dollars.

(5) Generation efficiency improvement.

(6) Strengthening of support services.

1.5 The technical loss reduction program comprises two main activities which will affect technical losses in the medium and long run. In the medium term, the mission recommends the implementation of specific loss reduction projects in three areas: reinforcement of 33 kV lines, secondary distribution network sectionalization, and power factor improvement. In order to deal with the problem of losses in a long run perspective, the mission recommends the strengthening of recently created distribution planning units. These units would determine uniform standards for distribution work, identify the major requirements for future expansion of the distribution system, and direct the work on specific loss reduction activities. Since a large portion of the BPDB's outside assistance is in the form of tied aid, this unit must also address the problem of differing national standards for power system equipment and construction. This problem should also be considered by the donor community itself. A suggestion is for BPDB to prepare a detailed set of distribution system standards which it would adhere to and would make available to interested donors to determine the scope of equipment they could supply. In addition, given that there are already efforts to deal with loss reduction supported by bilateral and multilateral donors, it is important to coordinate these to avoid duplication and improve the use of scarce resources.

1.6 Although the impact of the distribution planning units will be felt mainly in the long-term development of the system, they should be strengthened immediately. The total cost of the program is estimated to be US$18.25 million, and direct savings are estimated to be about US$19.08 million per year.

1.7 The program to improve distribution operations consists of a series of measures that should be taken immediately to increase the reliability of the system, reduce the number and extent of outages and set the basis for technical loss reduction activities. These measures comprise the rehabilitation of the protective system 5/, improvements in substation maintenance, and improvements in the work methods and equipment used by distribution construction/maintenance crews.

1.8 The non-technical loss reduction program contains three major components: (a) strengthening the Commercial Operation Unit, (b) an overhaul and modernization of the billing system, and (c) an overhaul of the metering system. The total cost of the program is about US$6.74 million and its financial benefits are estimated to be about US$31 million

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5/ Relay and fuse coordination, and replacement and maintenance of relays, fuses and instruments.

per year. 6/ This program is potentially the most profitable in financial terms. Nevertheless, it must be stressed that its success depends entirely on pursuing it with determination, which in turn requires a degree of political commitment and support both in BPDB's management and at the national government level. Subsequent to the discussions of the mission's findings, a follow-up mission, under the ESMAP program, was sent to help the BPDB initiate a crash program to reduce non-technical losses (see Annex 11).

1.9 The economic operation of the generation system has three different components: (a) economic dispatch of the existing system; (b) system changes to allow more extensive use of gas; and (c) improved operation of individual units. The total cost of this program is estimated at about US$12 million, and the savings are estimated to be, at minimum, US$10 million per year.

1.10 The generation efficiency program comprises two different activities: (a) partial rehabilitation of the Shajibazar gas turbine generating station, and (b) the reduction of auxiliary power consumption at several generating stations. 7/ The cost of the program is estimated at US$6.0 million and the savings are roughly US$6.1 million per year.

1.11 Strengthening the support services includes: (a) improvement of the stores inventory system, and (b) the creation of a vehicle maintenance system along with providing some replacement vehicles. This program will cost about US$4.58 million. The program's benefits are not easily quantified, but both of its components are required to facilitate implementation of the other programs.

Justification of the Action Programs

1.12 The costs and annual savings of the action programs are shown in Table 1.1. In some cases it was possible for the mission to assess the extent of the work required. In other cases the required work cannot be defined until the first phase of the program is implemented. For these cases, an order of magnitude estimate is provided.

1.13 Capacity savings are valued at the long run average incremental cost of capacity, while energy savings are valued at the marginal cost of energy. Savings arising from improvements in system operation are valued as the difference in the economic value of fuels being substituted or the economic value of fuel being saved through increased efficiency. The benefits from non-technical loss reduction activities are calculated using the average present financial tariff since they represent addi-

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6/ This assumes a 10% reduction of non-technical losses by FY86.

7/ Ashuganj, Siddhirganj, Goalpara and Ghorasal.

tional cash that the utility would collect for service which is already being provided but which is not paid for.

Coordination of Financing

1.14 To maintain the integrity of the programs and to minimize problems of coordination it is desirable for a single agency to finance each program. However, parts of some of the programs have already been financed and thus it is important that donors associated with an individual program coordinate their activities to maintain its integrity. 8/

Program Priorities

1.15 The set of programs recommended above will be a major undertaking for the BPDB. Effective implementation of the programs will imply considerable changes in the management and operational practices of the utility. Simultaneous implementation of all programs is likely to strain the managerial resources of the BPDB, so it is important to set priorities for the implementation schedule.

1.16 The programs on economic dispatch and on generation efficiency should be carried out simultaneously under the supervision of the Generation and Transmission Department. As the programs are complementary it would be most convenient to have the rehabilitation of the Shajibazar plant completed at the same time as the system changes to allow more extensive use of gas.

1.17 The programs of non-technical and technical loss reduction may strain the human resources of the organization, especially at the middle management level. It is therefore recommended that the program for non-technical loss reduction under the responsibility of the Finance Department be initiated first with full collaboration, as required, from the Distribution Department. At the same time, the Distribution Department should start the technical loss reduction program, by strengthening the distribution planning units and undertaking the rehabilitation and restoration of the protective and maintenance systems. Implementation of specific technical loss reduction projects should be deferred until the distribution planning units are functioning.

8/ For example, ADB, under its sixth power project is financing metering equipment and some rehabilitation of the distribution system; CIDA is financing projects to provide a dispatch center and modernize the stores inventory system; the World Bank, under its proposed Transmission and Distribution project plans to finance the Technical and Non-technical loss reduction programs identified in this report.

1.18 The support systems should be under the Finance Department, and the stores inventory control and vehicle maintenance systems should be under the Administration Department. These activities can be started immediately since they do not involve the same personnel that would be working on other programs.

1.19 The estimated costs of the programs separated into components showing professional services, equipment and expenses are shown in Table '.2. This table, which is provided for the convenience of potential financiers, shows the programs divided into two phases. In most cases phase one includes identification of precise needs and preparation of specifications for equipment and services; while phase two includes the implementation and training. The mission believes that all of the programs presented are economically justified and can be carried to completion, but the use of two phases enables a final decision to be taken on implementation after the costs and technical aspects of each program have been reviewed in detail.

Table 1.1: SUMMARY OF COSTS AND BENEFITS OF ACTION PROGRAMS
(millions of US$)

Program	Cost	Savings a/	EDR b/ (%)	S/C c/
Technical Loss Reduction	18.25			
1. Distribution plannning unit	0.95			
2. Specific loss reduction projects				
- Reinforcement of 33kV lines	8.93	3.1	30.2	2.4
- Secondary distribution sectionalization	6.07	9.4	86.6	10.1
- Power factor improvement	2.30	6.6	182.6	19.8
Distribution Operations Improvement	4.21		NQ d/	
1. Rehabilitation of protective system and establishment of substation mainrenance	1.30			
2. Training and equipment for line construction and maintenance crews	2.91			
Non-Technical Loss Reduction	6.73	30.9 e/	272.9 f/	32.0
1. Strengthening of commercial operations unit	0.40		-	
2. Overhaul and modernization of billing system	2.20		-	
3. Overhaul of metering system	4.13		-	
Economic Operation of Generating System	12.00	10.9	90.30	6.7
1. Economic dispatch of existing system			-	-
2. System changes to allow more extensive use of gas	-		-	
3. Improved operation of individual units			-	-
Generation Improvement	6.00			
1. Rehabilitation of Shahjibazar gas turbine plant				
- Recovery of capacity	3.05	3.3	83.7	3.7
2. Reduction of plant auxiliary power consumption	2.95	2.8	73.0	6.0
Strengthening of Support Systems	4.58		NQ	
1. Stores inventory control	0.87		NQ	
2. New vehicles and fleet maintenance system	3.71		NQ	

a/ Annual savings once program is fully implemented.
b/ Equalizing discount rate.
c/ Present value of savings to present costs ratio (at 12% interest rate).
d/ Benefits have not been quantified.
e/ Direct financial benefits.
f/ The benefits for non-technical loss reduction are financial benefits, and the EDR is the internal rate of return.

Table 1.2: SUMMARY OF ACTION PROGRAM COSTS FOR SERVICES EXPENSES AND EQUIPMENT (US$ '000) a/

	Phase 1				Phase 2				
	Professional Services	Travel and Subsistence	Equipment and Software	Total Phase 1	Professional Services	Travel and Subsistence	Equipment and Software	Total Phase 2	Total b/
Technical Loss Reduction	495	257	199	951	1,454		14,539	15,993	16,944
1. Distribution Planning Unit	495	257	199	951	-	-	-	-	951
2. Specific loss reduction projects									
- Reinforcement of 33 kV Lines	-	-	-	-	750		7,502	8,252	8,252
- Secondary distribution sectionalization	-	-	-	-	510		5,099	5,609	5,609
- Power factor improvement	-	-	-	-	194		1,938	2,132	2,132
Distribution Operations Improvement	237	107	55	399	737	586	2,475	3,798	4,197
1. Rehabilitation of protective system and establishment of substation maintenance	178	76	55	309	297	132	550	979	1,288
2. Training and equipment for line construction and maintenance crews	59	31	-	90	440	454	1,925	2,819	2,909
Non-Technical Loss Reduction	1,133	789	1,940	3,862	-	-	2,877	2,877	6,739
1. Strengthening of Commercial Operations unit	253	156	11	420	-	-	-	-	420
2. Overhaul and modernization of billing system	165	118	1,907	2,190	-	-	-	-	2,190
3. Overhaul of metering system	715	515	22	1,252	-	-	2,877	2,877	4,129

Table 1.2 (cont.)
(US$ '000) a/

	Phase 1				Phase 2				
	Professional Services	Travel and Subsistence	Equipment and Software	Total Phase 1	Professional Services	Travel and Subsistence	Equipment and Software	Total Phase 2	Total b/
Economic Operation of Generating System	634	260	-	894	1,566	867	8,690	11,123	12,017
1. Economic dispatch of existing system	337	132	-	469	-	-	-		469
2. System changes to allow more extensive use of gas	178	77	-	255	1,108	601	8,360	10,069	10,324
3. Improved operation of individual units	119	51	-	170	458	266	330	1,054	1,224
Generating Plant Efficiency	277	129		406	966	304	4,237	5,507	5,913
1. Rehabilitation of Shahjibazar gas turbine plant - Recovery of capacity	218	94	-	312	240	117	2,338	2,695	3,007
2. Reduction of plant auxiliary power consumption	59	35	-	94	726	187	1,899	2,812	2,906
Strengthening of Support Services	297	173	-	470	445	202	3,465	4,112	4,582
1. Stores inventory control	119	58	-	177	356	167	165	688	865
2. New vehicles and fleet maintenance system	178	115	-	293	89	35	3,300	3,424	3,717
TOTAL	3,073	1,715	2,194	6,982	5,168	1,959	36,283	43,410	50,392

a/ Costs are expressed in constant 1984 US$.
b/ Includes 10% physical contingency and excludes local labour (which is included in Table 1.1).

II. METHODOLOGY

Introduction

2.1 This section outlines the methods used to estimate the value of savings from power loss reduction, the methods used to estimate sales and generation figures in the BPDB system, and the assumptions underlying the calculation of technical and non-technical losses.

Evaluation of Benefits

2.2 Benefits accruing from loss reduction may be of two kinds: capacity savings, and energy savings. Capacity savings are valued at the long run average incremental cost of capacity (LRAIC), while energy savings are valued at the marginal cost of energy (MCE). The LRAIC is estimated as the average present cost of a kilowatt of capacity, based on the projected investment of the current system expansion plan. 9/ This is a proxy for the economic cost of the marginal unit of capacity that would be required to supply an incremental unit of demand in a least cost expansion plan. The MCE is estimated using the fuel cost per kWh. For the Bangladesh system this varies considerably depending on the time of the day. Consequently, peak, off-peak, and average MCE's are estimated and applied, as appropriate. Throughout this exercise, we assume that the present demand forecast is to be satisfied and that the current expansion plan is the least cost solution to satisfy the demand forecast. Thus, loss reduction activities identified by the mission reflect marginal savings in the context of a least cost expansion solution.

2.3 Both energy and capacity costs are estimated at different voltage levels, reflecting the fact that investments and technical losses in the transmission and distribution system increase supply costs at each delivery point. For instance, the LRAIC at plant level is US$117/kW/yr, while at the 400 volt consumer level it is US$297/kW/yr; similarly, the average MCE is US$0.029/kWh and US$0.036/kWh at these respective levels. Savings due to loss reduction are valued at the points at which they occur.

2.4 The study also evaluates savings arising from improvements in system operation, that is, savings accrued from changes in the dispatch plan or in plant operations which save on fuel costs without having a short run effect on capacity or the energy availability of the system. In this case, the savings consist of the difference in the economic value

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9/ Details of all calculations are presented in Annex 1.

of fuels being substituted, or the economic value of fuel being saved through increased efficiency.

2.5 Financial benefits arising from the reduction of non-technical losses are valued using the existing BPDB average tariff for energy (US$0.06/kWh). 10/

Generation, Sales and Power Losses

2.6 The mission estimated the generation, sales and losses in close consultation with BPDB's Commercial Operation Unit, which centralizes this information in the organization. In the process of reviewing the data numerous conceptual and numerical inconsistencies were found, and in some cases it was necessary to go back to data sources at plant and circle 11/ levels in order to obtain consistent data. The resulting figures, while not entirely accurate 12/, are a better approximation than any previously available. It was agreed with BPDB management that these estimates would be used for the analysis in this report.

2.7 For the purpose of this report, the definitions used are:

(a) Gross Generation: the total amount of electricity produced in the system at the generation terminals.

(b) Station Use: the energy used in the generating plants, excluding the use of electricity by BPDB's employees in or around the plant, small towns in the vicinity of the plant, and/or any electricity delivered by BPDB free of charge.

(c) Net Generation: the energy "sent out", or gross generation minus station use.

(d) Sales: the total number of kWh billed for any given period of time, including any electricity delivered free of charge. 13/

10/ That is, TK 1.5/kWh at the current exchange rate of TK 25.0/US$.

11/ A circle is the smallest administrative unit that sends its sales records to the centralized Commercial Operation Unit.

12/ There were instances where metering was obviously inaccurate at the generation and/or high voltage distribution levels.

13/ For example, BPDB defines a quantity of energy delivered to employees as "colony use". These are really sales at no charge.

2.8 Estimates for all these figures are presented and discussed in Section III of the report.

Breakdown of Technical and Non-Technical Losses

2.9 The distribution of technical and non-technical losses is obtained by estimating the technical losses in the system 14/, and taking the non-technical losses as the difference between these and the estimated average total losses for the period July 1982 to May 1984.

2.10 The technical components of losses along the transmission and distribution network are identified by engineering calculations based on loading conditions and physical characteristics of the system at the various voltage levels. Series losses in lines, feeders and transformers, as well as shunt losses arising in transformer iron cores and in the form of corona and leakage losses at the 132 kV level are considered. The estimates include both peak load and annual energy losses.

2.11 At the higher levels of structural hierarchy (generating stations, bulk transmission and grid substations) the entire system is evaluated. At distribution levels, losses are estimated partly by extrapolating the results of a sample analysis (33/11 kV stations), and partly by setting up simplified models of the 33, 11 and 0.4 kV networks. In addition, rigorous sample studies on selected feeders are carried out with special computer programs.

14/ For details see Annex 2.

III. DESCRIPTION OF THE SYSTEM

Management of the Power Sector

3.1 The Bangladesh Power Development Board (BPDB) is a statutory government entity responsible for the generation, transmission and distribution of electricity in Bangladesh. A separate entity, the Rural Electrification Board (REB), is responsible for the distribution of electricity in rural areas. It is organized in the form of rural cooperatives (PBS) which purchase electricity in bulk from the BPDB.

3.2 The two main government institutions determining policy for the power sector are the Ministry of Energy, to which the BPDB and the REB are accountable, and the Planning Commission, which coordinates the development of the power sector with those of other sectors of the economy. The BPDB is organized into four departments, some of which are divided according to geographical areas. 15/ The flow of information and the distribution of tasks among the departments seem to be adequate, and the staff at the managerial level are competent. The main characteristics of the power system are presented in Table 3.1.

Generation

3.3 The BPBD system is predominantly gas-fired (about 65% of gross generation), and the rest is composed of oil-fired plants and a hydro plant. Bangladesh is divided by the Ganges/Brahmaputra River system into two zones, the East Zone and the West Zone. The size and changing course of these rivers prevented the construction of any road, rail or electrical transmission facilities between the two zones until 1982, when a double circuit 150 MW, 132 kV transmission link was established. 16/

15/ The departments are Administration and Finance, Distribution, Planning and Development, and Generation and Transmission. There are two regional divisions which are further divided into two zones each, and each zone is divided into circles.

16/ Although initially operated at 132 kV, the line is designed to operate at 230 kV and its capacity will be approximately 570 MW when it is upgraded to 230 kV operation.

3.4 The generating facilities in the Eastern Zone consist of 474 MW of gas-fired plants, 17/ 24.5 MW of oil-fired plants, and 130 MW of hydroelectric plant. Those in the Western Zone consist of 290.7 MW of oil-fired plants (See Annex 3 for a list of generating plants).

Table 3.1: BPDB: BASIC SYSTEM CHARACTERISTICS, 1983-84

Frequency	50 Hz
Installed Capacity a/	1,110 MW
Generation Capability a/	998 MW
Peak Demand b/	760 MW
	307 MVAR
System Peak Power Factor	0.93
Annual gross generation:	
Gas	2,350 GWh
Liquid fuel	711 GWh
Total Thermal	3,061 GWh
Hydro	897 GWh
Total	3,958 GWh
Annual Net Generation	3,746 GWh
Number of Grid Substations	42
Transformer Capacity	1,550 MVA
Number of 33/11 kV Substations	141
Transmission and Dist ibution Lires	
230 kV	178 km
132 kV	2,000 km
66 kV	168 km
33 kV	7,273 km
11 kV and 0.4 kV	20,704 km
Number of 11/0.4 kV Transformers	7,259
Number of Consumers	720,000

a/ Estimated for June 1984. Includes Khulna 110 MW, Chittagong 60 MW and 30 MW combined cycle recent additions.

b/ The demand was restricted by load shed. BPDB estimates that the peak demand would have been about 810 MW if generation were available.

Source: BPDB data and mission estimates.

3.5 The establishment of the interconnector in 1982 opened the possibility of reducing generation costs throughout the system, by

17/ Capacities are based on nameplate ratings. The actual ratings are considerably lower in some cases due to deterioration of the units. Distribution of plants corresponds to plants existing in FY82.

utilizing more of the indigenous gas reserves in preference to imported oil. However, the net exchange between the zones is still modest due to security constraints and technical difficulties in running the main oil-fired plants in the West at low loads. 18/ This is a very important issue since considerable savings could be obtained by generating more power in the East zone and transferring it to the Western zone. This problem is addressed in Section IV.

Transmission System

3.6 The major generating stations and load centers are interconnected by a 132 kV transmission grid (2,000 km) consisting of double and single-circuit transmission lines (Fig. 1). There are also 168 km of 66 kV subtransmission. However, the 66 kV subtransmission system which branches out from Ishurdi substation extends over a relatively limited area and is not intended for further development.

3.7 Frequency is normally kept between 49.5 and 50.5Hz. Automatic load shedding is applied with underfrequency relays set at 49Hz, which trip low-priority loads in order to limit the extent of power interruption in case of major grid outages. This scheme saved the system from total collapse on several occasions, when the East-West interconnector tripped.

3.8 The 178 km East-West double-circuit interconnector between Tongi (Eastern Zone) and Ishurdi (Western Zone) substations is designed and built for a rated voltage of 230 kV but was put into service at 132 kV in December 1982, and has been operated at that voltage since then. Conversion of the interconnector to 230 kV operation is planned for 1986-87, when completion of the terminal 132/230 kV substations is expected.

3.9 The BPDB is considering the necessity of reinforcing the interconnection with another tie-line by about 1993 to further increase the power exchange capability and system security.

3.10 Many reinforcements and extensions are under construction or planned for the next decade. These include stringing second circuits on existing double-circuit towers, extending the 230 kV grid down to Comilla, as well as internal reinforcements and extensions of the 132 kV grid in both the Eastern and Western zones.

18/ The marginal cost of energy (MCE) is substantially different in each of the two zones. For instance, the MCE at the station level for the gas-fired plants in the East is about US$0.009/kWh, while in the West the MCE reflects the cost of oil-fired generation and is about US$0.12/kWh.

Distribution System

3.11 The distribution system consists of about 7,000 km of 33 kV lines and 21,000 km of 11 kV and 400 volt lines. The systems under the control of the BPDB are three wire, three phase and are built mainly to British standards. The REB systems are three phase, four wire and utilize single phase spurs according to North American standards.

3.12 The 33-kV network functions as a bulk distribution system to supply large consumers, including the REB, as well as 33/11 kV stations with typical transformer capacities of 2x10 or 2x14 MVA. Because the 132 kV transmission grid does not extend to certain remote areas, the 33 kV lines are very long, exceeding 100 km in some cases (e.g. south of Chittagong).

3.13 From the 33/11 kV substations, power is delivered to 11 kV primary feeders that supply large consumers as well as the 400 volt low-voltage secondary networks through 11/0.44 kV transformers. Some of the 11 kV feeders are connected directly to 132/11 and 132/33/11 kV grid substations.

3.14 The 400 volt networks are supplied from centrally located 11/0.4 kV transformers according to European practice. As a consequence, the 400 volt network is very extensive, serving an average of about 100 consumers from one transformer.

Demand

3.15 With more than 90% of the population still having no access to electricity, the demand for electric power and new connections is extremely high. As a result, energy generation has grown at about 15% per annum during the last four years, in spite of load shedding, limitations on new connections, and supplying loads at reduced voltages in many areas. Thus, in the short to medium term, the growth of the system is going to be supply rather than demand-determined.

3.16 The BPDB considers 12% a conservative estimate of annual load growth for the next decade, and is taking this figure as the benchmark for their expansion plan. According to this, energy demand would reach 13,005 GWh in FY94, while the system's installed capacity is planned to be 3,390 MW.

3.17 While the daily variation of load is quite significant, with peak load occurring at around 7:00 p.m. (see Fig.2), seasonal changes are almost negligible since air conditioning and fan load in the summer is offset by irrigation load in the winter months. The power factor of the system peak (0.92) implies that the peak is influenced by a significant incandescent lighting load.

Sales and Losses

3.18 BPDB's electricity sales by customer are presented in Table 3.2. The large industrial and commercial customers account for nearly 60% of sales. Their relatively small number makes them the prime target for initial non-technical loss reduction efforts.

Table 3.2: SALES AND NUMBER OF CUSTOMERS, 1982-83

Category	Number of Customers	Energy Sold	Percentage of Sales
		(GWh)	
Domestic	420,580	438.599	18.3
Small Industrial	34,595	225.473	9.4
Small Commercial	205,629	235.907	9.8
Large Industrial and Commercial	1,531	1,390.592	58.0
Agriculture	6,603	37.433	1.6
Other	261	70.592	2.9
Total	669,199	2,398.596	100.0

Source: BPDB Annual Report.

3.19 Power losses in the BPDB system have been an endemic problem recognized both by the utility and the World Bank. 19/ Table 3.3 presents the best available picture of the situation for the past 23 months.

3.20 Examining the actual figures for losses (on net generation) it becomes immediately apparent that these cannot be used directly due to distortions introduced by the billing cycle and the practice of the BPDB to inflate the sales by issuing "supplementary bills" (vis June 1983). These bills are issued when the BPDB believes that a customer has been underbilled. They relate to time periods as long as 10 years in the past, but the energy is added to current sales and compared with current generation for loss calculations. The resulting fictitious loss figures

19/ Bangladesh: Issues and Options in the Energy Sector, October 1982, World Bank Report No. 3873-BD; and appraisal reports, "Ashuganj Thermal Power Project", May 1982, Report No. 3719c-BD; and "Greater Khulna Power Distribution Project:, May 1989, Report No. 2476a-BD.

serve to instill a false sense of security in the BPDB management. In addition, most of the supplementary bills are contested by customers and are largely uncollectable. The result is an inflation of the accounts receivable. 20/

3.21 The mission used two techniques to assess the trend in system losses. Losses (expressed as a percentage of net generation) were trended, and a twelve-month moving average of the losses (expressed as a percentage of gross generation) was taken for each month. The twelve-month averages, shown in Table 3.3, are based on sales which have been adjusted downward to remove some of the supplementary billing.

3.22 The trended figures for losses and the moving average show that the power loss reduction program launched by BPDB has had a moderate degree of success. Based on the trended figures, the system loss appears to have decreased by about 6% of net generation during the period July 1982 to May 1984. The BPDB loss reduction program addressed the reduction of both technical and non-technical losses. By the time of the mission the BPDB had implemented some of the measures required for reducing technical losses, such as: (a) the installation of capacitors; (b) replacement of undersized service drops; 21/ and (c) a pilot project utilizing single phase distribution and small single phase transformers with low tension distribution eliminated. All of these measures were implemented on a small scale and are unlikely to have had a noticeable effect on losses.

3.23 The measures to reduce non-technical losses were more successful. These included organizing the Commercial Operation Unit to oversee the non-technical loss reduction program, making distribution area managers accountable for losses in their area of responsibility and having legislation passed to increase the penalties for theft of electricity.

3.24 The mission believes that progress in loss reduction has been slow because of the present approach and the limited resources devoted to the program. A major effort using the necessary financial resources and modern project management techniques is required to achieve further significant loss reduction.

20/ As an example of the effects of this practice, from July 1982 to June 1984 supplementary bills totalling 225.6 GWh and valued at TK. 152 million were issued by Dhaka electric Supply. It collected only about TK.25 million, 16.4% of the total.

21/ The service drop is the correction between the distribution lines and the customer's meter.

Table 3.3: LOSSES ON GROSS AND NET GENERATION

Year/ Month	Gross Generation (GWh)	Station Use (% Of Gross)	Net Generation (GWh)	Adjusted Sales (GWh) a/	System Losses (% of Net)	Total Losses (% of Gross)
Jul 82	254.609	4.9	242.235	151.535	37.4	40.5
Aug	276.143	4.5	263.605	172.185	34.7	37.6
Sep	276.355	4.8	263.031	170.012	35.4	38.5
Oct	283.556	4.6	270.572	174.707	35.4	38.4
Nov	268.200	4.7	255.704	170.584	33.3	36.4
Dec	279.336	4.6	226.420	191.204	28.2	31.6
Jan 83	291.938	3.3	282.280	174.041	38.3	40.4
Feb	271.882	3.9	261.285	160.632	38.5	40.9
Mar	309.937	3.8	298.137	181.545	39.1	41.4
Apr	298.233	4.4	284.990	185.273	35.0	37.9
May	309.912	4.3	296.512	188.261	36.5	39.3
Jun	312.574	2.4	299.525	403.886	-34.8	-29.2
Jul	297.464	4.6	283.919	167.056	41.2	43.8
Aug	328.118	4.1	314.600	196.006	37.7	40.3
Sep	311.539	3.4	300.850	199.062	33.8	36.1
Oct	331.039	4.1	317.420	206.978	34.8	37.5
Nov	309.240	2.4	296.243	230.361	22.2	25.5
Dec	311.407	4.1	298.561	219.017	26.6	29.7
Jan 84	326.996	4.2	313.340	208.059	33.6	36.4
Feb	323.748	4.2	310.242	208.018	32.9	35.7
Mar	369.018	4.2	353.693	250.587	29.2	32.1
Apr	358.359	4.4	342.704	242.720	29.2	32.3
May	348.066	4.3	322.988	232.241	30.3	33.3
				Average:	30.8	33.7

a/ These are sales adjusted for losses erroneously attributed to staff and/or station use.

Source: Mission estimates based on BPDB data.

3.25 The mission estimates that of the total losses -- 31% of net generation -- 14% are technical, and the remaining 17% are non-technical. The breakdown of technical losses is presented in Table 3.5.

3.26 About 74% of the the technical losses occur in the 33/11/0.4 kV distribution system, particularly at the 400 V level (36%) and along the 33 kV distribution lines (22%). The main reasons for the technical losses are:

(a) The distribution system has not been developed at a sufficient pace to cope with rapidly increasing loads and has therefore become overloaded.

Table 3.4: TWELVE-MONTH MOVING AVERAGE OF LOSSES

Year/ Month		Gross Generation (GWh)	Adjusted Sales (GWh)	Losses as % of Gross Generation a/
Jul	1982	254.609	151.535	
Aug		276.143	172.135	
Sep		276.355	170.012	
Oct		283.556	174.707	
Nov		268.200	170.584	
Dec		279.336	191.204	
Jan	1983	291.938	174.041	
Feb		271.882	160.632	
Mar		309.937	181.545	
Apr		298.233	185.273	
May		309.912	188.261	
Jun		312.574	231.880 b/	37.3
Jul		297.464	167.036	37.6
Aug		328.118	196.006	37.9
Sep		311.539	199.062	37.7
Oct		331.039	206.978	37.6
Nov		309.240	230.361	36.7
Dec		311.407	219.017	36.5
Jan	1984	326.996	208.059	36.2
Feb		323.748	208.018	35.8
Mar		369.018	250.587	35.0
Apr		358.359	242.720	34.5
May		348.066	232.241	34.0
Jun		347.283	247.870 b/	34.1

a/ Losses are shown as 12 month average and are on the base of gross generation.
b/ Sales have been adjusted downward to reflect only about 25% of the supplementary billing for this month.

Source: Mission estimates based on BPDB data.

(b) Distribution planning has been based on traditional criteria of voltage drop and current rating, rather than on economic optimization of investments against the cost of losses. Economic optimum loss levels have dropped significantly all over the world in the last 10 years due to the sharp increases in fuel costs. The old rules of thumb for design implicitly embody relative costs that reflect pre fuel crisis conditions. 22/

(c) Power factor correction has been inadequate.

