LIBERIA ELECTRICITY CORPORATION
THE REPUBLIC OF LIBERIA

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR REHABILITATION OF MONROVIA POWER SYSTEM IN THE REPUBLIC OF LIBERIA

MARCH 2013

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YACHIYO ENGINEERING CO., LTD.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey on the project for Rehabilitation of Monrovia Power System in the Republic of Liberia and entrusted the survey to Yachiyo Engineering Co., Ltd.

The survey team held a series of discussions with the officials concerned of the Government of Liberia, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Liberia for their close cooperation extended to the survey team.

March 2013

Kyoko KUWAJIMA
Director General,
Industrial Development and Public Policy Department
Japan International Cooperation Agency

Summary

① Overview of the Country

The Republic of Liberia is located in the western part of African continent and has a land area and population of 111,370 km^2 and approximately 360 million (Census 2009) respectively. The population is consisted of sixteen ethnic groups such as Kpelle, Bassa, Gola, Kuru, etc.

Liberia was developed as a settlement for freed American slaves at the beginning of the 19th century, gaining independence in July 1847. However, civil war continued for more than 14 years from 1989 to 2003, leaving an estimated 270,000 people dead and another 790,000 as refugees. After the civil war, President Ellen Johnson Sirleaf was inaugurated as Africa's first popularly-elected female president in January 2006. Upon taking office, she began and continues to make efforts to reconstruct Liberia by obtaining aid from international agencies and donor countries including the U.S. These efforts were based on her First 150-day Action Plan (emergency reconstruction plan for infrastructure and the economy), the Interim Poverty Reduction Strategy (2006~2008), and the Poverty Reduction Strategy (2008~2011) instituted in April 2008.

② Background of the Project

In regard to the electrical power sector, a large portion of the power supply facilities in the capital region of Monrovia and in rural areas were destroyed in the civil war, forcing the Liberia Electricity Corporation (LEC) to stop supplying power in 2003. Under the aforementioned 150-day Action Plan following the war, an Emergency Power Plan (EPP-I, II) was implemented and the power supply was restored using high-speed diesel generators with a total capacity of 9.64 MW.

Following the National Energy Policy (NEP) instituted in May 2009 in Liberia, a national power policy is currently being drafted and the state of the electrical power sector continues to shift from emergency restoration to the formulation and execution of medium to long-term plans. Under these conditions, and as a goal for satisfying medium-term power demands in the Monrovia capital region, the Government of Liberia has requested grant aid from Japan for the installation of 10 MW HFO-fired diesel generator facilities and primary substation (66/22kV) with facility capacity of 15 MVA.

In order to use HFO-fired diesel generators, it is essential to repair the oil storage tanks and unloading facilities that were destroyed in the war. However, as this falls under the burden of the Liberian side, predictions were unable to be made regarding the repair of said facilities, thus inhibiting progress toward a full-scale survey. At this time, under the Liberia Electricity System Enhancement Project (LESEP) with the World Bank, repair of the aforementioned oil facilities is anticipated and a Preparatory Survey for the implementation of grant aid was conducted.

③ Outline of the study findings and Project contents

In response to the request, JICA dispatched the Study Team to Liberia from September 11 to October 1, 2011 (first field survey) and from January 10 to February 8, 2012 (second field survey) in order to

reconfirm the contents of the request and discuss the contents for implementation with related agencies on the Liberian side (responsible government agency: Ministry of Lands, Mines and Energy (MLME), and implementing agency: Liberia Electricity Corporation (LEC), survey the Project sites and gather related materials and data.

On returning to Japan, the Study Team examined the necessity, social and economic impacts and validity of the Project based on the field survey materials and compiled the findings into the draft preparatory study report. Afterward, in July 2012, the Liberian side made a request to JICA for the modification of a part of the Project component. The requested modification is to exclude 66/22kV substation components from Japan's grant aid and to change the voltage of generator transformer from 66/6.6kV to 66/22kV, taking account of the expansion of 66/22kV substation to be assisted by the Norwegian government. Upon this request, JICA dispatched the Supplemental Study Team from August 7th to 10th in order to evaluate the relevance of the request as well as to identify the detailed contents of the modification. On returning to Japan, the Study Team modified the contents of the draft preparatory study report Furthermore, JICA dispatched the Study Team to Liberia for the third field survey (outline explanations) from October 16th to 26th, 2012 in order to explain and discuss the draft preparatory study report and reach a basic agreement with the Liberian counterparts.

