JAPAN INTERNATIONAL COOPERATION AGENCY

THE REPUBLIC OF SIERRA LEONE
NATIONAL POWER AUTHORITY (NPA)

# BASIC DESIGN STUDY REPORT
# ON
# THE PROJECT FOR IMPROVEMENT
# OF
# ELECTRICITY POWER SUPPLY TO GREATER FREETOWN
# IN
# THE REPUBLIC OF SIERRA LEONE
# (SUPPLEMENTARY STUDY)

MAY 1993

YACHIYO ENGINEERING CO., LTD.

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## PREFACE

In response to a request from the Government of the Republic of Sierra Leone, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Electricity Power Supply to Greater Freetown (Supplementary Study) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Sierra Leone a study team headed by Mr. Yasuhiro MORIMOTO, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs and constituted by members of Yachiyo Engineering Co., Ltd., from March 16 to April 2, 1993.

The team held discussions with the officials concerned of the Government of Sierra Leone, and conducted a field study at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Sierra Leone for their close cooperation extended to the team.

May, 1993

Kensuke Yanagiya
President
Japan International Cooperation Agency

May, 1993

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Improvement of Electricity Power Supply to Greater Freetown in the Republic of Sierra Leone.(Supplementary Study)

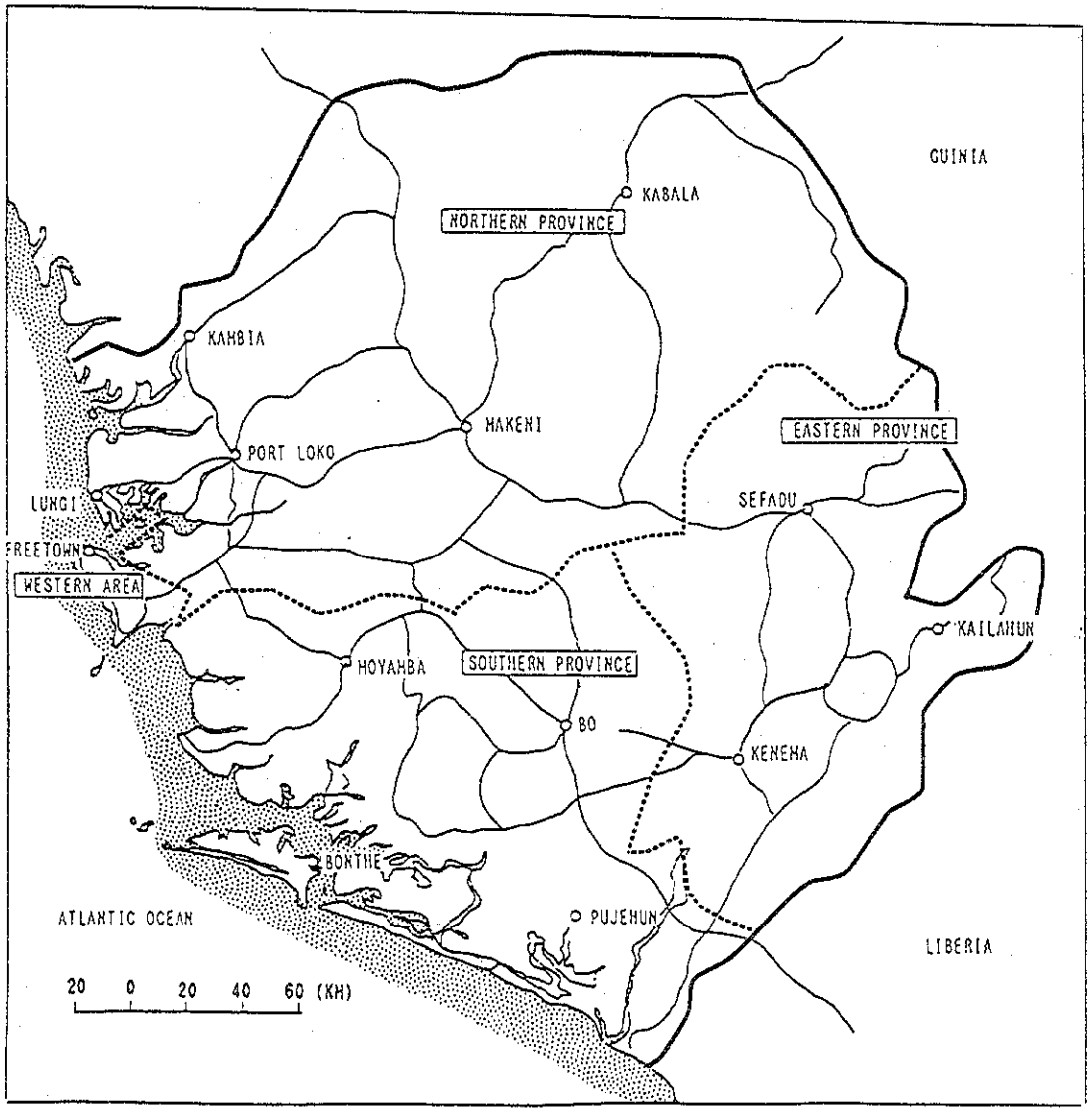
This study has been made by Yachiyo Engineering Co., Ltd., based on a contract with JICA, from March 8th to May 14th, 1993. Throughout the study, we have taken into full consideration of the present situation in Sierra Leone, and have planned the most appropriate project in the scheme of Japan's grant aid.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, Ministry of Trade and Industry. We also wish to express our deep gratitude to the officials concerned of National Power Authority, Embassy of Japan in Ghana, Consulate General of Japan in Sierra Leone for their close cooperation and assistance during our study.

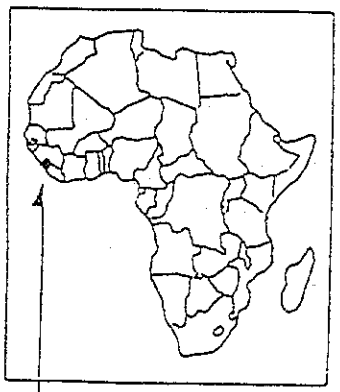
Finally, we hope that this report will be effectively used for the promotion of the project.

Very truly yours,

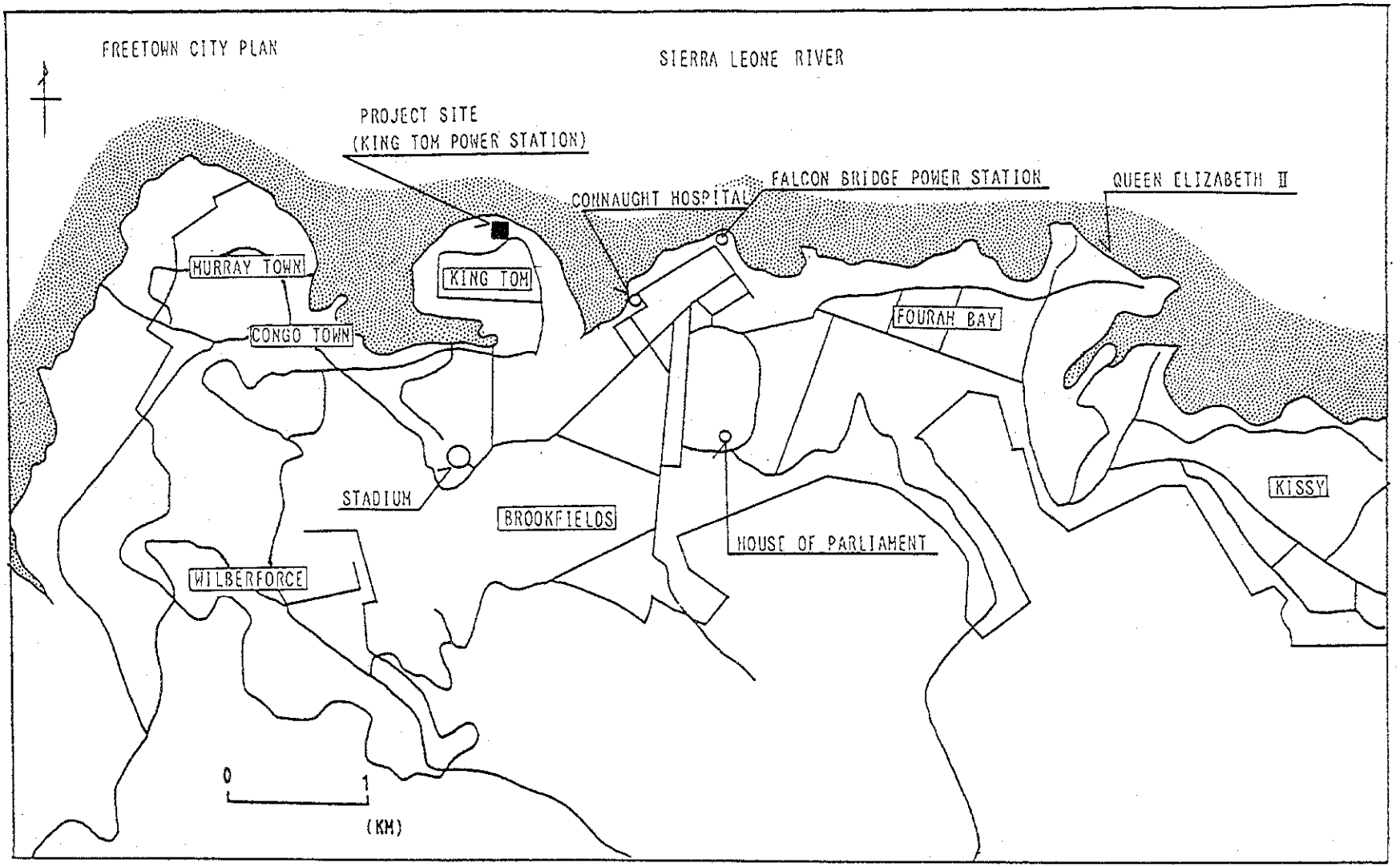
Mitsuhisa Nishikawa
Project Manager,
Basic design study team on the Project for
Improvement of Electricity Power Supply to Greater
Freetown (Supplementary Study)
Yachiyo Engineering Co., Ltd.



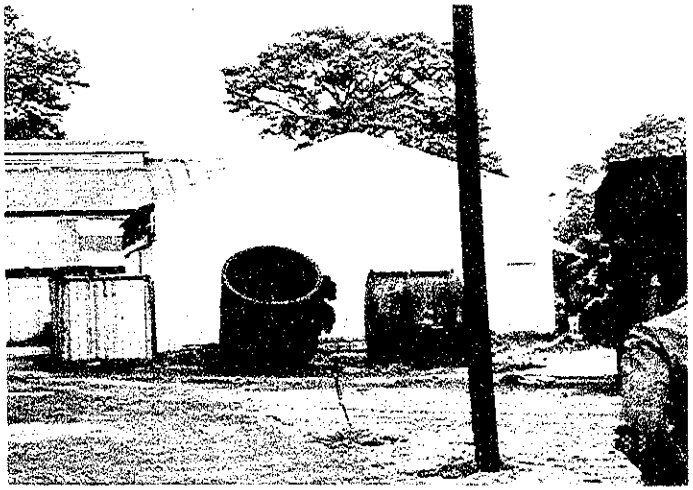

SIERRA LEONE LOCATION MAP

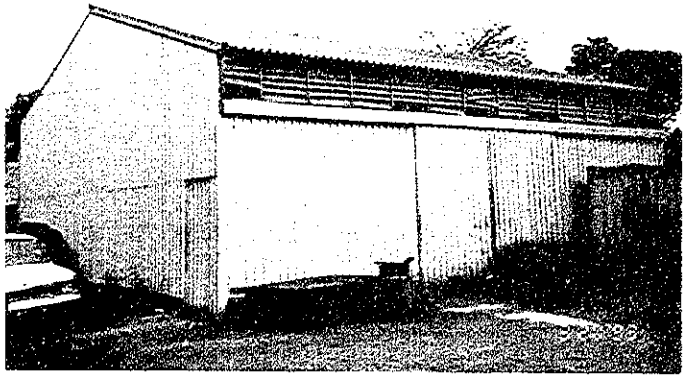


SIERRA LEONE



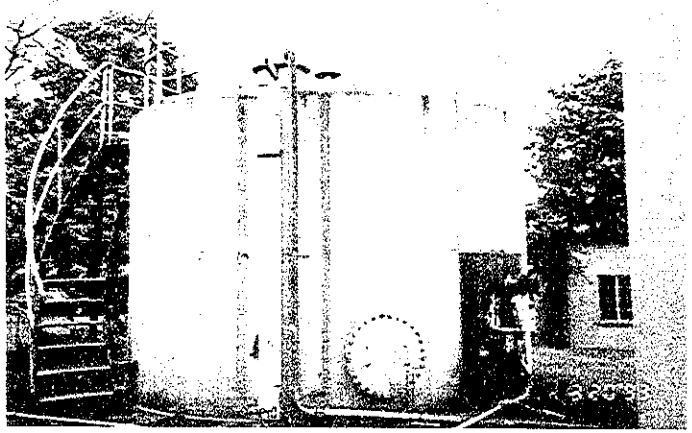

PROJECT SITE LOCATION MAP





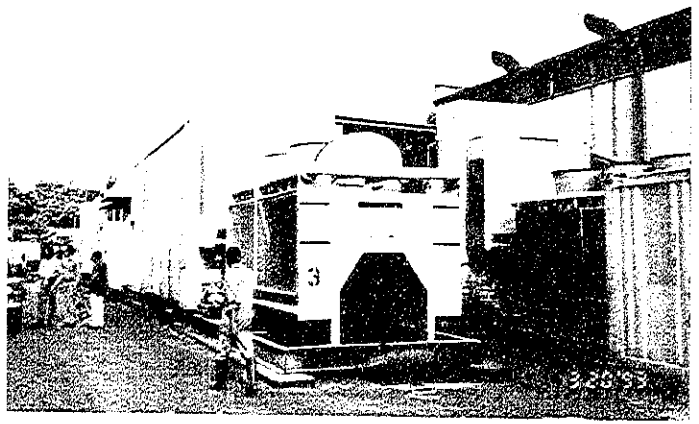
**The Construction Site for a New DEG**

(The transport of existing warehouses and ground preparation is to be scheduled by country S.)
Relocation of existing warehouse and land reclamation will be carried out by the Sierra Leone side)



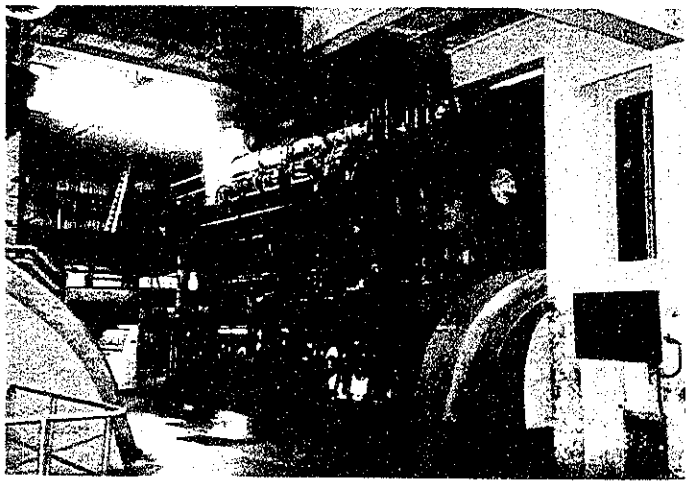
**Existing Diesel Oil Tank**

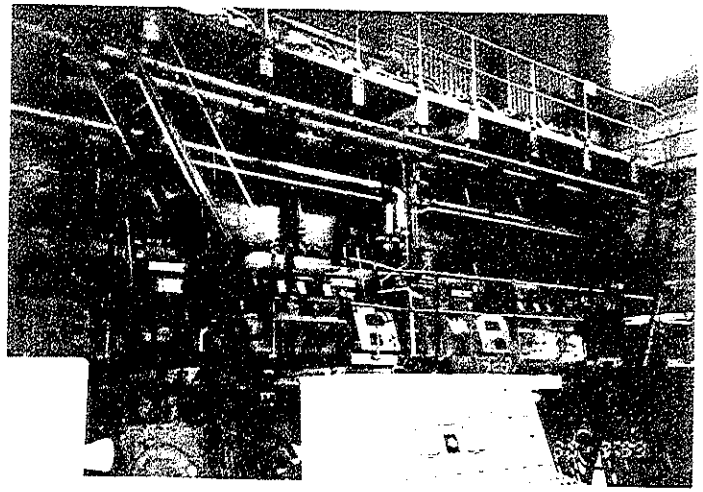
(This project uses this tank as well.)