Table 3.5: BPDB: ESTIMATED TECHNICAL LOSSES - 1983/84

Source	Demand Loss (MW)	Demand Loss (%)	Energy Loss (GWh)	Energy Loss (%)
Generation Substations (Step-Up Transformers)	7.6	1.0	17.6	0.5
Transmission Lines (132 and 66 kV)	20.9	2.8	83.3	2.2
132 kV Substations	8.2	1.1	20.2	0.5
33/11 kV Distribution Lines	24.2	3.2	83.8	2.2
33/11 kV Substations	3.7	0.5	23.0	0.6
11 kV Distribution Feeders with 11/0.4 kV Transformers	19.2	2.5	74.3	2.0
400 V Distribution Network	48.5	6.4	224.5	6.0
Total	132.3	17.5	526.7	14.0

Reference Generation Data:

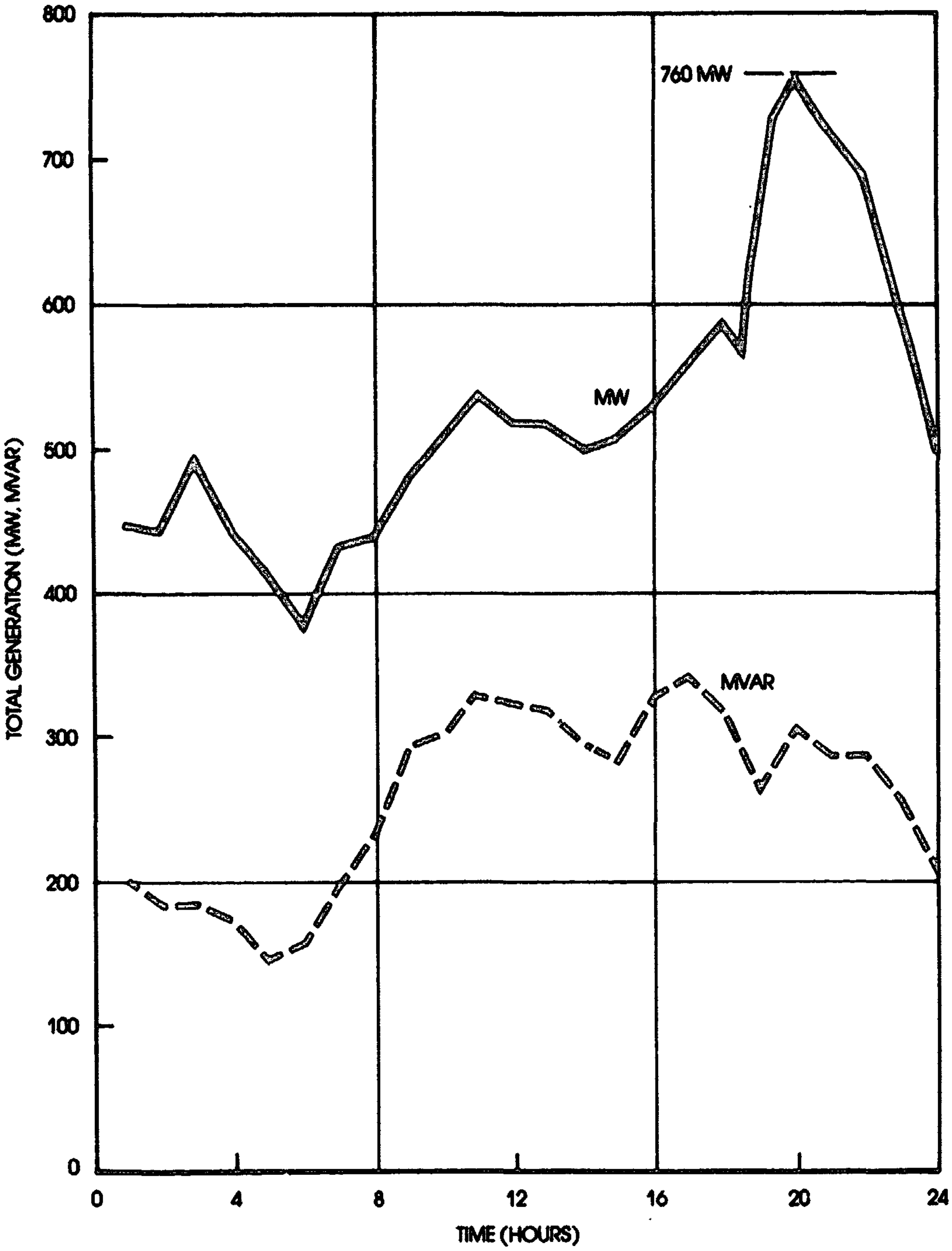
- Peak Demand: 760 MW
- Net Annual Energy 3,746 GWh

Source: Mission estimates.

3.27 Non-technical losses (17% of net generation) are mainly due to inadequate metering and billing systems, theft, and corruption. Details and specific measures to reduce technical and non-technical losses are presented in Section IV.

22/ See "World Bank Energy Department Paper No. 6: Energy Efficiency: Optimization of Electric Power Distribution System Losses."

BANGLADESH POWER SYSTEM
Daily Variation of Total Active (MW) and
Reactive (MVAR) Generation



1984 Annual Peak Day: June 21st
Source: Dispatch Center, Siddhirganj

World Bank—26679

IV. MAIN FINDINGS AND RECOMMENDATIONS

Introduction

4.1 This section identifies the sources and relative magnitude of system losses and recommends specific actions to bring them down to economic levels. In addition, it identifies changes in the generation dispatch and improvements in operating individual generating units that will reduce the cost of producing electricity.

4.2 The losses in the Bangladesh power system are high compared to other developing countries. The mission believes that the most significant factors contributing to the high losses are the dependence of the BPDB on aid for basic construction activities, and the low salaries paid to its employees. When using aid financing, the utility is not always free to specify the most appropriate equipment or use the most appropriate standards.

4.3 The low salaries have two effects. First, it is difficult for the utility to attract and retain well qualified professionals and well educated technicians. 23/ Second, the low salaries paid, especially to the lower grades of employees, make them more susceptible to corruption. The low salary levels is a well known problem which affects the entire public sector in Bangladesh. A comprehensive and effective solution would entail a delicate macroeconomic balance, but this analysis is beyond the scope of this report.

4.4 The BPDB in its project proforma of June 1983 correctly identified many of the sources of system losses and proposed an ambitious set of measures to reduce them. As mentioned in Section III, the BPDB has implemented some of the measures with moderate success. The work in this section is intended to complement the work already done by the BPDB and to more clearly focus the available resources on the specific items causing inefficiency in the power system. It should be stressed that while the analysis sometimes separates problems and actions to be taken in different areas, the implementation of the solutions to a specific problem should be undertaken as an integrated package of measures. Partial implementation is doomed to failure. For example, in the program to reduce non-technical losses, if a good billing system is established but the quality of metering is unchanged, it is unlikely that a significant reduction of losses would occur.

23/ In contrast, the Rural Cooperatives have more flexible salary policies and can reward an employee for merit. For instance, unlike the BPDB, they are able to attract people with secondary education for training as linesmen.

4.5 In some cases funds already have been allocated by other agencies (e.g. the Asian Development Bank) to implement parts of the overall program suggested here. At the time of the mission, the BPDB did not have a complete list of the number and scope of activities being financed by various agencies to reduce losses and improve efficiency. The mission hopes that this document will be used to assist in obtaining the remainder of the financing required to make the implementation effective. Special efforts should be made to improve coordination between agencies and avoid duplication of funding.

Economic Operation of the Generation System

4.6 The mission believes that three significant opportunities exist in the BPDB system for reducing the cost of generating electricity through improved operation. These are:

(a) Improved overall system efficiency by implementing economic dispatch practices; 24/

(b) effecting equipment and system changes to allow more extensive use of gas-fired plant during off-peak hours; and

(c) more careful operation of individual generating units.

4.7 The potential benefits of these measures can be put in perspective by the following examples. The BPDB generated about 3,432 GWh in 1982-83 at a cost of approximately US$68 million. Thus, even a 1% improvement in overall efficiency, which would easily be achieved by implementing economic dispatch practices, is worth about US$680,000 per year. The cost of generation using gas is about US$0.009/kWh compared to US$0.12/kWh for generation using oil. The mission estimates that if the Khulna oil-fired plant could be shut down for eight hours per day, and the energy is generated by gas-fired plants, savings of about US$10 million per year would result. At the individual plant level, a 50°F deviation of the superheat temperature (about 4-5% of normal operating temperature) reduces the efficiency of the plant by one percent. For a 100 MW oil-fired unit this is worth about US$500,000 per year. The economic benefits of improved system operation are thus considerable.

4.8 The technical details and benefit/cost analysis for each of the recommended measures are discussed in the following paragraphs. The cost

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24/ Although the BPDB system now is short of generation and at peak the practice is to put on line as much generation as is available, there is considerable opportunity during the 18 off-peak hours of the day to use economic dispatch techniques.

of implementing the entire package of measures is estimated at US$11 million and the benefits are conservatively estimated at US$10 million per year. The terms of reference and cost estimates for the work are provided in Annex 4.

Economic Dispatch

4.9 The economic operation of a power system requires that individual generating units be dispatched in such a way as to minimize the cost of generation at every load level. Some of the factors which must be considered are the input-output curve for each unit 25/, the cost of the fuel used by the unit, the energy required to drive plant auxiliaries, the incremental maintenance cost and the transmission losses incurred by running the unit.

4.10 In addition to the "real" power dispatch, considerable savings may be obtained by careful dispatch of the reactive power. 26/ This is achieved by the provision of reactive compensation where it is required, correct setting of power transformer taps, and correct setting of the voltage regulators of individual generating units.

4.11 The mission assumes that these issues will be addressed when a proposed dispatch center 27/ is commissioned in 1987. However, until the dispatch center is commissioned, the BPDB can adopt the following measures to improve system efficiency. 28/

(a) In stations where there are a number of similar units on line, load swings should be taken on a single unit while maintaining the others at their most efficient operating load.

(b) The instrumentation at the generating plants should be overhauled and upgraded, as required, to allow regular performance tests and continuous performance monitoring.

(c) The reactive power flows on the system should be studied to determine compensation requirements (static or rotating) and

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25/ This is a plot of heat energy into the unit versus electric energy out (e.g. BTu versus kWh) from minimum load up to maximum load.

26/ These savings accrue from a reduction of transmission losses which would otherwise occur if there were large reactive power transfers across the system.

27/ The dispatch center is being installed with financing from the Canadian International Development Agency (CIDA).

28/ Some of them would be required in any event to allow the best use of the dispatch center.

transformer tap settings at various load levels to minimize reactive power flows. The necessary compensation equipment should be installed immediately after the requirements are determined. 29/

(d) Power transformers should be switched out of service when not required. 30/

4.12 The mission estimates that the cost of implementing the above measures would be about US$469,000. A 2% improvement in system efficiency would pay for the investment in less than one year.

System Changes to Allow More Extensive Use of Gas

4.13 Figure 3 shows that even with the existing tie line capability and with reasonable assumptions regarding unit availability the Khulna oil- fired units may be required only for about 8 hours per day. There are, however, some problems that must be solved before the system could be run this way. The main ones are:

(a) The availability of gas;

(b) the reliability of the transmission line interconnecting the two zones;

(c) security of supply in the western zone in the event of a trip of the interconnector; and

(d) the suitability of the Khulna (110 and 60 MW) generating units for two shift operation.

4.14 The availability of gas is affected by delays in the completion of wells and pipelines. This problem is being addressed, and the mission has been informed that gas availability should cease to be a constraint in the next fiscal year.

4.15 The reliability of the transmission line interconnecting the east and west zones has been low mainly due to incorrect operation of the

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29/ It may be possible to decouple some of the existing gas turbine generators and use them as synchronous condensers.

30/ This would reduce transformer iron losses, although it must be implemented with care. For example, the breather system must be carefully maintained to prevent the ingress of moisture which would tend to occur with the temperature changes caused by switching the transformer off periodically. Also, the switching off of one transformer should not increase copper losses on a paralled transformer beyond the savings in iron losses on the switched transformer.

protective system, and poor layout at the substations. These are relatively minor problems which can be easily solved.

4.16 The supply in the western zone can be secured by upgrading the existing underfrequency load shed system, and by operating possibly one or two gas turbines in the western zone to cover emergency services in the event of a tie line trip. 31/ Full supply can be restored quickly (within about 15-20 minutes) by the use of the existing gas turbines until the tie line is restored or the Khulna plant is brought up to load.

4.17 Finally, although the Khulna units at present cannot operate on automatic controls below about 55% load, the mission believes that the controls can be replaced and upgraded to allow two-shift operation. The reduction in component life due to two-shifting should be valued but is expected to be negligible.

4.18 The cost of the above measures is estimated at US$10.3 million. The mission estimated that the savings in terms of reduced oil consumption that would be replaced by cheaper gas generation (even if Khulna is taken out of service only for eight hours per day) would be US$10 million per year.

More Careful Operation of Individual Units

4.19 This involves operator training, and establishing a monitoring system for each steam unit to show deviations of key variables through each shift. The measurement of deviations would allow management to monitor and control the performance of operators. The variables would include items such as condenser vacuum, superheat temperature, excess air, etc.

4.20 The cost of implementing the scheme, including training of operators, and the improvement of instrumentation is estimated to be US$1.2 million. A one percent change in the efficiency of a 100 MW oil-fired plant with a 40% plant factor is worth about US$500,000 per year.

Generating Efficiency Improvement

Introduction

4.21 The mission inspected the five largest plants in the BPDB system (Ashuganj, Goalpara, Ghorasal, Shahjibazar and Siddhirganj) and

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31/ Although the BPDB has experienced complete system collapse in the west zone when the tie line has tripped, an improved underfrequency load shed system and the provision of reactive power sources in the west zone would minimize this possibility.

found that generating plant efficiencies could be improved in all stations by varying degrees. In one case major additional capacity could also be obtained. Findings and recommendations made for plants that were not visited are based upon discussions, system forecasts and inspection of similar equipment. The most serious problem in all the plants visited is that maintenance and calibration of instruments is very poor. This has adversely affected plant efficiency and, in some cases, plant capacity. In view of this deficiency, all estimates for instrument rehabilitation include a training component.

4.22 As a general approach to efficiency improvement, the mission reviewed the possibility of adding regenerators or recuperators for each gas turbine. The analysis indicates that these additions are not generally justified.

4.23 Annex 5 outlines terms of reference to implement the recommendations. Details of each activity are discussed in the following paragraphs.

Khulna Station

4.24 This station is the most diversified in the BPDB system, with two large and three small steam units, eight diesel units and four combustion turbines, yielding a total installed capacity of 270.5 MW. Heavy fuel oil is burned in the steam units and light oil is burned in the gas turbine and diesel units. The main findings and recommendations for this station are the following:

(a) The small steam and diesel units are old (35 and 29 years, respectively) and represent a total available capacity of 15 MW. Because of their age and forecasted future operation it is recommended that they be decommissioned.

(b) The two barge-mounted gas turbine units and the two land based units are in fairly good condition and do not need upgrading.

(c) The two largest units (the 60 and 110 MW steam units) require modification of their controls and the use of variable speed drive motors for the boiler air and flue gas fans to reduce auxiliary power consumption.

Shahjibazar Station

4.25 This plant is made up of four 16 MW CEM (now Alsthom Atlantique of France) and three 14.75 Fiat gas-fired combustion turbine units installed in 1970-71. Many units are derated to about 50% of name plate rating and perform at a low thermal efficiency (17.55%). 32/ The main reasons are: poor maintenance; lack of repair tools and machinery; malfunctioning controls; lack of spare parts; and continuous operation at derated load.

4.26 Rehabilitation of some of these units would improve the reliability and efficiency of the BPDB system. Operation at base load after rehabilitation would reduce oil-fired generation in the western grid. 33/ For this purpose the following actions are recommended:

(a) Immediate inspection by factory representatives to determine the mechanical condition of the unit and unit controls;

(b) Implementation of a rehabilitation program to recover the derated capacity where appropriate. The costs of rehabilitation are estimated at US$3.0 million. Annual fuel savings and capacity availability would be in excess of US$5 million. Rehabilitation of these units will also enable BPDB to postpone the 1988 projected retirement of the plant.

4.27 Additional advantages of the rehabilitation plan are:

(a) reducing the loading in the overtaxed gas pipeline to the other BPDB gas-fired plants; and

(b) providing the capacity to accommodate the banking of the Khulna steam units during off-peak hours.

Reduction of Auxiliary Power Consumption and Heat Rate Improvement

4.28 Some of the units at Ashuganj, Ghorasal, Khulna and Siddirganj Stations operate with gas-fired boilers. They are all capable of operating at full rating but have an inordinately high auxiliary power consumption rate. Two of the plant thermal efficiencies are also lower than expected. With the exception of Siddirganj and Ghorasal, installation of new variable speed boiler fan drives would result in savings in auxiliary power consumption. The cost of this change and other modifications to reduce the auxiliary power consumption would be US$3.0 million with annual savings of US$2.8 million per year.

4.29 In addition, the mission recommends a general rehabilitation of the control systems, and a program to improve condenser vacuum where

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32/ These units are probably operating at least 25% below full load thermal efficiency.

33/ Some of the units are already being rehabilitated under an Asian Development Bank Loan.

appropriate. A redesigned forced draught fan inlet duct is also recommended for the Ghorasal units.

Non-Technical Losses

Introduction

4.30 The main reasons for non-technical losses, estimated at about 17% of net generation, are problems in the overall organization, poor metering, inadequate billing systems, theft and corruption. In order to tackle these problems BPDB should undertake an aggressive program consisting of the set of actions proposed below.

4.31 The package of actions outlined below is estimated to cost about US$6.74 million, most of it in foreign costs. It is impossible to present an accurate estimate of financial benefits resulting from these activities. However, the mission believes that the proposed package would reduce non-technical losses to about 7%. The value of the 10% reduction would be about US$31 million per year, in which case the financial payback period would be less than one year.

Organization of Non-Technical Loss Reduction Program

4.32 As an organization, BPDB has been aware of the problem of high non-technical losses in the system and has taken some steps to remedy this situation. The main ones are:

(a) The creation of the Commercial Operation Unit to collect data on generation and losses throughout the system, and to monitor the process of metering, billing and collection in the Dhaka area;

(b) a program to install and calibrate import-export meters at each distribution division; and

(c) The requirement for distribution managers to account for losses in their respective areas.

4.33 These efforts have yielded some positive results, but the changes instituted so far are insufficient to bring losses down to an acceptable level in a timely manner. The main problems identified are:

(a) The Commercial Operation Unit has frequently changed its reporting format, making it difficult to identify trends in the variables being monitored. Each station manager uses his own format to report the energy balance at his station. The Commercial Operation Unit is sometimes unsure of the exact coverage and/or content of the reported information.

(b) The Commercial Operation Unit is insufficiently staffed and does not seem to wield the authority required to deal with the tasks it is supposed to fulfill.

(c) The BPDB prepared an excellent program to install and test import-export meters at each distribution division. However, many of the recommendations in the reports associated with this project have not been implemented. There has been no follow-up activity, and the trained personnel have been dispersed throughout the organization to perform tasks unrelated to metering.

(d) The requirement for circle managers to account for losses may be counterproductive to the extent that managers have been given a serious responsibility without having the tools to reduce the losses. 34/

4.34 The success of any non-technical loss reduction program requires immediate strengthening of the Commercial Operation Unit. For this purpose the following actions with an estimated cost of US$420,000 are recommended:

(a) The provision of an experienced expatriate commercial manager for a period of about two years to set up and run the unit according to modern utility practice. He would be required to manage the non-technical loss reduction program and to train the existing staff. He should report directly to the Board and have full authority to change the reporting systems.

(b) The provision of computer facilities (computer time on a central billing computer of the type recommended below would be adequate) to enable rapid and accurate analysis of monthly data.

Metering System

4.35 The metering system is a crucial area where improvements are vital for the success of any loss reduction program. The metering system has several specific problems:

(a) There is no regular program for checking, sealing, calibrating, repairing and maintaining meters. In practice, meters are repaired only when reported defective or inoperative, but many

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34/ For instance, it is suspected that the sudden reported increase in transmission losses during some months may reflect attempts by managers of circles to transfer the burden of loss accountability into other areas of the system.

cases were found where meters went unrepaired for periods of eight or more months. 35/

(b) Meters are mounted inside buildings, making it easy for customers to tamper with them and difficult for meter readers to read them.

(c) Meter installations are insecure. In several installations, although meters are sealed, CT terminals and PT fuses are accessible to the customer. (see Figure 4)

(d) In an apparent overreaction, some meters are mounted on poles just below the secondary conductors, requiring the meter reader to climb the poles to read them. This slows the meter reading process considerably.

(e) Meters are generally in short supply, making it difficult to replace defective ones in a timely manner. 36/ Also, the variety of models in use makes it difficult to establish standard maintenance procedures.

(f) Meter records are not kept. In normal utility practice the movement and calibration history of each meter is maintained through its life cycle on the system.

4.36 The following actions with an estimated cost of US$4.13 million are recommended to improve the metering system:

(a) The provision of an experienced meter engineer to regroup the meter testing staff, set up a system for routine checking of power station and import-export metering, and add meters when necessary.

(b) The provision of a team of meter experts to move all the industrial and commercial meters to easily accessible positions, secure the installations, and train local staff. Training should be provided on standards for meter installations, meter sealing procedures, meter testing and meter reading procedures.

35/ The mission found that 12% of the meters out of a sample representing about 50% of Dakha's HV customers were inoperative, and 37% of the meters out of a sample of 100 LV customers were not working or not being read. In addition, reviewing the sales and generation figures, the mission occasionally found obvious problems with meter readings at circle and station levels.

36/ Some meters will be provided through an ADB loan, but even these will not be sufficient to cover BPDB's needs.

(c) The provision of metering units required for the above exercise. In this respect, it is essential that the tariff study which BPDB is committed to perform be completed quickly in order to identify the types of meters required for industrial and commercial customers.

(d) The provision of expatriate staff to set up and run an inspection department and train local staff (for a period of about two years) to investigate metering irregularities.

Billing System

4.37 The billing system is one of the key areas where efforts to reduce non-technical losses must be concentrated. At present, the main problems with this system stem from the fact that billing is done manually. As a consequence:

(a) The billing process is long and the compilation of aggregate figures is a cumbersome process.

(b) It is impossible to monitor the number of customers on the system, especially in urban areas. In fact, not even large industrial customers are adequately monitored.

(c) It is virtually impossible to prevent fraud in a system which depends on the action of so many individuals who cannot be adequately supervised.

4.38 BPDB has started to take some steps towards a computerized system by reorganizing the billing system in one of Dhaka's four commercial divisions, and by using outside computing facilities for this purpose. To bring about substantial and rapid changes this effort is still insufficient. It is therefore recommended that the following actions with an estimated cost of US$2.2 million be taken:

(a) Provision of a computer system for all the billing. A central facility with satellite units in the various major load centers is suggested. 37/

(b) Provision of a software package for billing, meter records, and monitoring of consumption.

37/ The satellite units would not be on-line with the central unit, but would independently produce bills and management information. The overall figures would be updated periodically by physically transferring a disc or tape from each satellite to the central computer.

(c) Provision of expatriate staff for a period of about two years to set up the billing and meter record systems, and to train local staff. It is essential that expatriate staff be used to set up and run the system initially, since a major overhaul of the present system is required.

Technical Losses

Introduction

4.39 About 14% of the losses in the BPDB system are due to technical reasons. The highest levels are 6% on the 400 volt system and 2.2% on the 33 kV system.

4.40 In order to address these problems a two-pronged approach is required. On one hand, the BPDB's distribution planning capabilities must be considerably strengthened in order to ensure that future development of the system achieves economic loss levels. On the other hand, a series of technical loss reduction activities should be implemented in the existing system.

Distribution Planning

4.41 The BPDB has only recently created a distribution planning department, but does not have a uniform set of standards and guidelines to undertake distribution work. The distribution system has evolved in a haphazard manner, with standards in different parts of the system depending on which consultant happens to be working in that area at the moment.

4.42 Most of the distribution system has been planned and developed on traditional concerns of voltage drop and current rating. However, partly because of the shortage of equipment, and partly to maximize the coverage with the available funds, the development has not kept pace with the rapidly increasing demand, resulting in a situation where not only are the losses excessive, but even the voltage drops have far exceeded the original design levels. This is particularly true in the 400 volt network, where most of the consumers receive their supply below 85% of the nominal voltage. Most of the conductors of the main feeders, branches and service drops are undersized; the 11/0.4 kV transformers are overloaded; and many joints and taps have been made with poor technology, resulting in unreliable connections and local overheating.

4.43 To remedy the present situation it is recommended that a distribution planning unit be created and trained to undertake the following tasks:

(a) A detailed study on the existing system to identify priority areas for loss reduction activities.

(b) The preparation of a distribution plan, comprising a detailed forecast of load growth by area, number of feeders required, size and location of substations and transformers, etc.

(c) The preparation of a set of distribution standards, outlining optimum voltage levels, conductor types and sizes, protective relay standards, relay and fuse coordination, substation meter types, etc. These standards should be used for all future expansion/rehabilitation in the system and, when feasible, for the immediate loss reduction activities.

4.44 The cost of improving the distribution planning capabilities is estimated at US$951,000. Direct benefits cannot be attributed to this improvement since it is partly a necessary fixed cost related to immediate loss reduction activities, as well as a prerequisite for an efficient expansion of the distribution system. Terms of reference for this work are included in Annex 5.

Loss Reduction Activities for Existing System

4.45 The recommended measures aim at an accelerated improvement of the distribution system. They are not intended to substitute development and rehabilitation projects being carried out at present, but to supplement and modify their execution as appropriate. They should be started after the Distribution Planning Unit is set up and working.

4.46 Since BPDB is aware of most of the prevailing deficiencies and has already prepared a "Loss Reduction Scheme" (June, 1983), the initial steps have already been taken and implementation of actions recommended below would not be expected to take a long time. An implementation time of two to three years is suggested.

Secondary Distribution Network Sectionalization

4.47 Reduction of the lengths of 400-volt secondary distribution networks by installing new 11/0.4 kV transformers along 11 kV feeders, and splitting the 400 volt networks according to their loading conditions. This project will eliminate overloading of transformers and improve quality of service to low voltage consumers. Allocation and sizing of transformers as well as determination of the best locations for splitting the networks will require detailed analysis, but it is estimated that about 80,000 kVA will be required. The total cost of this activity is estimated at US$6.1 million and yearly benefits at US$9.4 million. 38/

38/ Installation of this set of transformers is expected to bring about a 30% reduction in demand losses and 45% reduction in energy losses.

Power Factor Improvement

4.48 This activity consists of installing 165 fixed and 245 switchable capacitor banks on 11 kV distribution feeders with a total rating of 185 MVAR within the next two years. 39/ A loss reduction of 15% is expected at all voltage levels, except the 400 volt network. Some of the allocation of capacitors along the various parts of the system has been worked out by BPDB in its System Loss Reduction Scheme Report. Total costs of this activity are estimated at US$2.3 million and benefits at about US$6.6 million.

Reinforcement of 33 kV Lines

4.49 The 33 kV lines are heavily loaded. Considerable loss reduction can be attained by increasing the cross section of these lines. By extrapolating load conditions for the 33 kV lines in the greater Dhaka area to the whole country, it is estimated that line sections with a total length of 1,100 km would require reinforcement in the near future. This represents about 15% of the length of all existing lines. As a general guideline, lines with peak loading above 40% of thermal rating during the 1983-89 period need to be reinforced. Selection of lines and methods of reinforcement will require circuit-by-circuit studies. Total costs of this activity are estimated to be US$8.9 million and yearly benefits about US$3.1 million. 40/

4.50 In addition to the above actions, the following immediate operational measures should be taken by BPDB to reduce technical losses and avoid overstressing equipment.

(a) Avoid keeping parallel-operated transformers at different tap positions for long periods to reduce losses due to circulating currents both at grid and 33/11 kV substations. 41/

(b) Keep voltages during peak and intermediate loading conditions as high as possible, but within tolerance, particularly at the 132 and 33 kV levels.

39/ There may be some scope for power factor correction on end-use devices, for example, florescent lamps.

40/ For the purpose of a global estimate it is assumed that 220 km total line section is reinforced by parallel line additions and 880 km with conductor bundling or reconductoring. In each case doubling the existing cross-sections is assumed for this estimate.

41/ This practice was observed by the mission at stations where automatic tap-changing and telecontrol facilities were inoperative, and taps had to be changed manually at outdoor transformers.

(c) Avoid development of excessively high grid voltages during light load periods, particularly along lightly loaded lines (e.g. Ashuganj-Sylhet-Mymensingh and Halisahar) to reduce iron and corona losses, as well as voltage stress on equipment. Measures (b) and (c) can be accomplished by coordinated generator excitation and tap-changer control.

(d) Open ring-configured distribution circuits at optimum locations that result in the lowest losses.

Distribution Operations

4.51 The mission reviewed the operations of the distribution system to assess whether or not the reliability of the system was adequate and whether or not BPDB has the capability to construct and maintain any system changes required to reduce losses. 42/

4.52 Distribution operations in the BPDB present the following problems:

(a) Poor reliability of the distribution system is due to improper maintenance and malfunctioning of the protection system. Many transformer fuses are bridged out with wire. In addition, because of poor fuse coordination a fault in a consumer's premises often affects an entire feeder and sometimes causes interruptions at a higher voltage level. These contribute significantly to the high level of service outages.

(b) Many faults, particularly on 33 kV lines, are caused by the lack of tree-trimming activities which are an essential part of a line maintenance schedule.

(c) Control, metering and automatic devices are not adequately maintained at the 33/11 kV substations. Most of the automatic tap-changer facilities are inoperative, and transformer taps cannot be changed from the control room. Current transformer ratios seldom match the range of the quantities monitored, resulting in readings in the lower portion of instrument scales with questionable accuracy.

(d) The operating procedures of maintenance crews are poor. For example, an entire feeder is usually tripped to replace a single transformer fuse.

42/ The "capability" refers to the organization, training and equipment used by line crews.

(e) Some of the grid substations (132/33/11 kV) are overloaded, or do not have reserve in case of transformer outages.

(f) Metering and control systems at the grid substations are unreliable, with considerable equipment out of operation.

(g) The tools and techniques being used by the distribution crews are primitive compared to modern utility practice.

4.53 To overcome these problems, the mission recommends the following:

(a) A program to restore and reset the protection and control facilities in the transmission and distribution systems.

(b) The establishment of a planned maintenance program for substations.

(c) The provision of equipment and technical assistance to equip and train a number of crews in modern line construction and maintenance techniques.

4.54 The aim of the protection and control program would be to restore, reset and/or modify the existing protection, control and metering facilities in order to ensure protection of lines, cables and station equipment, as well as appropriate control of substations. The program should be carried out by BPDB with the assistance and supervision of expatriate protection and control specialists. The program should consist of the following actions:

(a) Review the existing protection, control and metering systems and identify deficiencies in order of their importance.