The grant portion of the Project compiled based on the survey findings targets the procurement and installation of two of 5MW diesel generators, the construction of a power house and the procurement of distribution line maintenance vehicles. The following table shows the components of the grant aid Project.

Components of the Grant Aid Project

	Plan Contents	Quantity
Procurement and installation	1. Diesel engine generators	
	1.1 Diesel engines	2 sets
	1.2 Synchronous generators	2 sets
	1.3 Common Beds	2 sets
	2. Mechanical auxiliary equipment for diesel engine generator	
	2.1 Fuel oil system	1 set for each generator
	2.2 Lube oil system	1 set for each generator
	2.3 Cooling water system	1 set for each generator
	2.4 Intake air and exhaust gas system	1 set for each generator
	2.5 Compressed air system	1 set for each generator
	2.6 Sludge treatment system	1 set
	2.7 Pipes and valves	1 set for each generator
	3.Electrical auxiliary equipment for diesel engine generator	
	3.1 Generator transformer	1 set for each generator
	3.2 Generator control panel	1 set for each generator
	3.3 Motor control center	1 set for each generator

	3.4 DC power supply system	1 set
	3.5 Station transformer	1 set
	4. 22 kV switchgears	1 set
Procurement	1. Emergency spare parts	1 set
	2. Spare parts	1 set
	3. Maintenance tools and vehicles	1 set
Construction	1. Powerhouse for diesel engine generators (total floor area: approximately 1,479 m^2)	1 set
	2. Heavy Fuel Oil transfer pump house(total floor area: approximately 60 m^2)	1 set

④ Project implementation schedule and cost estimation

In the event where the Project is implemented based on the Japan's Grant Aid scheme, the total cost of the Project will be (confidential). The contents and costs to be borne by the Liberian side will primarily be commissions for banking arrangement (approximately 2.27 million yen) and initial charge of fuel storage tanks (approximately 31.29 million yen). The implementation schedule for the Project including the detailed design will be approximately 24 months.

⑤ Project Evaluation

(1) Quantitative Effects

Indicators	Baseline data (FY 2012)	Anticipated achievement Without Project (FY2017)	Target achievement With Project (FY2017)
Capacity of generation equipment (Firm capacity)	**8MW**	**40MW** [Breakdown] Existing : 15MW World Bank : 10MW GOL : 10MW Mt. Coffee : 5MW	**50MW** [Breakdown] Existing : 15MW World Bank : 10MW GOL : 10MW Japan's grant : 10MW Mt. Coffee : 5MW
Fuel cost per unit generation (cost/kWh)	100% (current level)	27% (73% reduction)	25% (75% reduction)

(2) Qualitative Effects

Current situation and problems	Project measures	Effects of the plan and degree of improvement
(Medical facilities) The JFK Medical Center, the only tertiary care facility in Monrovia, is currently obtaining power from the LEC electrical system, but struggles with the unstable power supply. The use of basic diagnostic equipment	The components of the Project that contribute to the improvement of the power supply in Monrovia are as follows. (1) Installation of HFO-fired diesel generators at the Bushrod	Through the Project, the supply of power will be improved so that basic diagnostic equipment needed by doctors such as fluoroscopic x-ray apparatus, etc. can be used in a stable manner. Based on the data,