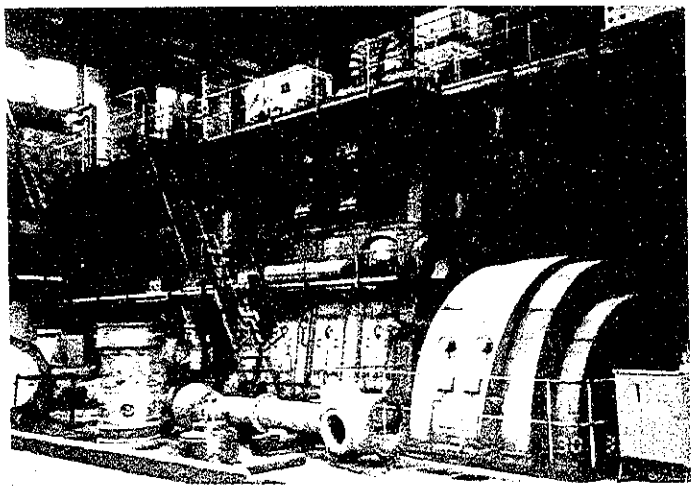
**KHD Outdoor-Type Generating Facilities**

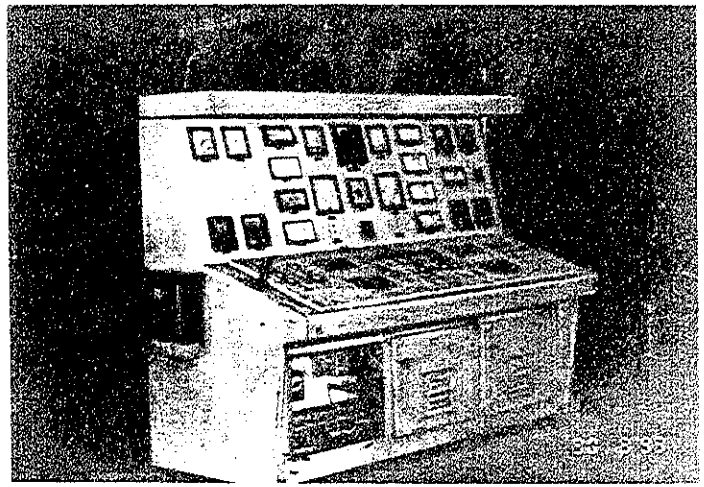
(These are under rehabilitation by the emergency project assistance financed by the EEC, the GTZ and others. Due to the high-speed specification of engine, power supply to the base load has not been performed.)



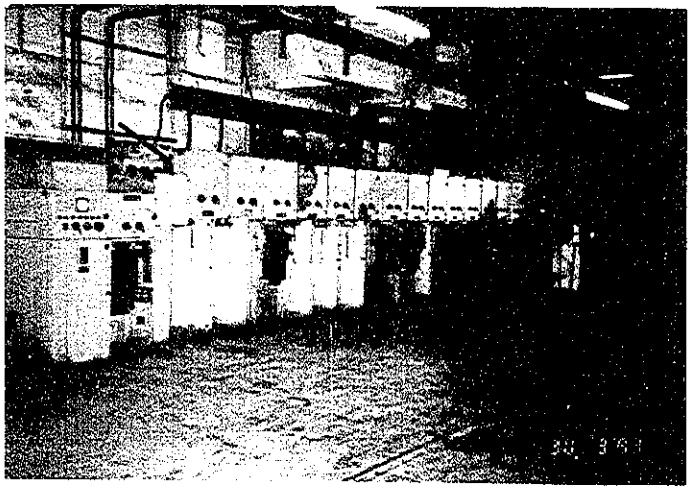


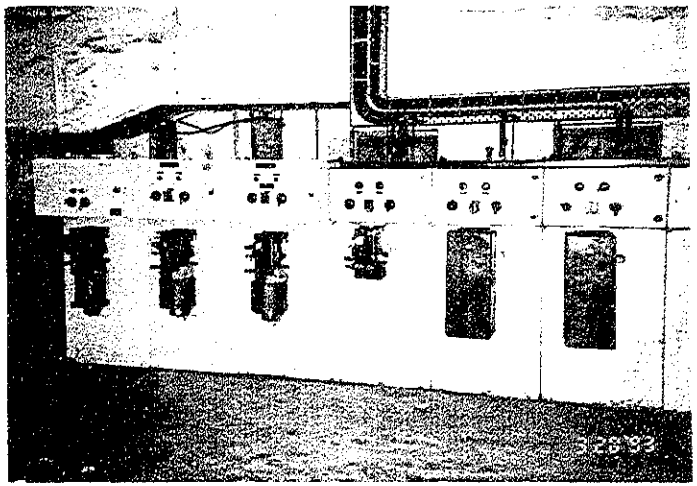
**Currently Operating Sluzer Generating Facility**
(The facility that is currently operating is to be rehabilitated with the assistance of experts dispatched by the EEC, the GTZ, and others.)





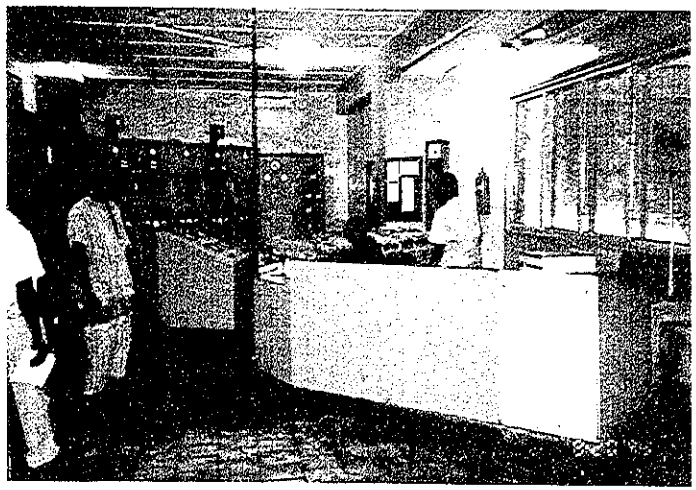
**MAN Generating Facilities Not in Operation**
(According to the World Bank plan, this facilities is to be removed and a new 5-MW generating facilities installed in the recovered space.)





**Circuit Breakers for Power Transmission/Distribution**

(It is planned to rehabilitate and/or replace of these equipment.)



**Control Room in the Existing Power House**

(The three desk-type control panels for MAN Generators located on the right side of the room are currently not being used. As with the circuit breakers for transmission and distribution of electricity, it is planned for these to be rehabilitate by the EEC and EIB.)

# SUMMARY

# SUMMARY

The Republic of Sierra Leone (hereinafter referred to Sierra Leone) is situated on the West African coast between Guinea and Liberia with a total land area of about 71,000 $km^2$ and a population of about 4.2 million (in 1991, the annual population increase was 2.6%). Freetown City is the capital of Sierra Leone, with a per capita GNP estimated at about US$ 240 in 1990/1991.

Sierra Leone's economy depends mainly on mining (diamond, etc.) and agriculture (cocoa, coffee, etc.). With the second five-year development plan, the Government stresses agriculture as a top priority sector to attain food self-sufficiency and promote exports. Under the third five-year plan implemented in 1989/90, emphasis was on the improvement of energy supplies to meet the growing needs for electric power, as well as to expand farm production.

However, many existing generating facilities operated by the National Power Authority (NPA), the nation's largest public power supply sector, have become obsolete and suffer from lack of spare parts due to severe financial conditions. Electric power supplied by existing generating facilities is far short of demand.

This means that there are frequent power outages in the Western Area of Sierra Leone and the greater Freetown area. As a result, people's lives, economic activities, and management of social welfare facilities such as hospitals and schools are subject to extremely serious conditions.

As a measure to improve this power supply situation, the Government of Sierra Leone formulated two major plans in 1988: the "Capital Area Power Supply Improvement Plan" which mainly consists of rehabilitation of existing Kingtom Power Station with the objective of increasing its output to about 25 MW, and "Construction Plan for New Bumbuna Hydraulic Power Station" with an output of 30.5 MW. However, due to the financial difficulties that Sierra Leone faces at present, the scale of the work involved is too large for the country to implement simultaneously. However, to supply urgently needed power for the time being, the Government

of Sierra Leone developed a plan to construct new diesel generating facilities with a 5 MW output in Kingtom Power Station and requested the Government of Japan for grant aid to implement this plan.

In response to this request, the Government of Japan decided to conduct the basic design study of this plan. Japan International Cooperation Agency dispatched a basic design study team to Sierra Leone from November 26 to December 25, 1989 to study the plan's contents, effect and viability as a grant aid project. An analysis of the situation in Sierra Leone conducted after the study team had returned to Japan recommended that Japan should construct an outdoor-type 5 MW diesel generating facility at the Kingtom Power Station in Freetown as grant aid.

However, subsequent negotiations between the Government of Sierra Leone, the World Bank and the IMF regarding structural adjustment broke down, donor countries thereby withheld coorporative financing to the power sector enforcing the termination of this project. When the Government of Sierra Leone managed to reach an agreement with the World Bank and the IMF regarding structural adjustment in April 1992, it requested that the power project be restarted. The Government of Japan determined to carry out a supplementary study of the project to see what should be done and the scale of the operation based on the findings of the previous design study team and to make adjustments with the World Bank and the EEC. As a result the Japan International Cooperation Agency dispatched a supplementary study team to Sierra Leone to conduct a field survey there from March 16 to April 2 1993.

The supplementary study team negotiated with the Government of Sierra Leone, the World Bank and the EEC. These negotiations determined that NPA, with the financial support of the World Bank, should improve administration, management and organization and repair the existing facilities at Kingtom Power Station and the transmission and distribution network in the Western Area under the "Power Sector Rehabilitation Project" established in March 1992 and complete the repairs at the earliest possible date.

This rehabilitation project planned with the cooperation of the World Bank will be financed by the bank, the EEC and the EIB. Japan will install the 5 MW diesel generating facility as a part of its grant aid effort.

The supplementary study team realized the seriousness of the power supply situation in Freetown metropolitan area through discussion with local officials concerned and field survey. In particular, the team confirmed the need for the urgent implementation of this project in recognition of the serious situation in which social welfare facilities such as hospitals and schools are placed

at present. In NPA's power distribution plan, these social welfare facilities are given high priority as important consumers. These are public facilities serving for large numbers of people. However, power supply even to these important facilities is virtually suspended due to power shortage.

The team also confirmed that the scale of the proposed generating facilities is appropriate because the anticipated power demand for the social welfare facilities is nearly equal to the output (5 MW) of the requested generating facilities in case the completion of the project is set at 1995.

Concerning the proposed site of the project, the generating facilities will be installed in a vacant space inside Kingtom Power Station. This is because no space is available in the existing power house by the expected commencement date of the Project. The construction period will be shortened by installing an outdoor type diesel generator with an enclosure which does not require construction of another power house. Special considerations will be given to the design so that the implementation of this project may not interfere with or cause overlapping work to the comprehensive rehabilitation work for Kingtom power station that NPA plans to undertake with aid from the EEC, the World Bank, etc.

Upon returning to Japan, the study team compiled basic requirements for this project based on the results of the field survey which are identical to the previous proposals. These basic requirements are as follows:

*Outline of Project (1/2)*

| | |
|---|---|
| Facilities construction | ■ Construction of outdoor-type diesel generating facilities (with output capacity of 5 MW, 1 set) and necessary foundation |
| | ■ Construction of the following machinery and equipment necessary for the generating facilities:<br>• Fuel supply<br>• Lubricant supply<br>• Cooling water supply<br>• Piping<br>• Compressed air supply<br>• Air supply and exhaust<br>• Sludge treatment<br>• Steam supply |
| | ■ Construction of the following electric equipment necessary for operation of the generating facilities:<br>• 11 kV switchgear for connection with existing facilities<br>• 11 kV switchgear on generator side<br>• Local control panel<br>• Remote control panel<br>• Excitation system<br>• DC power supply unit<br>• Transformer for auxiliary equipment<br>• Grounding system<br>• Communication system for maintenance<br>• Wiring and cabling system |
| | ■ Test run, adjustments and acceptance test of generating facilities |

*Outline of Project (2/2)*

| | |
|---|---|
| Equipment and materials procurement | ■ Procurement of spare parts necessary for operation after completion of this project.<br>■ Procurement of tools required for maintenance, inspection and service of generating facilities<br>■ Procurement of training materials for OJT |
| OJT | ■ Provision of training by engineers dispatched from Japanese contractor<br>■ Provision of education in entire flow and general of O & M through classroom training (about 1 week)<br>■ Provision of education in operation and maintenance technology through practical training during execution of construction work (about 4 months) |

The executing agency for this project in Sierra Leone is Generation department of the National Power Authority (NPA), which is expected to assume responsibility for controlling operation and maintenance of the generating facilities after the completion of the project.

Major items of work to be undertaken by the Sierra Leone side consist of arranging construction sites including sites for existing storehouses that are to be relocated, construction of sound-proofing walls of the training center and assignment of OJT trainees. The estimated cost is about 27 million leones (approx. US$50,000 as of March 1993, 1 US$ being 537.1 leones).

The time required for project implementation is estimated as follows: the detailed design work; a total of 3 months; procurement of equipment and materials, 6 months; and the site construction from the commencement of foundation works to the completion of the project, 10 months.

NPA is required to provide construction sites including temporary facilities for the Japanese contractor by the date of commencement of the Project. In addition, NPA must contact, coordinate and make adjustments with the government departments concerned and other related agencies in Sierra Leone in order to carry out the project smoothly in cooperation with the Japanese side.

The revenue from the sales of power supplied by the generating facilities for the project in 1995, the anticipated year for implementation of the project, is estimated at about 1.84 billion leones, assuming that the rate of operation is 80%. It is considered that this amount can fully meet the anticipated annual operation and maintenance costs of the generating facilities which is about 1.54 billion leones.

As a direct effect of implementation of this project, the output of Kingtom Power Station will be increased by 5 MW. This output will improve the present serious power supply situation in the

Western Area and the greater Freetown area, and in particular will contribute greatly to the stable operation of social welfare facilities and improvement of people's lives. Thus, it is concluded that the implementation of this project under Japan's grant aid is highly significant and proper.

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**Chapter 5**



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## ABBREVIATION

| | |
|---|---|
| ADB | African Development Bank |
| EEC | European Economic Committee |
| EIB | European Investment Bank |
| E/N | Exchange of Notes |
| GDP | Gross Domestic Product |
| GTZ | Deutsche Gesellschaft Für Technische Zusammenarbeit |
| GWh | Giga Watt Hour (= 1,000MWh = 1,000,000kWh) |
| IEC | International Electrotechnical Commission |
| ISO | International Organization for Standardization |
| JEC | Japanese Electrotechnical Commission |
| JICA | Japan International Cooperation Agency |
| JIS | Japanese Industrial Standards |
| NPA | National Power Authority |
| O & M | Operation and Maintenance |
| OJT | On the Job Training |
| UNDP | United Nations Development Programme |

# CHAPTER 1 INTRODUCTION

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Mining (diamonds, etc.) and agriculture (cocoa, coffee, etc.) are the mainstay of Sierra Leone's economics. With the 2nd national development plan as a starter, the country has been developing agriculture as the top priority sector in its economy from the standpoint of establishment of self-sufficiency and promotion of exports. Under the 3rd national development plan, major emphasis was placed on improvement of the energy supply situation to meet the growing need for electric power, along with the importance attached to increased agricultural production.

However, in the greater Freetown area, where nearly 20% of the nation's population is concentrated, only 25,000 households are receiving electric energy in 1989. Moreover, the present total output is only 12.7 MW (as of March 1993 the output has dropped to 11 MW) as against a peak demand of about 40 MW. As a result, restriction on power supply is imposed every day, which increases residents' dissatisfaction and brings about an adverse effect on economic activities.

The power shortage is caused by obsoleteness of many power generating facilities installed at the power station in the greater Freetown area and also a lack of adequate spare parts supply, which prevents proper operation of these generating facilities.

To improve this situation, the Government of Sierra Leone and NPA formulated the "Capital Area Power Supply Improvement Plan" centering on the plan for rehabilitation of the existing Kingtom Power Station (to increase the total available capacity after rehabilitation to about 25 MW) and the plan for construction of Bumbuna Hydraulic Power Station (with output of 30.5 MW) in 1988. However, in the present tight financial situation, the Government of Sierra Leone finds it impossible to implement all the projects under these plans at the same time. To supply urgently needed power for the time being, the Government of Sierra Leone requested grant aid from the Government of Japan to construct a 5 MW output diesel generating facilities.

In response to this request, the Government of Japan decided to conduct a basic design study of the Project and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent a basic design study team headed by Mr. Toshimichi Aoki, First Basic Design Study Division, Grand Aid Planning and Survey Department, JICA, to Sierra Leone from November 26 to December 25, 1989.

The objective of this study was to precisely understand the plan for construction of the diesel generating facilities (5 MW) in Kingtom Power Station, as requested by the Government of Sierra Leone, and study the effect of the Project and its propriety as a grant aid project. An analysis of the situation in Sierra Leone conducted after the study team had returned to Japan recommended that the Japanese cooperative effort should involve the installation of an outdoor-type 5 MW diesel generating facility at the Kingtom Power Station in Freetown.

However, subsequent negotiations between the Sierra Leone Government, the World Bank and the IMF regarding structural adjustment broke down. Contributing countries thereby withheld financial resources to the power sector enforcing the termination of this project. When the Sierra Leone Government managed to reach an agreement with the World Bank and the IMF regarding structural adjustment in April 1992, it requested that the power project be restarted. The Japanese Government determined to carry out a supplementary study of the project to determine what should be done and the scale of the operation based on the findings of the previous design study team and to make adjustments with the World Bank and the EEC. As a result the Japan International Cooperation Agency dispatched a Supplementary Study team headed by Mr. Yasuhiro Morimoto, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs to Sierra Leone to conduct a field survey there from March 16 to April 2 1993.(Appendix 1 shows the list of the study team members and Appendix 2, the itinerary of the local field survey)

The new government which honors democratic principles intends to continue the policies of the old government and the aid policies of the donors are not expected to change.

The supplementary study team negotiated with the Sierra Leone government, the World Bank and the EEC and conducted a field survey to gauge the power supply situation in the Western Area, the organization of NPA, the current state of Kingtom Power Station, current activities of assistance agencies and the construction situation.