(b) Perform three-phase and single-phase short circuit calculations for the whole system.

(c) Establish standard protection, control and metering methods and principles.

(d) Identify the restoration, setting and modification actions to be taken at each substation and the relevant new equipment and material requirements.

(e) Procure and install the equipment including fuses on the feeders. 43/

43/ An adequate supply of spares also should be bought at this time.

4.55 When the basic restoration is completed, the protection and control team should plan and install a substation maintenance system to ensure that the quality of the protective and control system is maintained in the future. The cost of these two activities is estimated to be US$1.3 million. Terms of reference are provided in Annex 8.

4.56 The mission estimates that about twenty well-trained line crews could serve as a nucleus which could be expanded by the BPDB to form an adequate resource of maintenance and construction crews. A two stage approach would be required. In the first stage, a consultant would review the present operational structure of the distribution department and the composition of line crews. He would specify the required changes, and the tools and equipment to restructure the department. After the necessary equipment is procured, training would be initiated. It would consist of on-the-job training for linesmen by expatriate crews, while simultaneously, BPDB supervisors would be trained in a utility in a developed country.

4.57 The cost of this exercise is estimated to be US$90,000 for stage one, and US$2.9 million for stage two, including the necessary vehicles and equipment. Terms of reference are provided in Annex 8.

Support Systems

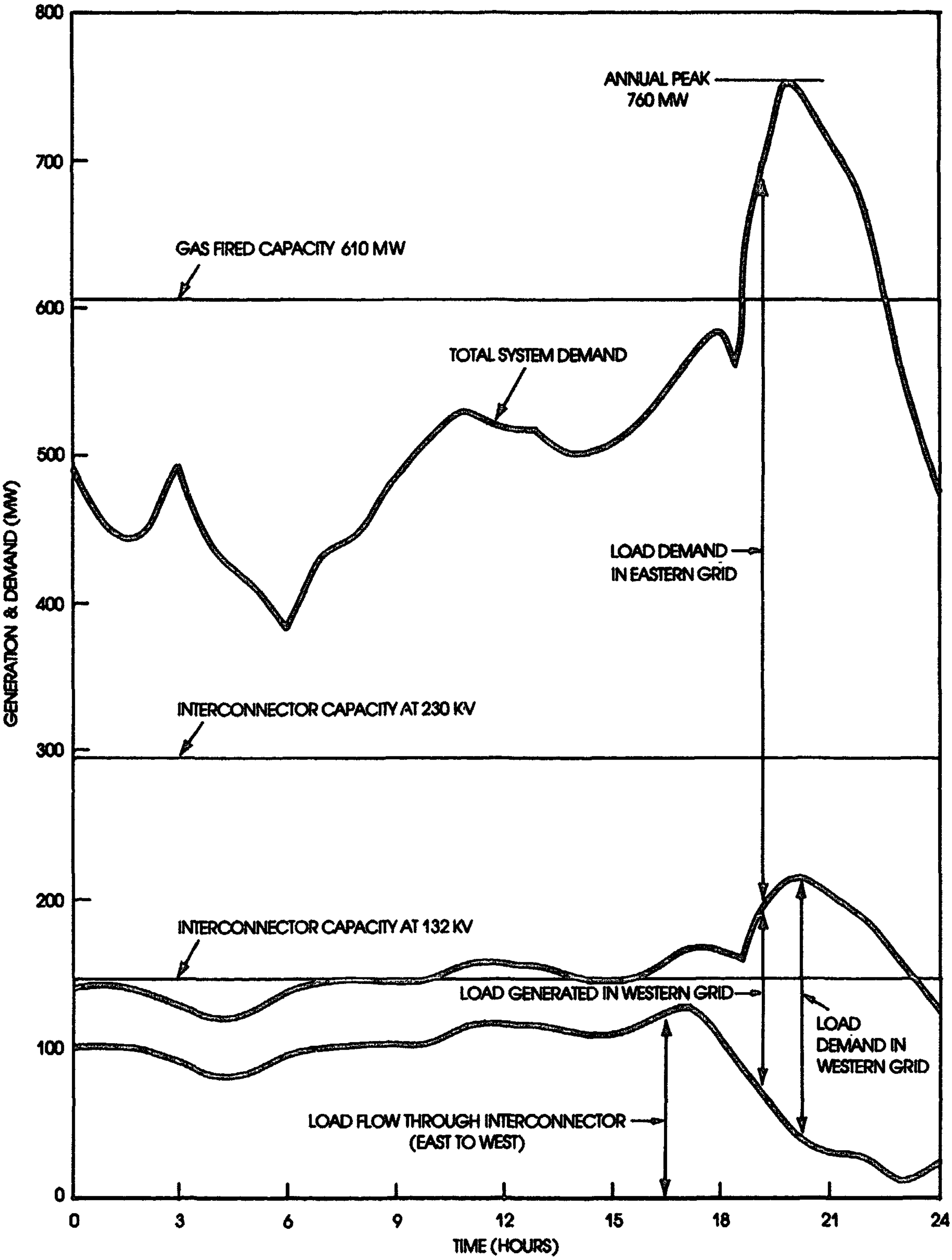
4.58 The two major support systems reviewed by the mission were the distribution stores and the motor transport facilities. Both of these affect the ability of the BPDB to implement loss reduction activities.

4.59 The mission found that the stores inventory control is inadequate. Material available in storage is sometimes thought to be out of stock, resulting in unnecessary work delays. Therefore, a comprehensive computerized inventory control system is recommended. This could carry on from the work that already has been done with CIDA assistance in establishing a material classification system. The main computer proposed for the billing system could be used for inventory control. The mission recommends that the exact requirements be first defined with implementation later. The cost of defining the requirements and specifying the system is estimated to be US$177,000. The implementation phase of this project is estimated to cost US$688,000. Terms of reference are provided in Annex 9.

4.60 There is no motor transport maintenance system. The mission found that preventive maintenance is not done, and vehicles are repaired only when they break down. Furthermore, it appears that vehicles are repaired far beyond the end of their economic life.

4.61 The mission recommends that a comprehensive motor vehicle maintenance system be established along with the necessary repair facilities. Replacement of portions of the fleet and the addition of certain specialized vehicles is also recommended. The cost of the first stage of this activity, defining the exact needs for both vehicles and the maintenance system is estimated to be US$293,000. The benefits of this activity are spread over the entire system operation and have not been quantified. Terms of reference are provided in Annex 9.

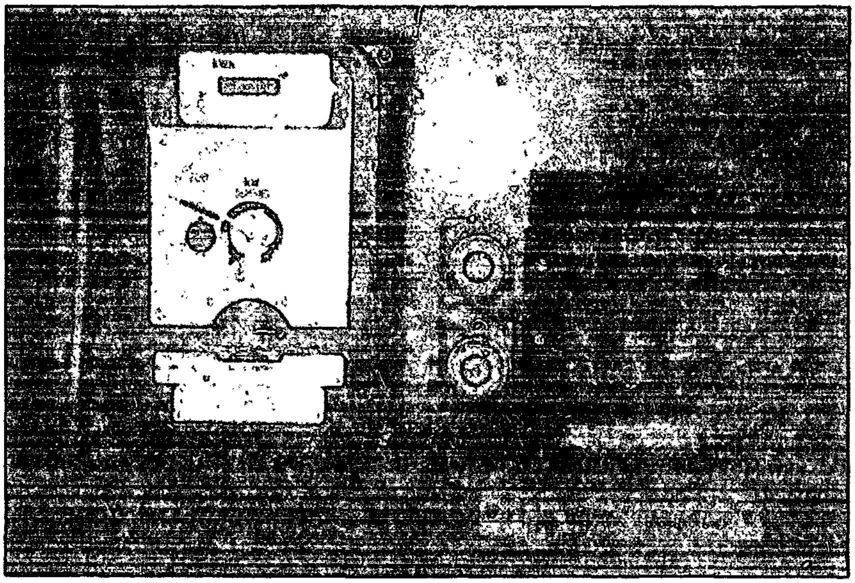
Demand and Generation in Eastern and Western Zones

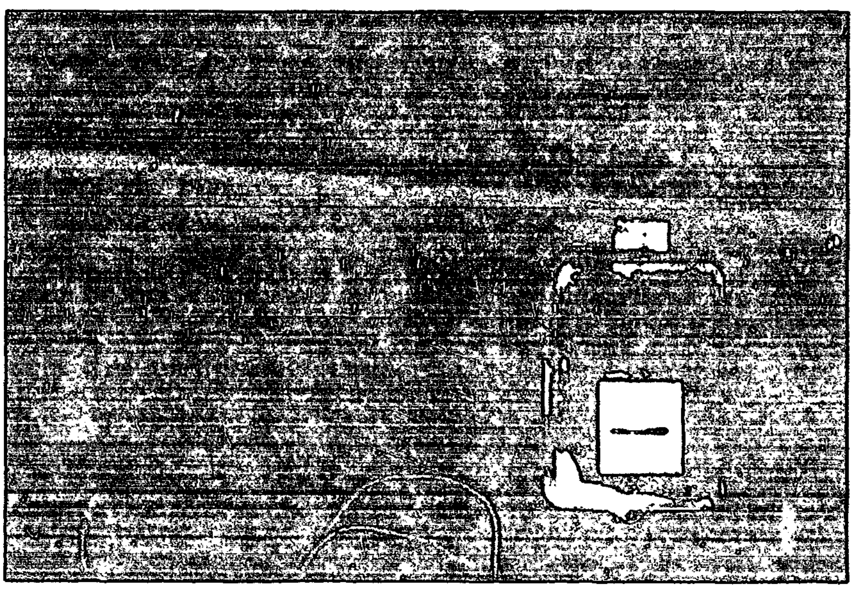


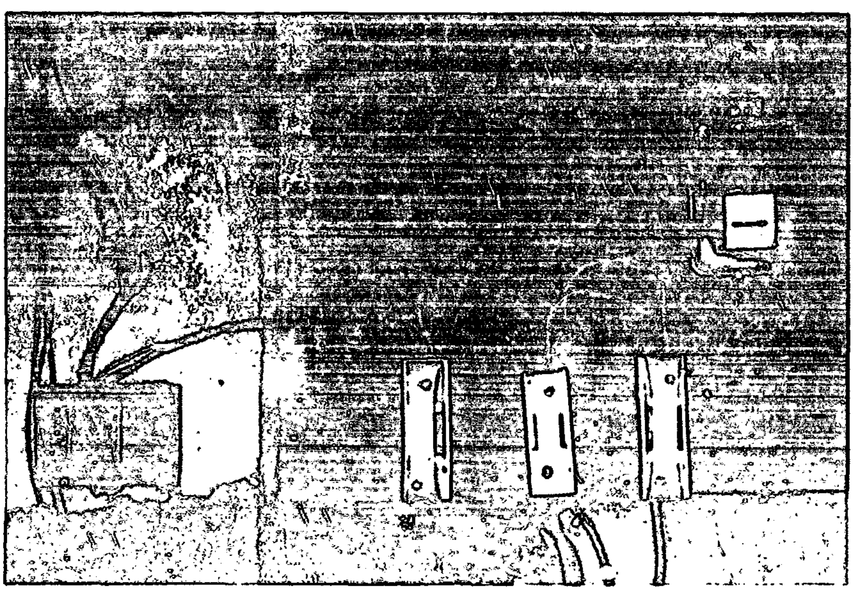
MAJOR HYDRO AND GAS FIRED UNITS, EASTERN GRID

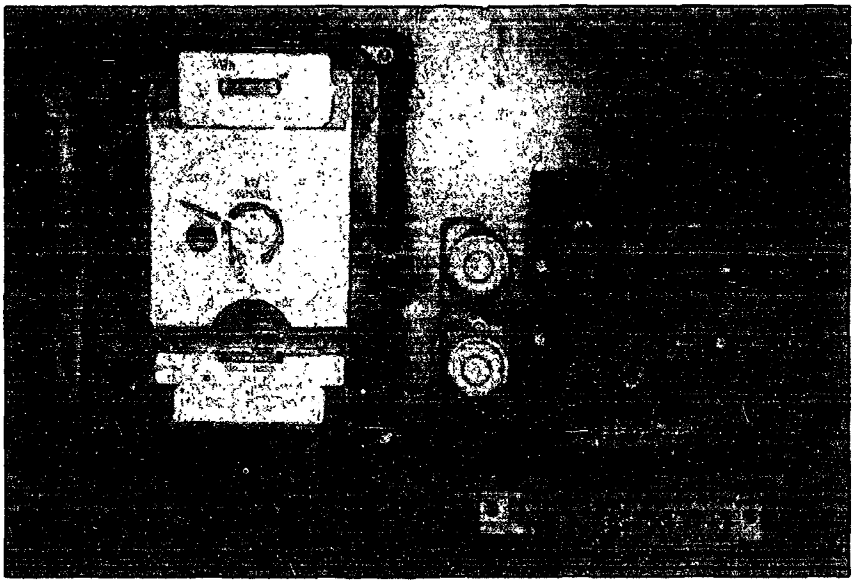
Ashuganj	220 MW	
Chittagong	60 MW	ASSUMPTIONS
Ghorasal	55 MW	One 550 MW Unit Out
Karnafuli	130 MW	of Service at All Times
Shahjibazar	95 MW	(6 of 7 Units in Service)
Siddhirganj	50 MW	

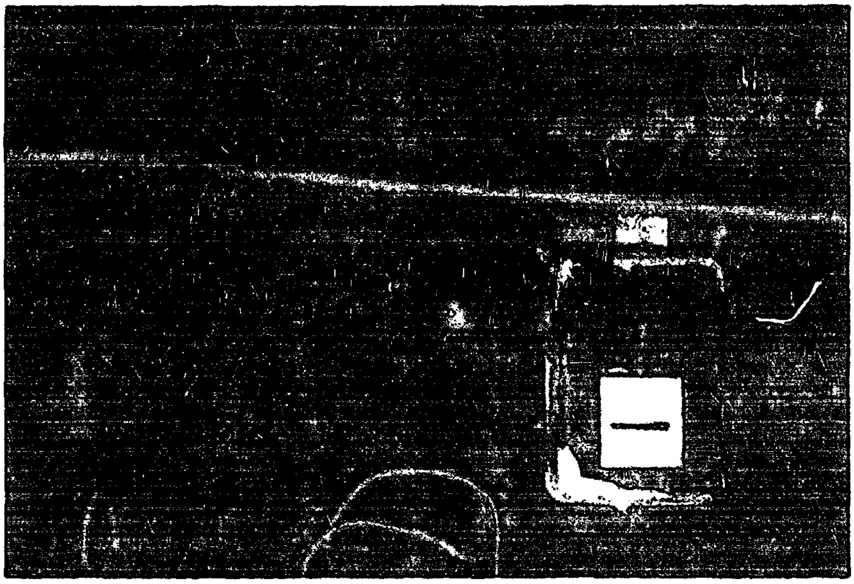
World Bank—26680











Execution Timetable

5.4 The timetable for executing each program is presented in detail in Annex 10. The following Table provides a summary of the execution time for each program.

Table 5.1: EXECUTION TIME OF ACTION PROGRAMS

Program	Phase 1	Duration Phase 2 (Months)	Total
1. Non-Technical Loss Reduction	9	21	30
2. Technical Loss	9	27	36
Reduction	6	24	30
3. Economic Operation of Generation System	6	24	30
4. Improvement of Distribution Operations	6	16	22
5. Generation Efficiency Improvement	6	17	23
6. Strengthening of the Support Services	6	27	33

5.5 For all programs, Phase 1 refers to the preparation period where the relevant studies are undertaken, job specifications and detailed scope of work organized, and detailed costing and economic evaluation (when necessary) undertaken. Phase 2 is the actual execution of the each program: from procurement of equipment and parts until the end of the program.

5.6 For all programs Phase 1 takes between 6 to 9 months, while phase two takes about 24 months for completion. The total duration of each program is about three years, but sequential links between programs (para 5.8) increase the span of time for completing two programs up to 4 years. It therefore should be stressed that timetables for the different program components should be closely monitored in order to avoid cost overruns and to keep the momentum of each program going. To this end, it is suggested that both the BPDB and the consulting firm responsible for each program agree on a detailed timetable for execution.

Program Coordination

5.7 The coordination of activities within each program will be crucial for the success of most programs. An indication of the appropriate organization of activities in each program can be found in Annex

10, which presents an implementation guideline and a time framework for each program to be used for reference.

5.8 The following linkages should be coordinated with care:

(a) The execution of line crews training before the implementation of technical loss reduction projects and improvements in the protective system: the execution of technical loss reduction projects and the rehabilitation of the protective system cannot be properly implemented without trained linesmen. This means that the program to improve distribution operations and the program to reduce technical losses should be coordinated so that neither one takes longer than four years to fully implement.

(b) Coordination of the installation of new instrumentation on generation plants with the implementation of economic dispatch procedures: economic dispatch procedures will only start producing substantial benefits once the instrumentation in all plants is in place.

(c) The coordination between rehabilitation of the Shajibazar plant and the changes to extend the use of gas in generation: while both projects are justified in themselves, the rehabilitation of the Shajibazar plant will ease gas restrictions and bring in additional gas-fired generation capacity to compensate for the reduction in oil-fired generation in the Khulna plant.

METHODOLOGY FOR CALCULATING LONG RUN MARGINAL CAPACITY AND ENERGY COSTS FOR BANGLADESH

The basic figures for calculating long run average incremental capacity costs (LRAIC) have been taken from the expansion plan study prepared by ACRES and the BPDB for the years 1984-1995. While several scenarios are considered in the plan, we have taken the "conservative" one, which assumes that the demand for energy will grow at about 12% for the next decade. Demand projections are shown in Table 1.

Investment in generation plants, and in transmission and distribution facilities, is divided into local and foreign components, each of which is adjusted to reflect the shadow price of labor and foreign exchange (see Table 2). The BPDB reports that about half of the local costs consist of labor costs. Since the shadow wage rate is considered to be about 75% of the market rate, all local costs are adjusted by a factor of 87.5%. On the other hand, the economy-wide standard conversion factor is considered to be 0.8, so the cost of all foreign components is adjusted by a factor of 125%.

The calculation of generation LRAIC costs for Bangladesh involves a few simplifying assumptions. The most important one stems from the fact that data on investment in generation facilities lumps together the expenditures for the next 14 plants, to be commissioned during the next 10 years. It is therefore impossible to separate the costs associated with peaking or with the next-in-line plant. Consequently, we consider each plant as a unit of a "composite" plant to be constructed during a ten-year period. Moreover, since additional capacity will be available at different times, the MW capability of each plant is discounted depending on the estimated date of commissioning.

The long run average incremental capacity cost of generation is the sum of the average investment cost in generation plus the average incremental cost of operation and maintenance of generation facilities. The average investment cost of generation is the discounted sum of expenditures on generation, divided by the MW capacity obtained through the investment. In the case of Bangladesh, as mentioned above, the MW capacity is the discounted sum of the capacity available from the 14 planned generation stations. This value is annuitized assuming a 25-year lifetime of the equipment and a 12% interest rate. The incremental costs of operation and maintenance of generation facilities (see Table 3) consist of the discounted sum of additional expenditure on operation and maintenance (excluding fuel costs) incurred during the 10-year period considered, divided by the sum of new MW capacity.

The long run average incremental costs of transmission and distribution are calculated for various voltage levels in the same way as we have calculated the LRAIC for generation. The only difference here is that the denominator in all average calculations is the projected incremental demand rather than the new capacity of the system. The resulting average is annuitized assuming a 33-year lifetime of the equipment and a

12% interest rate. Average incremental operation and maintenance costs are also added for each voltage level (including a third of the administrative expenses), while all costs for billing and collection are added to distribution. All figures in Takas have been converted to US dollars using a standard conversion factor of 1.25 on the official exchange rate. Results appear in Table 4.

Marginal costs of energy (MCE) are calculated from the data supplied for all generation plants by the BPDB. Since generation in Bangladesh is predominantly thermal, the marginal cost of energy is essentially the cost of fuel (all incremental operation and maintenance expenses are allocated to capacity costs). Before 1982 the power system was clearly divided into two regions -- the eastern region, which used mainly gas-fired plants, and the western region, with oil-fired plants. Since 1982 the system has been interconnected, and, while exchanges between both regions are still limited, we may consider it as a single system.

MCEs vary considerably during the day because at peak hours the system still relies heavily on oil-fired plants, which are considerably more expensive than gas-fired plants (the difference in financial costs between these types of plants is of the order of 10 to 20 times). For the estimation of energy costs we take a typical load duration curve during the month of March and estimate the percentage of energy generated at peak time (6.16%). Next, we take the average fuel costs for peaking plants in reverse order of merit (from least to most efficient) during July 83-April 84, to obtain the marginal cost of a peak kWh at market prices. Plants are added until the sum of their generation during March 1984 fulfill the required percentage of energy generated during peak hours. Finally, fuel costs per kWh are adjusted for losses at various stages of transmission and distribution.

A similiar procedure is used to allocate base load plants (in order of merit) to obtain the off-peak MCE. Final results are shown in Table 5. Both peak and off-peak MCEs are adjusted to reflect the shadow price of the fuel being used to produce electricity. Shadow Adjustment factors from market to shadow prices for fuels are presented in Table 6.

Average MCEs result from averaging peak and off-peak costs. There are two basic problems here. First, since most losses occur at peak time, the correct weight for peak and off-peak energy costs should correspond to the distribution of losses between peak and off-peak times. Secondly, since the system is evolving from gas plus oil-fired generation towards gas plus hydro generation, the true long run marginal cost of energy is going to approach the present off-peak MCE. The first factor would tend to raise the average MCE while the second factor would tend to decrease the average MCE. The compromise solution adopted here has been to average costs taking about 80% of off-peak costs and 20% of peak costs (the present system ratio is about 60% off-peak to 40% peak).

Table 1: DEMAND PROJECTIONS

FY	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95
GENERATION (GWH)											
Generation (GWh)	4289.1	4774	5305.5	6060.9	6895.8	7788	8723.9	9772.4	10757	11825.7	13005.2
Net Generation	4075.50	4536.25	5041.29	5759.07	6552.39	7400.16	8289.45	9285.73	10221.30	11236.78	12357.54
132 kV	4055.13	4513.57	5016.08	5730.27	6519.63	7363.16	8248.00	9239.31	10170.19	11180.60	12295.75
33 kV	3945.09	4686.21	5207.94	5949.45	6769.00	7644.79	8563.48	9592.70	10559.20	11608.24	12766.05
11 kV	3830.97	4264.08	4738.81	5413.52	6159.25	6956.15	7792.08	8728.59	9608.02	10562.57	11616.09
4 kV	3749.46	4173.35	4637.98	5298.34	6028.20	6808.14	7626.29	8542.88	9403.60	10337.84	11368.94
Customer	3504.93	3901.18	4335.51	4952.80	5635.05	6364.14	7128.93	7985.73	8790.32	9663.63	10627.49
CAPACITY (MW)											
Peak	887	993	1112	1279	1471	1692	1861	2047	2252	2477	2725
Net Peak	849.62	951.15	1065.13	1225.10	1409.00	1620.69	1782.57	1960.73	2157.09	2372.61	2610.15
132 kV	841.12	941.64	1054.48	1212.84	1394.91	1604.48	1764.74	1941.12	2135.52	2348.88	2584.05
33 kV	807.99	904.54	1012.94	1165.07	1339.96	1541.28	1695.22	1864.65	2051.39	2256.35	2482.26
11 kV	776.55	869.35	973.53	1119.74	1287.83	1481.31	1629.27	1792.11	1971.58	2168.56	2385.68
0.4 kV	755.31	845.57	946.90	1089.11	1252.60	1440.79	1584.70	1743.09	1917.65	2109.25	2320.43
Customer	700.93	784.70	878.74	1010.70	1162.43	1337.07	1470.62	1617.60	1779.60	1957.40	2153.38

Source: BPDB for gross generation and peak capacity. The rest is calculated using the mission's estimate of losses.

Table 2: INVESTMENT PROGRAM

FY	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95
INVESTMENT COSTS GENERATION											
Foreign	2443	3470	4057.2	2813.9	1705.1	2526.1	4480.1	2381.5	1730.7	2793.5	2961.3
Local	964.8	1250.9	1492.8	1422.1	626.4	945.8	1619.4	1020.6	741.7	995.3	1049.4
TOTAL	3407.8	4720.9	5550.0	4236.0	2331.5	3471.9	6099.5	3402.1	2472.4	3788.8	4010.7
DISCOUNTED GENERATION INVESTMENT COSTS											
Foreign	2443.00	3098.21	3245.76	2009.93	1086.05	1435.28	2274.16	1077.60	697.86	1008.48	952.15
Local	964.8	1116.9	1194.2	1015.8	399.0	537.4	822.0	461.8	299.1	359.3	337.4
TOTAL	3407.8	4215.1	4440.0	3025.7	1485.0	1972.7	3096.2	1539.4	996.9	1367.8	1289.8
SHADOW ADJUSTMENT											
Adj. Foreign	3053.75	3872.77	4057.20	2512.41	1357.56	1794.11	2842.70	1347.00	872.33	1260.60	1190.23
Adj. Local	844.20	977.27	1044.96	888.81	349.11	470.21	719.28	404.08	261.69	314.40	295.25
TOTAL	3897.95	4850.03	5102.16	3401.22	1706.67	2264.32	3561.98	1751.09	1134.02	1575.00	1485.48
INVESTMENT COSTS TRANSMISSION											
Foreign	839.3	1262.2	558.4	887.6	1181.9	1204.2	806.3	786	596.1	749.7	764.4
Local	513.7	938.5	469.4	371.6	481.1	420.6	268.8	262	198.7	249.9	254.5
TOTAL	1353	2200.7	1027.8	1259.2	1663	1624.8	1075.1	1048	794.8	999.6	1019.2
DISCOUNTED TRANSMISSION INVESTMENT COSTS											
Foreign	839.30	1126.96	446.72	634.00	752.80	684.20	409.29	355.66	240.36	270.65	245.75
Local	513.70	837.95	375.52	265.43	306.43	238.98	136.45	118.55	80.12	90.22	81.90
TOTAL	1353.00	1964.91	822.24	899.43	1059.24	923.18	545.74	474.21	320.48	360.87	327.72
SHADOW ADJUSTMENT											
Adj. Foreign	1049.13	1408.71	558.40	792.50	941.00	855.26	511.61	444.57	300.45	338.31	307.23
Adj. Local	449.49	733.20	328.58	232.25	258.13	209.11	119.39	103.73	70.11	78.94	71.65
TOTAL	1498.61	2141.91	886.98	1024.75	1209.13	1064.36	631.00	548.30	370.56	417.25	378.92
DISTRIBUTION INVESTMENT COSTS											
Foreign	619.5	1782.7	1971	2020.1	1717.3	1464	1464	1564.1	1714.2	1864.3	1964.4
Local	640	1387.9	1673.6	1694.9	1495.9	976	976	1042.7	1142.8	1242.9	1309.6
TOTAL	1259.5	3170.6	3644.6	3715	3212.2	2440	2440	2606.8	2857	3701.2	3274
DISCOUNTED DISTRIBUTION INVESTMENT COSTS											
Foreign	619.50	1591.70	1576.80	1442.93	1093.82	831.82	743.15	707.74	691.21	673.03	631.64
Local	640.00	1239.20	1338.88	1210.64	952.80	554.55	495.43	471.81	460.81	448.70	421.05
TOTAL	1259.50	2830.89	2915.68	2653.57	2046.62	1386.36	1238.58	1179.55	1152.02	1121.73	1052.73
SHADOW ADJUSTMENT											
Adj. Foreign	774.38	1989.62	1971.00	1803.66	1367.28	1039.77	928.93	884.67	864.01	841.29	789.55
Adj. Local	560.00	1084.30	1171.52	1059.31	833.70	485.23	433.50	412.83	403.21	392.61	368.45
TOTAL	1334.38	3073.92	3142.52	2862.97	2200.98	1525.00	1362.44	1297.51	1267.22	1233.90	1158.01
TOTALS											
GENERATION	30729.926										
TRANSMISSION	10171.784										
DISTRIBUTION	20458.835										

Source: BPDB and mission estimates.

Table 3: DISCOUNTED INCREMENTAL VALUES OF OPERATION AND MAINTENANCE COSTS

FY	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95
GENERATION	279.600	16.920	16.896	22.134	20.973	21.336	12.250	11.524	10.300	10.026	9.856
TRANSMISSION	44.080	2.698	2.635	3.482	3.325	3.351	1.926	1.829	1.626	1.582	1.547
DISTRIBUTION	269.040	19.102	19.126	25.042	24.163	24.803	14.680	13.949	12.654	12.395	12.221
BILLING	39.200	2.202	2.193	2.668	2.186	2.142	1.813	1.713	1.203	1.179	1.158
ADMINISTRATION	56.320	2.509	2.432	2.983	2.430	2.326	1.955	1.839	1.253	1.217	1.195

TOTALS	UNADJUSTED	ADJUSTED	
GENERATION	431.82	GENR.	400.14
TRANSMISSION	68.08	TRANS.	81.87
DISTRIBUTION	447.18	DISTRIB.	464.03
BILLING	57.66		
ADMINISTRATION	76.46		
TOTAL	1081.19		

Source: BPDB and Mission estimates.

Table 4: SUMMARY OF INCREMENTAL CAPACITY COSTS FOR BANGLADESH

Item	Incremental Cost	Incremental Capacity/ Demand	Ratio (AIC)	Annuitized Costs	Incremental Operation and Maintenance Cost	Demand	AIC	Total AIC	Cumulative (000 TK/TW/YEAR)	Cumulative (US$/KW/YEAR)
			(000 TK/kW)							
SHADOW PRICED GENERATION (COST)	30729.93				400.14					
(MW)		1263.93	24.313	3.100		974.29	0.41	3.51	3.511	117.02
TRANSMISSION (COST)	10171.78				81.87					
NET MW		929.67	10.941	1.345		929.67	0.09	1.43	4.943	164.78
MW 132 kV		920.37	11.052	1.358		920.37	0.09	1.45	4.958	165.26
MW 33 kV		884.11	11.505	1.414		884.11	0.09	1.51	5.017	167.24
DISTRIBUTION (COST)	[illegible]8.83				464.03					
MW 11 kV		849.71	24.077	2.959		849.71	0.55	3.51	8.522	284.08
MW 0.4 kV		826.47	24.754	3.042		826.47	0.56	3.60	8.621	287.37
MW CUSTOMER		766.97	26.675	3.278		766.97	0.61	3.88	8.901	296.68

Table 5: MARGINAL COSTS OF ENERGY
(US ¢/kWh)

Marginal Cost	Peak	Off-Peak	Average
Gross Generation	10.02	0.72	2.92
Net Generation	10.50	0.75	3.06
132 kV	10.55	0.76	3.08
33 kV	10.85	0.78	3.17
11 kV	11.17	0.80	3.26
0.4 kV	11.42	0.82	3.33
Customer	12.21	0.86	3.55

Table 6: ADJUSTMENT FACTORS FOR FUEL PRICES

Fuel	Border Price	Actual Price	Ratio
1. Jet Fuel (Naphta)	35.4	57.4	0.62
2. Kerosene (SKO)	35.4	43.8	0.81
3. Diesel Fuel (HSD)	33.6	42.8	0.79
4. Fuel Oil	28.2	34.6	0.82
5. Natural Gas	0.72	0.46	1.55

Note: Liquid fuels are in US$/Bbl and natural gas is in US$/MCF.