Current situation and problems	Project measures	Effects of the plan and degree of improvement
such as ultrasound scanners, fluoroscopic x-ray apparatus, and endoscopes used by doctors is hindered. Redemption Hospital (secondary care facility) obtained power from LEC's commercial system until one year ago. However, since the large fluctuations in voltage and frequency caused malfunctions in expensive medical equipment and the electricity fees were exorbitant, they cancelled LEC commercial system services. They then shifted to a system of obtaining 24-hour power from their own generation facilities using two generators. Health centers and clinics store drugs and vaccines in refrigerators powered by photovoltaic systems and use gas-burner sterilizers. Although photovoltaic systems are furnished with batteries, recharging is insufficient during the rainy season, often causing a situation where power cannot be obtained.	Power Station with a facility capacity of 10 MW (5 MW burn (2) Procurement of maintenance management vehicles ➢ Truck for transporting maintenance workers (5-seater): 5 ➢ Boom lift vehicle: 1 ➢ Digging/pole erection vehicle: 1 ➢ 2.9t crane truck: 2	medicine can be practiced in a stable manner. Additionally, the medical environment will be improved not only for area residents, but also for emergency patient and outpatients that come from distant regions. Through this project, the supply of power will be improved so that refrigerators for drugs/vaccines and sterilizers, etc. can be used with assurance. With this, basic medical care at health centers and clinics, as well as home visits in the community for vaccinations can be conducted in a stable manner. This will contribute to maintain the health of patients, including many children and pregnant women. Additionally, patients can also be seen safely at night.
(Educational facilities) As of September 2011, the supply capacity is insufficient, and the number of users connected to the LEC commercial system is stopped at 11,000. The highest educational institutions such as the University of Liberia and Stella Maris Polytechnic, etc. which should cultivate next political and industrial leaders remain unconnected to the commercial system. Therefore, each school operates its own power generating equipment, with a technical department created at the institutions for operations and maintenance. Since synchronized operation of the school generators is not possible, multiple generators must be placed in different areas of the school, creating inefficient operating conditions. There are also several primary (1,114), middle (550), and secondary (200) schools in the target region for the Project. Due to power shortages, the same educational equipment used in schools in other developing countries such as computers and television (for showing educational	Same as above	Through the Project, the supply of power will be improved so that lighting facilities, computers, equipment for experiments and training can be used at educational institutions in the target area in a stable manner, thus stimulating educational activities. Additionally, since power is stably supplied from the commercial electricity system, management work the generators installed at each school will be reduced.

Current situation and problems	Project measures	Effects of the plan and degree of improvement
programs) cannot be used. This hinders the acquisition of knowledge and skills necessary in society.		
(Foreign direct investment) In Monrovia, the unstable power supply and high electricity fees are obstacles for foreign direct investment. According to a statement by the Minister of Land, Mines, and Energy, investment opportunities of one million dollars were lost in 2011.	Same as above	Through the Project, power supply capacity will be strengthened, and by introducing medium speed diesel generators using low-cost HFO, the supply of power will stabilize and lowering electricity rates will become possible. Increased foreign direct investment in Liberia, the creation of job opportunities, and stimulation of the economy are expected.