The NPA has currently reached an agreement with the World Bank and the IMF concerning structural adjustments. Improvements of organization, administration and charge collecting system of the NPA, the repair of the existing facilities at the Kingtom Power Station and the

transmission and distribution network in the Western Area have started according to the "Power Sector Rehabilitation Project" sponsored by the World Bank. This rehabilitation project will be financed by the World Bank, the EEC and EIB. Japan will install a 5 MW diesel generating facility as a part of its grant aid effort. Each organization will shoulder the following duties.

*World Bank* : ① Implementing management contracts to restructure the NPA administration, management and organization
② Construction a 5 MW diesel generating facility (includes removal of broken down facilities)

*EEC* : Replacing and overhauling the transmission and distribution network in the Western Area

*EIB* : Replacing and repairing of existing facilities at the Kingtom Power Station

*Japan* : Construction of a 5 MW diesel generating facility

The study team confirmed the background, objective and other factors regarding the request for the project on the basis of the implementation of the "Power Sector Rehabilitation Project". It also made sure that the Japanese effort would not interfere with the repair and renovation of the existing facilities at Kingtom Power Station planned by the World Bank, EIB and other agencies. Cooperation in technical matters is likely for the following reasons.

(1) "Power Sector Rehabilitation Project" sponsored by the World Bank with a view to thoroughly improve the power supply situation in the Western Area and especially in the greater Freetown Area is part of the project so Japanese aid will not overlap with other aid efforts.
(2) Since the generating facilities to be provided under Japanese grant aid are installed in an outdoor vacant lot, they will not interfere with the facilities located inside the power station which are scheduled to be rehabilitated or renovated.
(3) No facilities will be overlapped because existing facilities not subject to repair or renovation (such as oil tanks, water tanks, grounding rods, and cable routes) are also used in the project under review.

Based on the reconfirmed major contents of the request such as its background, objectives, etc., a Minutes of Discussion (see Appendix 4) was concluded between the Study team and NPA on March 25, 1993. Appendix 3 shows a list of the responsible officials at the Sierra Leone side.

Upon returning to Japan, the supplementary study team prepared the following basic design study report for the Project for Improvements of Electricity Power Supply to Greater Freetown (supplementary study), taking into account the present status of power supply situation in Sierra

Leone, present condition of the project site, the project's relations with higher level plans, and propriety, contents and scale of the grant aid.

# CHAPTER 2 BACKGROUND OF THE PROJECT

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## 2-1 General Condition of the Country

### 2-1-1 Geographical Location

Sierra Leone is situated on the coastal zone of West Africa with a total land area of 71,740 $km^2$ (according to the 1989 Annual Statistical Digest).

The country is divided into 4 areas (Northern, Southern and Eastern Provinces, and Western Area).

Freetown city and its suburb, i.e., Greater Freetown (the greater Freetown area) is located in Western Area. The capital where government offices and both commercial and industrial activities are concentrated plays the role as the nation's political and economical center.

In Western Area other than Freetown city, no major commercial or industrial activities exist and these suburban areas are dotted with towns and villages mainly engaged in farming.

Sierra Leone became independent in 1961 as a member of the Commonwealth of Nations.

### 2-1-2 Population and Land Area

The land area of Sierra Leone is 71,740 $km^2$ of which the Western Area occupies 557 $km^2$ . The total population was estimated at 4.2 million in 1991. At 2.6%, the annual population increase is the lowest in Sub-Saharan Africa.

### 2-1-3 Socio-economic Condition

Sierra Leone's economy is supported by mining industry for bauxite, diamonds, etc., and agriculture in coffee, palm oil, etc.

With the 2nd development plan that started in 1983/84 as a starter, agriculture is treated as the top priority sector from the standpoint of establishment of self-sufficiency and promotion of exports, and agricultural production has begun to increase.

However, the nation's trade balance remains in a deficit as shown in Table 2-1. The consumer price index also shows an inflation rate of about 180% a year on average as will be noted from Table 2-2. Thus Sierra Leone is placed under a very severe economic condition.

Its per capita GNP was $240 as of 1991 or half of what it had been in 1980.

*Table 2-1 Changes in Sierra Leones trade balance*

[Unit: US$ million]

| Item | 1985/86 | 1986/87 | 1987/88 | 1988/89 | 1989/90 | 1990/91 |
|---|---|---|---|---|---|---|
| Domestic exports | 121.7 | 125.9 | 116.1 | 111.9 | 142.3 | 137.4 |
| Imports | 142.7 | 138.0 | 147.2 | 174.2 | 177.1 | 173.4 |
| Trade balance | -21.0 | -12.0 | -31.1 | -82.3 | -34.8 | -36.0 |

*Source: March 1992 IDA Report*

*Table 2-2 Changes in Sierra Leone's Consumer Price Index*

[Growth rate: %]

| | Performance | | | Estimated | Projected |
|---|---|---|---|---|---|
| | 1987/88 | 1988/89 | 1989/90 | 1990/91 | 1991/92 |
| GDP | 1.9 | 3.5 | 2.8 | 2.8 | -5.0 |
| Domestic exports | 0.6 | -17.8 | 16.9 | -2.0 | -1.0 |
| Imports | -2.9 | 15.1 | 1.4 | -16.1 | 16.0 |
| Consumer price index | 71.2 | 45.6 | 90.9 | 101.0 | 95.0 |

*Source: March 1992 IDA Report*

## 2-2 Outline of the Actual Condition on the Concerned Sector

### 2-2-1 Administrative Organization of Power Supply Service

Power supply service in Sierra Leone is carried out by the National Power Authority (NPA), which was established under the National Power Authority Act in 1982. NPA performs all operations and management of power supply service from the planning and construction of power stations and power transmission and distribution to collection of

electricity charges for the whole country excluding the Bo and Kenema areas. (The Bo and Kenema areas split away from the NPA in 1992 and is operated and managed by the Bo, Kenema Power Supply Company which is financed by the Government and the NPA.)

NPA developed from Electricity Department organized within the Ministry of Energy and Power in 1974 (The Ministry of Energy and Power was reorganized into the Ministry of Labor, Energy and Power in 1991.) Because of this background, the NPA is still under strong control of the Ministry of Labor, Energy and Power which appoints members of the NPA Board and examines NPA's annual budget, operation reports, etc.

In December 1989, NPA's total number of employees was 1,452 (comprising 1,269 regular employees and 183 part-timers). As of March 1993, the number of employees have been reduced to 730 under the "Power Sector Rehabilitation Project" sponsored by the World Bank.

As Fig. 2-1 shows, NPA is operated by a board comprising the NPA Director and Vice Director in charge of the General Affairs Division, the Finance Division, the Power Distribution Division and the Power Generating Division.

The Power Generation Section of the Kingtom Power Station is responsible for the execution of this project. As shown in Fig. 2-2, this section comprises 140 staff members under the Power Station Manager.

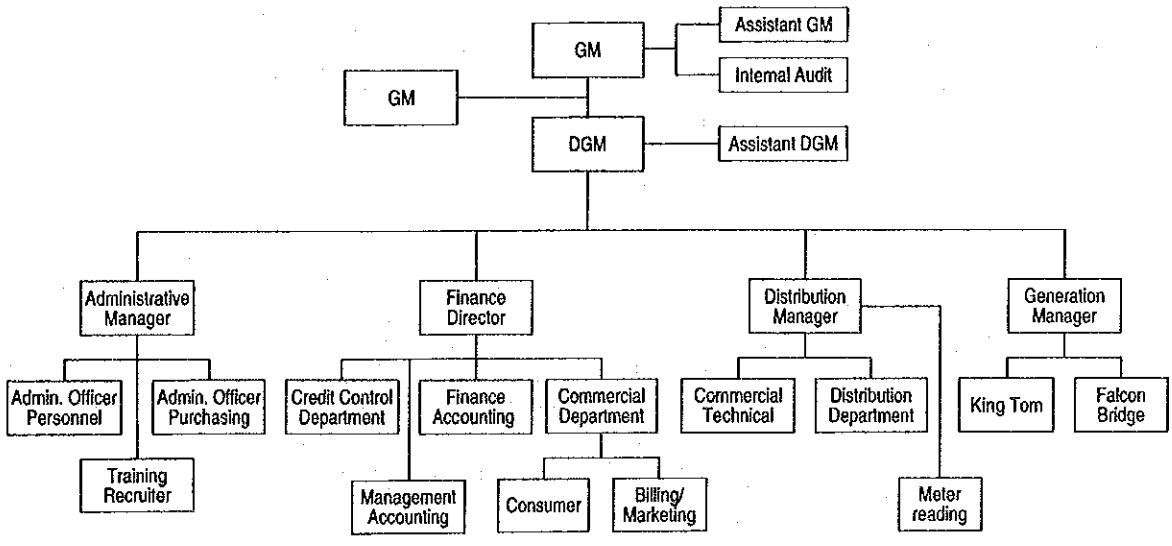



*Figure 2-1 Organization Chart in NPA*

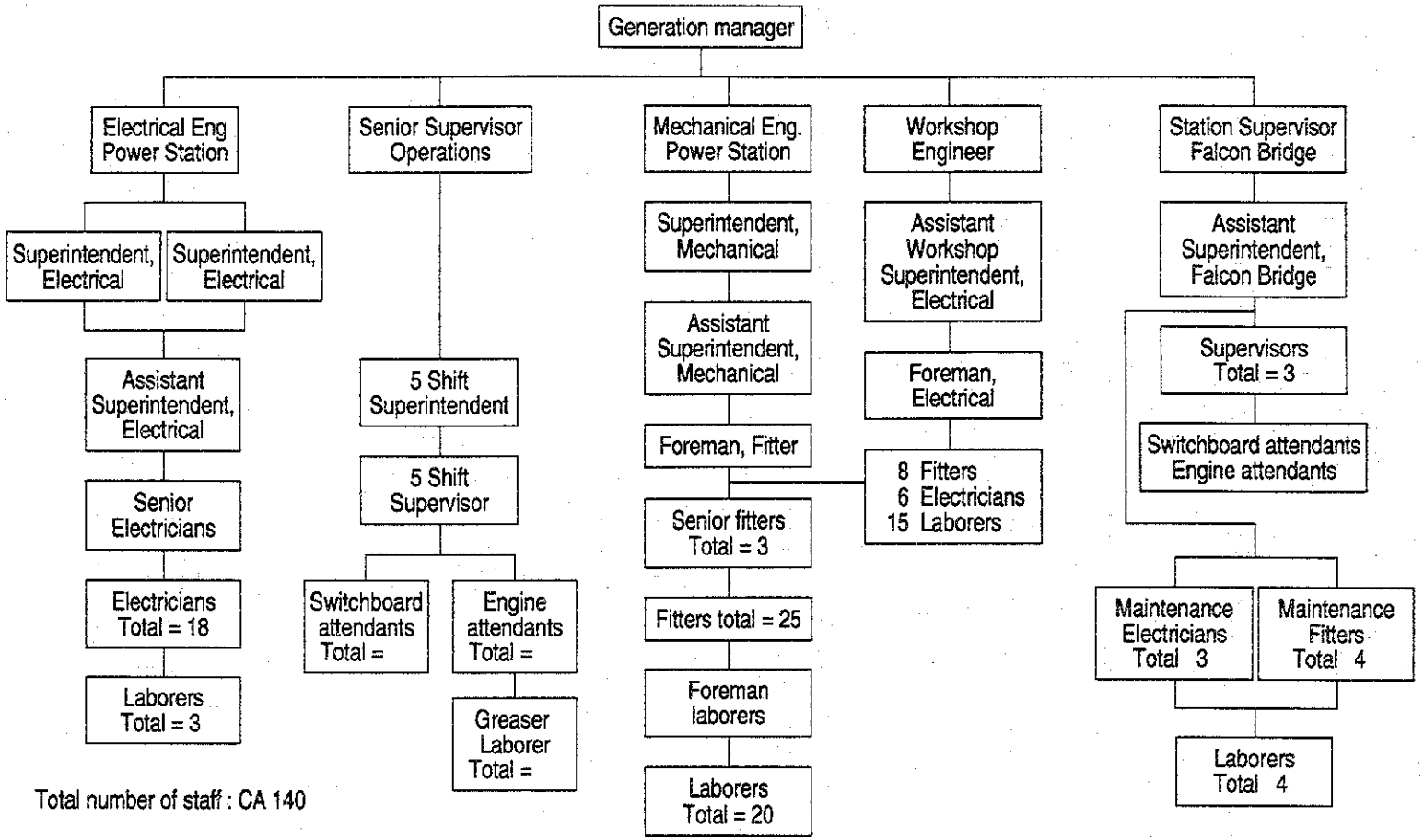



*Figure 2-2 Organization Chart of Power Generating Division, NPA*

### 2-2-2 Financial Condition of NPA

Table 2-3 shows the financial condition of NPA. As will be noted, although the business income during 1988/1989 was in the black, the running costs including fuel and labor for 1989/90 and 1990/91 exceeded the revenues from power supply. The balance of revenues and expenditure resulted in a deficit although NPA received Government assistance.

*Table 2-3 Changes in NPA's Financial Condition (Profit and Loss Statement)*

[Unit: Million leones]

| Item | 1988/89 | 1989/90 | 1990/91 |
|---|---|---|---|
| 1. Electricity Sales | 482,309 | 358,795 | 915,055 |
| 2. Cost of operations | | | |
| 2.1 Fuel | 96,222 | 254,715 | 509,588 |
| 2.2 Labor | 18,631 | 74,639 | 74,306 |
| 2.3 Maintenance | 14,616 | 67,569 | 41,424 |
| 2.4 Administration | 74,683 | 78,124 | 236,180 |
| 2.5 Depreciation | 158,985 | 77,315 | 101,213 |
| Subtotals | (363,137) | (552,362) | (962,711) |
| 3. Business income | 119,172 | Δ 193,567 | Δ 47,656 |
| 4. Financial expenses | | | |
| 4.1 Interest on long-term loans | 15,341 | 40,265 | — |
| 4.2 Bank borrowing | 2,817 | 35,092 | 19,993 |
| 4.3 Loss on exchange | 80,787 | 328,786 | 27,545 |
| 4.4 Provision for bad debts | 15,469 | 19,006 | 24,415 |
| Subtotals | (114,414) | (423,149) | (71,953) |
| 5. Other income | 2,783 | 9,901 | 107,441 |
| 6. Loss for the year | 7,541 | 606,815 | Δ 12,168 |
| 7. Loss brought forward | Δ 167,664 | 160,123 | Δ 766,938 |
| 8. Loss carried forward | 160,123 | 766,938 | Δ 799,106 |

*Source: NPA*

The insufficient financial condition is attributable to the failure to revise the tariffs as required to ensure reasonable revenues despite the fact that the power generation cost has risen due to sharp increase in fuel cost, rise in labor cost and foreign exchange fluctuations.

This aggravated financial condition has caused a shortage of fuel supply and a lack of necessary spare parts for maintenance of the power generating facilities.

To improve its financial conditions, NPA raised electricity charges by about 1.8 times in 1990 and new charges were introduced in October, 1992 (see Table 2-4). These increases were urged by the World Bank and other aid agencies to establish reasonable electricity charges linked to both fluctuations of exchange rates and increases in fuel oil cost. The new price of electricity is 100 leones per kWH (approx. US$0.182 = ¥21) which is about the same as Japanese prices. Table 2-5 shows the revised budget (proposed) of NPA based on anticipated income from the new charges.

*Table 2-4 Current Electricity Tariffs (as of October 1, 1992)*

| | | | |
|---|---|---|---|
| (1) | Domestic (Tariff 1) | | |
| | 0 - 50 Units | 50.00 | leones/Units |
| | 51 - 200 Units | 72.00 | leones/Units |
| | Above 200 Units | 105.00 | leones/Units |
| | Minimum charge | 250.00 | leones/Month |
| (2) | Small commercial (Tariff 2)(Below 15kW) | | |
| | 0 - 50 Units | 63.00 | leones/Units |
| | 51 - 200 Units | 80.00 | leones/Units |
| | Above 200 Units | 95.00 | leones/Units |
| | Minimum charge | 300.00 | leones/Month |
| (3) | Hospitals and schools (Tariff 3) | | |
| | All Units | 65.00 | leones/Units |
| | Minimum charge | 760.00 | leones/Month |
| (4) | Churches and mosques (Tariff 3A) | | |
| | All Units | 98.00 | leones/Units |
| | Minimum charge | 760.00 | leones/Month |
| (5) | Large commercial and industrial (Tariff 4) ... (15 kW and above) | | |
| | All Units | 133.00 | leones/Units |
| | Minimum change | 45,600.00 | /Month |
| | kW demand | 300.00 | leones/Units |
| (6) | Street lighting (Tariff 5) | | |
| | All Units | 116.00 | leones/Units |
| | Minimum charge | 7,500.00 | leones/Month |
| (7) | Temporary supply (Tariff 6) | | |
| | All Units | 194.00 | leones/Units |
| | Minimum charge | 5,000.00 | leones/Month |
| (8) | Welding (Tariff 7) | | |
| | All Units | 194.00 | leones/Units |
| | Minimum charge | 8,000.00 | leones/Month |

*Table 2-5 NPA Budget for 1992 and 1993*

[Unit: thousand leones]

| Item | Budget |
|---|---|
| 1. Income | |
| 1.1 Sales | 2,729,000 |
| 1.2 Other income | 22,000 |
| Total | 2,751,000 |
| 2. Expenditure | |
| 2.1 Prime cost of generating electricity (including direct expenses) | 1,961,000 |
| 2.2 Prime cost of supplied electricity (including direct expenses) | 61,000 |
| 2.3 Administrative costs (including direct expenses) | 190,000 |
| Total | 2,212,000 |
| 3. Business income (1-2) | 539,000 |
| 4. Other expenses | |
| 4.1 Other business expenses | 129,000 |
| 4.2 Depreciation expense | 90,000 |
| 4.3 Non-operating expense | 39,000 |
| Total | 258,000 |
| 5. Loss for the year (3-4) | 281,000 |

### 2-2-3 Power Supply Situation

(1) NPA's Generation Facility and Captive Generation Facility

As described earlier (see 2-2-1), NPA is mainly responsible for the power supply service in Sierra Leone (except for the Bo and Kenema area) and operates all the power generating facilities including power stations, substations and power transmission and distribution networks.