Sources:
- For (1) to (3) "Bangladesh: Economic Trends and Development Administration" Vol II. Statistical Appendix, World Bank Report No. 4822, Prices for July 1983.
- For (4) border prices come from "Prices of Crude Petroleum and Petroleum Products, Fourth Quarter 1983", Memo, World Bank, February 16, 1984; actual price comes from Burmah Eastern Limited, Memo, March 8, 1983.
- For (5) border price comes from "Marginal Cost of Natural Gas in Developing Countries: Concepts and Applications" Energy Department Paper No. 10, August 1983. Prices have been updated to 1984 US$ using the US consumer price inflation. Actual prices have been supplied by BPDB.

ESTIMATION OF THE TECHNICAL LOSSES

Load Characteristics and Basic Analyses

Load and Loss Factor. Hourly readings of total MW-generation were collected from the Dispatch Center at Siddirganj for one week around the annual peak demand (June 16-22, 1989) and for a typical week during minimum demand (December 10-16, 1983). Load characteristics are calculated by computer analysis using these two samples. The resulting load factor of 61.6% and loss factor of 39.6% are applied for the calculation of all current-dependent loss components, except for sample studies of 11-kV and 400-volt feeders, where the relevant loadings of those feeders are taken into account, whenever they are available.

Power Factor. For step-up transformer the actual value of 0.93 as calculated from the annual total peak generation is applied. For the 132-kV step-down transformers and the distribution system an average power factor of 0.85 is used, except in some sample studies, where actual values could be identified.

System Configuration and Data. This information, including structure of the transmission and the distribution systems, transformer ratings, and conductor sizes, was supplied by BPDB in sufficient detail for a general assessment of the losses. The data base was sample-checked during site visits.

No-Load and Full-Load Losses of Transformers. In a few cases, where the BPDB could identify the loss characteristics of transformers on specific locations (from manufacturer's test reports), BPDB's data are applied. For the majority of transformers international average values are assumed by establishing a correlation between no-load (iron) and full-load (copper) losses and the transformer rating. For this correlation analysis European, American, and BPDB's own data are used.

Infeeds at Various Distribution Levels. The peak load of consumers connected at each voltage level is assumed to be proportional to the energy sold at that level. The infeed to a certain distribution network is calculated, accordingly, as the difference between the infeed at the preceding higher level and the energy and power consumed and lost along that higher level of the distribution system.

Based on BPDB's billed energy statistics, the following consumption pattern is used for the loss calculations.

33 kV:	10%
11 kV:	48%
0.4 kV:	42%
	100%

System Component Categories

Step-up Transformers. MW outputs of all generating units were obtained from BPDB for a typical evening peak loading condition. The apparent power loadings of step-up transformers are calculated by the overall power factor of the system (0.93) The peak power losses are then determined by summing up the no-load and load losses of each transformer calculated with well-known formulas.

For the determination of the energy losses, the no-load losses are integrated along the whole year, while the load losses are calculated using the overall system loss factor.

Since not all the units were in operation during the peak load hour that was analyzed, the results reflect typical unit availability and peak generation dispatch strategy.

132/66 kV Transmission Grid. Results of load-flow studies for some typical peak loading conditions, with all transmission lines in operation, have been received from the System Planning Department of BPDB. The peak losses in the conductors of the 132 kV and 66 kV lines are determined from these studies with a slight adjustment to reflect small deviations between simulated and actual total peak generation. Annual energy losses are determined using the overall loss factor.

Though none of the lines are built with unusually small conductors, a certain amount of corona and shunt leakage losses must arise, particularly during the rainy season and foggy periods. An annual average value of 1 kW/km is used to estimate corona losses for the 132 kV lines.

Step-down Transformers at 132-kV Substations. The method of calculation is the same as for the step-up transformers, except that a power factor of 0.85 is assumed. Peak loading at each substation was measured at the same peak load hour as in the case of step-up transformers. All 132/33 kV, 132/11 kV, 132/33/11 kV and 132/66 kV transformers are considered.

33 kV Lines. An approximate assessment method is used. The method is based on a simplified model of the extensive 33 kV network reduced to feeders with average length, conductor size and average loadings, concentrated at the middle-point of the lines. The losses obtained for such a model line are multiplied by the number of lines. In addition, a rigorous diagnostic analysis is carried out for one of the heavily loaded 33 kV lines.

33/11 kV Transformers. The losses of a big sample including transformers at 29 substations in the Greater Dhaka area are determined with the same method used for step-up and step-down transformers. Loadings are determined from simultaneous current readings at those stations during the same evening peak referred to previously.

The losses obtained for the sample are extrapolated for the whole country in proportion to the ratio of the load at all 132 kV grid substations to that of the Greater Dhaka area. This is readily available from the step-down transformer loss study.

11-kV Feeders. The same method as for the 33 kV lines is applied, but the average load is concentrated at one third of feeder length from the infeed point because of the different pattern of 11/0.4 kV transformers allocation along the feeders. The losses of the 11/0.4 kV transformers are also approximately calculated and included in the 11 kV feeder losses. Sample studies on specific feeders are also performed.

400 Volt Network. Because of the extreme complexity of the 400 volt network, an indirect assessment method is applied.

The method is based on the information, confirmed by many individuals within and outside the BPDB, that the 400 V network is so heavily overloaded in most parts of the country that only consumers near the pole-mounted transformers receive single-phase voltage 230 volt, while the majority is supplied at 190 volt or lower voltage with extreme values as low as 130 volt.

Accordingly, for the total peak power infeed calculated for the 400 volt level, an equivalent resistance resulting in an average voltage drop of 15% is determined, and losses are calculated from the level of the infeed and the equivalent resistance.

In addition, sample studies are being carried out for a relatively lightly loaded urban residential supply area.

Annex 3

GENERATION CAPACITIES

	Installed Capacity in MW	Capability in MW as of June 1983
	(MW)	(MW)
East Zone		
Kaptai Hydro	130.0	142.0
Ashuganj Steam	128.0	128.0
Ashuganjt G.T.	60.0	55.0
Ghorasal Steam	110.0	110.0
Siddhirganj Steam	80.0	74.0
Shajibazar Gas Turbine	96.0	67.0
Chittagong Gas Turbine	6.5	5.0
Other Diesel	18.0	7.25
TOTAL East Zone	628.5	588.25
West Zone		
Khulna Steam	60.0	60.0
Khulna Barge Mounted	56.0	46.0
Goalpara GTPS	23.0	20.0
Bheramara GTPS	60.0	54.0
Khulna DPS	7.84	3.5
Khulna Steam	12.48	8.0
Bheramara Steam	4.16	-
Saidpur DPS	11.25	9.0
Bogra DPS	6.5	2.6
Bogra Gas Turbine	6.5	-
Thakurgaon DPS	10.5	3.2
Barisal and other	32.51	15.85
TOTAL West Zone	290.74	222.15
TOTAL	919.24	810.4

Source: BPDB, Annual Report 1982-83.

TERMS OF REFERENCE
FOR
ECONOMIC OPERATION OF GENERATING SYSTEM

Summary of Requirements

The Bangladesh Power Development Board (BPDB) is soliciting proposals from a consulting firm to prepare and implement a program to improve the operation and dispatch of generating plants and thus reduce the cost of generation. The work, which must be implemented as a coordinated program, consists of three elements:

(a) Improve the efficiency of the existing system by immediately implementing basic dispatch procedures.

(b) Effect procedural and equipment changes that will allow more extensive use of gas-fired operation during off peak periods.

(c) Set up procedures to monitor the performance of individual generating units (as it is affected by operator action and/or equipment defects).

The work will be done in two phases. Phase 1 will include familiarization with the system, detailed assessment of the costs and benefits of various measures, preparation of equipment and training specifications, and some immediate training activities. Phase 2 will include the procurement, installation and commissioning of equipment, the implementation of operating procedures and final training of BPDB operating and maintenance staff.

The overall cost of the program, excluding local staff and facilities, is estimated to be about US$12 million. The phase 1 cost is estimated at US$894,000 consisting of about US$634,000 in professional services and US$260,000 in expenses. The phase 2 cost is expected to be about US$11.0 million consisting of about US$1.6 million in professional services, US$8.7 million in equipment and the remainder in expenses.

The program is financed by ______________________________. The executing agency is ________________________. In the following discussion the consulting firm submitting a proposal to do the work is referred to as the "firm" and the work is referred to as the "program".

Background

The Bangladesh Power Development Board (BPDB) is a statutory government entity responsible for the generation, transmission and distribution of electricity in Bangladesh. The BPDB reports directly to the Ministry of Energy. The allocation of resources for the BPDB is guided by the Planning Commission, which coordinates the development of the power sector with those of other sectors of the economy.

This program to improve generation efficiency is one of a group recommended by a World Bank/UNDP Power Loss Reduction mission. The mission's report, which describes the power system and outlines the work to be done, is a part of these terms of reference.

Scope of Work

The work includes everything that is necessary to achieve the objectives listed in the Summary of Requirements. Some of the specific tasks are:

Phase 1

(a) Review present system operation and dispatch procedures.

(b) Prepare improved dispatch procedures and train BPDB staff in their application. (These procedures should be simple and should form the groundwork for the dispatch operations after proposed SCADA facilities become available approximately in 1987).

(c) Inspect the instrumentation on all of the steam, gas turbine and combined cycle units. Specify and prepare cost estimates for equipment and work required to upgrade the instrumentation to facilitate plant and unit efficiency measurement.

(d) Specify and prepare detailed cost estimates for the equipment and work required to enable the Khulna steam plants to be used for cycling operation (nightly shutdown of at least eight hours). This includes but is not restricted to:

(i) Inspect the two units' control systems in detail and issue a specification (request-for-proposal) to convert or replace the necessary controls and equipment to enable the 60 MW units to operate on automatic control down to the 25-30% load range, and the 110 MW unit down to 45% load and onto the turbine bypass system control. The request-for-proposal shall also require the bidders to include a separate proposal for a controls and instrument maintenance contract covering the more complex equipment and systems, such as the microprocessor.

(ii) Include in the new automatic systems a boiler fuel oil burner flame monitor/interlock system to protect the units at all operating load levels.

(iii) Include in the new control systems for these units a microprocessor for optimum overall operating control and efficiency. The design of the system shall include the capability to remove these units from service in a hot standby or banked mode. The units should be capable of being removed and returned to service on a daily basis.

(iv) Evaluate quotations for equipment revisions to minimize damage to the operating equipment.

(e) Determine, specify and prepare cost estimates for the equipment and work required to improve the reliability of the transmission line interconnecting the east and west zones. Special attention should be paid to the protective system, which has malfunctioned frequently in the past.

(f) Study the real and reactive power flows on the interconnected system at peak and low load periods. Determine reactive compensation requirements, provide guidelines for dispatch of reactive power, transformer tap settings, etc. Specify and prepare detailed cost estimates for the equipment and work required to provide adequate reactive compensation to minimize system losses at all load levels. Cost/benefit analyses should be used to determine the optimum levels of compensation.

(g) Review the existing under-frequency and under-voltage load shed system, determine what upgrading is required to attain reasonable system security (especially in the West Zone if the Khulna plant is two shifted), and prepare specifications and detailed cost estimates for the required equipment and work.

(h) Set up and implement individual unit monitoring procedures for all steam units and train BPDB staff in their use. The Operations Management Manual For Fossil Fuel Steam Electric Generating Plants -- United States Department of Agriculture Rual Electrification Administration - REA Bulletin 163-3 -- should be used as a guide for this activity. The Efficiency Control Scheme used by the Thermal Production Division of the Nova Scotia Power Entity in Canada is a good example of the required system.

(i) After the cost estimates are prepared, a benefit cost analysis should be performed using economic principles to determine whether or not the work to allow Khulna to be two shifted is justified.

Phase 2

To the extent that the work is justified by the analysis in Phase 1:

(a) Procure, expedite, manage the installation, and commission, the equipment required to upgrade the plant instrumentation, upgrade system security, improve the dispatch of real and reactive power and enable Khulna to be cycled. The intent is that the firm should manage these activities and any other required to implement the program outlined in the Summary of Requirements, and deliver a working system to the BPDB.

(b) Provide training to ensure that the BPDB operating staff is technically competent to run the system and achieve the envisaged cost savings.

Division of Labor and Responsibilities

The firm will be fully responsible for the implementation of the program. It will provide all of the services required to ensure the success of the project.

The BPDB will provide the following:

(a) Access to the plants, documents, and any data required to carry out the work.

(b) All transportation in Bangladesh.

(c) Counterpart staff as required.

(d) Office space, standard office equipment and supplies.

(e) Secretarial services.

(f) Translation services if required.

Guidelines for Proposal

The proposal should provide comprehensive details of the following:

(a) A work plan in accordance with these terms of reference;

(b) A preliminary estimation of the hours per person required for the work and the place in which the work will be carried out.

(c) The nature of the organization and previous experience in related work in developing countries.

(d) Curricula vitae of staff who will be assigned for the study as well as curricula vitae of support staff at Headquarters.

(e) Details of hardware offered or arranged for supply.

(f) Staff and period to be assigned for establishment of the systems and training of BPDB personnel inclusive of full curricula vitae and previous experience.

A sealed envelope should be enclosed with the proposal indicating the cost estimate of this work based on a system of fixed professional fees, which should also be determined in relation to the actual hours of work. The firm may suggest alternative schemes for attaining the objectives outlined in the Summary of Requirements. Any alternative scheme should be clearly identified as such, and separate work schedules and costs should be provided for each.

Once the proposals have been evaluated, BPDB will proceed to negotiate the contract with most qualified firms and if they are unable to reach agreement during the negotiations, proceed to negotiate with the second best qualified firm. BPDB may reject any or all of the offers received if none of them is satisfactory.

Form of Contract

The contract which will be awarded to the successful firm will be based on the International Model Form of Agreement Between Client and Consulting Engineer No. IGRA 1979 D&S -- produced and issued by the International Federation of Consulting Engineers (FIDIC).

Schedule of Payments

The schedule of payments will be negotiated and the firm is invited to propose a schedule. However, the BPDB will tie payment to clearly identified performance targets, which may include among others:

(a) The completion of analysis.

(b) The production of specifications.

(c) The completion of training.

Cost Estimate

Program: Economic Operation of Generation System

Project: Phase 1 - Training and preparation of specifications for equipment and installation services

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Objective: To reduce the cost of generation by improving dispatch procedures, by improving the operation of individual generating units, and by making changes that would allow more extensive use of gas-fired generation at off-peak periods.

Scope of Service/Equipment:

- Provide training in dispatch procedures.
- Inspect instrumentation at generating plants and specify rehabilitation or upgrading requirements to allow performance monitoring.
- Prepare specifications for changes required to two-shift Khulna plant including:
  - Improving reliability of interconnector between East and West Zones.
  - Upgrading underfrequency load shed system and setting up operating procedures to provide system security in West Zone if Khulna is shut down at night.
  - Specify work required to upgrade controls at Khulna to allow effective two-shifting.
  - Determine any potential reduction of component life.
- Set-up efficiency monitoring system for individual units.
- Determine reactive compensation requirements, prepare specifications for equipment and provide operating guidelines.

Estimate of Cost (1984 US$):	Professional Services	Travel and Subsistence
Training in dispatch procedures (4 man months)	36,000	20,000
Inspect and prepare specifications for plant instrumentation (30 man months)	270,000	100,000
Prepare specifications for upgrading controls Khulna, etc. (6 man months)	54,000	24,000
Reactive compensation, transmission line reliability system security (12 man months)	108,000	46,000
Set up individual unit operating efficiency monitoring (12 man months)	108,000	46,000
Contingencies (10%)	58,000	24,000
	634,000	260,000

Total Phase 1: US$894,000

Cost Estimate

Program: Economic Operation of Generating System

Project: Phase 2 - Installation of equipment and final training

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Objective: To reduce the cost of generation by improving dispatch procedures, by improving the operation of individual generation units, and by making changes that would allow more extensive use of gas-fired generation at off-peak periods.

Scope of Service/Equipment:

- Install equipment specified in Phase 1.
- Provide training in use of equipment.
- Project management.

NOTE: Estimates are approximate and are provided only to define the order of magnitude of the project.

Estimate of Cost (US$):	Professional Services	Travel and Subsistence	Equipment
Modification of Khulna plant to two shift operation	600,000	300,000	6,100,000
Upgrade instruments at other steam plants	200,000	150,000	300,000
Compensation equipment, underfrequency relays, changes to transmission line	300,000	200,000	1,500,000
Training (12 man months)	108,000	46,000	
Project Management (24 man months)	216,000	92,000	
Contingency 10%	142,000	79,000	790,000
	1,566,000	867,000	8,690,000

Total Phase 1: US$894,000
Total Phase 2: US$11,123,000
Total Program: US$12,017,000

Estimate of Benefits

Program: Ecomonic Operation of Generating System

Project: System Changes to Allow More Extensive Use of Gas

Scope of Services/Equipment:

- Upgrade controls at Khulna plant to allow two shift operation.
- Improve reliability of East-West interconnector.
- Upgrade underfrequency local shed system to improve system security.
- Determine final economic feasibility of the project.

Assumtions:

- Khulna plant can be shut down at least eight hours per day, 335 days per year.
- Khulna plant operated at about 110 MW.
- Energy not generated at Khulna is replaced by gas-fired generation.
- Assume similar heat rate for Khulna and the gas-fired plants used to replace the energy.
- Fuel cost differential US$0.0368/kWh.
- Life of project 20 years, discount rate 12%.

Calculation of Benefits:

Year	Energy Replaced (GWh)	Savings (US$)
1	-	-
2-20	294.8	10,850,000

Net Present Value (at 12%)	69,026
Savings/Cost Ratio	6.7
EDR	90.3%

TERMS OF REFERENCE
FOR
IMPROVEMENT OF GENERATING PLANT EFFICIENCY

Summary of Requirements

The Bangladesh Power and Development Board (BPDB) is soliciting proposals to organize and implement the rehabilitation of five thermal power stations (see attached list).

The objective of the rehabilitation program is to upgrade the operating condition of these units (stations) to achieve improved unit heat rates, increased capacity and plant availability. This work is to be referred to as "The Program" and is estimated to require 100 man months of service in Bangladesh and 135 man months of head office services. The overall cost of the program including local salaries and facilities is estimated at US$6.0 million. This includes approximately US$1.0 million in professional services, US$4.2 million in equipment and the remainder in local salaries, travel and living expenses. The program is financed by ______________________________. The executing agency is the ______________________________. The firm performing these services shall be referred to as the Engineer, and the Bangladesh Power and Development Board is to be referred to as BPDB.

Background

Bangladesh Power Development Board (BPDB) is a statutory government entity responsible for the generation, transmission and distribution of electricity in Bangladesh. The BPDB reports directly to the Ministry of Energy. The allocation of resources for the BPDB is guided by the Planning Commission, which coordinates the development of the power sector with those of other sectors of the economy.

This program to improve the efficiency of generating plants and recover derated capacity is one of a group recommended by a World Bank/UNDP Power Loss Reduction mission. The mission's report, which describes the power system and outlines the work to be done, is a part of these Terms of Reference.

General

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

(a) Make a field inspection of the five thermal plants, evaluate operating procedures and condition of each unit in each station, and submit an offer to undertake the scope of work described in these terms of reference. The Engineer is to perform a thorough investigation of the work elements outlined herein and shall also recommend additional rehabilitation work elements which become evident as a result of his investigation.

(b) Any additional tasks should be undertaken, provided their economic feasibility is supported by a cost/benefit analysis. The evaluation factors such as fuel cost and operating regime shall be furnished by BPDB. Cost estimates and benefits derived for each task will be submitted by the Engineer for review and approval by BPDB prior to implementing the work.

(c) The Engineer shall manage, design, specify, procure, expedite, implement, and supervise the installation work necessary to upgrade these stations. The Engineer shall prepare engineering design details and construction work job descriptions, where required, for specific tasks.

(d) 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 necessarily limited to, work time estimates with backup data and hourly rates for the work performed. These rates shall be included in the offer.

(e) Undertake on BPDB's behalf the specifying, expediting and scheduling of work including the fabrication, transport and timely delivery of equipment, material and/or systems required to complete the project. Where necessary, the Engineer will subcontract special engineering services with the prior approval of BPDB. 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 BPDB, a check estimate of the value of the service or item(s) being offered.

(f) 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 should be given, including rates and expenses. The Engineer shall include the services of a construction manager, who shall manage the work and liaise with BPDB. The field labor is to be provided by BPDB except for foreign specialized service personnel or special skilled craftsmen. The latter will be furnished by the Engineer as required and will be for BPDB's account. Field supervision, administration and accounting personnel will be furnished by BPDB for the Engineer's management.

(g) The Engineer shall plan and schedule the work. The schedule will accommodate the normal operating regime of the BPDB system. The tender document should give a first estimate of the overall time required to complete the specified work. Curricula vitae of the key personnel being offered to perform this work shall also be included in the proposal document.

(h) The Engineer shall train BPDB staff in the operation and maintenance of any new equipment installed during the Project.

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 (listed below) are to be completed twelve (12) months after contract has been awarded.

Scope of Work

The following work elements are to be included in the Engineer's base scope of service:

Ashuganj Station

An existing rehabilitation program on the German designed two x 64 MW units (installed 1970-71) is in the final stages of completion, but the station still presents two problems:

(a) Recorded auxiliary power consumption (6.45 %) is high for a gas-fired steam station; and

(b) the instrumentation at this plant is in poor condition and in need of repair and calibration.

In order to overcome these problems, the Engineer shall:

(a) Review the plant electrical system to ascertain the reasons for the high level of auxiliary power consumption and recommend steps to reduce it. He shall also evaluate in detail the economic feasibility of replacing the constant speed boiler induced draught fan motors with variable speed units.

(b) Arrange for an inspection of the instrumentation by a qualified instrument control engineer. He shall then retain the services of a controls contractor, who will repair, recalibrate and reset the major systems' instruments and controls and, where necessary, upgrade and/or replace controls which cannot be repaired. This contractor shall furnish his own repair tools and test stand equipment to carry out his work.

(c) The contractor shall perform on-the-job training for selected BPDB trainee engineers during this rehabilitation period by working with and instructing the trainees in the repair and calibration of controls and instruments.

(d) The contractor shall then update the existing recommended list of the spare parts, tools, and test equipment required to maintain the instrumentation in good running condition. The Engineer shall then list qualified suppliers of these materials for BPDB and issue specifications for purchase by BPDB as necessary.

Ghorasal Station

The 2 x 55 MW units of this station (installed 1974-75) are of Russian origin. This plant has a 7.95 percent auxiliary power consumption rate and a 28.6 percent thermal efficiency. In addition, the instrumentation is in poor condition. The following steps are required to attain improvement in both areas:

(a) The low thermal efficiency of these units should be investigated in conjunction with an evaluation of the condition of the instrumentation. Corrective steps are to be taken with BPDB approval to restore the units to peak efficiency and to restore the instrumentation to good working order using the same procedure as at Ashuganj.

(b) The existing forced draught fan inlet ducts are designed to remove air from the top of the turbine hall as an efficiency measure. The Engineer shall design a second connector to this duct with dampers, to take air from the enclosure at the top of the boilers.

Khulna Station

This plant is the largest in the BPDB system. Several units are very old and small. Replacement parts are in some cases unavailable. However, the newer steam units are judged to qualify for extensive redesign which will yield considerable savings to BPDB. The major redesign work to be performed concerns the limited capability of the 110 MW and 60 MW heavy oil-fired Czeckoslovakian design (Skoda) steam units to operate below 70% rating on automatic control. The major redesign work to achieve cycling capability is done under a separate contract and is not included in this Scope of Work. However, both units require minor modifications to improve operative and energy efficiency. In order to achieve this objective, the Engineer shall:

(a) Evaluate and specify, after BPDB's approval, the substitution of variable speed motor drives on the boiler (forced and induced) draught fans on both units. BPDB will provide all the values required for the evaluation.

(b) Review the electrical auxiliary system to establish the reasons for its high consumption rate. He shall then present to BPDB a cost-benefit analysis and recommend steps which can be taken to reduce auxiliary power consumption.

The cost of generating power with the diesel oil burning gas turbine units at this station is amongst the highest in the BPDB system. The two land-based units are in need of a general factory representative inspection. This inspection shall include repair, recalibration and clean up of the control system. These units are one 12.75 MW Fiat and one 10.5 MW Stal Laval units.

Shahjibazar Station

This plant is made up of 4 x 16 MW Cie Electro Mecanique (now Alsthom Allantique of France) and 3 x 14.75 MW Fiat gas turbine units, some of which are presently derated to approximately eight MW each.

For this station, the scope of work for the Engineer is as follows:

(a) An in-depth inspection by a factory representative, including unit controls, to establish the present load limiting factors and poor thermal efficiency on each unit. Quotations to correct these conditions shall be provided by the manufacturer. Additionally, he shall quote on changing the control system to a solid state design.

(b) The engineer shall also inspect and evaluate the other parts of the plant to determine additional rehabilitation work required to restore it to rated capacity. This work shall include an inspection of the turbine air filters, the rehabilitation of the plant closed cooling water system, (especially the cooling water pumps), the plant battery room facilities and the control room cooling air system. Based upon all the above inspections and estimates the Engineer shall perform a cost-benefit evaluation for review and approval by BPDB.

(c) The Engineer shall evaluate the installation of control, electrical and mechanical workshops, and the training of qualified BPDB personnel in plant equipment maintenance and instrument maintenance and calibration.

(d) A supplementary evaluation shall also address the overall extended useful plant life of these units beyond 1988, based on the rehabilitation of the plant.

Siddirganj Station

This plant has a one x 50 MW American designed gas-fired steam unit which has recently been through a major rehabilitation program. In general, this unit is in good condition with only minor existing problems.

Three areas shall be investigated by the Engineer at this station:

(a) The substitution of a variable drive unit for the single boiler forced draught fan motor. If approved by the BPDB, the Engineer shall specify and arrange for the procurement and delivery of the new drive unit and shall supervise its installation.

(b) The Engineer shall also investigate the remainder of the auxiliary power load and recommend any other steps or revisions to the unit auxiliary system which would further reduce power consumption to a more acceptable level. The Engineer shall establish unit efficiency and determine other revisions which will increase its present thermal efficiency.

(c) Inspection and assessment of the general condition of the unit control systems. The Engineer shall recommend any upgrading of these devices which will further enhance unit operation.

Priority of Work

The rehabilitation program contains some tasks which shall be started immediately as well as longer term programs which should also be promptly initiated. Other tasks have a lower level of urgency. The BPDB priorities of the work tasks to be performed are as follows:

First Priority

1. Plant inspection

2. Shahjibazar rehabilitation program

Second Priority

1. Variable speed drive units on major steam units boiler fans.

2. Auxiliary power reduction program, at steam plants.

3. Instruments and control i) rehabilitation program.
   ii) training program.

Division of Labor and Responsibilities

The firm will be fully responsible for the implementation of the program. It will provide all of the services required to ensure the services of the project.

The BPDB will provide the following:

(a) Access to the plants, to documents and to any data required to carry out the work.

(b) All transportation in Bangladesh.

(c) Counterpart staff as required and at the educational level specified by the consultant to ensure success of the training.

(d) Office space, standard office equipment and supplies.

(e) Secretarial services.

(f) Translation services if required.

Guidelines for Proposal

The proposal should provide comprehensive details of the following:

(a) A work plan in accordance with these terms of reference.

(b) A preliminary estimation of the hours per person required for the work and the place in which the work will be carried out.

(c) The nature of the organization and previous experience in related work in developing countries.

(d) Curricula vitae of staff who will be assigned for the study as well as Curricula vitae of support staff at Headquarters.

(e) Details of hardware offered or arranged for supply.

(f) Staff and period to be assigned for establishment of the systems and training of BPDB personnel inclusive of full Curricula vitae and previous experience.

A sealed envelope should be enclosed with the proposal indicating the cost estimate of this work based on a system of fixed professional fees, which should also be determined in relation to the actual hours of work. The firm may suggest alternative schemes for attaining the objectives outlined in the Summary of Requirements. Any alternative scheme should be clearly identified as such, and separate work schedules and costs should be provided for each. The firm should also provide a schedule of fees for phase 2 of the work, which should be defined at the end of phase 1.

Once the proposals have been evaluated, BPDB will proceed to negotiate the contract with the most qualified firm and, if they are unable to reach agreement during the negotiations, proceed to negotiate with the second best qualified firm. BPDB may reject any or all of the offers received if none of them is satisfactory.

Form of Contract

The contract which will be awarded to the successful firm will be based on the International Model Form of Agreement Between Client and Consulting Engineer No. IGRA 1979 D&S -- produced and issued by the International Federation of Consulting Engineers (FIDIC).

Schedule of Payments

The schedule of payments will be negotiated, and the firm is invited to propose a schedule. However, the BPDB will tie payments to clear performance targets.

List of Plants

Ashuganj Station:	2x64 MW gas-fired steam plant (German design)
Ghorasal Station:	2x55 MW gas-fired steam plant (Russian design)
Khulna Station:	1x110 MW heavy-oil-fired steam unit (Czech design) 1x60 MW heavy-oil-fired steam unit (Czech design) 1x12.75 MW diesel-oil-fired gas turbine unit (Stal Laval, Swedish design) 1x10.5 MW diesel-oil-fired gas turbine unit (Fiat, Italian design)
Shahjibazar Station:	4x16 MW Gas fuel gas turbine unit (Cie Electro Mecanique; French design) 3x14.75 MW gas-fired gas turbine units (Fiat; Italian design)
Siddhirganj Station:	1x50 MW gas-fired steam plant (American design)

Cost Estimate

Program: Generating Plant Efficiency

Project: Reduction of Plant Auxiliary Power Consumption

Objective: To modify plant auxiliary systems in order to reduce auxiliary energy consumption.