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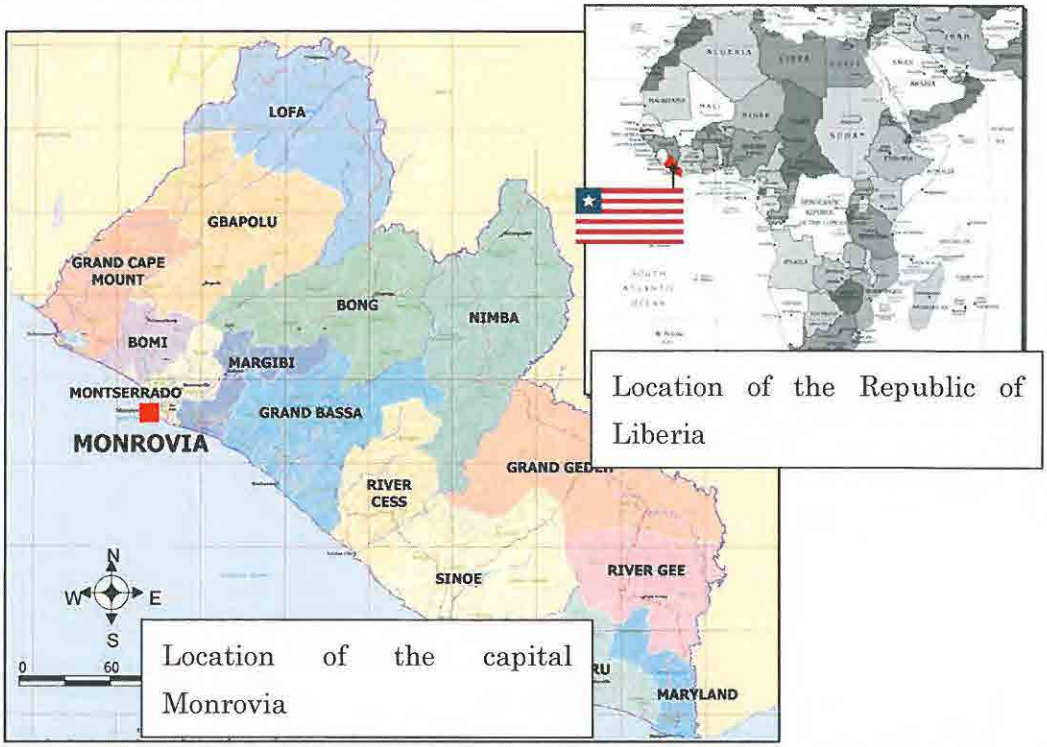