However, many of companies and establishments in the mining industry and commerce that constitute major consumers have installed their own captive diesel engine generating facilities. This is because power supply from NPA for industrial and commercial use is frequently interrupted due to lack of supply capacity so stable power supply cannot be hoped for. Table 2-6 shows the operation status of NPA's generating facilities and these captive generating facilities.

As will be noted from this table, the total installed capacity of captive generating facilities for the whole country in 1991/92 was 68.3 MW. This is 1.3 times the nation's total installed capacity (51.9 MW) under NPA control.

Electrification by NPA's generating facilities for industrial use is generally as shown below.

Whole country : Approx. 6% (estimated by the Study team)
Greater Freetown area : Approx. 32% (estimated by the Study Team)

*Table 2-6 Operation Status of NPA's Generating Facilities and Captive Generating Units (estimate)*

| Category | Output (MW) |
|---|---|
| National Power Authority | |
| Western Area | 33.4 |
| Other diesel generating facilities | 14.5 |
| Goma Power Station | 4.0 |
| Subtotal | 51.9 |
| Captive generation | |
| Mines | 28.3 |
| Others | 40.0 |
| Subtotal | 68.3 |
| Total | 120.2 |

*Source: The World Bank Report March 1992*

(2) Power Supply Situation of NPA (its power generating facilities)

The transmission and distribution networks for power generating facilities in Sierra Leone include networks by small-scale diesel generating units in 14 provincial districts aside from Western Area Grid in the greater Freetown area where the Kingtom Power Station is situated.

These transmission and distribution networks each supply power independently without being linked with any other network, and no nationwide network has been formed yet.

Fig. 2-3 shows the location of power stations and transmission lines in the whole country.

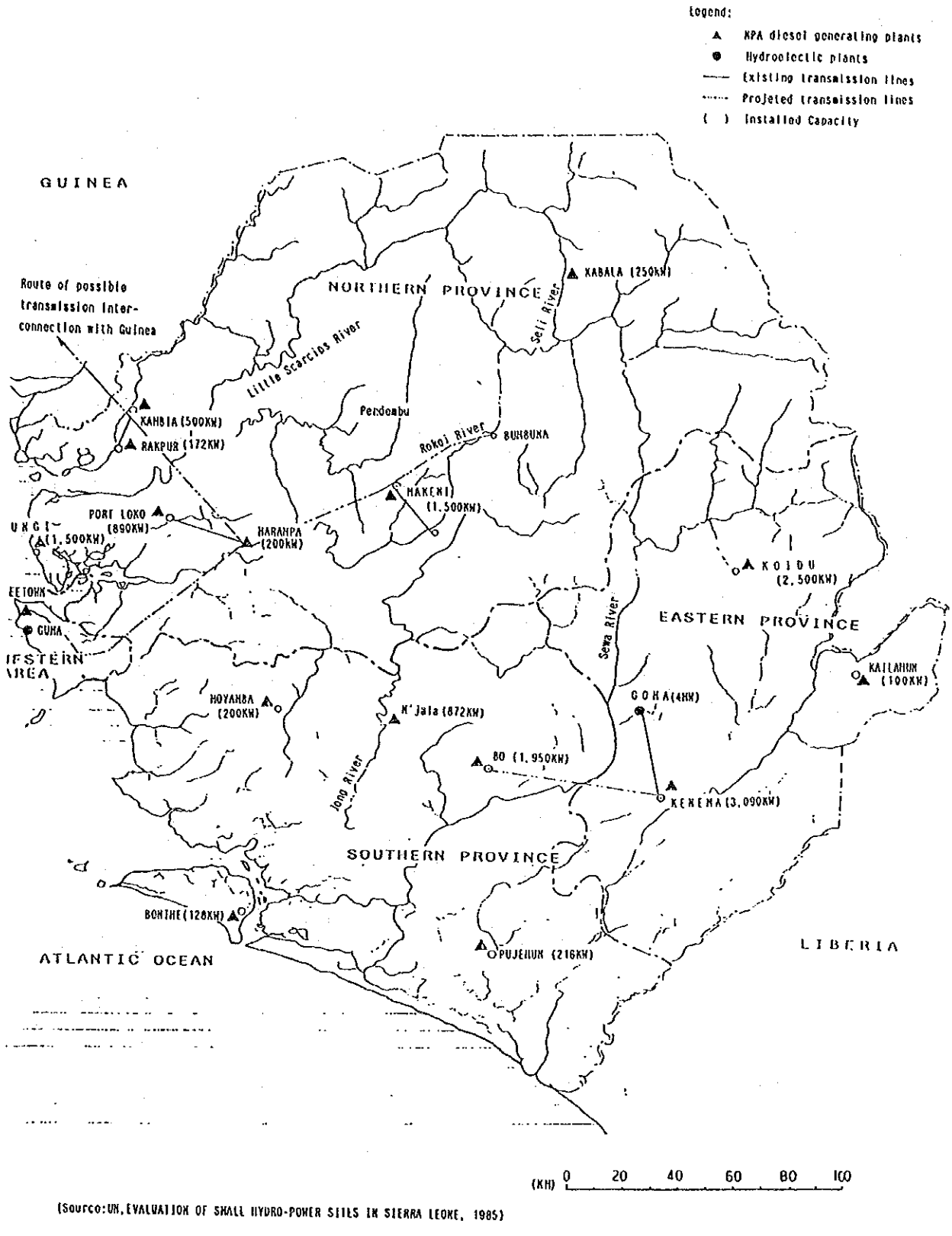



*Figure 2-3 Location of Power Stations and Transmission Lines in the Whole Country*

1) Power generating facilities

The power generating facilities operated by NPA consist of diesel and hydroelectric power stations. At present, power supply depends mainly on diesel generating facilities. The only hydroelectric power stations is Goma Hydroelectric Power Station (with an installed capacity of 4 MW) build under aid from China. However, it is not a stable source of supply because its output drops to 0.5 MW in the low water season.

The nation's largest power station is Kingtom Power Station, the subject for the current study (as of March 1993, its total installed capacity is 50.2 MW with an available capacity of 11.0 MW).

Table 2-7 shows the operation status of power stations in various places. Fig. 2-3 shows the location of these power stations.

*Table 2-7 Characteristics of Provincial Load Centers Supplied by the National Power Authority*

[NA = Not available]

| No. | Load center | Installed capacity (kW) | Peak demand (kW) | Volts (V) | Annual energy supply (MWh) 1977~85 | Annual energy supply (MWh) 1984~85 |
|---|---|---|---|---|---|---|
| 1. | Kambia | 500 | 100 | 415 | NA | NA |
| 2. | Rokupr | 172 | 90 | 415 | NA | NA |
| 3. | Port Loko | 890 | 400 | 415 | 1,608 | 1,245 |
| 4. | Lungi | 1,500 | 980 | 415 | NA | NA |
| 5. | Moyamba | 200 | 150 | 400 | 589 | 517 |
| 6. | N'jala | 872 | 380 | 415 | NA | NA |
| 7. | Bo | 1,950 | 1,300 | 3,300 | 6,013 | 2,908 |
| 8. | Bonthe | 128 | 100 | 415 | NA | NA |
| 9. | Koidu | 2,500 | 2,000 | 11,000 | 8,666 | 2,734 |
| 10. | Ksilshun | 100 | 98 | 415 | NA | NA |
| 11. | Kanema | 3,090 | 1,900 | 11,000 | 7,832 | 3,885 |
| 12. | Pujehun | 216 | 85 | 415 | NA | NA |
| 13. | Makeni | 1,500 | 1,000 | 415 | NA | NA |
| 14. | Kabala | 250 | 146 | 415 | 502 | 362 |
| Totals | | 13,868 | 8,029 | —— | —— | —— |

*Source: UN, Evaluation of small hydro-power sites in Sierra Leone, 1985*

Sierra Leone is blessed with favorable conditions for construction of hydroelectric power stations because it abounds in rivers with its considerably rugged terrain.

According to UNDP Report (Issue and Options in the Energy Sector, 1986), the total capacity of potential hydroelectric power generation for the whole country is estimated at 1,200 MW. Thus, the Sierra Leone Government, which suffers from a shortage of foreign exchange, has started the Bumbuna Hydroelectric Power Station Project as hydroelectric power stations are indispensable to ensure a future stable source of power during the rainy season.

2) Transmission and distribution facilities

At present, NPA uses the following voltages for transmission and distribution of power:

Transmission system : 11 kV and 3.3 kV, 50 Hz
Distribution system : 415/240 V, 50 Hz

Existing transmission and distribution lines are mainly underground cables in the city and aerial cable in the country side. An 11 kW distribution system network was established in the 60's and 6 transforming stations were connected by means of paper insulated cable. Most of this cable has become defective as it is no longer properly insulated and it will not be possible to provide electric power simply by repairing the power stations.

The performance of some high voltage switchgears at each power distribution station has substantially dropped due to rusty contact parts and obsoleteness.

Also, many meters on transmission and distribution systems are affected by mechanical breakdown and defects due to lack of adequate maintenance. Error in reading consumers' meters occurs frequently and overall improvement in this area is considered necessary. Because of defects in meters, electric charges cannot be accurately collected. This causes a loss in revenues by 10 to 15% in the greater Freetown area and as high as 20 to 25% on a nationwide scale. Thus, much improvement in meters is desired.

The 33 kV power transmission and distribution network is not currently used in the greater Freetown area. In order to improve the power supply, the 11 kW distribution network has to be repaired as well as the 33 kV network has to be urgently overhauled.

NPA plans to repair the power distribution system in the Western Area of the country under the "Power Sector Rehabilitation Project" with financial assistance from the EEC. In a two-year period starting from 1994 the networks in the most urgent areas will be repaired.

## 2-3 Related Plan and Program

### 2-3-1 National Development Plan

Sierra Leone has started its three-year Public Investment Program from fiscal year 1992/93 to 1994/95 under the structural adjustment program sponsored by the World Bank and the IMF. The objective of these Program are as follows.

(1) Poverty alleviation and the provision of basic social services;
(2) Rehabilitation of physical and social infrastructure; particularly roads, electricity, water and sanitation, health and primary education facilities

Objective (1) will be achieved by spending 2.5 billion leones (about ¥530 million) for the highlight, include labour-intensive rural workers, using 1.5 billion leones (about ¥320 million) for skill improvement for retrenched public sector employees and allotting 5.9 billion leones (about ¥1.240 billion) for institutional feeding projects.

Objective (2) will be achieved through investments in the following public utilities.

| | |
|---|---|
| • Power sector rehabilitation project | 29.4 billion leones (approx. ¥6.17 billion) |
| • Bumbuna Hydro Project | 28.6 billion leones (approx. ¥6.0 billion) |
| • Rehabilitation of the road network | 18.1 billion leones (approx. ¥3.8 billion) |
| • Rehabilitation of primary and secondary schools | 25.5 billion leones (approx. ¥5.36billion) |
| • Rehabilitation of hospitals and health centres | 4.5 billion leones (approx. ¥950 million) |
| • Construction of the Waterloo-Mashiak Road | 6.7 billion leones (approx. ¥1.41 billion) |
| • Construction Rogbere-Junction/Pamlap Road | 6.1 billion leones (approx. ¥1.28 billion) |
| • Expantion of water supply facility in both urban and rural areas | 6.5 billion leones (approx. ¥1.37 billion) |

Approximately 239.5 billion leones (about ¥50.3 billion at the exchange rate in 1992/93) will be invested in the three-year Public Investment Program that started in fiscal year 1992. Sierra Leone expects 31.8 billion leones (approx. ¥6.68 billion) from the World

Bank, 30.2 billion leones (approx. ¥6.34 billion) from the EEC, 25.6 billion leones (approx. ¥5.38 billion) from the African Development Bank, 7.8 billion leones (approx. ¥1.64 billion) from the World Food Organization in addition to financial assistance from Japan and other countries. The Sierra Leone Government is expected to invest 19.0 billion leones (approx. ¥4.0 billion) in the meantime.

### 2-3-2 Development Plan for Project Implementing Sector

As for development plans in the Project implementing sector, many aid agencies have been conducting surveys since 1986. These aid agencies include the UNDP, World Bank, GTZ of West Germany, EEC and others who have studied and made proposals for the rehabilitation plans of Kingtom Power Station and improvement of Sierra Leone's power sector (NPA).

These reports point out that the biggest contributing factor to the worsened power supply situation that Sierra Leone faces at present is lack of NPA's management and operation capability. Thus, various recommendations and proposals have been made for reconstruction of NPA on a long range base, such as the need for drastic structural reform of NPA if it is to operate as a stable source of electric energy in the future.

Table 2-9 shows survey objectives and recommendations in major survey reports.

This plan consists of two major goals. One of these goals is to improve NPA's management capability through organizational improvements as proposed in World Bank and EDF International reports as shown in the above table. The other goal calls for complete rehabilitation of Kingtom Power Station as mentioned in GTZ report.

However, these power sector rehabilitation plans could not be followed through because the required adjustments could not be reached between the aid agencies and the Sierra Leone Government by 1991. All power generating activities at Kingtom Power Station ground to a halt in July, 1991.

The World Bank, the IMF and the Sierra Leone Government managed to reach an agreement on structural adjustments in subsequent negotiations in March 1992. The Sierra Leone Government started the development of the power sector based on the "Power sector rehabilitation project report" published by the World Bank and was able to conclude an agreement on power sector rehabilitation assistance with the World Bank in October 1992.

All aid agencies are providing assistance according to the guidelines of the "Power sector rehabilitation project report".

Trends in aid activities

1) Emergency Projects Assistance by the EEC and the GTZ

The EEC and the GTZ have been conducting an Emergency Project Assistance that is independent of the World Bank's power sector rehabilitation project. They dispatched experts in management and power generating equipment who took up key posts in the NPA to conduct technical cooperation.

The objective of the Emergency Project Assistance was to perform an emergency rescue that would improve the faltering Sierra Leone economy and industrial sector and resuscitate NPA power generating facilities that had ground to a halt in July 1991 due obsolete equipment and lack of proper maintenance and spare parts.

On the advice of the foreign experts the NPA has slashed its number of employees by more than 45% and existing Sulzer generating equipment which has improved the output power of facility No. 5 from 50% to 85%.

This Emergency Project Assistance was to have been completed by February 1992. However due to delays in the Management Contract project sponsored by the World Bank, the World Bank and the IMF will participate in the emergency project and continue it until the end of 1993. The experts engaged in the project were sent by a German consultant and are now due to return. They will be replaced by experts dispatched to carry through the Management Contract sponsored by the World Bank in 1993. The Management Contract will run for a period of 3 years which will be followed by a 2 year contractual period as option.

2) Power sector rehabilitation project planned by the World Bank

The power sector rehabilitation project planned by the World Bank consists of the three goals listed below. The objective of the project is mainly twofold. First, to overhaul the power sector in Sierra Leone and thereby install a power generating capacity that will meet the electricity needs of the Western Area and especially the greater Freetown area and, secondly, to establish a sound financial basis for the NPA.

The three goals of the power sector rehabilitation project planned by the World Bank

a) Repair of existing facilities and installation of two new facilities

b) Repair and improvement of the power transmission and distribution network

c) Improvement of NPA organization covering operation and management technology and education of staff.

The World Bank has determined the role of each country in the construction project (see Table 2-8) and are waiting for their approval. The bank has estimated the total costs of the project at $70 million.

*Table 2-8 Role of Each Country in the Power Sector Rehabilitation Project Planed by the World Bank*

| Item | World Bank | Japan | EIB | EEC |
|---|---|---|---|---|
| Management Contract | ○ | | | |
| Construction of new power generating facilities | ○ 5 MW | ○ 5 MW | | |
| Rehabilitation of existing generating facilities | | | ○ | |
| Rehabilitation of transmission network | | | | ○ |
| Rehabilitation of distribution network | | | | ○ |

3) EEC aid

The EEC will assist in the rehabilitation work on the transmission and distribution network on the basis of the rehabilitation project planned by the World Bank.

The existing power transmission and distribution network in the Western Area of Sierra Leone and the greater Freetown area was constructed in the 60's. It can now provide only 13 to 15 MW and breakdowns due to obsolete equipment, inadequate maintenance and spare parts are frequent as are distribution failures due to faulty insulation. Therefore a repair of the power station facilities only will not improve the present electric power supply situations unless the transmission and distribution networks are also overhauled and repaired. The EEC will set up 6 transforming stations and plan to repair the entire system including the transmission and distribution lines and street lighting. The German consultant has already completed the tender documents and four European

contractors will be on the prequalification committee. As soon as the EEC gives its approval, the tender documents will be distributed in June or July of 1993 and tendering, evaluation of bids presented and contracting will be performed later in the year. Construction will start in 1994 giving priority to areas where the need is the greatest.

4) EIB aid

The EIB will provide financial assistance to repair existing power generating facilities and auxiliary equipment in the Kingtom Power Station. A new battery for DC power source was installed in June, 1992 and the work on an oil separator for the waste oil was started. Existing sulzer diesel generating facilities no. 4 and no. 5 and the KHD generator are under rehabilitation under the guidance of the experts dispatched to assist in the Emergency Project Assistance. The EIB also has plans to repair exhaust gas boilers, overhead cranes, power station buildings, cooling water facilities, distribution panels, control panels and other equipment.