Scope of Services/Equipment

Phase 1 Inspect the generating plants and study the technical and economic feasibility of various measures to reduce auxiliary power consumption.

Phase 2 Design, procure, install and commission equipment to reduce auxiliary power consumption as justified by Phase 1.

Estimate of Cost (US$):	Professional Services	Travel and Subsistence	Equipment
Phase 1			
Inspection of units (6 man months)	54,000		
Travel		10,000	
Living expenses		22,000	
Contingency 10%	5,000	3,000	
	59,000	35,000	
Phase 2			
Engineering and design	300,000		
Project management and installation (6 man months)	360,000		
Variable speed fan drives			1,280,000
Spare parts tools and test equipment			600,000
Travel		40,000	
Living expenses		130,000	
Contingency 10%	66,000	17,000	19,000
	726,000	187,000	1,899,000

Total Phase 1: US$94,000
Total Phase 2: US$2,812,000
Total Project: US$2,906,000
Local Cost: US$50,000

Cost Estimate

Program: Generating Plant Efficiency Improvement

Project: Shahjibazar Gas Turbine Station - Recovery of Derated Capacity

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Objective: To rehabilitate the generating units at this plant in order to recover derated capacity and improve efficiency.

Scope of Services/Equipment

The work will be done in two phases:

In phase 1, a consulting firm is required to assess and specify the required maintenance and rehabilitation work. In phase 2, it should supervise the procurement, installation and commissioning of the necessary eqipment.

Estimate of Cost (US$):	Professional Services	Travel and Subsistence	Equipment
Phase 1			
Review of requirements and preparation of specifications (22 man months)	198,000		
Travel (4 roundtrips)		20,000	
Living expenses		65,000	
Contingency 10%	20,000	9,000	
	218,000	94,000	
Phase 2			
Air filter replacements			30,000
Battery replacements			23,000
Conversion of turbine controls to solid state			320,000
Repair shops			300,000
Replacement of circulating water pumps			40,000
Control system repairs			12,000
Spare parts and materials			1,400,000
Factory service representative	20,000		
Project management (24 man months)	198,000		
Travel		20,000	
Living expenses		86,000	
Contingency 10%	22,000	11,000	213,000
	240,000	117,000	2,338,000

Total Phase 1: US$312,000
Total Phase 2: US$2,695,000
Total Project: US$3,007,000 (excluding local labour)
Local Labour: US$45,000

Estimate of Benefits

Program: Generating Plant Efficiency Improvement

Project: Reduction of Plant Auxiliary Power Comsumption

Scope of Services/Equipment

Upgrade auxiliary systems to reduce energy usage.

Assumptions

- Capacity released by reducing auxiliary demand 9MW
- Energy saved (9 MW at 75% load factor) 59 GWh/yr
- Long run marginal cost of capacity US$117/kW/yr
- Discount rate 12%
- Average life of project 15 years

Calculation of Savings

	Loss Reduction		Savings (1984 US$)		
Year	(MW)	(GWh)	Demand	Energy	Total
1	-	-	-	-	-
2	4	26	486,000	759,000	1,227,000
3-15	9	59	1,053,000	1,723,000	2,776,000

(Million US$)	Net Present Value	14,618
	Savings/Cost Ratio	6.03
	EDR	73.0%

Estimate of Benefits

Program: Generating Plant Efficiency Improvement

Project: Shahjibazar Gas Turbine Station - Recovery of Derated Capacity

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Scope of Services/Equipment

Inspect and rehabilitate the gas turbine units at this plant to return them to rated capacity and heat rate.

Assumptions

- Recovered plant capacity approximately 20MW
- Value of energy saved by improving efficiency US$0.72 per million Btu
- Value of capacity savings US$117/kW/yr.
- Plant factor 70%
- Life of improvement work 10 years

Calculation of Savings

	Loss Reduction		Savings (1984 US$)		
Year	Increased Capacity (MW)	Energy Savings (106 Btu)	Capacity	Energy	Total
1	-	-	-	-	-
2	10	333,704	1,170,000	483,260	1,659,260
3-11	20	667,273	2,341,090	978,132	3,319,272

(Million US$)	Net Present Value	14,220
	Savings/Cost Ratio	5.7
	EDR	83.7%

TERMS OF REFERENCE
FOR
NON-TECHNICAL LOSS REDUCTION PROGRAM

Summary of Requirements

The Bangladesh Power Development Board (BPDB) is soliciting proposals to organize and implement a program to reduce non-technical losses from the present level of about 17% of net generation to 7% of net generation, or better, in two years. The program should be structured so that it can be continued under the BPDB's supervision to achieve and maintain an ultimate non-technical loss level of 1% of net generation or better.

The work will include, but not be restricted to, the following major items:

(a) Reorganize and manage a commercial operating unit which will be responsible for the entire non-technical loss reduction program.

(b) Evaluate billing system requirements; specify, purchase, install and commission billing software and computers.

(c) Organize a meter department, advise on the purchase and supervise the installation of meters for industrial and commercial customers to improve the quality and security of metering.

The estimated manpower and equipment requirements for the program are to:

(a) Provide an experienced commercial manager for two years.

(b) Provide overseas training to BPDB's existing commercial manager.

(c) Evaluate billing system needs and specify software and hardware (about 6 man months).

(d) Purchase and install a computerized billing system, including training (about 18 man months).

(e) Provide an experienced meter engineer for two years and organize a meter department.

(f) Provide five meter technicians for about two years.

(g) Specify purchase and install about 675 high tension metering units, 623 three-phase demand meters and 2,000 three-phase energy meters.

Upgrading the metering system should be done in two phases. The equipment requirements should be specified in phase 1, and the equipment procured and installed in phase 2. Although a similar situation exists with the billing system, the equipment cost estimate is considered to be accurate and thus the activity is shown as a phase 1 process only.

The overall cost of the program excluding the cost of local salaries and facilities is estimated at US$6.7 million. The phase 1 cost is estimated at US$3.9 million, consisting of US$1.1 million in professional services, US$1.9 million in equipment and software and the remainder in expenses. The phase 2 cost is estimated at US$2.8 million in equipment.

The program is financed by ______________________________.
The executing agency is the ______________________________.

In the following discussion, the work is referred to as the "program" and the firm performing the work is referred to as the "firm".

Background

The Bangladesh Power Development Board (BPDB) is a statutory government entity responsible for the generation, transmission and distribution of electricity in Bangladesh. The BPDB reports directly to the Ministry of Energy. The allocation of resources for the BPDB is guided by the Planning Commission, which coordinates the development of the power sector with those of other sectors of the economy.

This program to reduce non-technical losses is one of a group recommended by a World Bank/UNDP Power Loss Reduction Mission. The mission's report, which describes the power system and outlines the work to be done, is a part of these Terms of Reference.

Scope of Work

The program must be regarded as an integrated set of measures which must be carefully coordinated to reduce non-technical losses to the target level within the scheduled time of two years. It consists of strengthening a commercial unit which will coordinate improvements in the billing and metering system to improve accuracy and reduce fraud. For convenience, the three activities are described separately.

Strengthening of Commercial Unit

The firm shall provide an experienced commercial manager for a period of two years to reorganize and strengthen the commercial unit. He will be directly responsible to the Board of the BPDB. The manager will create a management information system, reorganize the billing process, organize a meter department and organize an inspection unit, all with the express objective of monitoring and reducing non-technical losses. The manager will also implement measures to improve the collection of cash. The specific tasks of the commercial manager shall include, but not be restricted to:

(a) Establish a consistent reporting format and frequency for power system, statistical and financial data.

(b) Set reporting requirements and format for all departments from which data must be collected.

(c) Provide regular summary reports, graphs, charts, etc. to the members of the Board.

(d) Monitor customer accounts and initiate investigative action when necessary.

(e) Advise the government on legislation related to theft of service.

(f) Establish appropriate billing cycles and collection targets.

The firm will provide simultaneous training for the existing commercial manager in a public utility in a developed country. The training should be for two six-month periods, the first starting six months after the start of the program and the second finishing six months before the end of the program.

Reorganization of Billing System

The firm shall review the existing billing system. It shall then determine the volumes to be processed and management reporting requirements of a billing system consistent with modern utility practices, specify the software and hardware requirements, procure the necessary software and hardware, install, test and put into operation the billing system. The firm will reorganize the billing department and provide the necessary training. The software must be a proven billing system which is being used in utilities elsewhere, with only slight modifications to provide for the BPDB's tariff structure and reporting needs. The hardware must be proven equipment with adequate service facilities available in the region (a service request must be adequately responded to within 24 hours).

The BPDB would prefer a system based on a central computer in Dhaka, with satellite stand-alone units in the various distribution areas. The satellite units would provide a complete billing and management information service to each distribution area and would update the central records periodically by the physical transfer of magnetic discs to the central unit. The system should use stand-alone equipment for interchange and backup. A typical system based on the IBM System 36 computer with magazine discs units and magnetic tape for security backup is shown on the project estimate appended to these Terms of Reference. This description is provided only to outline the type of system envisioned and does not imply a preference for IBM equipment.

In addition to providing a billing system, the consultant will, through the commercial manager, organize billing cycles, the rotation of meter readers and other measures to minimize fraud in the system.

Improvement of Metering System

The firm shall provide an experienced meter engineer and five meter technicians for a period of two years. Their main functions will be to, under the overall direction of the commercial manager, establish a meter department and an inspection unit consistent with modern utility practice. It is envisaged that two of the meter technicians will be devoted entirely to the inspection unit to follow up and train BPDB staff in following up metering irregularities. Some of the tasks of the meter department will be to:

(a) Install new meters or relocate and refurbish existing meters for the approximately 1,500 Large Industrial and Commercial customers, with the express purpose of securing the meters against tampering. The measures to reduce tampering should be low cost, simple and easy to maintain. They should not unduly inhibit the servicing and reading of meters.

(b) Create metering standards relating to the location, sealing, testing and maintenance of meters.

(c) Relocate and secure the meters of other large customers outside the Large Industrial and Commercial group.

(d) Install meter test equipment.

(e) Train BPBD staff in testing and maintaining meters.

Division of Labor and Responsibilities

The firm will be fully responsible for the implementation of the program. It will provide all of the professional services, software and equipment required to ensure the success of the program.

The BPDB will provide the following:

(a) Access to documents and data.

(b) Counterpart staff as required.

(c) Office space.

(d) Secretarial services.

(e) Translation services if required.

Guidelines for Proposal

The proposal should provide comprehensive details of the following:

(a) A work plan in accordance with these terms of reference.

(b) A preliminary estimation of the hours per person required for the work and the place in which the work will be carried out.

(c) The nature of the organization and previous experience in the related work in developing countries.

(d) Curricula vitae of staff who will be assigned for the study as well as curricula vitae of support staff at Headquarters.

(e) Details of equipment offered or arranged for supply.

(f) Staff and period to be assigned for establishment of the systems and training of BPDB personnel. The information should include full curricula vitae and previous experience.

A sealed envelope should be enclosed with the proposal indicating the cost estimate of this work based on a system of fixed professional fees, which should also be determined in relation to the actual hours of work. Once the proposals have been evaluated, BPDB will proceed to negotiate the contract with most qualified firm and, if they are unable to reach agreement during the negotiations, proceed to negotiate with the second best qualified firm. BPDB may reject any or all of the offers received if none of them is satisfactory.

Form of Contract

The contract which will be awarded to the successful firm will be based on the International Model Form of Agreement Between Client and Consulting Engineer No. IGRA 1979 P.I. -- produced and issued by the International Federation of Consulting Engineers (FIDIC).

Schedule of Payments

The schedule of payments will be negotiated and the firm is invited to propose a schedule. However, the BPDB will tie the payments to clearly defined performance targets.

Cost Estimate

Program: Non-Technical Loss Reduction.

Project: Strengthening of Commercial Unit.

Objective: To restucture and retrain the commercial unit according to modern utility practice.

Scope of Service/Equipment:

Provide a commercial manager for two years to restructure the commercial department, establish reporting systems, train the local staff and coordinate the non-technical loss reduction program. Simultaneously, provide overseas training for existing commercial manager.

Estimate of Cost (US$):	Professional Services	Travel and Subsistence	Equipment
Phase 1			
Salary and benefits	180,000		
Travel (2 roundtrips for self and family of 3)		40,000	
Living expenses		48,000	
Miscellaneous office equipment			10,000
Training for commercial manager two six-month periods overseas	50,000		
Travel (2 roundtrips)		10,000	
Living Expenses		44,000	
Contingency 10%	23,000	14,000	1,000
	253,000	156,000	11,000

Total Phase 1: US$420,000
Total Phase 2: ____
Total Project: US$420,000

Cost Estimate

Program: Non-Technical Loss Reduction

Project: Upgrading of Billing System

Objective: To establish a comprehensive computerized billing system to improve the efficiency of producing bills, improve the accuracy of bills, improve the management controls on billing and the management information from billing.

Scope of Service/Equipment:
The provision of computer hardware, software and training to implement a computerized billing and management information system. The hardware estimate is based on the use of IBM system 36 computers or similar, and consists of:

1 Central computer with 24 workstations, 2 printers, and 1 magnetic tape drive.

1 large stand-alone remote unit (100,000 customers) with 16 workstations, 2 printers and 1 magnetic tape drive.

13 small stand-alone remote units with 8 workstations and 2 printers.

The software consists of operating utilities along with application software including: File creation and maintenance; account inquiry system; billing system; cash receipts; account adjustments; credit rating; management reporting; audit trails and controls; meter maintenance; and on-line cash desk facility.

Estimate of Cost (US$):	Services	Professional Subsistence	Travel and Equipment
Phase 1			
Services to evaluate needs and specify system (6 man months)	54,000		
Travel		5,000	
Living expenses		22,000	
Control computer and peripherals			200,000
Large stand-alone computer and peripherals			160,000
13 small stand-alone computers and peripherals			1,144,000
System support and utility software			86,000
Application Software including an on-line training tutorial and personnel training	96,000		144,000
Travel (3 roundtrips)		15,000	
Living expenses (3 people 6 months)		65,000	
Contingency 10%	15,000	11,000	173,000
	165,000	118,000	1,907,000

Total Phase 1: US$2,190,000
Total Phase 2: ____
Total Project: US$2,190,000

Cost Estimate

Program: Non-Technical Loss Reduction

Project: Overhaul of Metering System

Objective: To improve the quality and security of metering of industrial and commercial customers by providing new meters, relocating meter positions, establishing meter testing procedures and meter records, and establishing a meter inspection department.

Scope of Service/Equipment:

- Provide an experienced meter engineer to manage the meter program and establish systems consistent with modern utility practice.
- Meter technicians to establish and secure meters and train local staff.
- Meter technicians to establish an inspection department and train local staff.
- Meters to replace 75% of the commercial and industrial meters.

Note: This project would be implemented in two phases: first, the personnel would be recruited and sent on site to assess the actual needs for equipment; second, the equipment would be ordered and installed.

Estimate of Cost (US$):	Services	Professional Subsistence	Travel and Equipment
Phase 1			
Meter engineer for 2 years			
- Salary & benefits	150,000		
- Travel		30,000	
- Living expenses		48,000	
5 meter technicians for 2 years			
- Salary & benefits	500,000		
- Travel		150,000	
- Living expenses		240,000	
Basic equipment			20,000
Contingency 10%	65,000	47,00	2,000
	715,000	515,000	22,000
Phase 2			
675 high tension metering units			1,688,000
623 3-phase demand meters			212,000
2000 3-phase meters			200,000
Meter test equipment			300,000
Materials to relocate meters			200,000
Meter seals			15,000
Contingency 10%			262,000
			2,877,000

Total Phase 1: US$1,252,000
Total Phase 2: US$2,877,000
Total Project: US$4,129,000

Estimate of Benefits

Program: Non-Technical Loss Reduction

Project: Entire program of 3 projects

Scope of Service/Equipment:

- Provide commercial manager and training for incumbent manager.
- Provide billing system.
- Overhaul and upgrade metering system.

Assumptions:

- Non-technical losses would be reduced by about 5% at end of 2-year period, and by 10% thereafter.
- Assume loss reduction to start from second year.
- No increase in benefits after second year (very conservative assumption).
- Life of equipment/system 20 years.
- Savings valued at average financial tariff US$1.5/kWh, at an exchange rate of TK 25/US$
- Forecasted gross generation for 1985/6 and 1986/7 and 4.8% station use.

Calculation of Financial Benefits

Year	Loss Reduction Energy (GWh)	Financial Benefits (US$) Energy
1	-	-
2	230.1	13,800,000
3-20	515.5	30,930,000

Net present value (at 12%)	208,996,250
Benefit/Cost ratio	32.0
IRR	272.9%

TERMS OF REFERENCE FOR TECHNICAL LOSS REDUCTION PROGRAM

Summary of Requirements

The Bangladesh Power Development Board (BPDB) is soliciting proposals from a consulting firm to prepare and implement a program to reduce the technical losses on the power system from the present level of about 14% of net generation to about 12% or better in two years. The program should be structured so that it can be continued under BPDB's supervision to achieve and maintain economic loss levels about 8% or 9% of net generation. The work, which must be implemented as a coordinated program, consists of two main elements:

(a) Establish a distribution planning department to analyze losses in the existing system, plan the orderly expansion of the system and prepare standards and guidelines for future expansion (the standards must include items such as the optimum size of power transformers, the loading and length of distribution lines, optimum voltage levels, etc.).

(b) Analyze, plan and implement measures in the existing system to reduce losses and improve the quality of service. The measures may include sectionalization of the secondary network, power factor improvement and reinforcement of the 33 kV lines.

The work will be done in two phases. Phase 1 will include familiarization with the system, the provision of a computer system and software to facilitate analysis of the distribution system and training BPDB engineers to establish a distribution system data base to perform analyses and to plan the system expansion. The analyses done in this phase will lead to the work in phase 2, which should start before the end of phase 1 utilizing equipment already in BPDB stores. In addition, the consulting firm will prepare a comprehensive set of distribution standards and guidelines based on criteria to achieve optimum economic loss levels. Phase 2 will include the procurement of material and the management of specific loss reduction projects identified in phase 1. It will also include the training of BPDB personnel in project management. The overall cost of the program excluding local staff and facilities is estimated to be about US$16.9 million. The phase 1 cost is estimated at US$951,000 consisting of about US$495,000 in professional services and US$199,000 in equipment and software, and the remainder in expenses. The phase 2 cost is expected to be about US$16.1 million consisting mainly of equipment. The program is financed by ______________________________. The executing agency is __________________________. In the following discussion the consulting firm submitting a proposal to do the work is referred to as the "firm" and the work is referred to as the "program".

Background

The Bangladesh Power Development Board (BPDB) is a statutory government entity responsible for the generation transmission and distribution of electricity in Bangladesh. The BPDB reports directly to the Ministry of Energy. The allocation of resources for the BPDB is guided by the Planning Commission, which coordinates the development of the power sector with those of other sectors of the economy.

This program to improve generation efficiency is one of a group recommended by a World Bank/UNDP Power Loss Reduction mission. The mission's report, which describes the power system and outlines the work to be done, is a part of these Terms of Reference.

Scope of Work

The work includes everything that is necessary to achieve the objectives listed in the Summary of Requirements. Some of the specific tasks are:

Phase 1

(a) Advise the BPDB on the quantity and qualification of engineers and technicians and on the physical facilities required for the distribution planning department, which will consist of a central unit and operating units in each of the five distribution zones.

(b) Train and assist the BPDB in the following:

(i) The representation of the existing distribution system by suitable nodes and line sections for the purpose of computerized system studies.

(ii) Development of suitable study models.

(iii) Determination of existing system characteristics and loss levels.

(iv) Application of suitable load forecasting techniques.

(v) Study of alternative system development proposals.

(vi) Application of economic optimization techniques particularly in the context of system losses.

(vii) Determination of the least cost system expansion plans.

(c) Supply a suitable minicomputer system including CRT terminals, printers, digitizers for data entry of maps and drawings, and plotters for obtaining output in the form of maps and circuit diagrams.

(d) Supply a package of system analysis software (the software must be proven and be in use elsewhere in a developing country) consisting but not restricted to the following:

(i) Load Forecasting Program

This program should be capable of using basic data such as land use classifications, population growth rates etc. in order to develop future load forecasts. The capabilities should include analysis of past data and regression techniques.

(ii) Distribution System Study Program

The output of these studies should provide load flows, voltage profiles and sectional and total losses. Programs are also required for transformer load management, single phase and three phase short circuit studies and (optionally) for transient stability studies. The load flow programs should be capable of quick repetition for modifications (particularly in the case of capacitor installations) or should include optimization methods built into the programs. Programs are also required for interfacing with the proposed computerized billing process for the collection of consumption data and also for interfacing with cassette recorder or other types of output that may be obtained from special instruments (such as demand profile recorders) installed in the field. The various programs supplied should be capable of being used together and capable of operation as a complete integrated package.

Installation & Training

The firm shall be responsible for the complete installation in satisfactory working order of all the hardware and software. The offer should also indicate the period of maintenance guaranteed and other follow-up services offered. The firm should also be responsible for the training of the staff of the BPDB for undertaking the related studies. Such training facilities should include advice on data collection such as special metering devices to be used in the field, organization and validation of input data, operation of the programs and the analysis and interpretation of results. In addition, the firm should:

(a) Prepare and specify the equipment and work program to effect specific loss reduction projects in the existing system.

(b) Prepare a comprehensive set of distribution standards and guidelines, with special emphasis on the customer voltage level. Benefit cost analysis should be done to determine what type of distribution system should be used, for example, 3 wire three phase or 4 wire three phase with single phase sections.

(c) Prepare a comprehensive 5-year distribution plan for the major distribution centers, using a 20-year horizon for conceptual planning. This plan should be complete with budgetary estimates and should be suitable for presentation to financing agencies to ensure that the use of aid funds is directed to achieve the overall least cost development of the distribution system. The data collection and analysis should be done by BPDB engineers under the guidance of specialists from the firm.

Phase 2

Provide procurement services and project management to implement specific projects developed in phase 1. It is expected that phase 2 will start before the end of phase 1. This phase should also include a training component so that BPBD engineers will be competent to continue with implementing loss reduction activity after the end of this contract.

Division of Labor and Responsibilities

The firm will be fully responsible for the implementation of the program. It will provide all of the services required to ensure the services of the project.

The BPDB will provide the following:

(a) Access to the plants, to documents and to any data required to carry out the work.

(b) Counterpart staff as required and at the educational level specified by the consultant to ensure success of the training.

(c) Office space.

(d) Secretarial services.

(e) Translation services if required.

Guidelines for Proposal

The main proposal should be for phase 1 of the program, but unit rates should be provided for phase 2. It should provide comprehensive details of the following:

(a) A work plan in accordance with these terms of reference.

(b) A preliminary estimation of the hours per person required for the work and the place in which the work will be carried out.

(c) The nature of the organization and previous experience in the related work in developing countries.

(d) Curriculum vitae of staff who will be assigned for the study as well as Curriculum vitae of support staff at Headquarters.

(e) Details of hardware offered or arranged for supply.

(f) Complete details of software package offered. This should include a description of each program, form of input data, sample of output and details of where such program have been used to date.

(g) Staff and period to be assigned for establishment of the systems and training of BPDB personnel inclusive of full Curriculum vitae and previous experience.

A sealed envelope should be enclosed with the proposal indicating the cost estimate of this work based on a system of fixed professional fees, which should also be determined in relation to the actual hours of work. The firm may suggest alternative schemes for attaining the objectives outlined in the Summary of Requirements. Any alternative scheme should be clearly identified as such, and separate work schedules and costs should be provided for each. The firm should also provide a schedule of fees for phase 2 of the work which should be defined by phase 1.

Once the proposals have been evaluated, BPDB will proceed to negotiate the contract with the most qualified firm and, if they are unable to reach agreement during the negotiations, proceed to negotiate with the second best qualified firm. BPDB may reject any or all of the offers received if none of them is satisfactory.

Form of Contract

The contract which will be awarded to the successful firm will be based on the International Model Form of Agreement Between Client and

Consulting Engineer No. IGRA 1979 P.I. -- produced and issued by the International Federation of Consulting Engineers (FIDIC).

Schedule of Payments

The schedule of payments will be negotiated and the firm is invited to propose a schedule. However, the BPDB will tie payments to clear performance targets, some of which may be:

(a) A report of the analysis for the existing system.

(b) A detailed system expansion plan.

(c) A detailed set of distribution standards.

(d) The construction of specific loss reduction schemes.

Cost Estimate

Program: Technical Loss Reduction

Project: Creation of a Distribution Planning Unit

Objective: To create a Distribution Planning Unit in the BPDB responsible for distribution planning and distribution construction standards and guidelines.

Scope of Services/Equipment

Provide three distribution planning engineers for two years and the necessary computer software and hardware to:

- Train BDPB engineers in load forecasting and distribution expansion planning.
- Perform detailed loss reduction studies on the existing system.
- Prepare a distribution expansion plan (20-year horizon, in detail for first 5 years).
- Prepare a comprehensive set of construction standards and guidelines.

Estimate of Cost (1984 US$):	Professional Services	Travel and Subsistence	Equipment
Phase 1			
Professional services of 3 engineers for 2 years			
- Salary and benefits	450,000		
- Travel (self and family)		90,000	
- Living expenses		144,000	
Minicomputer systems (6)			150,000
Software			30,000
Physical Contingency (10%)	45,000	23,000	19,000
	495,000	257,000	199,000

Total Phase 1: US$951,000
Total Phase 2: ____
Total Project: US$951,000

Note: This project is shown as a single activity. It provides the engineering input to the other projects under this program.

Cost Estimate

Purpose: Technical Loss Reduction

Project: Secondary Distribution Network Sectionalization
(Note -- Order of magnitude estimate only)

Objective: To reduce losses on existing secondary networks by splitting the network into smaller sections and installing more transformers.

Scope of Service/Equipment:

Install about 80,000 kVA of transformers and extend the 11 kV system, as required, to allow the sectionalization of the secondary network.

Note: The engineering input and precise definition of these activities will be provided by the newly formed Distribution Planning unit. The standards used will be those developed by the unit to attain optimum loss levels.

Estimate of Cost (1984 US$):	Professional Services	Travel and Subsistence	Equipment
Phase 1 - Engineering provided by Distribution Planning Unit.			
Phase 2			
Equipment and material including freight		4,635,000	
Project management	464,000		
Contingency	46,000	464,000	
Erection (Local cost)	$464,000		

Total Phase 1: ____
Total Phase 2: US$6,073,000
Total Project: US$6,073,000

Estimate of Benefits

Program: Technical Loss Reduction

Project: Secondary Distribution Network Sectionalization

Scope of Services/Equipment:

Installation of about 80,000 kVA of transformers and line extensions to allow sectionalization of secondary network.

Assumptions:

- Energy losses decreased by 45% and demand loss by 30% of present levels (difference is due to fact that improved voltages at customer level will increase demand -- estimates based on sample calculations).
- Project implemented over 3 years with equal amount of transformer capacity installed each year.
- During the implementation period losses assumed to increase at rate of system growth (12% per annum).
- Benefits do not increase after the end of implementation period, since new standards would be in effect for any new extensions.
- Life of transformers and associated equipment 33 years.
- Discount rate 12%.
- Value of capacity savings US$287/kW/yr.
- Value of energy savings US$0.0333/kWh.

Calculations of Savings:

Year	Loss Reduction: Demand (MW)	Loss Reduction: Energy (GWh)	Savings (1984 US$): Demand	Savings (1984 US$): Energy	Savings (1984 US$): Total
1	-	-	-	-	-
2	5.4	28.3	1,552,000	942,000	2,494,000
3	12.2	63.4	3,506,000	2,111,000	5,617,000
4-33	20.4	106.5	5,863,000	3,546,000	9,409,000

Net Present Value (at 12%)	54,034
Savings/Cost Ratio	10.1
EDR	86.6%

Cost Estimate

Program: Technical Loss Reduction

Project: Power Factor Improvement
(Note -- Order of magnitude estimate only)

Objective: To reduce technical losses by the installation of fixed and switched capacitors on distribution circuits to improve the power factor.

Scope of Service/Equipment:

Installation of 185 MVAR of capacitors in 450 kVAR banks, 165 fixed banks and 245 switchable banks.

Note: The engineering and precise definition of this activity will be provided by the newly formed Distribution Planning Unit. This includes exact locations and the size of capacitor banks to attain optimum loss levels.

Estimate of Cost (1984 US$)	Professional Services	Travel and Subsistence	Equipment
Phase 1 - Engineering provided by Distribution Planning Unit.			
Phase 2			
Capacitors and accessories			1,394,000
Switches and controls (time clock)			368,000
Project Management	176,000		
Contingency (10%)	18,000		176,000
	194,000		1,938,000

Erection (local cost) US$176,000

Total Phase 1: ____
Total Phase 2: US$2,308,000
Total Project: US$2,308,000

Estimate or Benefits

Program: Technical Loss Reduction

Project: Power Factor Improvement

Scope or Services/Equipment

Installation of 185 MVAR of capacitors in 450 kVAR banks, 165 fixed banks and 245 switchable banks.

Assumptions:

- Technical losses reduced by 15% of present level (estimated from sample calculations).
- Half of the total amount of capacitors is installed each year over a two-year period.
- During the two-year period the absolute value of losses related to power factor increases at the rate of load growth (12%).
- An· new feeders or any additions to existing feeders will be adequately compensated, outside the scope to the project, after the second year. (Thus, benefits do not increase after end of project).
- Life of capacitors 20 years.
- Discount rate 12%.
- Value of capacity savings US$284/kW/yr
- Value of energy savings US$0.0326/kWh

Calculations of Savings

Year	Loss Reduction: Demand (MW)	Loss Reduction: Energy (GWh)	Savings (1984 US$): Demand	Savings (1984 US$): Energy	Savings (1984 US$): Total
1	-	-	-	-	-
2	6.41	34.0	1,820,000	1,108,000	2,928,000
3	14.36	76.2	4,078,000	2,484,000	6,562,000
4-20	14.36	76.2	4,078,000	2,484,000	6,562,000

Net Present Value (At 12%)	43,464
Savings/Cost Ratio	19.8
EDR	182.6%

Cost Estimate

Program: Technical Loss Reduction

Project: Reinforcement of 33 kV lines
(Note -- Rough Estimate Only)

Objective: To reduce technical losses by strengthening 33 kV lines (reconductoring or parallel circuits).