## *Table 2-9 Report on the Survey of Leading Overseas Assistance Agencies*

| Title of report | Implementation System | Financing System | Term | Outline of the Objects of Survey and Proposals |
|---|---|---|---|---|
| Sierra Leone: Issues and Options in the Energy Sector (UNDP/World Bank Joint Report) | World Bank | UNDP: ENERGY Account | 1986 – 87 | Objects of Survey<br>(1) The survey was conducted as a coherent part of the UNDP/WB Energy Sector Survey Program.<br>(2) Survey of the existing states of energy, economy and each energy sector (petroleum, electric power, firewood) including management of organizations and future programs with a view to bringing up points at issue.<br><br>Proposals<br>(1) NPA should be made independent from MEP (Ministry of Energy and Power).<br>(2) Establishment of tariff system capable of covering the cost of power generation and allocation of foreign currency needed for importing spare parts used for periodical check and maintenance of equipment.<br>(3) Drafting of short-and -long-range programs by MEP.<br>(4) Upward revision of pay for the NPA engineers.<br>(5) Reinforcement of high-ranking management groups.<br>(6) Drafting of middle management group training programs.<br>(7) Construction of training facilities for the middle-raking engineers.<br>(8) Implementation of OJT for acquiring maintenance know-how for preventive maintenance and periodical check. |
| Diesel Power Station King Tom (GTZ Report) | Lahmeyer International | GTZ | 1987 | Objects of Survey<br>(1) Rehabilitation of the King Tom Power Station having been the object, the survey was aimed at undertaking scrutiny of the existing state of the power generating facilities from the technical aspect and bringing out points at issue.<br>(2) Survey of existing state of civil engineering and construction works related to the above and bringing up of the points at issue.<br>(3) Survey of existing organization of NPA from the standpoint of operation, maintenance, management and repairs and raising points at issue.<br><br>Proposals<br>(1) Rehabilitation work should be proceed in the following order:<br>1. Rehabilitations on the power generating facilities (including auxiliary equipment) made by KHD and repair on the hoist and crane. Replacement of the 11 kV switchboard, Installation of new sludge and waste oil disposal equipment.<br>2. Rehabilitations on the power generating facilities, (including auxiliary equipment) made by SULZER.<br>3. Rehabilitations on the foundations for MAN No. 1 and No. 2 unit including auxiliary equipment.<br>4. Rehabilitations on MAN No. 1 and No. 2 including auxiliary equipment.<br>5. Rehabilitations on all the structures and outer compounds.<br>(2) The rehabilitation work period shall be 17 months and the cost of repairs shall be 22,830 KDM.<br>(3) For the purpose of providing guidance for operating and managing the power generating facilities and rehabilitation work, at least two (2) foreign specialists should be stationed at the power station during the work.<br>(4) Improvement of the NPA organization is needed in parallel with the rehabilitation work.<br>(5) Acquisition of related documents (drawings, specifications included) management know-how is needed simultaneously with acquisition of spare parts management know-how.<br>(6) In order to complete the repair work in safety during the given period, safe cleaning of the power generating plant and repair on defective parts are needed under guidance of some European engineers. |
| Rehabilitation of the Electricity Sector Fact Finding Study (EDF Int'l Report) | EDF International | EEC | 1988 | Objects of Survey<br>(1) Survey of ystem, organization, financial resources talented personnel resources and technical problems of the esctor and raise points at issue.<br>(2) Preparation of repair program, including organization reforms and technical guidance.<br><br>Proposals<br>(1) As emergency countermeasures the following measure should be worked out within six (6) months:<br>1. Change the committee members.<br>2. NPA's technical and management divisions should be cut off from the government organization as an independent entity.<br>3. Tariff system should be collected from the foreign enterprises in foreign currency.<br>4. A technical guidance team should be accepted into the organization in order to improve NPA's management function.<br>5. The government should freeze NPA's debts till completion of the emergency countermeasures.<br>6. Measures aimed at reducing NPA's staff members by 30% within three (3) years should be worked out.<br>7. The government should excuse NPA from paying all taxes till completion of the reforms.<br>8. The government should intercede with the National Oil Company on behalf of NPA to supply fuel at min. price lower than int'l market price.<br>9. The government should allow NPA to change tariff automatically in line with the fuel price and inflation till completion of reconstruction.<br>(2) As short-term countermeasures the following measures should be worked out during 12 to 18 months:<br>1. Implementation of power generating facilities (including auxiliary equipment) repairs.<br>2. Implementation of rehabilitation work on the power transmission and distribution network in the Greater Free Town.<br>3. Reorganization of user control division for grasp of user data, such as accurate demand on power.<br>4. Implementation of organization and equipment reinforcement to promote higher efficiency in general affairs and accounting divisions.<br>5. Installation of equipment for power generating facilities development.<br>(3) As intermediate countermeasures the following measures should be worked out during 25 to 36 months:<br>1. Establishment and maintenance of local centers.<br>2. Determination of power generating facilities development program.<br>3. Development of training centers for learning new technologies and control methods.<br>4. Unification of equipment specifications.<br>5. Reforms in the pay system of NPA. |

### 2-3-3 Role of This Project

The structural adjustments agreed on by Sierra Leone, the World Bank and the IMF emphasizes the overhaul of basic infrastructure including electric power in order to attain economic independence.

This project for installation of 5 MW diesel generating facilities will serve as an emergency measure taken to meet targets for the national development plan. The generating facilities to be constructed under the project will play the role of providing a social foundation for public facilities that contribute to social welfare such as medical service and education in the present tight energy supply situation.

The power sector rehabilitation project planned by the World Bank stresses necessity of this Project which to install a new generating facilities. As shown in Figure 2-4, the projection of electric power demand indicates that the fulfillment of this project is indispensable to improve the power supply situation in Sierra Leone.

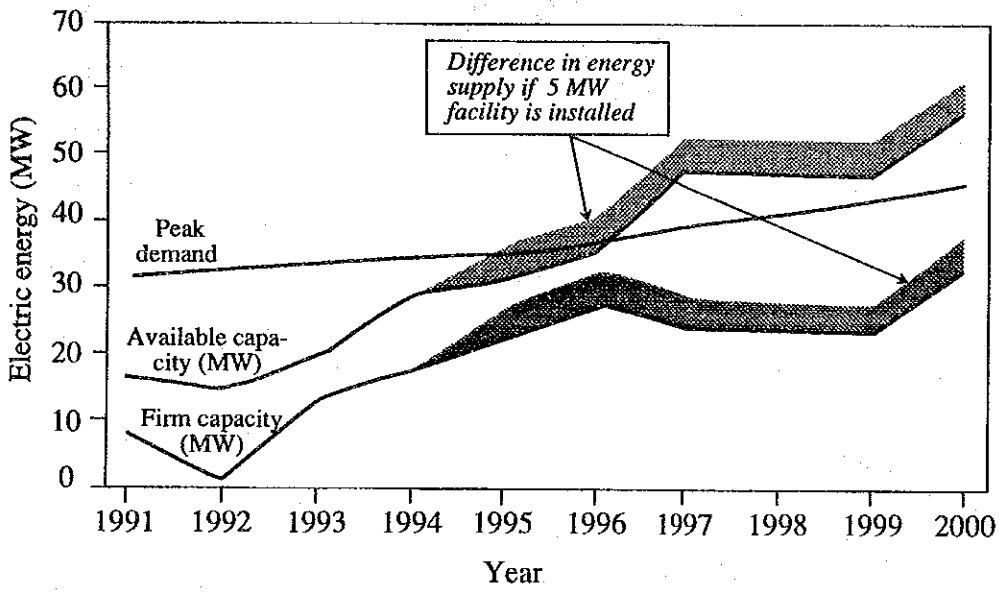



*Figure 2-4 Expected Power Supply in the Western Area When the Power Sector Rehabilitation Project Planned by the World Bank is Implemented*

## 2-4 Outline of the Request

### 2-4-1 Background of the Request

In Sierra Leone, the demand for electric power has been growing. However, power output capacity at Kingtom Power Station, the only power supplier in the greater Freetown area which is the center of the Western Area of the country has plunged. It is plagued by obsolete facilities, inadequate spare parts and proper maintenance due to lack of foreign currency. Consequently, the area served by this power station is affected by power cuts on a daily basis which has an adverse effect on everyday life and economic activities of the citizens.

Thus, to supply urgently needed electricity, the Sierra Leone government requested grant aid from the Government of Japan to construct a diesel generating facility.

### 2-4-2 Contents of the Request

The following work will be performed at the Kingtom Power Station:

(1) To supply and install 5 MW output diesel generating facilities (including necessary auxiliaries and electric equipment)
(2) To perform test runs, adjustments and acceptance tests of the above generating facilities
(3) To supply spare parts for the above generating facilities
(4) To undertake foundation work for the above generating facilities
(5) To train the staff of National Power Authority (NPA) and make sure that they master technology on operation and maintenance of the generating facilities during execution of the Project

NPA understands that the lack of spare parts is one of the causes of the drop in the output of the existing power station. Thus, they strongly desire the supply of spare parts to cover at least 24,000 hours of operation in order to provide adequate maintenance to the generating facilities for the Project and ensure their long, stable operation. (The World Bank states in the power sector rehabilitation project report that the 5-year project will require some 40,000 work hours.)

NPA also requests transfer of technology for optimum control of maintenance and operation of the generating facilities to secure a highly reliable and stable source of power to meet the serious power shortage in Sierra Leone. For this reason, they strongly desire NPA staff's training in Japan and the dispatch of engineers from Japan after completion of the Project, in addition to OJT during execution of the construction work.

# CHAPTER 3 OUTLINE OF THE PROJECT AREA

# CHAPTER 3 OUTLINE OF THE PROJECT AREA

## 3-1 Location and General Condition of the Area

### 3-1-1 Location of Project Area

As the chart at the beginning of this report shows, Kingtom Power Station as the project site is situated along the coast about 2 km to the west of the center of Freetown city. Its altitude is about 5 m above sea level.

### 3-1-2 Present Status of Kingtom Power Station

Basic design drawing SLB-01 shows facilities and equipment layout at Kingtom Power Station (see 5-3-2-(2)).

(1) Control Status of Operation and Maintenance

This power station was built in a considerably small plot of land as is noted from the number and size of its facilities. Much oil leakage was observed from the fuel supply pipe and leaked oil was spread over an extensive area. Particularly, the pump room and basement room were stained with oil, making normal maintenance control difficult.

In keeping with the previous basic design study (December 1989), the power station supplies power using 2 sets of SULZER diesel generating facilities (Nos. 4 and 5). Due to the endemic nature of the power shortages occurring in the greater Freetown area, the operation of these 2 SULZER generating facilities has been plagued by a lack of regular maintenance and inspection time and shortage of spare parts caused by lack of NPA funds. This resulted in power output falling to zero in July 1991. Under the supervision of a technical team sent as part of an emergency project assistance by the EEC etc. since last year, the NPA has succeeded in restoring the No. 5 generator to an operational state. It currently operates at 85% of effective output (8MW) and we understand that the No. 4 unit is undergoing servicing to restore it to an operational state as well. It should come online in May of this year at

which time the No. 5 unit will require another rehabilitation. It is expected that both of the SULZER generators will resume normal and stable operation from September of this year. Table 3-1 shows the record of the number of power failures at the power station. Table 3-2 shows the average length of power failures,

NPA is making plans to implement a periodical maintenance and inspection plan in an attempt to improve this situation. However, the plan has not been implemented as intended due to lack of funds and an acute shortage of power supply. Table 3-3 shows NPA's periodical maintenance and inspection plan (draft).

*Table 3-1 Record of Number of Power Failures at Kingtom Power Station*

[Unit: no. of times]

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|
| January | 22 | 23 | 13 | 13 | 17 | 16 |
| February | 41 | 30 | 12 | 18 | 16 | |
| March | 45 | 22 | 18 | 27 | 21 | |
| April | 38 | 14 | 20 | 40 | 16 | |
| May | 38 | 11 | 7 | 25 | 21 | |
| June | 38 | 10 | 14 | 14 | 39 | |
| July | 34 | 14 | 24 | 20 | 23 | |
| August | 29 | 16 | 35 | 5 | 37 | |
| September | 57 | 2 | 30 | 8 | 54 | |
| October | 87 | 7 | 25 | 12 | 37 | |
| November | 18 | 1 | 21 | 21 | 53 | |
| December | 36 | 5 | 14 | 21 | 62 | |
| Total | 483 | 155 | 233 | 224 | 396 | 16 (Total until Jan.) |

*Source: NPA*

*Table 3-2 Average Length of Power Failures at Kingtom Power Station (min./time)*

| Year | 1987 | 1988 | 1989 |
|---|---|---|---|
| Ave. failure time | 22 min | 25 min | 30 min |

*Source: NPA*

*Table 3-3 Periodical Maintenance & Inspection Plan (draft)*

| Generating facilities | Overhaul | Periodic inspection |
|---|---|---|
| No.4 (Sulzer) | 1.5 month/year | 0.5 month/year |
| No.5 (Sulzer) | 1.5 month/year | 0.5 month/year |
| No.6 (KHD) | 0.75 month/year | 0.5 month/year |
| No.7 (KHD) | 0.75 month/year | 0.5 month/year |
| No.8 (KHD) | 0.75 month/year | 0.5 month/year |
| No.9 (KHD) | 0.75 month/year | 0.5 month/year |

*Source: NPA*

Notes

1) The above shows the duration of time per year for which the generating set will be shut down for overhaul or scheduled inspection and repair.
2) This plan has not been implemented yet because of the acute power shortage situation in the greater Freetown area.

(2) Present Status of Existing Facilities

1) SULZER UNITS (DEG No. 4 – 5)

(a) Sulzer engines

These units were commissioned respectively in 1979 and 1980. As of March 1990, the two units have been in operation for more than half of their service lifetime (83,000 hours for unit No. 4 and 51,300 hours for unit No. 5, respectively).

However, these engines were in very bad working condition due to the lack of preventive maintenance for many years. They were kept in constant operation to maintain energy supply, thereby increasing the risk of major breakdown.

The output was limited to 50% of nominal output and fell to zero power generation in July 1991 due mainly to a deterioration of turbochargers and insufficient cooling. Operation parameters, and especially, exhaust gas temperatures were outside reference conditions. Fuel was not heated at the nominal 120°C because of a steam system failure.

The water treatment system did not work any longer, causing extreme fouling of the cooling subsystem.

However, with the Emergency Project Assistance started in 1992 with the help of the EEC, etc., the No.5 unit has been restored to date to about 85% of the rated output and repair of the No. 4 unit will be completed within several months, at which time it is expected that it will be able to function normally.

(b) Mechanical auxiliary systems

The mechanical auxiliary systems are also in insufficient condition and do not allow the engines to work properly, especially with regard to fuel heating, cooling systems, oil treatment and control systems. At this time, they are waiting for overall repairing with the assistance of EIB.

(c) Electrical auxiliary systems

The control section is faulty or out of operation. For the DC battery system, 100AH was renewed for the new system in 1992 through the Emergency Project Assistance. The cable system is in operational condition but the lighting in the power house system is faulty and inadequate.

2) MAN UNITS (DEG No. 1 – 3)

All 3 MAN units of Diesel engine generators are stopped at the present time. The No. 1 unit was stopped in 1985 after 70,000 hours of operation. Its engine was removed, and there are also plans to remove also the generator.

The No. 2 unit and the No. 3 unit were in better state comparing with the No. 1 unit, and as a fact the No. 2 unit was started again in 1988 but both units are stopped at the present time due to the lack of preventive maintenance and shortage of spare parts. Moreover, all 3 units have defects in their foundation, and it is presumed to be quite difficult to resume the operation even after carrying out the restoration work. Under the circumstances, the NPA is planning to remove the all 3 existing units and substitute them with new equipment with aid of the World Bank and other sources.

The World bank stated in the power sector rehabilitation project report dated March 1992 that it is impossible to repair the 3 MAN power generators units which include their auxiliary units and the plan is to replace them with two 5MW units.

3) KHD STANDBY SETS (DEG No. 6 – 9)

(a) Generators

The four (4) KHD Standby generators were commissioned in 1986.

However, many failures such as crankshaft damages, etc., have occurred during the last two years.

The reasons for the defects could be a high contamination, or a chemical incompatibility of the heavy fuel oil (HFO) and an insufficient purification, or a chemical incompatibility of the HFO and the lube oil.

None of the four units were operational when the local research for the previous basic design was conducted. However, because of the guidance given by the experts dispatched for the Emergency Project Assistance, as of March 1993, the No. 6 unit and No. 8 units have been repaired to an operational condition that is about 50% of rated output. However, their high speed specification does not allow power supply to the base road.

(b) Mechanical and electrical auxiliary system

They are still in good condition but several modifications have to be carried out continuously to improve engine operation and reliability.

4) COMMON SYSTEMS

(a) Common mechanical systems

① Cooling water system

Seawater is pumped from the Sierra Leone River at the pumphouse. Four newly installed pumps provide water for the heat exchange plant. The cooled water is distributed to the different coolers of MAN and SULZER engines. The condition of the heat exchanger plant cannot be said to be good and is a cause of the stop of the power generator. It is planned for repair to be begun in the fall of 1993 with the support of EIB.

② Heavy fuel oil system

The HFO is supplied from a barge at Sierra Leone river and pumphouse. A transfer pipe leads to each of the two storage tanks. Many leakages can be observed along the pipe lines.