Scope of Services/Equipment:

- Build approximately 220 km of 33 kV line.
- Reconductor approximately 880 km of 33 kV line.

Note: The engineering and precise definition of this activity will be provided by the newly formed Distribution Planning Unit.

Estimate of Cost (1984 US$)	Professional Services	Travel and Subsistence	Equipment
Material for new line construction			4,180,000
Material for reconducting			2,640,000
Project management	682,000		
Contingency (10%)	68,000		682,000
	750,000		7,502,000

Erection (local cost) US$682,000

Total Phase 1: ____
Total Phase 2: US$8,934,000
Total Project: US$8,934,000

Estimate of Benefits

Program: Technical Loss Reduction

Project: Reinforcement of 33kV Lines

Scope of Services/Equipment:

Build approximately 220 km of 33 kV line. Reconductor approximately 880 km of 33 kV line.

Assumptions:

- The losses on the 33 kV system will be reduced by 37% of their present level (average load on 33 kV lines is 12.6 MVA, 45% thermal rating. Losses are reduced by 37% if conductor cross section is doubled).
- Project implemented over two years with equal amounts done each year.
- During implementation, losses assumed to grow by 12% (of existing losses) per year.
- Benefits do not increase after the end of implementation period, since system extensions assumed to be constructed using new standards.
- Life of lines 33 years, discount rate 12%.
- Value of capacity savings US$167/kW/yr.
- Value of energy savings US$0.0317/kWh.

Calculations of Savings

Year	Loss Reduction Demand (MW)	Loss Reduction Energy (GWh)	Savings (1984 US$) Demand	Savings (1984 US$) Energy	Savings (1984 US$) Total
1	-	-	-	-	-
2	5.0	17.4	836,000	552,000	1,338,000
3-33	11.2	39.0	1,873,000	1,236,000	3,109,000

Net Present Value	12,752,000
Savings/Cost Ratio	2.43
EDR	30.2%

TERMS OF REFERENCE
FOR
IMPROVEMENT OF DISTRIBUTION OPERATIONS

Summary of Requirements

The Bangladesh Power Development Board (BPDB) is soliciting proposals for a consulting company or utility to prepare and implement a program to improve the operations of its Distribution Department. The work, which should be implemented as a completely coordinated program, is intended to:

(a) Restore and reset the protection, the control facilities and the instrumentation in the Transmission and Distribution systems and thus reduce the extent and duration of outages.

(b) Establish a planned maintenance program for substations.

(c) Equip and train about twenty distribution line construction/ maintenance crews.

The line crew training is required to ensure that proposals for improving the fusing of distribution circuits can be implemented. The entire program should be completed in two years, and training must be provided to enable BPDB staff to continue to maintain substations and to maintain the integrity of the protective system. The line crew training should enable BPDB to continue to form and train new crews.

The work will be done in two phases. Phase 1 will include familiarization with the system, detailed assessment of the costs and benefits of various measures, preparation of specifications for equipment, preparation of training plans and some immediate training activities. Phase 2 will include the procurement, installation and commissioning of equipment, the implementation of operating procedures, and final training of BPDB operating and maintenance staff.

The overall cost of the program, excluding local staff and facilities, is estimated to be about US$4.2 million. The phase 1 cost is estimated at US$399,000, consisting of about US$237,000 in professional services, US$107,000 in expenses, and US$55,000 in equipment. The phase 2 cost is expected to cost about US$3.8 million, consisting of about US$737,000 in professional services, US$2.5 million in equipment, and the remainder in expenses.

The program is financed by ____________________________. The executing agency is __________________________. In the following discussion the firm submitting a proposal to do the work is referred to as the "firm", and the work is referred to as the "program".

Background

The Bangladesh Power Development Board (BPDB) is a statutory government entity responsible for the generation transmission and distribution of electricity in Bangladesh. The BPDB reports directly to The Ministry of Energy. The allocation of resources for the BPDB is guided by the Planning Commission, which coordinates the development of the power sector with those of other sectors of the economy.

This program to improve the operations of the Distribution department is one of a group recommended by a World Bank/UNDP Power Loss Reduction mission. The mission's report, which describes the power system and outlines the work to be done, is a part of these Terms of Reference.

Scope of Work

The work includes everything that is necessary to achieve the ojectives listed in the Summary of Requirements. Some of the specific tasks are:

Phase 1

(a) Review existing system protection and substation maintenance practices.

(b) List the existing protective equipment (relays, etc.) and instrumentation.

(c) Perform the necessary short circuit studies and any other studies required for protective system coordination.

(d) Prepare relay setting letters and fusing schedules (back-up coordination curves must be provided).

(e) Provide structure of organization required to maintain the protective system and maintain substation equipment.

(f) Prepare specifications, detailed cost estimates and implementation schedules for the equipment and the work required to rehabilitate the protective system and instrumentation.

(g) Review existing line crew structure, work methods and equipment.

(h) Prepare specifications, detailed cost estimates and an implementation schedule for the line trucks, equipment and training required to form about twenty line crews.

Phase 2

(a) Procure, expedite, manage the installation, and commission any equipment required to upgrade the protective system and instrumentation. (The protective system includes relays from the transmission substation level down to fuses on distribution spurs and distribution transformers).

(b) Train PBDB staff in relay setting, relay testing and relay maintenance.

(c) Provide guidelines for the application of fuses, sectionalizers, reclosers, etc.

(d) Procure, expedite and put into operation the line trucks and equipment required for the line construction/maintenance crews.

(e) Provide personnel to train the line crews in Bangladesh up to the standard of linesmen in a developed country.

(f) Arrange training for Bangladesh supervisors in a utility in a developed country (actual hands-on training, not superficial classroom instruction).

(g) Supervise the handover of the new line crews to the trained supervisors on their return.

Division of Labor and Responsibilities

The firm will be fully responsible for the implementation of the program. It will provide all of the services required to ensure the success of the program.

The BPDB will provide the following:

(a) Access to the plants, to documents and to any data required to carry out the work.

(b) All transportation in Bangladesh.

(c) Counterpart staff, as required, at the educational level specified by the firm to ensure success of the training.

(d) Office space, standard office equipment and supplies.

(e) Secretarial services.

(f) Translation services if required.

Guidelines for Proposal

The proposal should provide comprehensive details of the following:

(a) A work plan in accordance with these terms of reference.

(b) A preliminary estimation of the hours per person required for the work and the place in which the work will be carried out.

(c) The nature of the organization and previous experience in related work in developing countries.

(d) Curricula vitae of staff who will be assigned for the study as well as curricula vitae of support staff at Headquarters.

(e) Details of equipment offered or arranged for supply.

(f) Staff and period to be assigned for establishment of the systems and training of BPDB personnel, inclusive of full Curricula vitae and previous experience.

A sealed envelope should be enclosed with the proposal indicating the cost estimate of this work based on a system of fixed professional fees, which should also be determined in relation to the actual hours of work. The firm may suggest alternative schemes for attaining the objectives outlined in the Summary and Requirements. Any alternative scheme should be clearly identified as such, and separate work schedules and costs should be provided for each.

Once the proposals have been evaluated, BPDB will proceed to negotiate the contract with the most qualified firm and, if they are unable to reach agreement during the negotiations, proceed to negotiate with the second best qualified firm. BPDB may reject any or all of the offers received if none of them is satisfactory.

Form of Contract

The contract which will be awarded to the successful firm will be based on the International Model Form of Agreement Between Client and Consulting Engineer No. IGRA 1980 P.M. -- produced and issued by the International Federation of Consulting Engineers (FIDIC).

Schedule of Payments

The schedule of payments will be negotiated, and the firm is invited to propose a schedule. However, the BPDB will tie final payments to clear performance targets.

Cost Estimate

Program: Improvement of Distribution Operations

Project: Restoration of Protection and Control Facilities and Substation Maintenance

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Objective:

- To restore and reset the protection and control facilities in the transmission and distribution systems.
- To establish a planned maintenance program for substations.

Scope of Service/Equipment:

Phase 1: Provide protection specialists to study the protective system and to provide relay setting guidelines and coordination curves. Specify new or replacement relays, fuses, or instruments. Train BPDB staff in relay and fuse coordination.

Phase 2: Procure, install and commission the recommended equipment, including fuses on transformers and spur lines. Prepare and implement a substation maintenance program. Train BPDB staff in substation maintenance and relay testing.

Estimate of Cost (1984 US$):	Professional Services	Travel and Subsistence	Equipment
Phase 1			
Consulting services to analyze protective system (18 man months)	162,000		
Travel (3 roundtrips)		15,000	
Living expenses		54,000	
Test equipment			50,000
Contingency 10%	16,000	7,000	5,000
Subtotal	178,000	76,000	55,000
Phase 2 (rough estimate for order of magnitude)			
Consulting services including project management (30 man months)	270,000		
Travel (4 roundtrips)		20,000	
Living expenses		100,000	
Equipment			500,000
Contingencies 10%	27,000	12,000	50,000
	297,000	132,000	550,000

Total Phase 1: US$309,000
Total Phase 2: US$979,000
Total Project: US$1,288,000

Cost Estimate

Program: Improvement of Distribution Operations

Project: Reorganization and Training for Distribution Department.

Objective: To improve the productivity of the line construction and line maintenance crews by restructuring them and by training them in the use of modern equipment and work methods.

Scope of Service/Equipment:

A two-phase approach is necessary for the project. In the first phase a consultant would review the present structure of the line crews and the organization of the Distribution Department and identify the required changes. He would also prepare specifications for the required tools and equipment. In the second phase the crews would be reorganized, linesmen would be brought in to train the crews, and Bangladesh Supervisors would be sent overseas for training in a utility.

Estimate of Cost (US$):	Professional Services	Travel and Subsistence	Equipment
Phase 1			
Consulting firm/utility to determine requirements (6 man months)	54,000		
Travel (2 roundtrips)		10,000	
Living expenses		18,000	
Contingency 10%	5,000	3,000	
	59,000	31,000	
Phase 2 (order of magnitude estimate)			
Services for four linesmen for one year	300,000		
Travel (8 roundtrips)		40,000	
Living expenses		173,000	
Line trucks complete with equipment (20)			1,600,000
Tools and equipment			150,000
Overseas training for four supervisors	100,000		
Travel and living expenses		200,000	
Contingency 10%	40,000	41,000	175,000
	440,000	454,000	1,925,000

Total Phase 1: US$90,000
Total Phase 2: US$2,819,000
Total Project US$2,909,000

TERMS OF REFERENCE FOR STRENGTHENI.. OF SUPPORT SERVICES

Summary of Requirements

The Bangladesh Power Development Board (BPDB) is soliciting proposals from consulting firms or public utilities to prepare and implement a program to strengthen and organize its support services. The proposed work is intended to streamline the operation of the Distribution stores and the motor vehicle transport section. The main components of the program are:

(a) To design and implement a computerized stores inventory control system.

(b) To design and implement a computerized vehicle maintenance system and to provide the physical facilities for vehicle maintenance.

(c) To determine the needs for additional or replacement vehicles and procure the necessary vehicles and spares.

Preliminary work has been done under Canadian International Development Agency (CIDA) financing, by establishing a material classification system and a model storeroom. This work should be used as a basis for developing the inventory control system.

The work will be done in two phases. Phase 1 will include familiarization with the system, detailed assessment of the costs and benefits of various measures, preparation of equipment and training specifications, and some immediate training activities. Phase 2 will include the procurement, installation and commissioning of systems and equipment, the implementation of operating procedures and final training of BPDB staff.

The overall cost of the program, excluding the cost of local staff and facilities, is estimated to be about US$4.6 million. The phase 1 cost is estimated at US$470,000 consisting of about US$297,000 in professional services and US$173,000 in expenses. The phase 2 cost is expected to be about US$4.1 million, consisting of about US$445,000 in professional services, about US$202,000 in expenses, and the remainder in equipment.

The program is financed by ______________________________. The executing agency is ______________________________. In the following discussion the consulting firm or public utility submitting a proposal to do the work is referred to as the "firm" and the work is referred to as the "program".

Background

The Bangladesh Power Development Board (BPDB) is a statutory government entity responsible for the generation, transmission and distribution of electricity in Bangladesh. The BPDB reports directly to the Ministry of Energy. The allocation of resources for the BPDB is guided by the Planning Commission, which coordinates the development of the power sector with those of other sectors of the economy.

This program to improve generation efficiency is one of a group recommended by a World Bank/UNDP Power Loss Reduction mission. The mission's report, which describes the power system and outlines the work to be done, is a part of these Terms of Reference.

Scope of Work

The work includes everything that is necessary to achieve the objectives listed in the Summary of Requirements. Some of the specific tasks are:

Phase 1

(a) Review the present operation of the stores.

(b) Prepare specifications for a system to achieve good inventory control and produce regular management reports. The system should be based on a software package which is in use successfully elsewhere. The extent of customization should be minimal.

(c) Prepare the requirements for staffing and training in the Distribution stores.

(d) Review the condition and procedures used for maintaining the existing transport fleet.

(e) Define the requirements and prepare specifications for a computerized vehicle maintenance management system. The system should be based on a software package being used successfully elsewhere. The extent of customization should be minimal.

(f) Determine to what intent vehicle maintenance should be done by the BPDB, and to what extent it should be contracted.

(g) Prepare specifications for the required maintenance facilities.

(h) Prepare specifications for the vehicles required to replace or supplement the existing fleet.

Phase 2

(a) Procure, expedite, manage the installation, and commission the inventory system defined in phase 1.

(b) Procure, expedite, install and commission the maintenance management system, maintenance facilities and vehicles specified in phase 1.

(c) Provide training for BPDB employees and ensure that they are competent to operate the inventory control and vehicle maintenance system.

Division of Labor and Responsibilities

The firm will be fully responsible for the implementation of the program. It will provide all of the services required to ensure the success of the program.

The BPDB will provide the following:

(a) Access to the plants, to documents and to any data required to carry out the work.

(b) Counterpart staff as required.

(c) Office space.

(d) Secretarial services.

(e) Translation services if required.

Guidelines for Proposal

The proposal should provide comprehensive details of the following (phase 1 and phase 2 work must be shown separately):

(a) A work plan in accordance with these terms of reference.

(b) A preliminary estimation of the hours per person required for the work and the place in which the work will be carried out.

(c) The nature of the organization and previous experience in the related work in developing countries.

(d) Curricula vitae of staff who will be assigned for the study as well as curricula vitae of support staff at Headquarters.

(e) Details of Hardware offered or arranged for supply.

(f) Complete details of Software package offered. This should include a description of each program, form of input data, sample of output and details of where such programs have been used to date.

(g) Staff and period to be assigned for establishment of the systems and training of BPDB personnel inclusive of full curricula vitae and previous experience.

A sealed envelope should be enclosed with the proposal indicating the cost estimate of this work based on a system of fixed professional fees, which should also be determined in relation to the actual hours of work. The firm may suggest alternative schemes for attaining the objectives outlined in the Summary and Requirements. Any alternative scheme should be clearly identified as such, and separate work schedules and costs should be provided for each.

Once the proposals have been evaluated, BPDB will proceed to negotiate the contract with the most qualified firm and, if they are unable to reach agreement during the negotiations, proceed to negotiate with the second best qualified firm. BPDB may reject any or all of the offers received if none of them is satisfactory.

Form of Contract

The contract which will be awarded to the successful firm will be based on the International Model Form of Agreement Between Client and Consulting Engineer No. IGRA 1979 P.I. -- produced and issued by the International Federation of Consulting Engineers (FIDIC).

Schedule of Payments

The schedule of payments will be negotiated, and the firm is invited to propose a schedule. However, the BPDB will tie payments to clearly defined and measurable performance targets.

Cost Estimate

Program: Strengthening of Support Services

Project: Replacement of Part of Transport Fleet and Installation of a Computerized Fleet Maintenance System

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Objective: To replace the vehicles in the existing fleet which are past economic repair; to supply new vehicles; and to install and train BPDB in the use of a computerized fleet management system.

Scope of Services/Equipment:

This project would be done in two phases. First, an overseas public utility that operates a large fleet efficiently would be engaged to assess BPDB's requirements for replacement vehicles, new vehicles and spare parts. They would also design and install a computerized fleet management system. In the second phase, the utility would assist BPDB in procuring the necessary vehicles and provide training with the fleet management system.

Estimate of Cost (US$):	Professional Services	Travel and Subsistence	Equipment
Phase 1			
Consulting services to define vehicle and management system needs (18 man months)	162,000		
Travel (5 roundtrips)		20,000	
Living expenses		70,000	
Miscellaneous expenses		15,000	
Contingency (10%)	16,000	10,000	
Sub Total	178,000	115,000	
Phase 2 (order of magnitude estimate)			
Consulting services to procure vehicles and provide training (9 man months)	81,000		
Travel (2 roundtrips)		10,000	
Living expenses		22,000	
Vehicles and Spares			3,000,000
Contingency 10%	8,000	3,000	300,000
Sub Total	89,000	35,000	3,300,000

Phase 1: US$293,000
Phase 2: US$3,424,000
Total Project: US$3,717,000

Program: Strengthening of Support Services

Project: Stores Inventory Control

Objective:

- To specify the requirements of a computerized stores inventory control system.
- To install the system and train local staff in its use.

Scope of Service/Equipment:

Phase 1: Professional services to specify the requirements of a computerized stores inventory control system.

Phase 2: Professional services to install the stores inventory control system and train local staff in its use (order of magnitude estimate only).

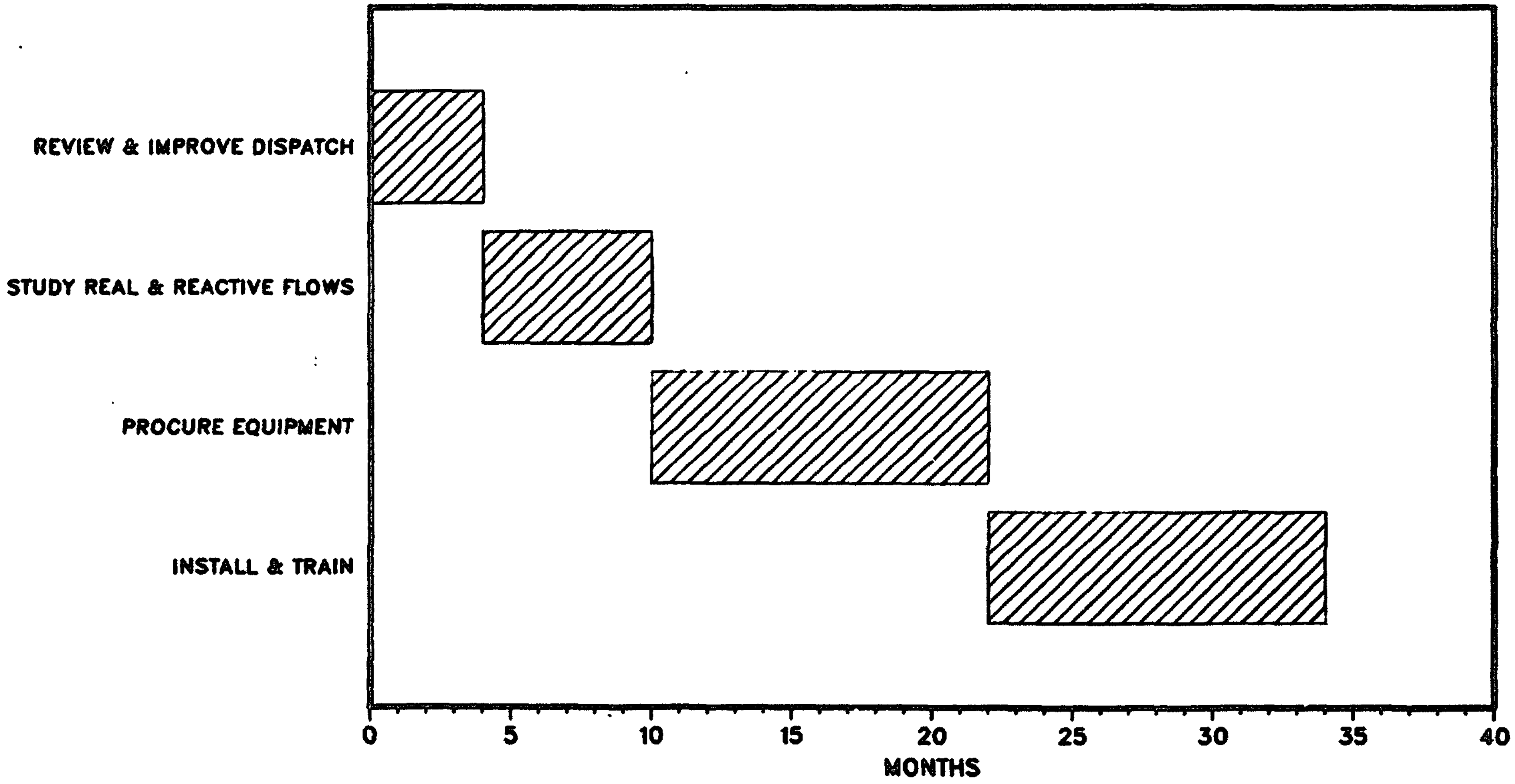
Note: Preliminary work has been done in preparing a material classification system under a CIDA project. The computers proposed for the billing system can be utilized for this program.

Professional Estimate of Cost (US$):	Travel and Services	Subsistence	Equipment
Phase 1			
Consulting services (12 man months)		108,000	
Travel (2 roundtrips)		10,000	
Living expenses		43,000	
Contingency 10%	11,000	5,000	
	119,000	58,000	
Phase 2			
Consulting services (36 man months)	324,000		
Travel (6 roundtrips)		30,000	
Living expenses		122,000	
Software			150,000
Contingency 10%	32,000	15,000	15,000
	356,000	167,000	165,000

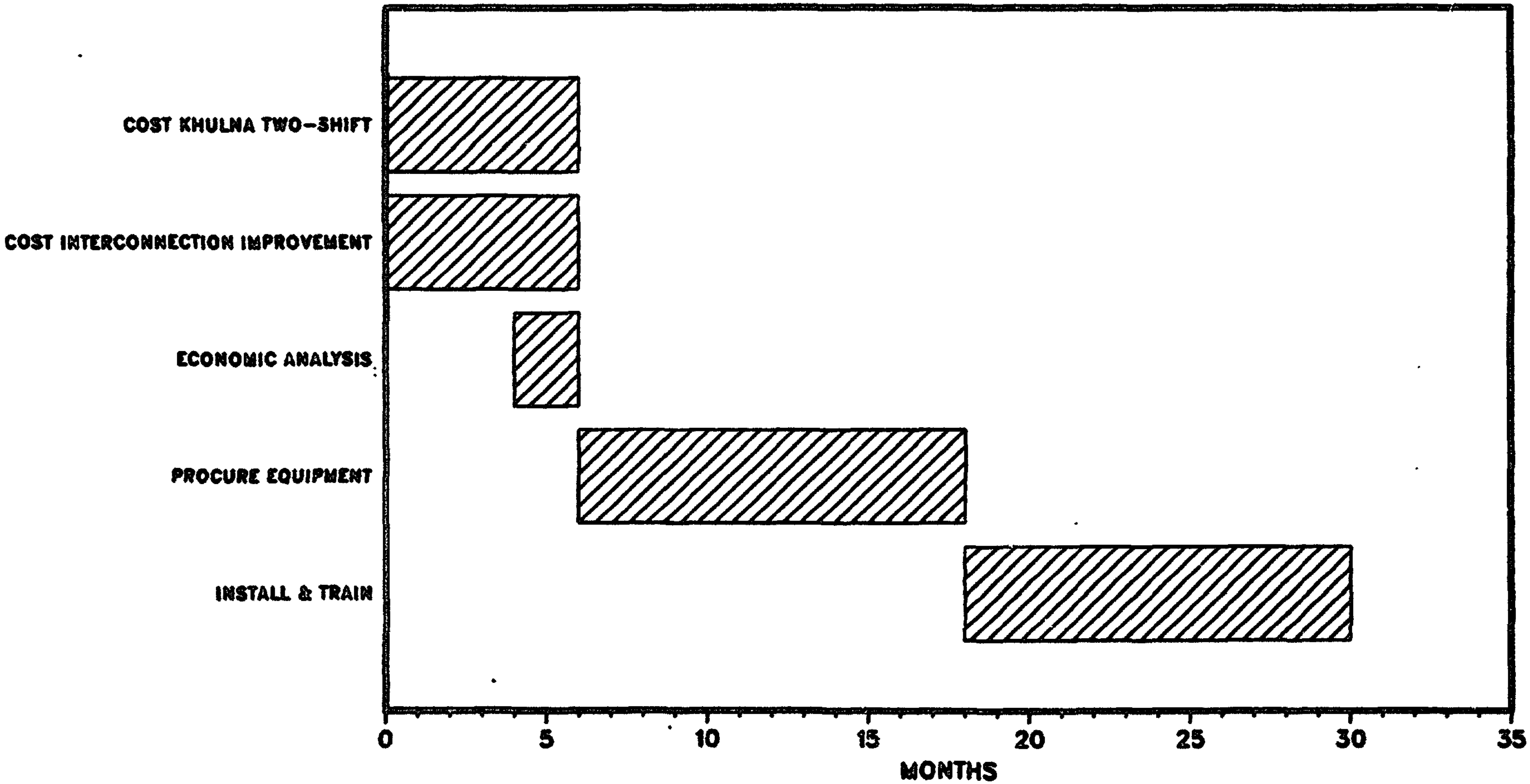
Phase 1: US$177,000
Phase 2: US$688,000
Total Project: US$865,000

PROGRAM: ECONOMIC OPERATION OF GENERATION SYSTEM

ECONOMIC DISPATCH

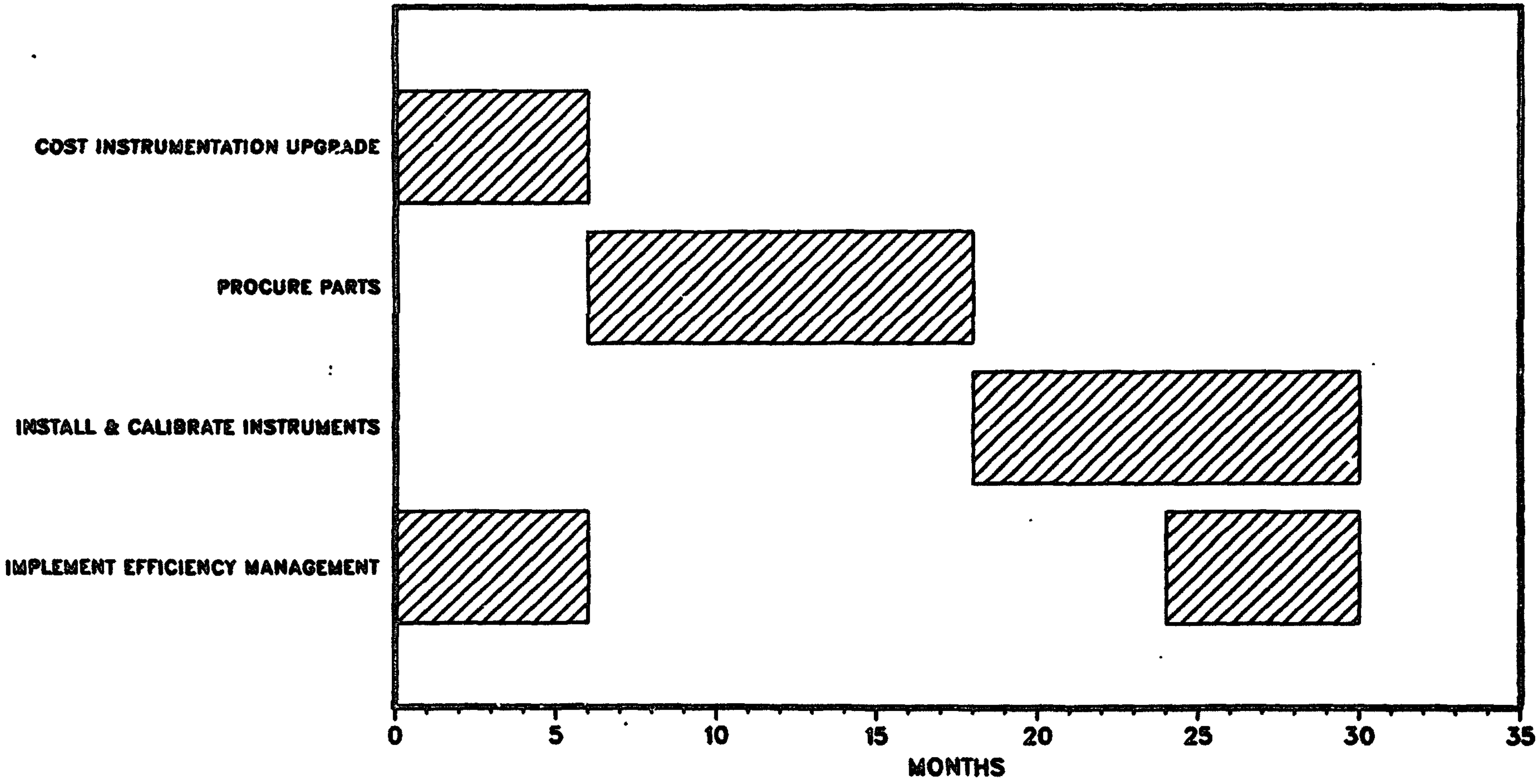


USE MORE GAS



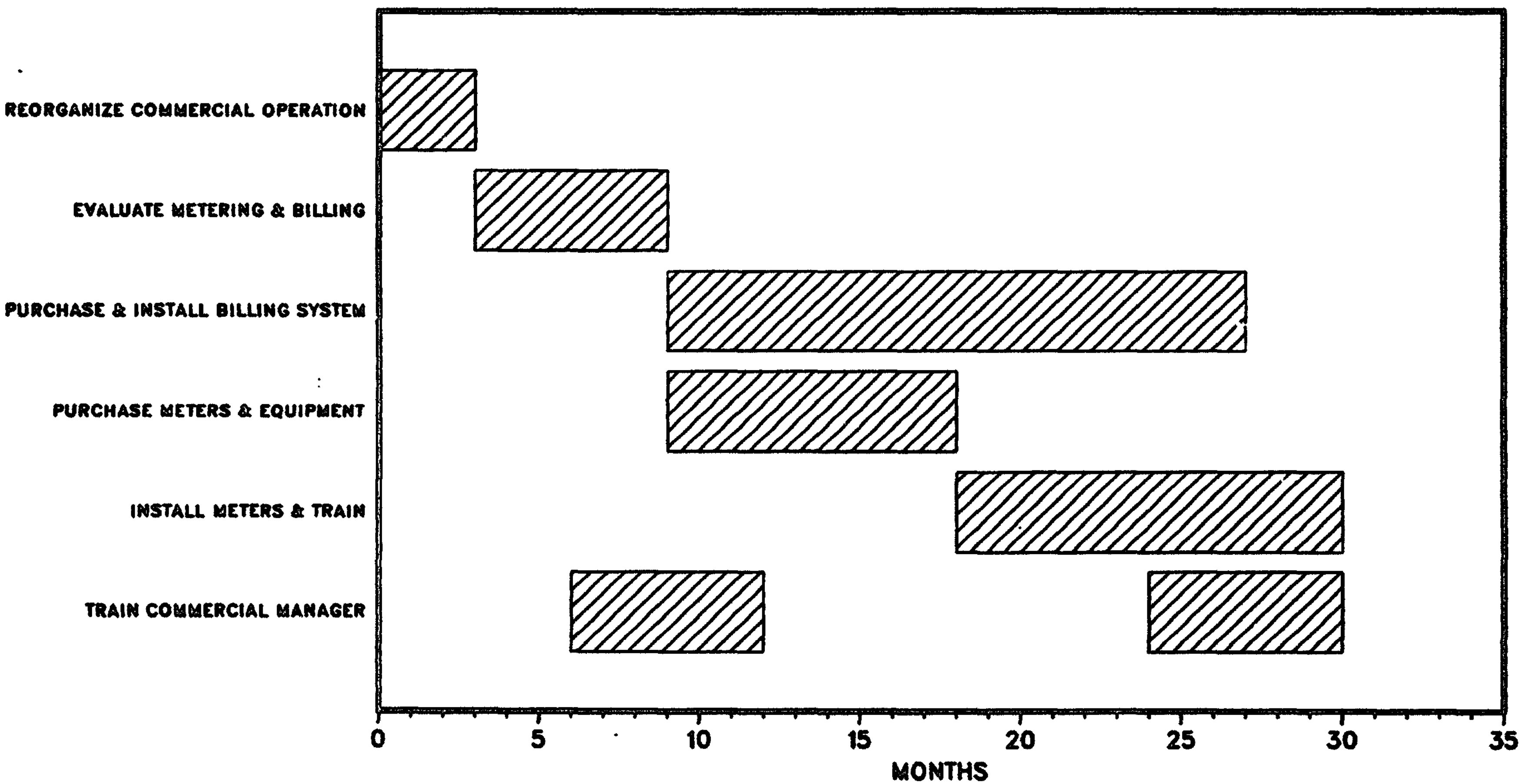
COST KHULNA TWO-SHIFT
COST INTERCONNECTION IMPROVEMENT
ECONOMIC ANALYSIS
PROCURE EQUIPMENT
INSTALL & TRAIN
0
5
10
15
20
25
30
35
MONTHS

IMPROVED OPERATION OF INDIVIDUAL UNITS



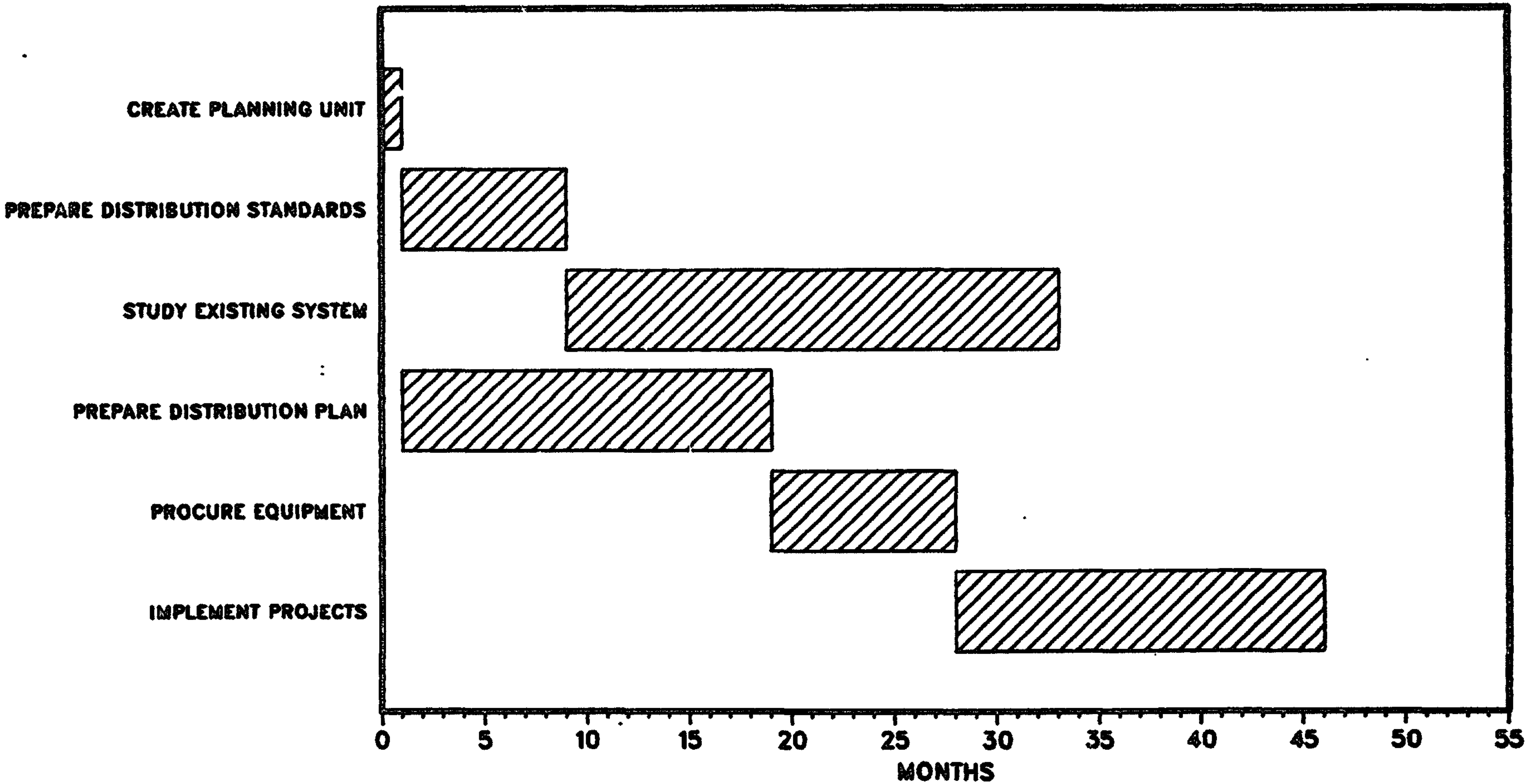
PROGRAM: NON-TECHNICAL LOSS REDUCTION

NON-TECHNICAL LOSS REDUCTION



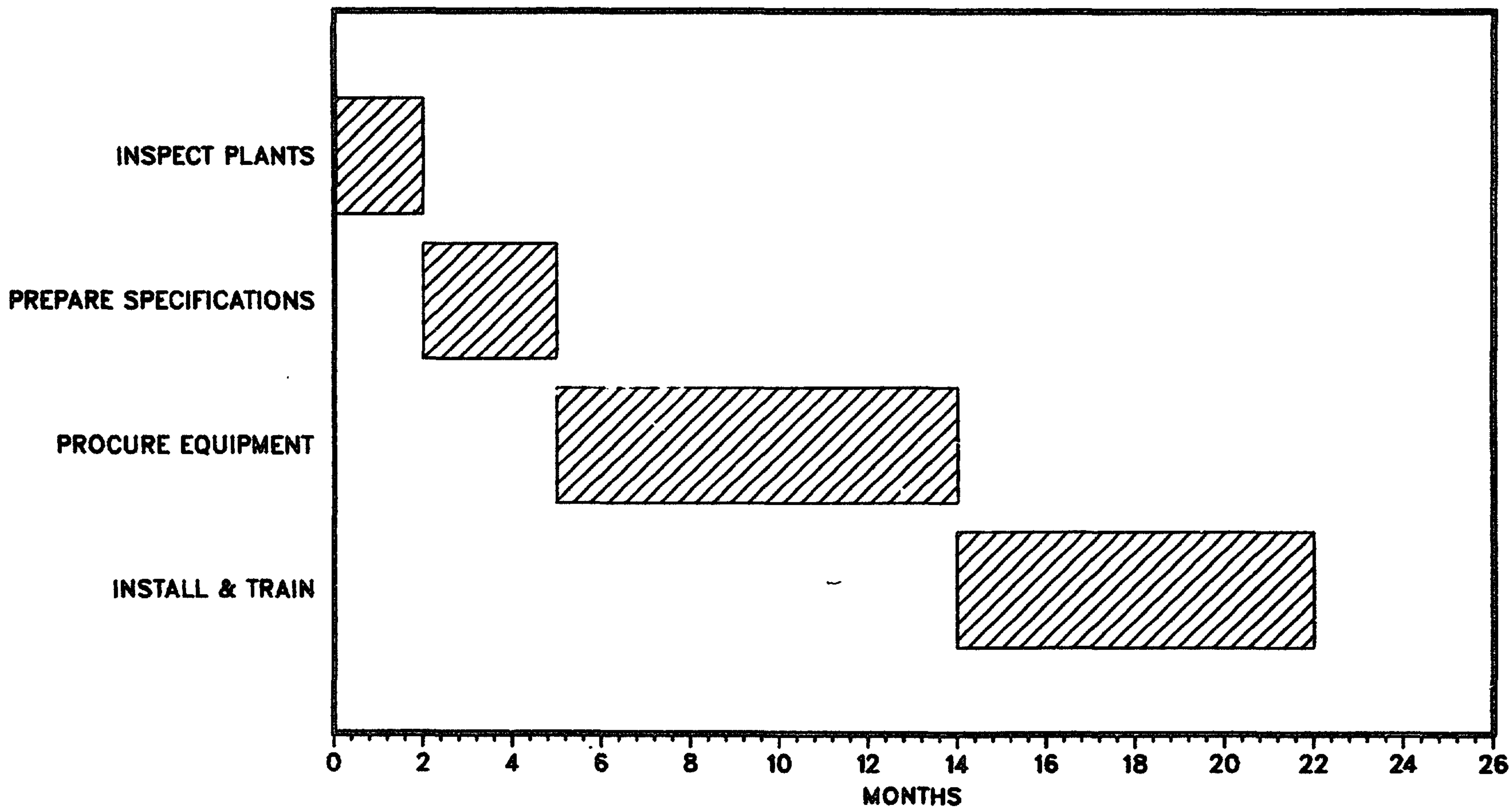
PROGRAM: TECHNICAL LOSS REDUCTION

TECHNICAL LOSS REDUCTION



PROGRAM: GENERATION EFFICIENCY IMPROVEMENT

AUXILIARY POWER REDUCTION PROGRAM



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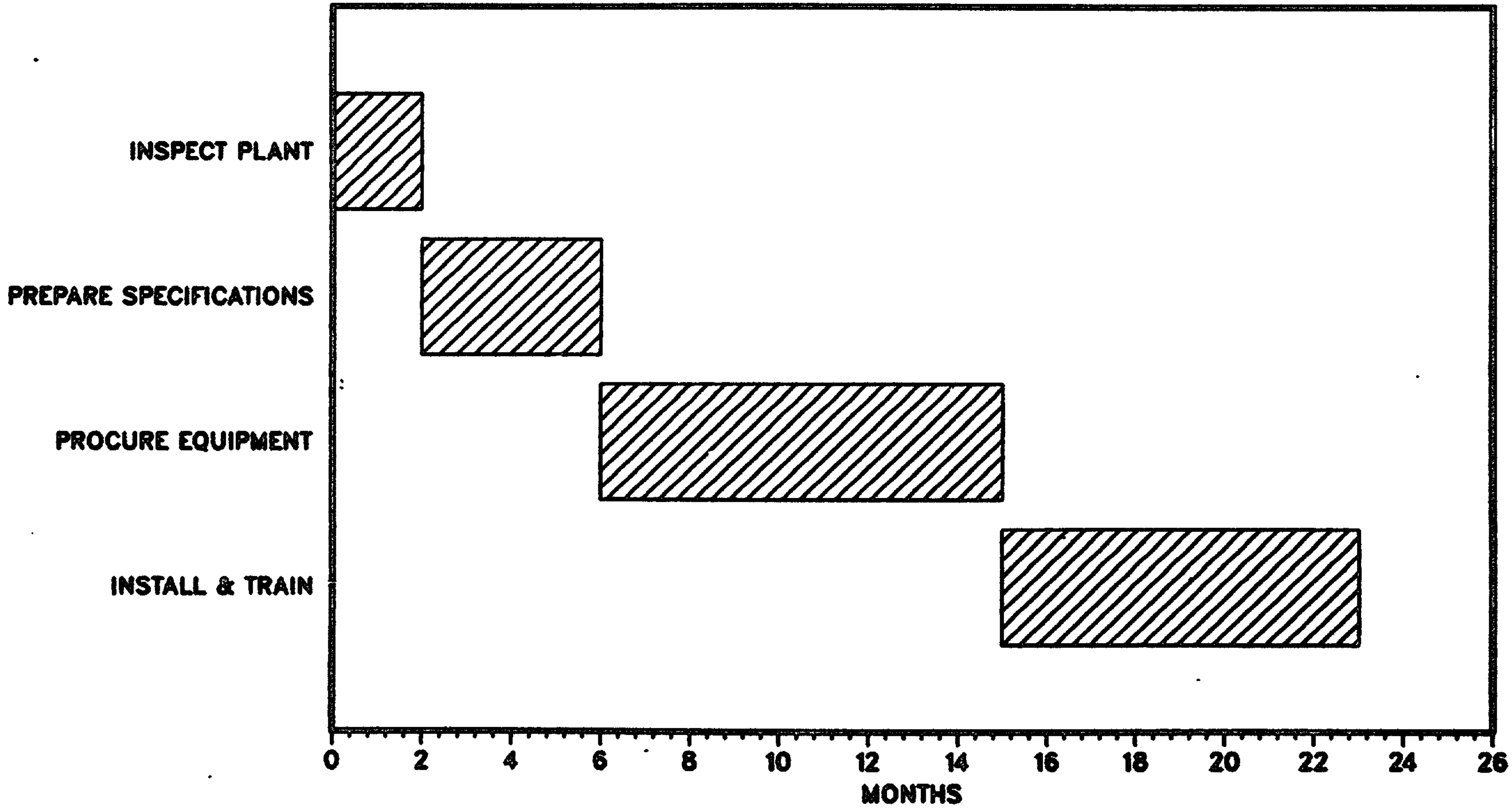
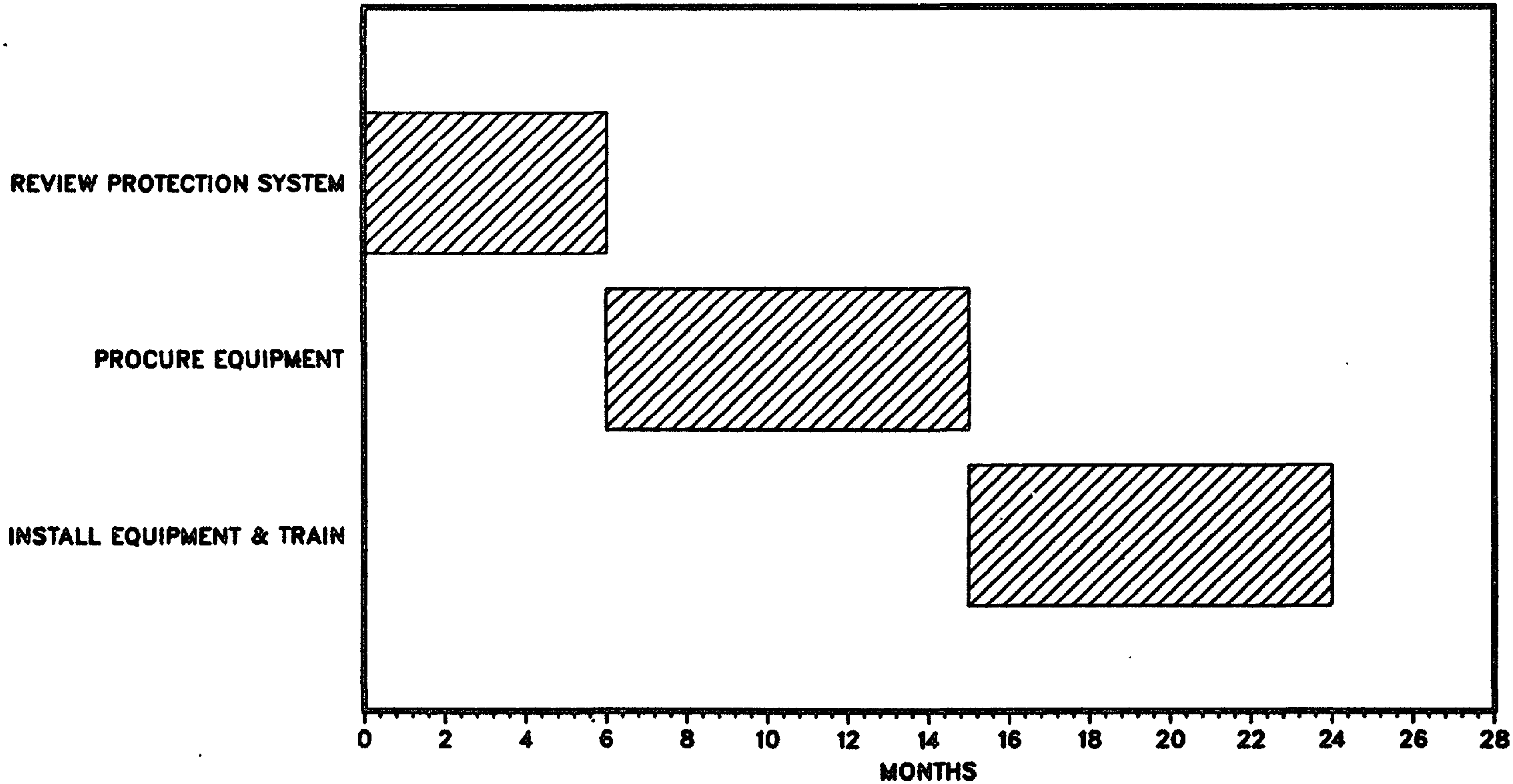
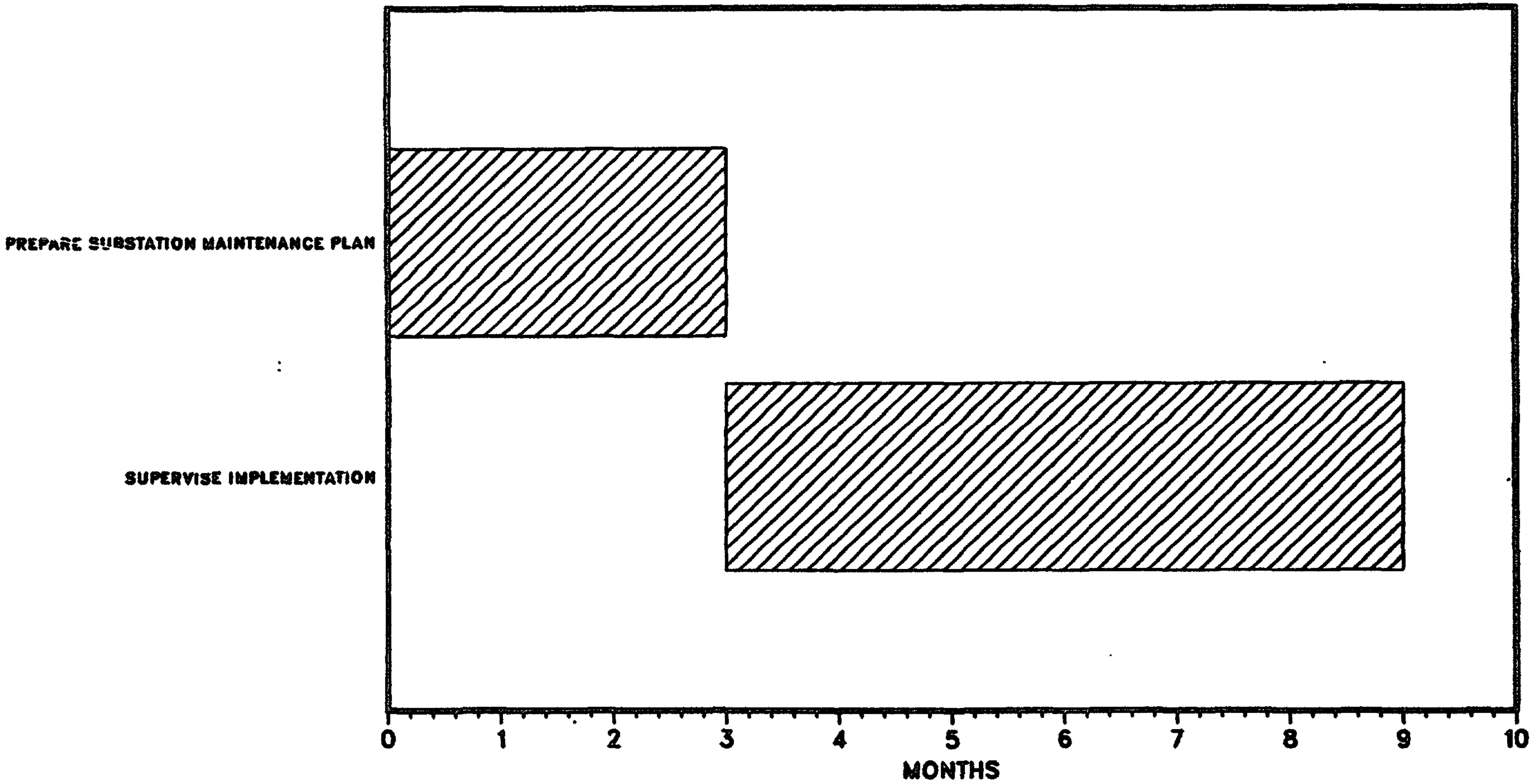


PROGRAM: IMPROVEMENT OF DISTRIBUTION OPERATIONS

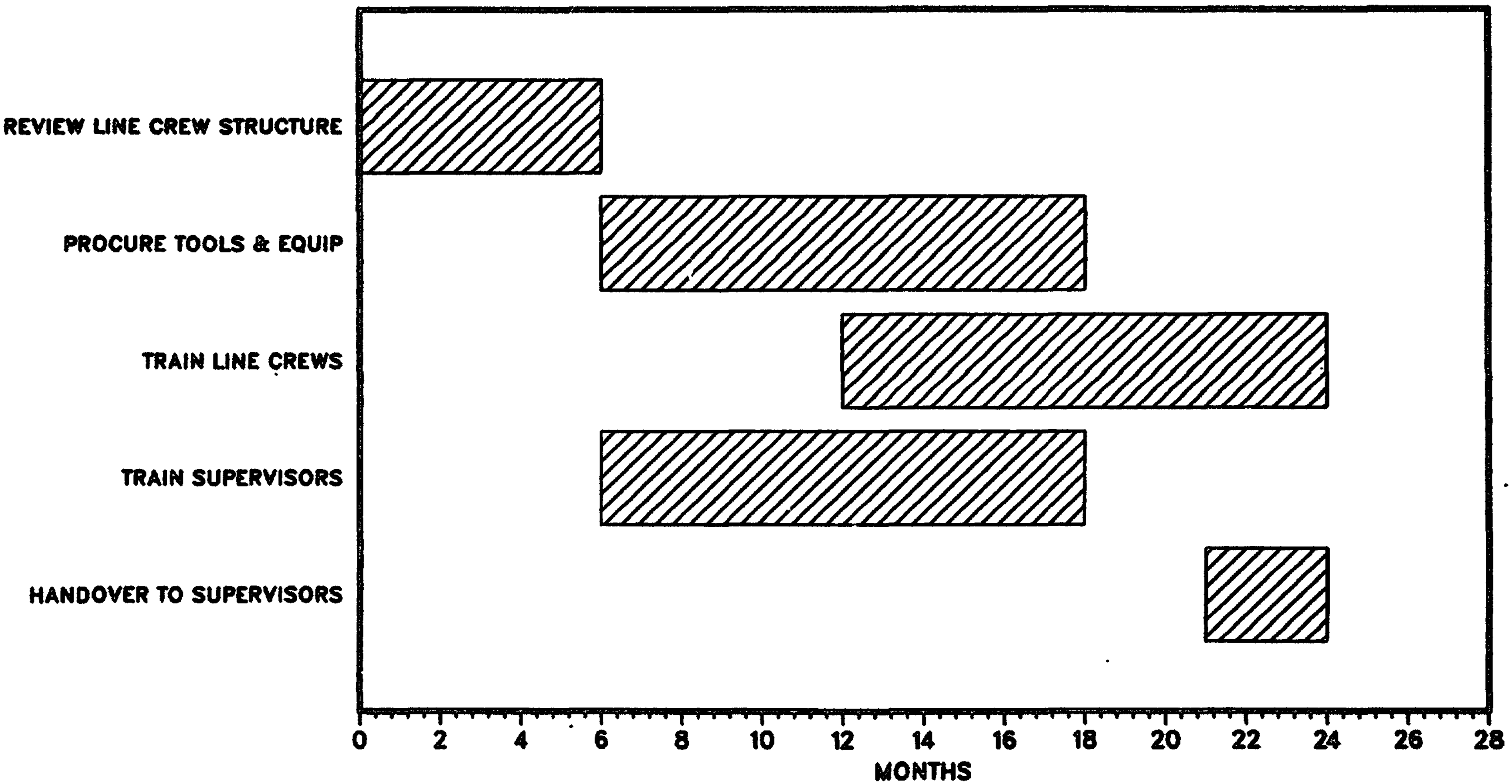
RESTORE PROTECTION & CONTROL



MAINTENANCE PROGRAM FOR SUBSTATIONS

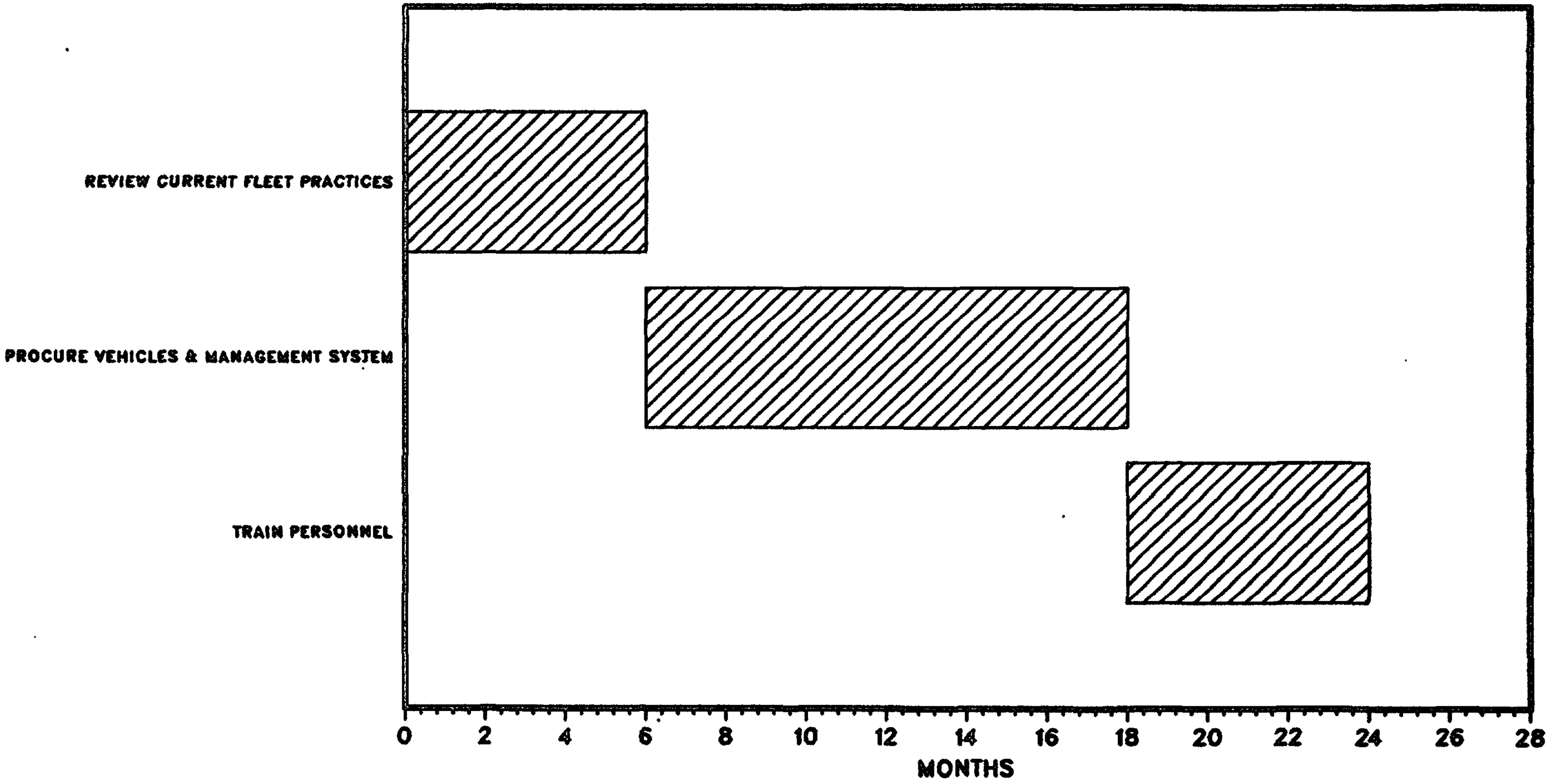


TRAINING OF LINE/MAINTENANCE CREWS

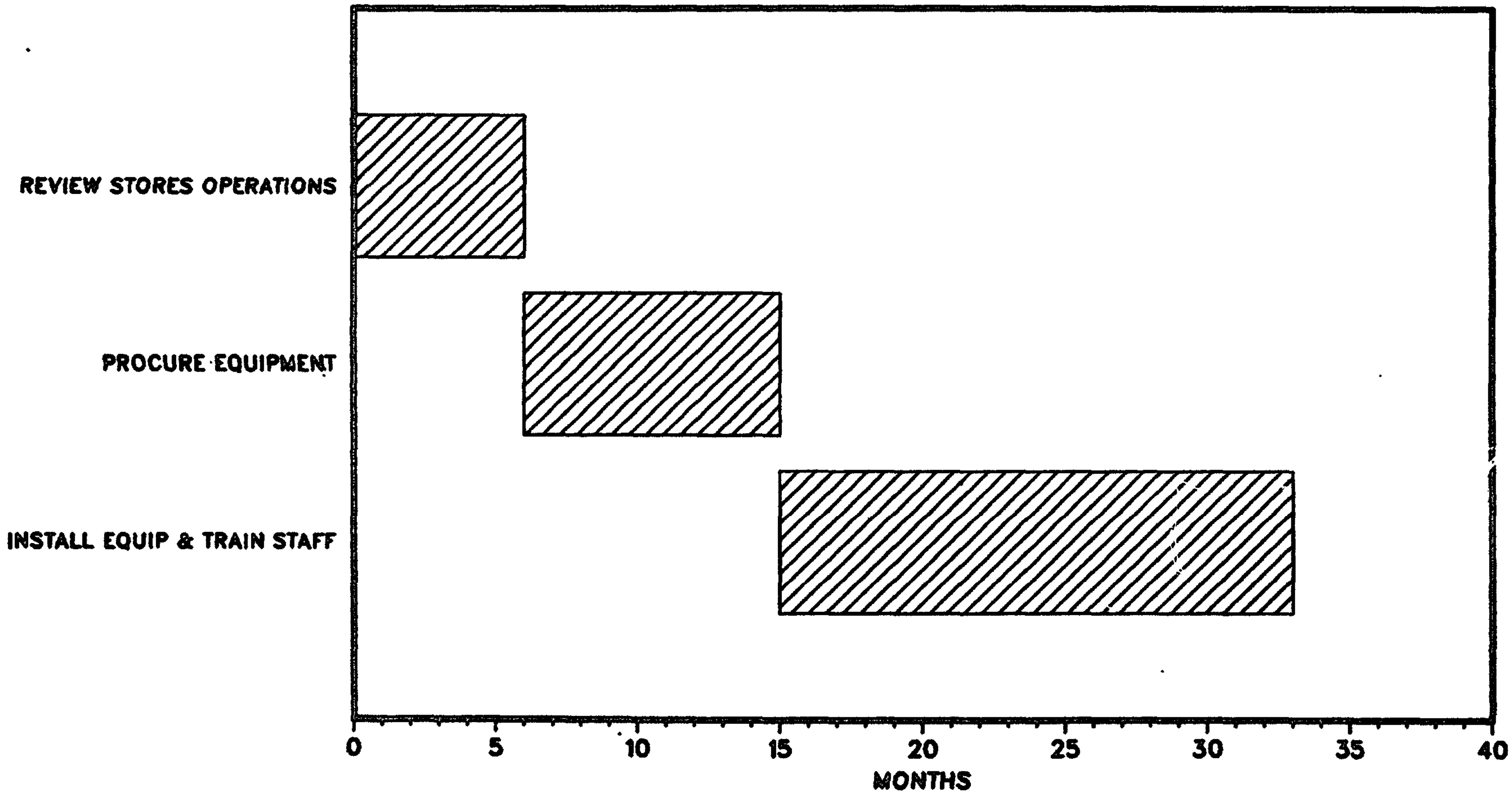


PROGRAM: STRENGTHENING OF THE SUPPORT SYSTEMS

UPGRADING & MAINTENANCE OF VEHICLE FLEET



INVENTORY CONTROL SYSTEM



REPORT OF MISSION TO ASSIST BPDB WITH INTERIM LOSS REDUCTION

Introduction

As a follow up to the joint UNDP/World Bank Power Efficiency Mission, the Government of Bangladesh requested technical assistance to initiate a crash program to reduce non-technical losses. The crash program is intended to achieve some loss reduction until the complete non-technical loss reduction program recommended by the Power Efficiency Mission can be implemented.