③ Diesel oil system

The diesel oil system is in bad condition. Pumps have to be overhauled. Piping shows many leakages. A complete overhaul of valves, cocks, gaskets, etc. is necessary with the assistance of EIB.

④ Steam and condensate system

The boiler is in insufficient condition. The output of the steam production is insufficient. Renewal of the equipment is planned with the assistance of EIB.

⑤ Municipal water and water treatment

Two water storage tanks for city water are in quite good condition. Their tanks are also utilized for the fire fighting system. It is also planned to repair this facility with the assistance of EIB.

⑥ Fire fighting system

The diesel driven fire pump for the fire fighting to the power station building is not operated at all due to high oil contamination.

(b) Common electrical system

11 kV switchgears are in an unsafe and unreliable condition due to:

- Non performance of cleaning and maintenance and frequent switching due to network and station failures,
- Non availability of spares and consumables.

Moreover, a neutral earthing system will be required for modification. It is planned to repair the whole facility with the assistance of EEC as a part of the power transmission distribution network rehabilitation project.

## 3-2 Natural Conditions

### 3-2-1 Climate

The temperature remains nearly unchanged at about 27°C throughout the year. During the dry season from October to May, the average monthly rainfall is less than 100 mm. The rainy season is from June to September and particularly during July and August the average monthly rainfall reaches as high as about 900 mm.

### 3-2-2 Sand Storms

Sand storms called Harmattan occur during the period from November to March.

## 3-3 Social Conditions (Environment)

### 3-3-1 Ports

Not only the nation's but also the African continent's largest port of Queen Elizabeth II should be used for unloading machinery, equipment and materials to be shipped from Japan. Although large vessels can berth at this port, there are no cargo handling facilities that can unload heavy equipment (25tons in max.). Therefore, vessels equipped with cranes must be used for unloading heavy equipment of the project such as the diesel engine.

### 3-3-2 Roads

Both roads in the city and main roads in Freetown are paved but due to insufficient maintenance there are potholes everywhere, which seriously hinder traffic.

There is one bridge (Kingtom Bridge) in the inland transport route from the Queen Elizabeth II Port tot he project site. It is considered that this bridge presents no problem to the transport of Project equipment.

### 3-3-3 Telecommunications

Although telephone and telex communication facilities are available, the local communication condition is insufficient. Sierra Leone External Telecommunication Limited (SLET) provides for international communications such as telex, telegrams and facsimile and there are the local automatic switchers for 5,000 lines in Freetown city. However, the terminals of both domestic and international lines to be connected to the Kingtom power station have not yet been prepared.

### 3-3-4 Living Environment

In low lying areas of undulating Freetown City, a large number of residents live in asbestos cement sheet roofed apartment houses. High class houses of concrete black construction stand in high ground areas.

The quality of city water is good but water could not be supplied to houses on high ground because water pressure is too low due to defective pumping facilities, frequent power failures, etc. Thus, many houses on high ground install a water tank inside the building. Many communal faucets are installed along roads in low lying areas and are used by many residents.

Freetown City and its suburbs are dotted with hotels. However, few hotels have captive generators, telex, telephone and other useful facilities.

As for means of public transport, no railway service is operated now and only city and private owned bus services are available.

## 3-4 Outline of the Sector Concerned in the Area

### 3-4-1 Power Supply Situation in Greater Freetown Area

(1) Operation Status of Power Station

NPA, the nation's public power supply agency, runs 2 power stations in the greater Freetown area, Kingtom and Falcon Bridge power stations.

In Falcon Power Stations, 5 sets of diesel generating facilities (with a total installed capacity of 5.5 MW) are installed. However, only 2 sets are operated at present due to obsolete equipment and a lack of spare parts. (See Table 3-5)

These generating sets use, as main fuel, diesel oil, which is more costly than heavy oil. Therefore, to save operating cost, NPA uses the generating facilities at Falcon Bridge to supply power to Kingtom Power Station for initial start (black start) of the latter's generating facilities only in emergency when all the generating facilities at Kingtom Power Station have stopped. Thus, Falcon Bridge Power Station does not supply power to consumers.

Consequently, the western area centered on greater Freetown area depends for power supply solely on Kingtom Power Station, the subject for the project, and its operation status has great impact on both the nation's economy and civic life. Thus, its importance in Sierra Leone is very high.

Kingtom Power Station has 9 sets of diesel generating facilities as shown in Table 3-4. Of these sets, 3 (Maker: MAN) are not operating at present due to damage to the foundation, expired life of machinery, etc.

The power station is generating power with the remaining 6 sets. Among them, 4 sets (Maker: KHD) are operating only as emergency power generating facilities and do not supply power to base load because these diesel engines are of high-speed specifications. For the layout drawing of the generating facilities at Kingtom Power

Station, see Fig. 4-1 in Chapter 4 and Basic Design Drawing SLB-01 (see 5-3-2-(2)).

For the above reasons, ultimately only 2 sets (Maker: Sulzer) out of total 9 at this power station can supply power to base load. However, the No.4 set is currently under repair, thus is not operational; only the No.5 set (available output 8MW) is available to provide power for the whole greater Freetown area. As a result, as of March 1993, the power supplied to the greater Freetown area is just 11.0MW against a maximum demand of about 33.9MW (World Bank estimation), thus there is a shortfall of about 22.9MW (68% of peak demand).

NPA also owns Guma Dam Hydroelectric Power Station in Western Area (with an installed capacity: of 2.2MW) but this power station has not been operating since 1982 due to mechanical failures.

*Table 3-4 Generated Energy of Kingtom Power Station*

[As of March 1993]

| Unit no. | DEG manufacturer | Year operations commenced | Installed capacity (MW) | Available capacity (MW) | Remarks |
|---|---|---|---|---|---|
| 1 | MAN | 1971 | 6.6 | — | Out of order |
| 2 | MAN | 1964 | 6.6 | — | Out of order |
| 3 | MAN | 1964 | 6.6 | — | Out of order |
| 4 | SULZER | 1978 | 9.2 | — | Under repair |
| 5 | SULZER | 1980 | 9.2 | 8.0 | Under operation |
| 6 | KHD | 1986 | 3.0 | 1.5 | Emergency use only |
| 7 | KHD | 1986 | 3.0 | — | Out of order |
| 8 | KHD | 1986 | 3.0 | 1.5 | Emergency use |
| 9 | KHD | 1986 | 3.0 | — | Out of order |
| Totals | | | 50.2 | 11.0 | |

*Source: NPA*

*Table 3-5 Generated Energy of Falcon Bridge Power Station*

[As of March 1993]

| Unit no. | DEG manufacturer | Year operations commenced | Installed capacity (MW) | Available capacity (MW) | Remarks |
|---|---|---|---|---|---|
| 1 | ENGLISH ELECTRIC | 1962 | 1.5 | — | Out of order |
| 2 | ENGLISH ELECTRIC | 1962 | 1.5 | — | Out of order |
| 3 | MIRRLEES | 1976 | 1.0 | — | Out of order |
| 4 | MIRRLEES | 1976 | 1.0 | 0.8 | Black start use only |
| 5 | MIRRLEES | 1976 | 1.0 | 0.8 | Black start use only |
| Totals | | | (6.0) | (1.6) | |

*Source: NPA*

(2) Power Supply Situation

As described in (1) above, the power supply is far short of the demand (the total generated energy is only about 32% of the peak demand). This forces NPA to systematically stop power supplied to the greater Freetown area every day.

The plan for power distribution to consumers including stop and start of power supply is carried out NPA's Power Distribution Division located at Blackhole Road about 5 km away from Kingtom Power Station.

No systems are available at this facility to remotely monitor generated energy, status of distribution networks, etc. Therefore, it communicates with the power station and each of substations (total 6 places) by wireless to obtain information on constantly changing power demand and operation status of the power station and issues power distribution instructions based on this information.

According to the engineer in charge of Power Distribution Division, important consumers that are given priority in power supply are as follows:

Hospitals, schools, water purification plants, National Assembly buildings, government agencies, etc.

However, when the study team inquired at the national hospital (Connaght Hospital), the largest institution in Freetown City, it learned that although hospitals are given priority as important consumers in NPA's power distribution plan, due to acute power shortages, power is cut for 2 hours a day — even to the national hospital, a public welfare institution which many citizens use.

The study team was also informed that the power to schools is also mostly cut although the Sierra Leone Government directs its major attention to education, aiming to turn out capable persons who will support development of the country in the future. Street lights on major roads in Freetown City have not been used at all since 1987 due to the power shortage, and the maintenance of security and order is seriously affected by blackout conditions at night. Under these conditions, a power cut repeated everyday imposes serious restrictions on medical services, civil life and economic activities.

Table 3-6 shows the transition of power consumption by consumer in the greater Freetown area.

As this table shows, power consumption at hospitals and schools sharply dropped in 1987/88 compared with the previous year 1986/87. This reflects the effect of systematic power cuts to hospitals and schools due to the power shortage resulting from the lower generated energy.

*Table 3-6 Transition of Annual Power Consumption by Consumer in Greater Freetown Area*

| No. | Category | Tariff class | 1984/85 | | 1985/86 | | 1986/87 | | 1987/88 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Power consumption (MWh) | Ratio (%) | Power consumption (MWh) | Ratio (%) | Power consumption (MWh) | Ratio (%) | Power consumption (MWh) | Ratio (%) |
| 1 | General consumers | 1 | 42,783 | 48.1 | 29,803 | 47.7 | 32,487 | 51.9 | 28,484 | 56.4 |
| 2 | Small commerce and industry | 2 | 8,600 | 9.7 | 7,145 | 11.4 | 6,727 | 10.7 | 5,540 | 11.0 |
| 3 | Hospital and schools | 3 | 13,766 | 15.5 | 6,418 | 10.3 | 6,367 | 10.2 | 116 | 0.2 |
| 4 | Churches and mosques | 3A | 7,092 | 8.0 | 3,306 | 5.3 | 3,280 | 5.2 | 60 | 0.1 |
| 5 | Large commerce and industry | 4 | 16,070 | 18.1 | 15,768 | 25.2 | 13,669 | 21.8 | 16,245 | 32.1 |
| 6 | Street lighting | 5 | 405 | 0.5 | 20 | 0.0 | 10 | 0.0 | 0 | 0.0 |
| 7 | Temporary facilities | 6 | 151 | 0.2 | 62 | 0.1 | 86 | 0.1 | 87 | 0.2 |
| 8 | Welding facilities | 7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.0 |
| Totals | | | 88,867 | 100.0 | 62,522 | 100.0 | 62,626 | 100.0 | 50,533 | 100.0 |

*Source : NPA*

Remarks: Average ratio of combined total power consumption from 1984 to 1987 is 12.0%.

### 3-4-2 Future Plan and Power Balance in Greater Freetown Area

(1) Future Plan

NPA has the following 2 plans to improve the condition of the power supplied to the western area of Sierra Leone.

1) "Power sector rehabilitation project" planed by the World Bank with the cooperation of other aid organizations.

2) Construction of Bumbuna Hydroelectric Power Station (planned as a project under aid from the Italian government, etc.)

Tables 3-7 and 3-8 show the contents of these 2 plans. The data for completion of the plan shown in each of these tables is indicated in the report prepared by the World Bank on its "Power Sector Rehabilitation Project".

*Table 3-7 Future Plan for Kingtom Power Station*

| Unit no. | DEG manufacturer | Installed capacity (MW) | Generated energy (as of Mar 1993) (MW) | Planned available after rehabilitation (MW) | Expected completion | Source funds | Remarks |
|---|---|---|---|---|---|---|---|
| 4 | SULZER | 9.2 | (Under repair) | 8.5 | 1993-06 | EIB | Indoor |
| 5 | SULZER | 9.2 | 8.0 | 8.5 | 1993-12 | EIB | Indoor |
| 6 | KHD | 3.0 | 1.5 | 3.0 | 1994-03 | EIB | Outdoor |
| 7 | KHD | 3.0 | (out of order) | 3.0 | 1994-03 | EIB | Outdoor |
| 8 | KHD | 3.0 | 1.5 | 3.0 | 1994-03 | EIB | Outdoor |
| 9 | KHD | 3.0 | (out of order) | 3.0 | 1994-03 | EIB | Outdoor |
| — | ? | 5.0 | (Planning stage) | 5.0 | 1995-02 | JAPAN | Outdoor |
| — | ? | 5.0 | (Planning stage) | 5.0 | 1995-12 | WB | Indoor |
| Totals | | 40.4 | 11.0 | 39.0 | | | |

*Source : NPA*

*Table 3-8 Other Future Plans*

| Name of project | Planned completion | Source of funds | Description of project | Remarks |
|---|---|---|---|---|
| Bumbuna Hydraulic Power Station | March 1997 | Italian Government or Africa Development Bank | Construction of 47.0 MW output hydraulic power station | Civil engineering work for this project has already been started. However, the source of funds for machinery and electric equipment has not been decided yet. |

*Source : NPA*

The balance between the power demand and supply by the year of 2,000 based on the "Power Sector Rehabilitation Project" planned by the World Bank is shown in Table 3-9.

If the operation is started with Bumbuna Hydroelectric Power Station as of the 1997 fiscal year, NPA would hold the available capacity exceeding the peak demand. However, since the four KHD power generation units will reach their life expectancy by the end of 1996, firm capacity will be less than peak demand. However, firm capacity at that time is expected to be 65%~75%, a drastic improvement compared to 5% in 1992.

*Table 3-9 Balance between Demand and Supply of Power in the Western Area of Sierra Leone*

[Unit : MW]

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual | Estimated | ← Planned → | | | | | | | |
| Peak demand | 31.9 | 32.9 | 33.9 | 34.5 | 34.8 | 36.4 | 38.5 | 40.5 | 43.1 | 45.5 |
| Available capacity | 16.5 | 14.5 | 19.5 | 28.0 | 35.5 | 40.5 | 52.5 | 52.5 | 52.5 | 62.5 |
| Firm capacity | 7.5 | 1.5 | 13.5 | 16.5 | 27.0 | 32.0 | 28.5 | 28.5 | 28.5 | 38.5 |
| Peak demand – Firm capacity | 24.4 | 31.4 | 20.4 | 18.0 | 7.8 | 4.4 | 10.0 | 12.0 | 14.5 | 7.0 |

# CHAPTER 4 OUTLINE OF THE PROJECT

# CHAPTER 4 OUTLINE OF THE PROJECT

## 4-1 Objectives

As described in Chapter 1, the power supply situation in Sierra Leone is extremely serious. Restriction of power supply, which has been practiced on a regular basis, has led to increasing dissatisfaction among residents and brought about adverse effect on economic activities. This restriction is also hindering activities of public welfare facilities such as hospitals and schools, which many citizens use.

As shown in Fig. 2-4 and Table 3-9, the power demand and supply balance as of 1992 is the worst ever because output of the generating facilities dropped due to lack of spare parts, accidents, etc., while demand continues to grow. Even if the Power Sector Rehabilitation Project planned by the World Bank is implemented as scheduled, the firm capacity will only be about 48% of the peak demand by 1994. Thus it would be difficult for NPA to provide a stable power supply to the western area of Sierra Leone.

From this it is predicted that a tight supply situation requiring repeated systematic power cuts as practiced now will have to be continued in the greater Freetown area until generated energy catches up with peak demand with the completion of Bumbuna Hydroelectric Power Station in 1997.

Sierra Leone is seriously concerned with this situation and intends to complete this project as an emergency measure so that a stable supply of power, particularly to social welfare facilities, will be ensured. At present, these facilities are also subjected to repeated power cuts because of the acute power shortage, even though they are given priority as important consumers and are public facilities indispensable to civil life.

In view of these situations, this project has the following objectives:

To construct the generating facilities as an emergency measure to cope with the power supply situation in Sierra Leone and thereby provide the greater Freetown area, the nation's center, with a social foundation to support residents' stable living and to manage and maintain social welfare facilities.

## 4-2 Study and Examination on the Request

### 4-2-1 Study of the Project's Propriety and Necessity

As already described (see 3-4-1), the power supply situation in the greater Freetown area is extremely serious at present. The output of the generating facilities has dropped due to the effect of the nation's financial difficulties and lack of adequate maintenance control over a long period. In 1992, the generating facilities were able to supply only about 44% (14.5 MW) of peak demand (33 MW) of the available capacity which is about 5% (1.5MW) of the firm capacity.

Because of this shortage, a power cut on a regular basis has been practiced as an inevitable consequence and has been seriously affecting civil life, social welfare facilities and economic and industrial activities.

If this condition was left as it is without making an appropriate improvement in power supply and without taking any emergency measures, residents' dissatisfaction would further grow, and medical services and education activities indispensable to residents' lives would become stagnant.

Consequently, it is considered urgent to undertake this project and prevent the stagnation of social welfare activities by properly operating the generating facilities to be built under the project.

As will be clear from the future power demand and supply balance in the western area centered on greater Freetown area described earlier (see 3-4-2), it is considered that these generating facilities will continue to assume the responsibility for supplying power to base load under the capital area's power supply system even after completion of the planned two major projects (power sector rehabilitation project and construction of Bumbuna Hydroelectric Power Station). From this, it is believed that the early implementation of this project will contribute to the securing of a stable power supply in the western area. Thus, the project will significantly contribute not only to residents' activities but to the stability of Sierra Leone's economy and development. Base on these points, the project is considered proper as a subject for grant aid.

### 4-2-2 Study of Implementation and Management Plans

(1) Personnel Assignment Plan

NPA is the agency responsible for implementation of this project on the Sierra Leone side, and the Generation Division is directly involved. (See section 2-1-1.)