In response to this request, the Energy Sector Management Assistance Program (ESMAP) fielded a one-man Technical Assistance Mission to start the crash program using existing BPDB resources and capabilities, and to establish an interim work program to be implemented by BPDB.

The potential for reducing non-technical losses was demonstrated by the immediate results of the mission. The energy recuperated as a result of the mission's work is estimated to be about 4,200,000 Kwh, representing Tk 7 million (US$280,000) a year. In other words, with a limited effort of only one month, non-technical losses were reduced almost by 1% of the total (estimated at 600 GWh). A summary of the energy recuperated is shown in Table 1.

In addition to the immediate results, the mission has provided a more precise diagnosis of the factors that affect non-technical losses, and has presented a detailed work program that BPDB should implement while awaiting the full non-technical loss reduction program.

Table 1: SUMMARY OF ENERGY LOSSES RECUPERATED

Name of Industry	Losses/Year (kWh)	Findings
DHAKA		
Industrial Entity	96,355	CT polarity reversed
Container Company	79,875	Meter not working
Aluminum Works	5,000	Voltage connection 120° out of phase
Flour Mill	163,937	CT shorted
Metal Industries	95,623	Suspected pilferage
Jute Mill	596,347	Meter slow
General Business	372,883	Unmetered service
Sub-total	1,410,020	
CHITTAGONG		
Chemical Complex	2,762,116	Voltage fuse open
Total	4,172,136	

Findings and Recommendations

General

The mission worked with the Commercial Operation Department, trying to regroup some of the engineers who had been associated with the testing of import-export meters. Since these engineers are scattered all over the country, it was difficult to bring them to Dhaka.

The final team created to investigate and to visit high tension consumers initially consisted of six engineers, but ended with only three. The lack of interest by some engineers, and the shortage of vehicles, prevented the use of more than one team for the program.

The team examined the meter readers' books for 383 high tension consumers from Dhaka (representative of different types of consumers and areas) and 35 consumer records from Chittagong. In Dhaka and the surrounding areas, 25 services were visited. In Chittagong only 10 services were visited, mainly because all the meter books were in Bengali.

Organization

The recently created Commercial Operation unit is responsible for the collection of data on generation and losses and for monitoring the process of metering, billing and collection in the entire system. Additional responsibilities are the reduction and control of non-technical losses. Meter testing equipment consisting of a rotating standard meter and a phantom load has been provided to the three major divisions of Dhaka, Khulna and Chittagong.

This equipment is necessary, but there there are still major problems preventing the unit from being an effective loss reduction unit:

(a) There are no full-time qualified technicians to operate the equipment (rotating standard meter and phantom load) and to test meters. There are no meter technicians except at the central meter shop. As a result, little basic testing is performed by the engineers who are occupied with other responsibilities within the unit.

(b) The lack of experience by some of the engineers prevents them from having confidence and authority to perform their duties. In addition, the weight and size of the phantom load discourages many engineers from taking them for field testing.

(c) Although each division is responsible for testing all three phase meters before installation, and to recalibrate meters in their own "meter shop", only meters with known problems are tested. The only exception is Chittagong where all meters (single phase and three phase) are tested before installation. In this case, previous tests showed many meters to be running fast, some over 40%. Because of the short time spent in Chittagong it was not possible to verify this, but it is clear that there are problems with the testing procedures and/or the equipment. 1/

(d) The percentage error of the rotating standards is unknown and hence is not used when calibrating meters. The mission tested one of the standards at the central meter shop and found it to be 0.5% fast. In addition, the standard error used by BPDB for high voltage consumers (i.e. 2%) is too large.

Recommended actions to deal with these problems are presented in the following sections.

Meter Shop

The main problems found at the meter shop are the following:

(a) The Central Meter Shop lacks adequate equipment, but more important, it lacks meters to test. The meter shop is only used when there is a dispute over meter accuracy. The place is nearly empty and the personnel appear bored and in need of motivation.

(b) The special test room where three phase meters are tested and where the only test bench is located is not air conditioned and thus is susceptible to contamination by dust. The room is dirty and testing is not correctly done.

(c) With over 700,000 customers and a lack of qualified personnel to field test meters, the meter shop should be full of defective meters or doubtful meters. However, the lack of communication among the departments seems to prevent the use of the available facilities. 2/

In order to tackle these problems, a better utilization and complete reorganization (including a redefinition of the duties of the

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1/ It is unlikely that new meters would be that badly calibrated. If in fact the test equipment is almost 40% slow the losses in this area would be considerable.

2/ For example, the Division Chiefs believe that the main meter shop is responsible for the testing of all three phase meters, while the meter shop believes that the Division is responsible for testing all three phase meters. The end result is that meters are not tested.

central meter shop) is urgently needed. Among the most important steps to achieve this are the following:

(a) Training of the personnel. This is needed to keep them updated and to increase productivity.

(b) Establish metering standards and policies. If they exist, they are not well known by everyone.

(c) Maintain the testing room clean and organized. An air conditioning unit is necessary to maintain the room clean.

(d) Maintain a control book for all the meters received and distributed. The central meter shop should be the only department responsible for the distribution of meters. Control of serial numbers should be kept by the meter shop.

(e) Start testing meters in the field. This can be used as training for some staff who later could become part of the loss control unit.

(f) Establish a program to test all portable rotating standards once a year.

Metering Equipment

The main problems detected with respect to meters are the following:

(a) The high tension metering equipment is located with easy access to the consumer. With the exception of very few cases, the current and voltage transformers belong to the consumer and are not accessible to BPDB. In some cases even the meter belongs to the consumer. It is not possible to ascertain who (if anybody) tested the meter before installation and who verified the connections.

(b) Low tension metering is in worse condition. The current transformers are installed in the open. Voltage is taken directly from the conductors or the secondary of the power transformer. The metering equipment is so accessible to the consumer that he can do anything he wants with the equipment, without BPDB knowing about it.

(c) A program to reseal all high tension metering equipment has been recently completed in Dhaka. The success of the program is doubtful, since meters were not tested before sealing them. Furthermore, it is believed that several unacceptable meters (and CT's and VT's) were sealed.

(d) Lead seals in conjunction with paper seals are commonly used to avoid tampering. The paper seals are nothing more than a rectangular piece of paper with the signature of the Division Chief and the BPDB seal. The seals are then glued to the sides of the meter and to the CT's and VT's terminals. This type of seal has been introduced because BPDB discovered that an alarming number of people (outside BPDB) had perfectly duplicated the seals and sealing tools used by BPDB. The lead seals used are of poor quality and without serial numbers. The success of the paper seals is yet to be determined. The mission believes that it is easier to duplicate paper seals than lead seals.

(e) Very little importance is attached to meter accuracy. Because of the lack of full-time meter technicians, meters estimated to be around 7% slow are assumed to be acceptable.

(f) Meters in some areas (viz. Narshingdi) are tested by using 3 Kw light bulbs. Besides being inadequate, this procedure is only used for light load testing. Full load testing is not performed. In one of the visited services the new meter ("recalibrated") is registering less consumption than the previous meter, even though load and working conditions of the service remain the same.

(g) Three phase meters for industrial consumers are not tested or calibrated when they are received from the factory. Some of these meters could lose their accuracy during shipment.

In order to tackle these problems the following actions are recommended:

(a) Meter calibration should be implemented immediately. A program to recalibrate all meters installed on large industrial and commercial consumers is essential for the reduction of non-technical losses. Meters must be tested as close to 0% error as possible; the ±2% regulation is not acceptable for high consumption consumers. The participation of the Central Meter Shop is crucial for the meter recalibration program.

(b) The metering equipment is in most cases installed on the consumer panel and out of the BPDB control. This metering equipment must be enclosed in a metallic box owned by BPDB. BPDB should start by resealing all CT's, VT's and meters with new seals until the boxes are obtained. The seals and dies will have to be imported to make them more difficult to reproduce. The use of color-coded plastic seals is also recommended in some cases. 3/

(c) "Clip-on" plastic boxes with an opening for the conductor and wires to cover CT's and VT's is also recommended. These boxes can be made in Bangladesh and should be used on all those services where there is no other solution.

(d) For easy inspection, all metering equipment must be wired using a color code. It is much easier to follow color-coded wires than wires with the same color.

(e) It is essential that the consumer provides an adequate space for the metering equipment. If the consumer does not meet this requirement, the services should be denied until an adequate space is provided. This policy will save many problems and misunderstandings in the future.

Meter Readers

Engineers are responsible for taking the monthly high tension meter readings. Each engineer has been assigned a particular area. The present system, as practiced, has the following problems:

(a) Rotation of meter readers is not practiced, and is believed to be one of the reasons for the high number of metering problems. On one hand, the system lends itself to collusion; on the other hand, when the meter reader goes continously to the same places the inspection becomes a routine job.

(b) The meter book showed that in some instances the readings are readjusted to reflect what is believed to be the normal consumption. This practice is based on judgement and is acceptable for one month while an investigation is conducted. However in all cases reviewed the service is never investigated and the meter reader continues to estimate consumption for months or years. Reports from the meter readers are seldom investigated. For instance, in Narshingdi, the visit to a jute mill showed the meter registering between 10-15% slow. More surprising was the discovery that this meter was reported defective in July 1983 but no action had been taken.

(c) In general, very slow action is taken on reports of defective meters, incorrect connections or any other irregularity. The mission saw reports in meter books recommending the revision of

3/ For example, red could represent a consumer that was found stealing energy before, yellow a doubtful consumer, green a consumer with no previous problems, etc.

meters or replacement of fuses, and after more than a year, nothing is done. For instance, in the Chittagong area a chemical plant had a voltage transformer fuse open, representing losses between 200,000 to 300,000 kWh a month, or over Tk 510,000 a month. The fuse problem was reported many times in 1983 by the meter readers, but again no action was taken. The consequence is the demoralization of the personnel reporting these irregularities. The lack of definition of responsibilities and the lack of will to exert firm action are believed to be the main causes for not taking immediate action on this and other cases.

(d) On many occasions metering problems are not reported for fear of retaliation from the consumer. The personnel believes that reporting irregularities in the service of an important person or firm will endanger their job.

In order to start solving these problems, the following actions are recommended:

(a) A crucial factor in the reduction and control of the non-technical losses is the motivation of the personnel. People should be made aware of the importance of reducing system losses and the importance of their collaboration. Better use of the meter readers should be made, they are the "eyes" of the organization, the only group that visits every consumer each month. They should be asked to report every detail they think is important, but most of all they should be shown the results and importance of the findings.

(b) BPDB has to obtain complete support of the higher authorities of the Government in dealing with non-technical losses. There should not be any interference with the work and findings of the Commercial Operation unit. BPDB must support and protect the people reporting metering problems by not providing their names, under any circumstances. The unit must be responsible for the findings and of any actions taken and not the individuals taking part in the program. This should be made clear to the personnel reporting or investigating consumers.

(c) The establishment of targets and rewards (not necessarily economic) for the group (or staff member) reporting cases that have contributed the most to the reduction of system losses will give the incentive needed for the success of the program.

(d) Advertise that BPDB will start a program to find and prosecute any consumer found stealing energy. The prosecution of a few customers and publication in daily newspapers of their names will serve as an example to others and will prevent expansion of the problem.

Billing

The billing of the estimated 700,000 consumers is still done by hand using only hand calculators. This procedure gives a very doubtful estimation of total sales. Major problems in the billing system are:

(a) There are no records showing previous billings, but it is certain that in some occasions billing errors are introduced in the calculation of sales and are therefore reflected on the non-technical losses.

(b) BPDB signed a contract with the University to use their computer and personnel for billing purposes. The major disadvantage is that outside personnel will be responsible for the billing. It is doubtful that the University will dedicate enough time and effort to improve the billing system and some times will even delay the billing to take care of their own requirements. The requests for billing records might take days, until they find the time to do it.

There is no reason to investigate the billing procedure at this time until the new computerized system proposed in the non-technical loss reduction program is in operation. New procedures and policies will have to be introduced to take advantage of the new system. The first computerized billing is expected in December 1984. This will represent an improvement but should be considered as temporary until BPDB obtains its own computer system.

Work Program

Non-technical losses will not be reduced to an acceptable level until the complete program described in Section IV of the main report is introduced. However, since this will take some time we suggest to start a pre-loss reduction prógramme at a lower scale, which is well within BPDB's present capabilities. As can be seen by the results of the inspections performed by the team during three weeks, a modest reduction without a large investment can be accomplished.

Until the full program is implemented, we recommend, based on the findings, to start reducing the non-technical losses by:

(a) Installing meters on all services without meter or with defective meters.

(b) Calibrating all three phase meters before installation.

(c) Re-training the BPDB staff responsible for the testing of meters.

(d) Using the central meter shop by requesting their assistance to re-calibrate meters.

(e) Improving inter-department coordination and defining their responsibilities more precisely.

(f) Starting a program of visits and investigations of all large industrial and commercial consumers, including re-calibration of meters.

(g) Motivating the personnel to participate in the reduction of system losses.

To make better use of BPDB resources the program should be divided in three stages.

Stage One:

This stage has already started and should be continued as follows:

(a) Make a list of all unmetered industrial and commercial services, including address, account number and estimated consumption.

(b) Make a program to visit all the services listed in (a) and plan the installation of meters.

(c) Install meters in all these services and calibrate the meters before installing them.

(d) Organize a loss control unit. The unit will comprise a service inspection team, meter testing and calibration, and review of billing records.

(e) Prepare a program to visit high tension consumers.

Stage Two:

(a) Visit and inspect all high tension consumers. Most of the findings will assist BPDB to determine which services have priority for the installation of metering outfits. 4/

(b) Visit the consumers and calibrate meters following the plan developed in stage one. If it is not possible to do it in the field, bring the meter to the shop. In case the service is left without a meter, calculate its daily consumption and add the consumption after the meter is reinstalled.

4/ Meter unit containing potential and current transformers.

(c) Keep records of every service visited and meter testing results.

(d) Monitor all those services where an irregularity was found (after having it corrected).

Stage Three:

(a) Analyze results. Make a list of the kwh recuperated.

(b) Prepare a plan for the inspection of medium size industrial and commercial consumers.

(c) Prepare a plan to install metering boxes.

(d) Prepare a plan for the periodical testing of High Tension consumers.

Timetable

The following is the timetable given to BPDB at the end of the mission (December 18, 1984) to start the "pre" loss reduction program.

Stage One:

The list of services without a meter or with a defective meter is now available. There are 85 services with estimated consumption in Dhaka and surrounding areas (Chittagong does not have any services without a meter and at the time of the mission the list from Khulna was not available). However, 20 meters have been already installed, leaving 65 services without meters.

Visit all 65 services and take note of the type of meter needed, CT's and VT's ratios and of special requirements needed to install the meter. Determine if the service will have to be suspended to install the meter, estimate time and judge whether the assistance of the Operation Department will be required to interrupt the service. Coordinate with the Operation Department in advance. Make a complete list of CT's, PT's and meters required and have them ready for installation.

Estimated time to complete visit:	3 weeks
Starting date:	December 23, 1984
Completion date:	January 7, 1985
Earliest completion date:	January 4, 1985
Latest completion date:	January 10, 1985

Since there are many services with two meters, request all the high tension meter readers to report all services with two or more meters. This must be done at the end of the month of December. Make a list of all services and plan a visit to remove them. This action will provide a number of meters for the services without meters.

Estimated time to complete visit and removal of meters:	3 weeks
Starting date:	January 7, 1985
Completion date:	January 26, 1985
Earliest completion date:	January 20, 1985
Latest completion date:	February 2, 1985

Prepare all CT's, VT's and meters required. All meters must be tested and calibrated before installing them. A test report of each meter tested must be issued. This report will be filed in a special high tension consumer file. Meters should be calibrated as close to 0% as possible, <u>2% is not acceptable.</u>

Estimated time to test and calibrate meters:	2 weeks
Starting date:	January 7, 1985
Completion date:	January 20, 1985
Earliest completion date:	January 20, 1985
Latest completion date:	February 2, 1985

Estimated time to complete installation of meters:	5 weeks
Starting date:	February 2, 1985
Completion date:	March 9, 1985
Earliest completion date:	March 2, 1985
Latest completion date:	March 16, 1985

It is necessary to create a "Loss Control Unit" to reduce and control all non-technical losses. This unit will be in charge of making programs and plans for the inspection of services and calibration of meters. The unit will start by "opening" a file for each high tension consumer. This file will contain everything related to the respective service, correspondence, date of installation, meter number, type, CT ratios, date of meter testing, etc.

The above information will assist the unit in programming periodical checking and meter testing. The unit will consist of three sections:

- Service inspection
- Meter testing and calibration
- Review of records, billing and control and monitoring of services.

There should be one loss control unit in Dhaka, one in Chittagong and one in Khulna.

(a) Service Inspection Section: This section will be responsible for the inspection of all high tension services (later they will also inspect low tension and small commercial consumers). It should consist of three inspection teams, with three members per team: one Engineer (or experienced meter technician), an electrician with some experience in metering and an assistant.

After each visit each team must submit a report of the visit, including their recommendations. The report will be analyzed by the head of the control unit (or the head of the service inspection section), who will then take immediate action.

(b) Meter Testing and Calibration Section: All meters will be tested and calibrated by this section. A test report will be issued after each test, including the error in accuracy (if any) and the calibration obtained. This report will assist BPDB to determine the quality of meters, so that they can be standardized.

The section should consist of a field testing team and laboratory testing team. The laboratory team shall have at least two meter technicians, two assistant meter technicians and a general assistant. The field team should consist of two groups, each group will consist of one meter technician, an assistant meter technician and a general assistant.

(c) Review of Billing Records and Control Section: The responsibility of this section will be the the calculation of omitted billing, monitoring of high tension consumers, and monitoring of services with new meter or a corrected meter.

The section will review every month all the high tension metering books and make a list of all those services that require an inspection by the service inspection section. The list may result from the meter readers' observations or their own considerations. This section will keep control of the non-technical losses and will generate work for the inspection and meter testing sections.

Estimated time to organize the loss control unit:	10 weeks
Starting date:	December 23, 1984
Completion date:	March 2, 1985
Earliest completion date:	February 15, 1985
Latest completion date:	March 16, 1985

Once the unit is formed, a program to visit high tension consumers and to calibrate high tension meters must be established. The program should also include the coordination of vehicles available for the visits.

The program should start by making a list of all large industrial consumers with loads above 1 MW and another with loads below 1 MW. There are 353 services with load above 1 MW and 1211 below 1 MW. They are distributed as follows.

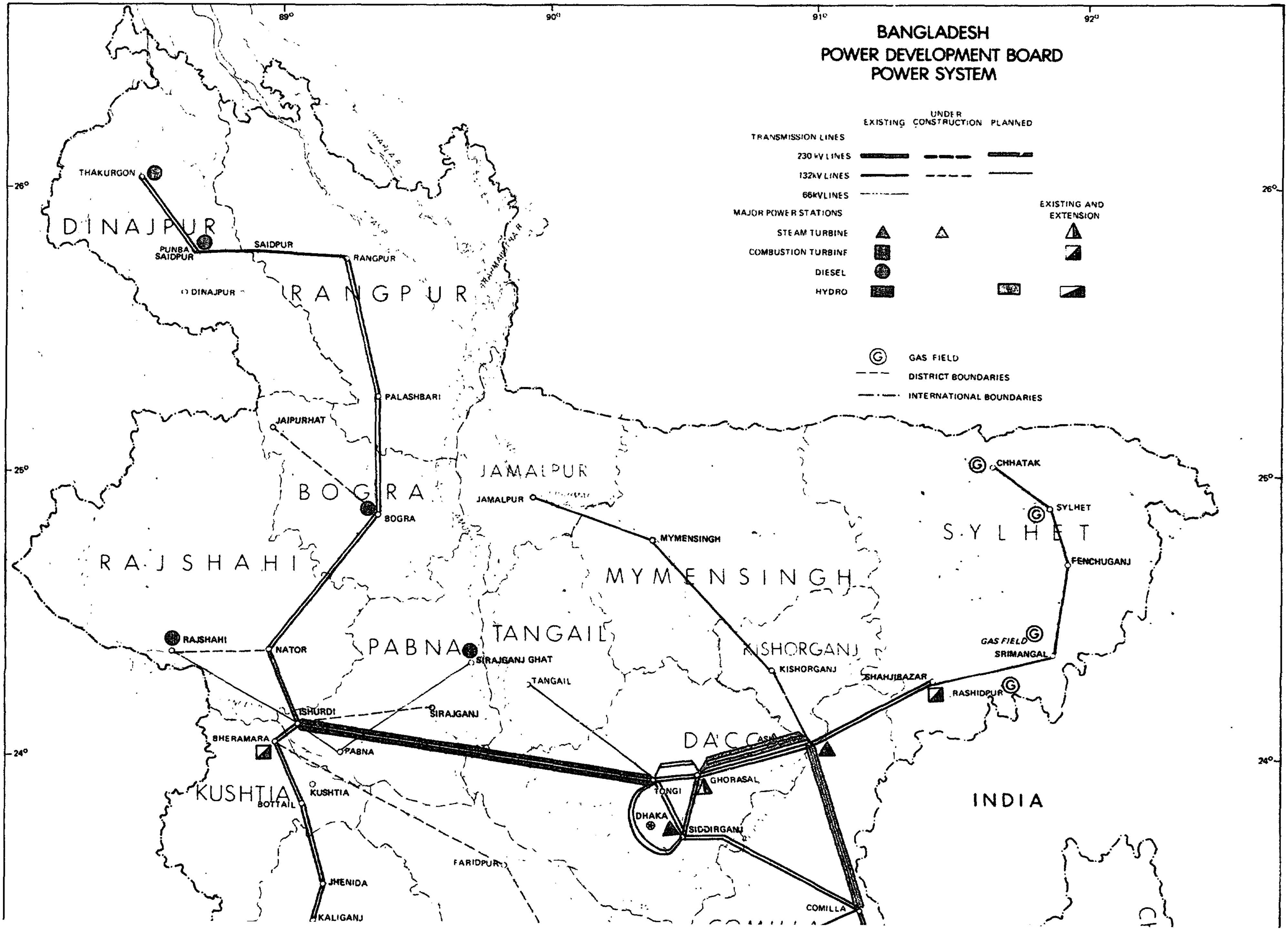
		Above 1 MW	Below 1 MW
1.	Dhaka Electricity Supply	91	360
2.	Narayanganj Circle	45	166
3.	Mymensingh Circle	9	27
4.	Chittagong Electricity Supply	60	243
5.	Distribution Circle, Chittagong	10	36
6.	Distribution Circle, Comilla	36	39
7.	Distribution Circle, Sylhet	20	61
8.	Khulna Electricity Supply	18	61
9.	Distribution, Jessore	8	18
10.	Distribution, Faridpur	6	21
11.	Distribution, Barisal	20	79
12.	Distribution, Rajshahi	20	60
13.	Distribution, Dinajpur	10	40
	TOTAL:	353	1211
Total of H. T. Consumers:			1564

Expected time to complete list:	1 week
Starting date:	March 16, 1985
Completion date:	March 23, 1985

Estimated time to complete program of visits & meter calibration of service with loads above 1 MW:	15 weeks
Starting date:	March 16, 1985
Completion date:	July 1, 1985
Earliest completion date:	June 24, 1985
Latest completion date:	July 8, 1985

This work on meters with loads below 1 MW should start in July 1985 and continue until the main loss reduction program is underway.

The work program for Stages Two and Three should be developed in Stage One.


BANGLADESH
POWER DEVELOPMENT BOARD
POWER SYSTEM
EXISTING
UNDER CONSTRUCTION
PLANNED
TRANSMISSION LINES
230 kV LINES
132kV LINES
66kV LINES
MAJOR POWER STATIONS
EXISTING AND EXTENSION
STEAM TURBINE
COMBUSTION TURBINE
DIESEL
HYDRO
GAS FIELD
DISTRICT BOUNDARIES
INTERNATIONAL BOUNDARIES
89°
90°
91°
92°
26°
25°
24°
THAKURGON
DINAJPUR
PUNBA
SAIDPUR
SAIDPUR
RANGPUR
DINAJPUR
RANGPUR
PALASHBARI
JAIPURHAT
BOGRA
BOGRA
JAMALPUR
JAMALPUR
MYMENSINGH
MYMENSINGH
RAJSHAHI
RAJSHAHI
NATOR
PABNA
SIRAJGANJ GHAT
TANGAIL
TANGAIL
KISHORGANJ
KISHORGANJ
CHHATAK
SYLHET
SYLHET
FENCHUGANJ
GAS FIELD
SRIMANGAL
SHAHJIBAZAR
RASHIDPUR
ISHURDI
SIRAJGANJ
BHERAMARA
PABNA
DACCA
ASHUGANJ
GHORASAL
TONGI
DHAKA
SIDDIRGANJ
KUSHTIA
KUSHTIA
BOTTAIL
INDIA
FARIDPUR
JHENIDA
KALIGANJ
COMILLA

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

Activities Completed

		Date Completed
Energy Assessment Status Report		
Papua New Guinea		July, 1983
Mauritius		October, 1983
Sri Lanka		January, 1984
Malawi		January, 1984
Burundi		February, 1984
Bangladesh		April, 1984
Kenya		May, 1984
Rwanda		May, 1984
Zimbabwe		August, 1984
Uganda		August, 1984
Indonesia		September, 1984
Senegal		October, 1984
Sudan		November, 1984
Nepal		January, 1985
Project Formulation and Justification		
Panama	Power Loss Reduction Study	June, 1983
Zimbabwe	Power Loss Reduction Study	June, 1983
Sri Lanka	Power Loss Reduction Study	July, 1983
Malawi	Technical Assistance to Improve the Efficiency of Fuelwood Use in Tobacco Industry	November, 1983
Kenya	Power Loss Reduction Study	March, 1984
Sudan	Power Loss Reduction Study	June, 1984
Seychelles	Power Loss Reduction Study	August, 1984
Gambia	Solar Water Heating Retrofit Project	February, 1985
Institutional and Policy Support		
Sudan	Management Assistance to the Ministry of Energy & Mining	May, 1983
Burundi	Petroleum Supply Management Study	December, 1983
Papua New Guinea	Proposals for Strengthening the Department of Minerals and Energy	October, 1984
Papua New Guinea	Power Tariff Study	October, 1984
Costa Rica	Recommended Tech. Asst. Projects	November, 1984
Uganda	Institutional Strengthening in the Energy Sector	January, 1985