This section is expected to assume the responsibility for operation and maintenance control of the generating facilities after their completion. The section has a staff of 140 members. It is considered possible to maintain and operate the generating facilities with the present personnel strength after completion of the project. This is because OJT provided to existing maintenance control personnel during implementation of the project is expected to improve technical and other capabilities of existing personnel.

(2) Study of Operation Cost

1) Annual Operation Balance

As described earlier (see 3-4-2), the generating facilities to be installed under the project are expected to be operated to supply power to the base load in the western area centered on greater Freetown area upon completion. In this case, the annual operation rate of the generating facilities will be about 90% and annual operation of about 8,000 hours. However, taking safety into consideration, assuming the operation ratio is 80% (about 7,300 hours/year), the operation and maintenance cost (expenditures) required for the generating facilities is estimated at 1.54 billion leones.

Revenue from the supply of power after deduction of power loss including transmission loss is roughly estimated at 1.84 billion leones. Thus a profit of about 0.3 billion leones can be expected from the operation balance (revenues from sale of power minus operation cost).

Appendix 9 shows a table for forecast operation balance by operation rate. As is clear from this table, the operation balance will result in a profit at each operation rate. From this, it is determined that the operation cost of the generating facilities can be fully recovered after commencement of their commercial operation.

2) Reserve funds for future use

When operating a power station, reserve funds are necessary for replacement of generating facilities, considering the deterioration of their functions as they become obsolete. These funds should be set aside as depreciation cost.

When depreciation cost of the generating facilities is calculated by the fixed amount method with no salvage value, assuming their serviceable life is 15 years, the anticipated operation balance will be as shown in Appendix 9.

As shown in the above table, if the generating facilities are operated at an operation rate of more than 80%, the operation balance, even allowing for depreciation cost, will result in a profit (about 30 million leones at an operation rate of 80%). Thus, reserve funds for the future can be secured.

### 4-2-3 Study of Relations and Overlapping with Other Aid Plans

Other aid plans related to this project include the aforementioned Power Sector Rehabilitation Project planned by the World Bank on March 1992 (see Chapter 1).

This aid plan can be divided into 3 parts as follows:

① Rehabilitation of the existing diesel generating facilities in Kingtom Power Station.

② Rehabilitation of the power transmission distribution network in the western area centered on greater Freetown area.

③ Improving of management, organization and Operation system of NPA.

The project under review calls for construction of the new generating facilities (No. 10 DEG) in Kingtom Power Station. Thus, the project has relations with above plans in both construction plan and operation and maintenance control plan after completion of the new facilities.

Consequently, in implementation of the Project, it is necessary to carry out construction work upon accurately understanding contents, the time of execution, etc., of the above plans.

(1) Study of Construction Plan

When implementing the Project for the construction of the generating facilities, it is believed possible to avert its overlapping with the above plans and eliminate interference with other projects by paying particular attention to the following points.

1) Connection between the new generating facilities for the project and the existing facilities (fuel, steam, cooling water and power distribution systems etc.) should be carefully designed, taking into account the present condition of the existing facilities and NPA's plan for their rehabilitation and improvement, so that the installation of the new generating facilities will neither cause a change in the system of the existing facilities nor require other rehabilitation work, etc.

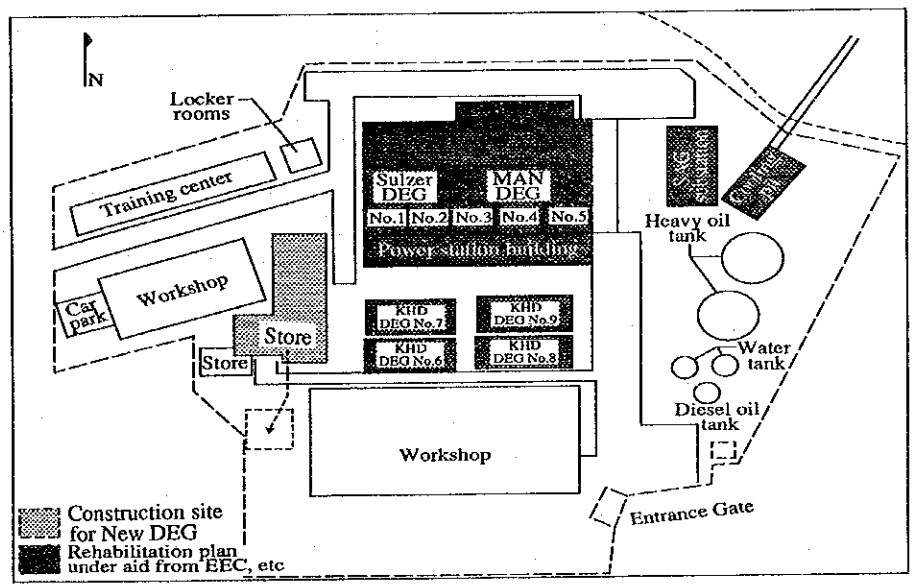
2) The new generating facilities should be installed where they will not interfere with NPA's planned rehabilitation and improvement work or other future projects.

Figure 4-1 shows the demarcation between the area under this project and the block for the rehabilitation plan which NPA is planning based on the power sector rehabilitation project using aid from the World Bank, EEC, etc.

(2) Study on Plan for Operation and Maintenance System After Completion of Project

subclause 4-2-3,③, the plan for "③ restructuring of NPA" is considered indispensable to the continued stabilization of the power supply situation in Sierra Leone in the future. This is because, as the plan itself points out, the root of the aggravated power supply situation that Sierra Leone faces at present is believed to be the lack of NPA's management ability as the electric energy supply sector.

Consequently, it is desired that after construction of the generating facilities NPA maintain these facilities with O & M technology which NPA will acquire through OJT to be provided in the course of execution of the Project. NPA should combine this technology with management ability as the electric energy supply sector to be developed under the above major plan when it will be implemented as a higher project, formulate an optimum maintenance control plan, and manage power supply service in the country.




(See 2-3-2 for aid items by EEC and other organizations.)

*Figure 4-1 Present Status and Future Plan of General Layout at Kingtom Power Station*

### 4-2-4 Study of Component Elements of the Project

This project consists of the following 3 elements: (1) construction of diesel generating facilities with installed capacity of 5 MW, (2) procurement of spare parts, and (3) implementation of OJT on O & M technology.

These 3 elements are organically interwoven with each other. It is considered that the project could not produce its intended effect if any one of these elements is missing.

Figure 4-2 shows the interrelations between these component elements.

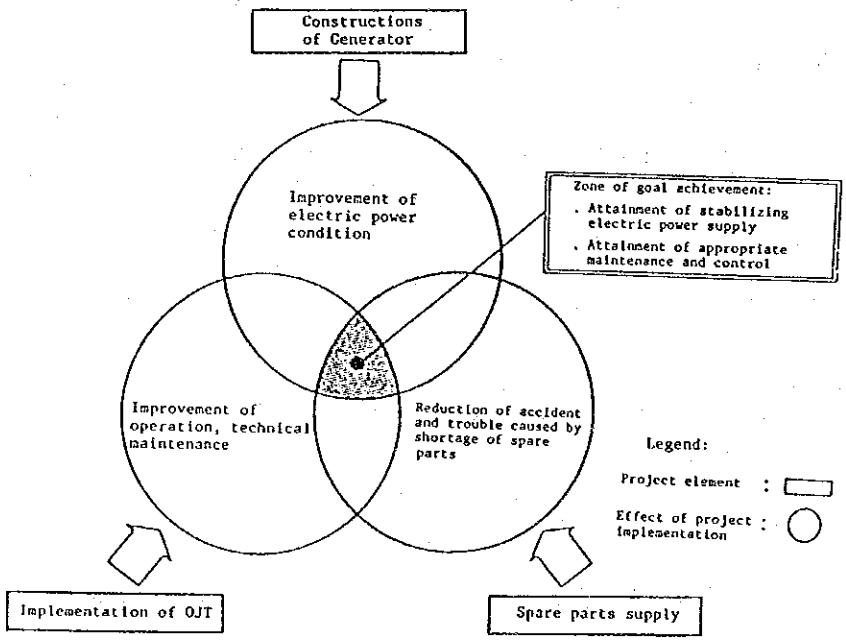



*Figure 4-2 Interrelation of Component Elements of Project*

### 4-2-5 Study of Scale of Generating Facilities

As described earlier (see 4-1), the objective of this project is to stabilize civil life and operate and maintain social welfare facilities such as hospitals, schools, etc., by undertaking emergency construction of generating facilities.

Consequently, in studying the scale of the generating facilities, the required installation capacity should be determined by defining the users of generated energy as hospitals, schools, etc., and assuming starting date of the operation as the 1995 fiscal year.

(1) Study of Ratio of Demand for Social Welfare Facilities to Peak Demand

According to the transition of power consumption by consumer in the greater Freetown area as described earlier, the ratio of power consumption by social welfare facilities such as hospitals and schools to total power consumption generally had ranged from 15 to 10% before 1987 when substantial power cutting was started. The ratio in the period from 1984 to 1990 averaged about 12%.

Considering Sierra Leone's industrial structure, which mainly consists of small enterprises and agriculture, as well as the country's social life, the ratio of power demand by consumer is believed to be nearly the same as the ratio of consumption by the same consumer category. Based on this, power demand for social welfare facilities is assumed to be the average value (12%) of the above power consumption to peak power demand in the subject area.

With industrial development and population increase, social welfare facilities are expected to grow because the improvement of social welfare is one of Sierra Leone's development targets as shown in the aforementioned (see 2-3-1) public investment programme.

For this, it is expected that power demand for social welfare facilities will grow in proportion to the growth of peak demand. Accordingly, it is considered appropriate to apply the above ratio (12%) even to the 1995 fiscal year, the completion date of the project.

(2) Expected Peak Demand

Peak demand in the greater Freetown area in the 1995 fiscal year is assumed to be 34.8 MW as indicated by NPA. (See Appendix 8 "Table for Forecast Power Demand in Western Area").

(3) Installed Capacity Required for the Project

Based on results of the above study, the installed capacity required for the project can be obtained as follows:

| Expected peak demand in 1992 | | Ratio of load of hospitals and schools to total load | | Required installed capacity |
|---|---|---|---|---|
| 34.8 MW | x | 0.12 | = | 4.2 MW |

When the capacity of the generating facilities falls, 5MW is selected because it is the rated capacity of the standard power generating facility for the necessary facility capacity (4.2MW) obtained with the above formula. In the Power Sector

Rehabilitation Project decided on by the World Bank, this 5MW facility capacity has the same output of the power generating facility to be installed with the help of Japan.

### 4-2-6 Study of the New Facilities Location

Since the 3 units of the existing MAN generating facilities in the power house at the existing power station are impossible to repair, the Power Sector Rehabilitation Project decided on by the World Bank will remove them, then 2 sets of 5MW generating facility units will be installed. (One with the assistance of Japan and the other with the assistance of the World Bank.) For this reason, Sierra Leone requested that the plans for the installation of the two separate generating facilities be compatible each other in order to generalize operation maintenance control and spare parts requirements, and also that the two facilities be installed next to each other at the location where the existing facilities are located. However, the following matters were confirmed during the field survey.

① There is no guarantee that the two facilities are compatible because of differences between Japans' grant aid and the guidelines for equipment procurement of the World Bank,

② If the generating facilities of this plan are installed in the powerhouse at the existing power station, because of the scale involved it will be difficult for the Sierra Leone side to complete removal of the existing MAN generating facilities according to the project implementation schedule,

③ It will be impossible for the Sierra Leone side to repair of the crane facility in the existing power station and the powerhouse of the said station which is to be completed before the implementation of the project.

Under the above circumstances, for the project, which aims to improve the power supply situation as an emergency measure, outdoor type diesel generating facilities have been selected which do not require construction of another building and which feature a short construction period. As for the location of the new generating facility, a plot of land surrounded by the existing power house, training center and work shop will be selected. NPA already confirmed that they will relocate the warehouse of spare parts for Sulzer generators currently on this plot. Thus, the construction site can be secured.

However, the foundation for the generating facilities must be constructed because in this area no foundation exists that can be used for the new generating facilities.

### 4-2-7 Study on Necessity of Technical Cooperation

The Government of Sierra Leone understands that lack of adequate operation and maintenance technology is one of the contributing factors to the aggravated power supply situation which the nation faces at present, particularly the drop in the output of the generating facilities.

Based on this understanding, the Government of Sierra Leone strongly desires a transfer of technology for operation and maintenance of the generating facilities to be installed under the Japan's grant aid in order to make effective use of the facilities over a long period for improvement of the nation's power supply situation. Technology requested ranges from basic technology pertaining to composition and assembly of facilities to high level O & M technology that must be imparted through actual operation and maintenance work. In the stage when the project has been implemented under grant aid, Sierra Leone requests Japan's assistance in the following forms:

(1) To provide training to NPA staff in Japan in generating facilities

(2) To dispatch technical assistance (expert) engineers in O & M of the generating facilities to Sierra Leone after completion of the project (electrical engineer and mechanical engineer: 1 each)

It is considered that the necessity of Japan's technical cooperation in the above is very high in view of the present condition of power stations in Sierra Leone as well as the technical level of NPA staff.

However, since this project is for construction of facilities under grant aid, it is difficult to include the above request into the project. Instead, it is considered desirable that the Government of Sierra Leone make this request to the Government of Japan separately.

### 4-2-8 Basic Policy of the Project

It is considered appropriate that this project should be implemented under Japan's grant aid because the foregoing study has confirmed its effect, viability, and Sierra Leone's execution capability, and because the effect of the project conforms to Japan's grant aid system. Accordingly, as a grant aid project, the basic design will be made by studying the following general items of the project.

Table 4-1 shows comparison in contents between Sierra Leon's request and the project plan.

*Table 4-1 Comparison in Contents between Sierra Leon's Request and Project Plan*

| Item | Contents of Sierra Leone's request | Contents of project plan |
|---|---|---|
| (1) Procurement and installation of diesel generating facilities with 5 MW output (including necessary auxiliary machines and electric equipment) | ○ | ○ (To be outdoor type) |
| (2) Test run, adjustments and acceptance test of above generating facilities | ○ | ○ |
| (3) Supply of spare parts for above generating facilities | ○ | ○ |
| (4) Foundation work for above generating facilities | ○ | ○ |
| (5) Provision of OJT in O & M technology for above generating facilities during execution of project | ○ | ○ |
| (6) Provision of training in Japan in generating facilities | ○ | (Request to be made separately) |
| (7) Dispatch of experts after completion of project | ○ | (Request to be made separately) |

## 4-3 Project Description

### 4-3-1 Execution Agency and Operational Structure

The execution agency for this project in Sierra Leone is the National Power Authority (NPA) and its division in charge is Power Generating Division of Kingtom Power Station (see 2-2-1).

This section is expected to assume responsibility for operation, maintenance and management of the generating facilities after completion of the project. (see 4-2-2)

### 4-3-2 Plan of Operation (Activity)

By implementing this project, Sierra Leone strongly desires (1) urgent improvement in power supply and (2) provision of adequate operation and maintenance of the generating facilities after start of operation.

Taking these points into consideration, the project will be formulated with following particular points in mind:

1) Facilities construction plan

(a) To construct new diesel generating facilities with 5 MW output with the objective of urgently improving the power shortage situation

(b) To shorten the construction period as much as possible

(c) To carefully design this project so that it will not have an adverse effect on other projects that NPA plans to undertake

(d) To make effective use of existing facilities

(e) To give considerations that serviceable life of machines in procured equipment will be extended and their maintenance be easy and control costs be kept low

(f) To pay attention to the general appearance of facilities to be newly installed under the project (distribution panel and remote control board) so that these new facilities will conform to existing facilities in configuration, etc., when installed next to them

(g) To install communication systems for maintenance purposes to facilitate operation and maintenance control after procurement as requested by Sierra Leone

(h) To give consideration to prevention of environmental pollution when the project is completed and supply necessary facilities for pollution control

2) Equipment procurement plan

(a) To procure necessary spare parts and tools for stable operation of the generating facilities after completion of the project

(b) To procure equipment and materials for improved safety of operation (such as soundproof head covers)

(c) To provide training materials so that acquired technology can be reviewed

3) OJT plan

(a) To have trainees understand the flow of O & M and the relative importance of maintenance work that they will conduct

(b) To have Japanese engineer(s) provide practical education to trainees during construction work at the site

4) Operation plan for the generating facilities

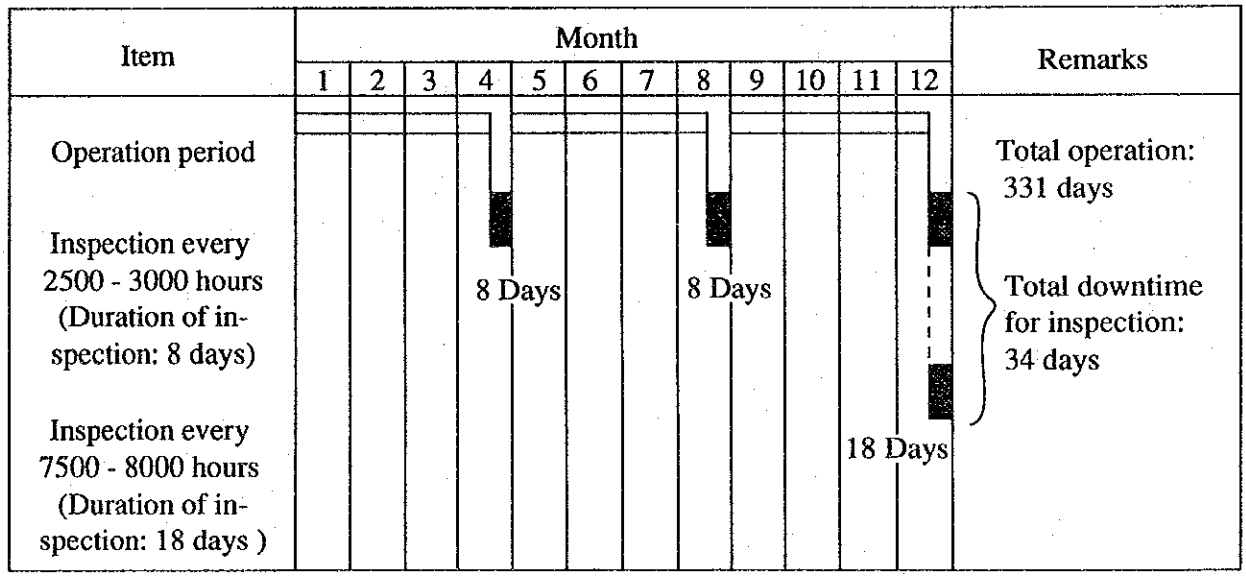
As described earlier (see 4-2-2-(2)), the generating facilities to be installed under the project are believed to supply power to base load in the western area centered on greater Freetown area.

From this, the operation plan for the generating facilities should be made under the following conditions:

Annual rate of operation : About 90%
Annual operation hours : About 7,800 hours

Items for periodical inspection, which is required for proper operation of the generating facilities, are as shown in the maintenance control plan to be described later (see 4-3-5).

Considering these periodical inspection items, the annual operation plan of the generating facilities under the above conditions for the initial year is shown in Figure 4-3.




Remarks: This table is assumes 90% of annual operation rate.

*Figure 4-3 Annual Operation Plan for Project Generating Facilities*

### 4-3-3 Location and Condition of the Project Site

The generating facilities to be installed under the project call for an area of about 400m$^2$. As a result of the field survey, a vacant lot surrounded by the power house, training

center built under aid from GTZ, and work shop, as shown on the power station facilities layout drawing given in Figure 4-1, was selected as the construction site for this project. However, the necessary area could not be secured from this vacant lot alone. As a result of discussion with NPA, it was decided to secure the necessary area for the project by relocating the warehouse for spare parts of the existing Sulzer generating sets and removing the unused brick warehouse. (These warehouses will be relocated and removed by the Government of Sierra Leone.) Regarding the warehouse for spare parts of Sulzer Generating sets, it was decided to move this warehouse to the place shown on the power station facilities layout drawing upon consultation with NPA.

### 4-3-4 Outline of Facilities and Equipment

The construction plan for the new generating facilities and procurement plan for equipment and materials is outlined below.

(1) Construction Plan for the Generating Facilities

1) Outdoor type medium speed diesel generating facilities (with 5 MW output, 1 set) will be constructed.

2) Mechanical equipment and system necessary for operation of the generating facilities will be constructed as follows:

(a) Fuel supply system

(b) Lubricant oil supply system

(c) Cooling water supply system

(d) Steam supply system

(e) Compressed air supply system

(f) Air supply and exhaust systems

(g) Sludge treatment system

(h) Piping facilities

3) Electric equipment and system necessary for operation of the generating facilities will be installed as follows:

(a) 11 kV switchgear for connection with existing facilities

(b) 11 kV switchgear on generator side

(c) Local control panel

(d) Remote control panel

(e) Excitation system

(f) DC power unit

(g) Transformer for auxiliary equipment

(h) Grounding system

(i) Communication system for maintenance

(j) Cabling facilities

4) Test run, adjustments and acceptance test for the above facilities will be conducted.

(2) Procurement Plan for Equipment and Materials

1) To procure spare parts that cover the needs for operation hours corresponding to one complete cycle of periodical inspection (overhaul) of the generating facilities

2) To procure tools necessary for maintenance, inspection and service of the generating facilities

3) To procure teaching materials for OJT

(3) OJT Plan for NPA's engineer:.

1) To provide education by engineer(s) despatched to the site by the Japanese Contractor

2) To provide education in the general flow and outline of O & M in class room training (about 1 weak)

3) To give education in operation and maintenance technology through practical training during the construction work (about 4 months)

### 4-3-5 Maintenance Plan

(1) Basic Policy

In stabilized activities of the power station, it is essential that operation and maintenance (O & M) and preservation of facilities environment be provided to ensure stable supply of power in response to demand.

One of the major contributing factors to the tight power supply situation in Sierra Leone is a lack of proper maintenance of the existing facilities including their preventive maintenance, as already described (see 3-1-2). To improve this present situation, to maintain the performance and function of the project generating facilities and to secure stable power supply to the greater Freetown area, adequate maintenance and control including preventive maintenance should be provided with

reliability, safety and efficiency of the generating facilities as the main pillars of specific maintenance operation. Figure 4-4 shows the basic concept to maintain the stable operation and maintenance of DEG.

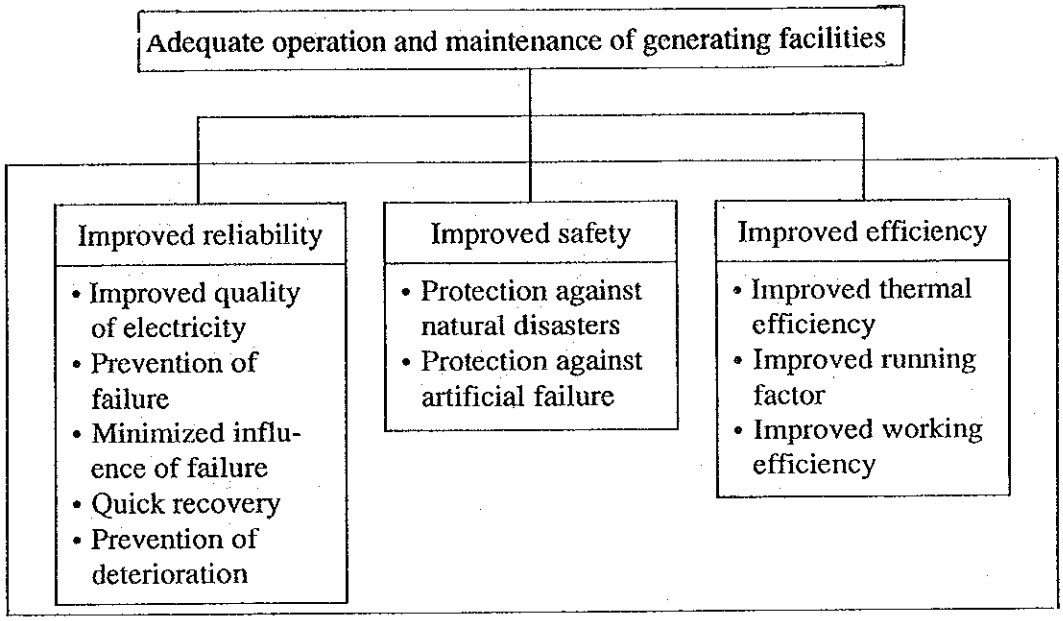



*Figure 4-4 Basic Concept of Maintain the Stable Operation and Maintenance of DEG*

The basic policy for formulating maintenance control plan of generating facilities is as follows:

① Conduct of preventive maintenance

② Systematic control

③ Effective use of the operation and maintenance records and data, and their reflection in the future plan

In this Project, with the above basic points in mind, the Sierra Leone side is required to carry out operation and maintenance of the generating facilities after completion of the project according to the operation and maintenance manuals to be submitted and O & M technology through OJT which the Japanese contractor will provide during execution of the construction.

(2) Items for Periodical Inspection

Table 4-2 shows standard items for periodical inspection of the subject generating facilities.

Personnel concerned in Sierra Leone are required to develop an operation and maintenance plans for the generating facilities according to this table into the entire operation plan for Kingtom Power Station.

*Table 4-2 Standard Items for Periodical Inspection*

| Inspection frequency | | Main work items |
|---|---|---|
| Diesel engine | Daily inspection | • Check fuel oil level, and oil level in lubricant sump tank and lubricant tank<br>• Check water level in jacket water tank, and pressure of starting air tank |
| | Inspection every 1000 hours | • Check bolts and nuts for their tightness<br>• Clean fuel and lubricant filters |
| | Inspection every 2500 to 3000 hours | • Check exhaust valve, starting valve, fuel valve and fuel pump<br>• Check piston valve and liner |
| | Inspection every 7500 to 8000 hours | • Check piston and cylinder liner, and replace gasket<br>• Replace piston ring, oil scraping ring and O-ring<br>• Analyze cylinder head and replace gasket O-ring in exhaust valve<br>• Check fuel injection valve and replace nozzle<br>• Disassemble and inspect supercharger and replace ball bearing, etc.<br>• Change lubricant sump tank oil (based on results of analysis) |
| | Inspection every 16000 hours | In addition to above inspection and replacement at every 7500 to 8000 hours, check and replace following items:<br>• Check and replace crank pin bearing<br>• Check and replace exhaust valve rotator<br>• Disassemble and replace lubricant pump |
| Gene-rator | Daily inspection (during operation) | • Visually check each part, check for abnormal sound, and check each part for temperature |
| | Inspection once a month | • Check for abnormal vibration<br>• Check lubricant flow and leak from bearing<br>• Perform simple cleaning |
| | Inspection once a year | • Measure insulation resistance and check lead wires and connection<br>• Check accessories such as space heater<br>• Visually check and clean bearing |

(3) Procurement Plan for Fuel Oil

Table 4-3 shows the expected annual consumption of main fuel (heavy fuel oil, HFO) necessary for operation of the generating facilities.

NPA is required to make and implement a procurement plan for fuel oil shown in the table so that smooth operation of the generating facilities will be maintained.

*Table 4-3 Anticipated Annual fuel Consumption by Subject Generating Facilities*

| Item | Unit | Rate of operation | | | | |
|---|---|---|---|---|---|---|
| | | 75% | 80% | 85% | 90% | 95% |
| Consumption of heavy oil C per hour | l/hr | 1,131 | 1,131 | 1,131 | 1,131 | 1,131 |
| Annual consumption of HFO | l/yr | 7,327,329 | 7,815,818 | 8,304,307 | 8,792,795 | 9,281,284 |

Remarks: Fuel consumption of the generating facilities was calculated based on 0.21kg/kWh. For HFO, the following specification was used.

- Specific gravity of HFO : 0.95
- Lower heating value of HFO at Kingtom Power Station : 9,970kcal/kg
- Heating value of HFO of ISO code : 10,200kcal/Kwh

## 4-4 Technical Cooperation

As already described (see 4-2-7), it is considered necessary to extend technical cooperation. Specifically, to obtain the intended effect from the generating facilities by providing adequate maintenance control after completion of the project, it is believed necessary to plan the transfer of O & M technology through Japan's technical cooperation.

Table 4-4 shows an outline of technical cooperation that is considered necessary.

*Table 4-4 Technical Cooperation Considered Necessary*

| Item | Objective | Remarks |
|---|---|---|
| Training to be provided in Japan | To acquire basic knowledge of generating facilities, especially of engines | |
| Dispatch of experts from Japan | To give technical guidance on O & M of generating facilities to be practiced after completion of the project | Mechanical engineer : 1<br>Electric engineer : 1 |

# CHAPTER 5 BASIC DESIGN

# CHAPTER 5 BASIC DESIGN

## 5-1 Design Policy

### 5-1-1 Policy on Natural Conditions

(1) On Temperature Condition

The temperature in the subject area is nearly constant, being moderate at a high of 38°C and a low of 20° and about 26°C throughout the year.

(2) On Precipitation Condition

In the subject area, the June – September period is the rainy season. Since the monthly rainfall may reach as much as about 900 mm during July and August, no local work could be undertaken for safety reasons. It is therefore necessary to plan the execution of equipment installation, earth work, concrete work, underground installation, etc., other than during this period.

### 5-1-2 Policy on Construction Situation

In planning the construction works, equipment and materials to be used will be as a rule procured locally as much as possible. However, adequate equipment materials are not locally available except for aggregate such as sand and gravel because few large scale construction projects have been undertaken at the Project area. Consequently, most equipment and materials must be supplied from either Japan or some other countries.

Installation of the generating facilities for the project requires skilled engineers and technicians. These engineers and technicians will be sent to the site from Japan.

### 5-1-3 Policy on the executing Agency's Operation and Maintenance Capabilities

The mainstay generating facilities in the country at present are diesel plants. Thus, NPA is considered to be very familiar with the operation and maintenance of these power generating facilities. Based on this understanding, diesel generating facilities will be procured under this project.

Furthermore, considering NPA's financial situation (see 2-2-2), economic design will be applied so that the running cost of the generating facilities can be held down to the minimum possible.

### 5-1-4 Policy on Scope and Level of Facilities, Equipment, etc.

Considering the various aforementioned conditions, the scope and technical level of the facilities to be constructed, equipment and materials procured under this project will be based on the following basic concept:

(1) Policy on Scope of Facilities, equipment, etc.

Composition of the facilities, type and quantity of equipment and materials and contents of OJT will be determined in order to accomplish stable supply of power to social welfare facilities, the objective of this project (see 4-1), through ① construction of generating facilities, ② procurement of equipment and materials such as spare parts, and ③ provision of OJT under the Project.

(2) Policy on Technical Level

For specifications of each equipment for the generating facilities, careful consideration will be taken not to deviate from the technical level of the existing facilities whose operation and maintenance NPA is familiar with.

OJT under this project will be provided to develop NPA's engineers to the technical level at which they can operate the generating facilities, analyze data on failure records, etc., and plan and execute adequate measures (perform preventive maintenance), with NPA's present O&M technology as the basis.

### 5-1-5 Design Policy on Facilities Construction

As a result of a study taking into account the above basic policies, land feature of Kingdom Power Station, existing power house, present equipment arrangements, and operating condition of electric and mechanical equipment, as well as future expansion plans, the project facilities will be constructed under the following design policy:

(1) The generating facilities for this project will be located where they will not affect the rehabilitation and improvement work that NPA plans to undertake in the future.

(2) The generating facilities will be installed outdoors because no space is expected to be prepared by the time construction is initiated in the existing power house. Furthermore, to shorten the local construction period as much as is practical, outdoor type generating facilities with an enclosure for the diesel generator, which

require no generator building, will be used.

(3) Power generated by the generating facilities will be supplied through the existing 11 kV distribution system.

(4) Connection between the project generating facilities and existing facilities (fuel, steam, cooling water and power distribution systems) will be designed by taking into account the present condition of the existing facilities and rehabilitation and improvement plans for these facilities that NPA will undertake in the future. In other words, due consideration will be given to this design so that it will neither require changes in the system of the existing facilities nor necessitate additional rehabilitation work, etc.

With all these points in mind, the project generating facilities will make the fullest use of any of the existing facilities that may possibly be used for the new facilities.

(5) As for the engine, a medium speed type will be used to allow a reduction in installation space.

(6) HFO, which the existing facilities use and is available at low cost, will also be used as main fuel for the Project generating facilities.

(7) Since the plan calls for procurement of most equipment and materials from Japan (see 5-4-4), Japan's standards and codes will be as a rule referred to in the design and manufacture of the generating facilities.

## 5-2 Study and Examination on Design Criteria

As a result of study on above various conditions, the following design criteria have been established for use in defining the scale and specifications of the Project:

### 5-2-1 Climatic and Site Conditions

(1) Ambient temperature : 38°C max

(2) Temperature inside enclosure of diesel generator : 45°C max

(3) Relative humidity : 98% max

(4) Mean annual precipitation : Approx. 3,500 mm

Approx. 900 mm/month in July – August period
Approx. 300 mm/month in June and September

(5) Wind velocity : 120 km/h (33.3 m/s) max

(6) Earthquake : Not particularly considered

(7) Measures against salt damage : Measures will be taken on housing of major pieces of equipment

(8) Measures against dust : Dust condition shall be considered

(9) Soil bearing pressure : 10 tons/$m^2$ or over (based on GTZ Report)

(10) Countermeasures against noise : Noise will be controlled to 75db or less as measured 1m from the facility side so that the Training Center is not affected.

### 5-2-2 Composition of Fuel

At present, Kingtom Power Station uses both heavy oil (HFO) and diesel oil. Main specification of these oils are as shown below. These oils are equivalent to heavy oils C and A, respectively according to JIS classification.

*Table 5-1 Specifications of Fuels Used at Kingtom Power Station*

| Item | Unit | Heavy oil | Diesel oil |
|---|---|---|---|
| Specific gravity (60°F) | — | 17.36 | 32.0 |
| Dynamic viscosity (50°C) | Stokes (cSt) | 380.0 | 3.5 |
| Pour point | ℃ | 5 | -20 or less |
| Flash point | ℃ | 92 | 106 |
| Sulfur content | % | 0.47 | 0.13 |
| Water content | % | 0.02 or less | 0.02 or less |
| Ashes | % | 0.02 | 0.02 or less |
| Calorific value | kcal/kg | 9,970 | 10,250 |

### 5-2-3 Composition of Cooling Water

Table 5-2 shows an analysis of water supplied to Kingtom Power Station at present.

*Table 5-2 Analysis of Water Supplied to Kingtom Power Station*

| Item | Unit | Water |
|---|---|---|
| PH value, 18°C | — | 7.0 |
| Conductivity | μs/cm | 23.0 |
| Chlorine ion | $Cl^-$ mg/*l* | 1.86 |
| Total hardness | $CaCO_3$ mg/*l* | 5.7 |
| Silica | mg/*l* | 2.82 |