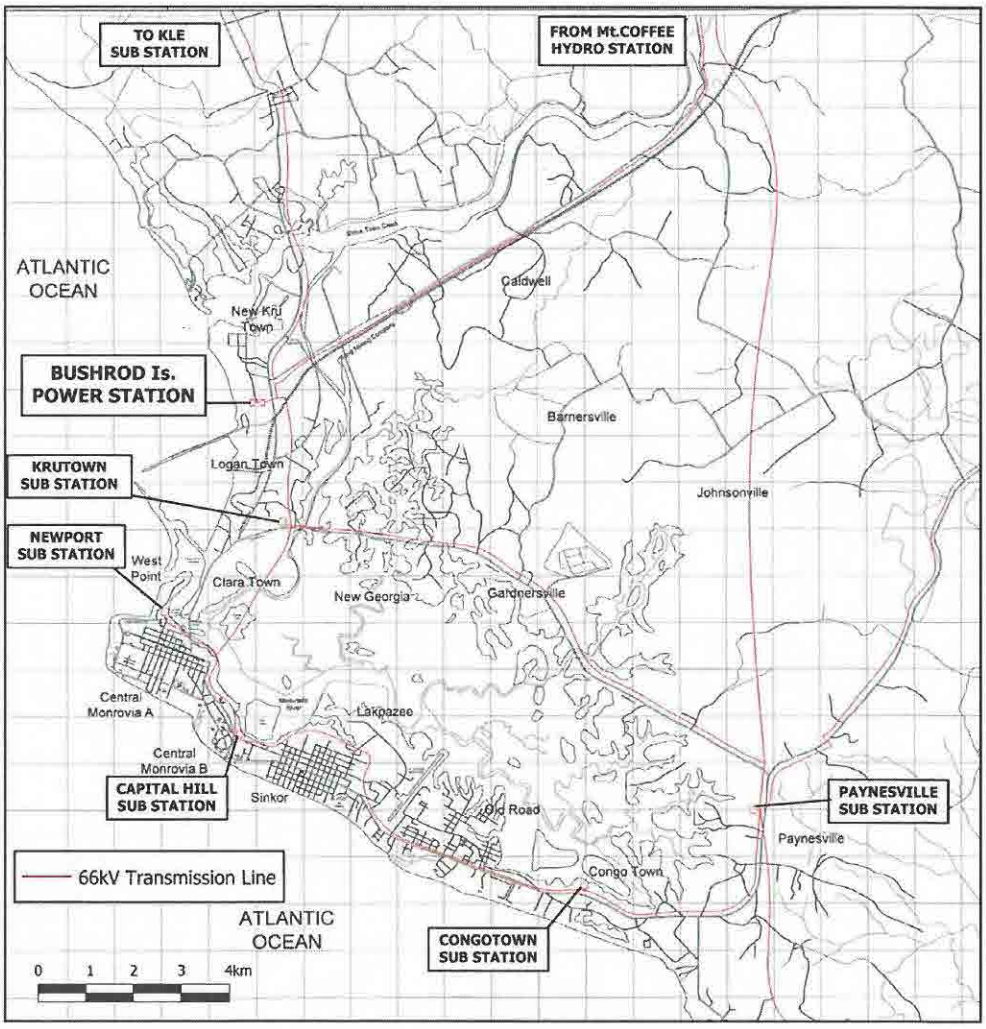
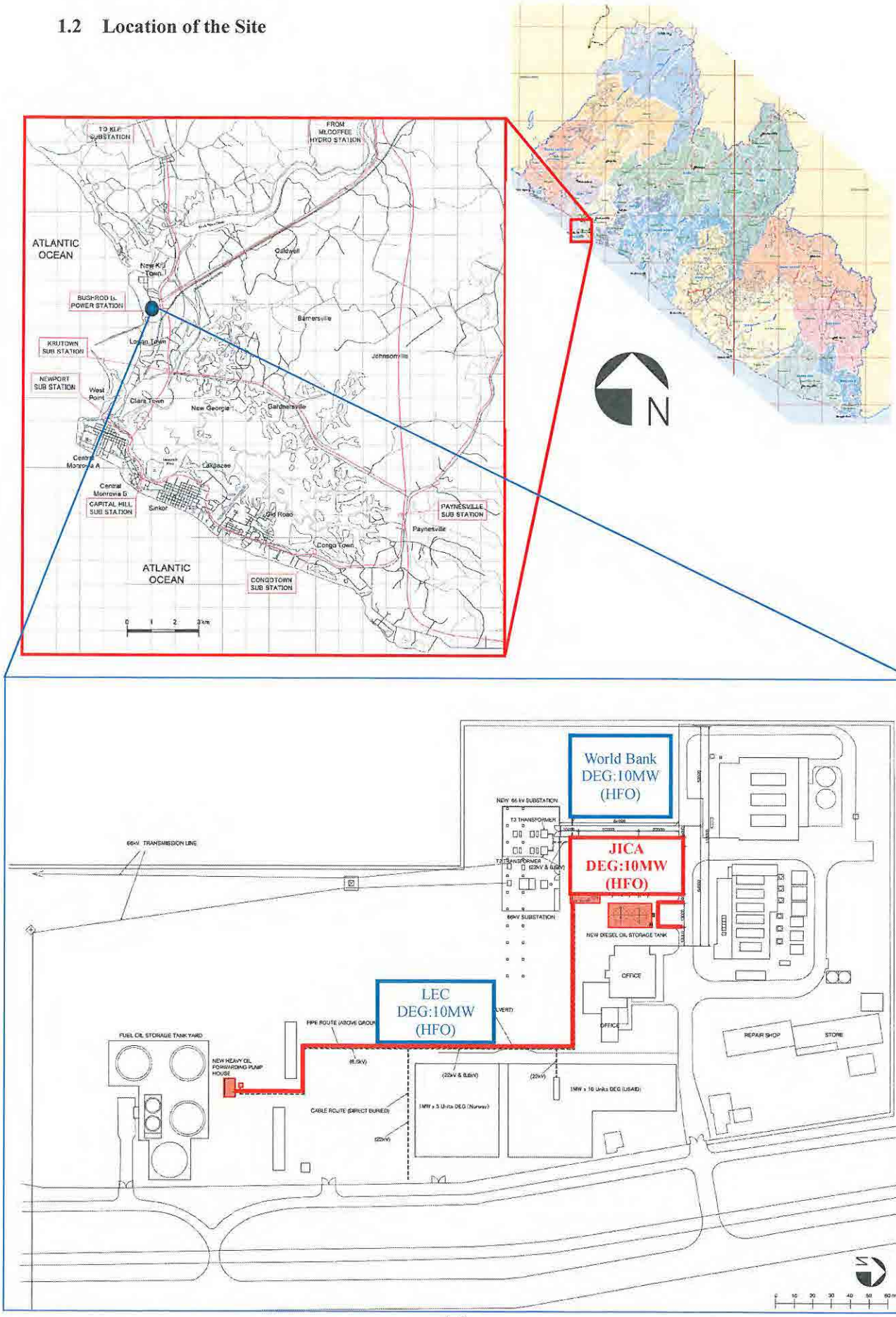
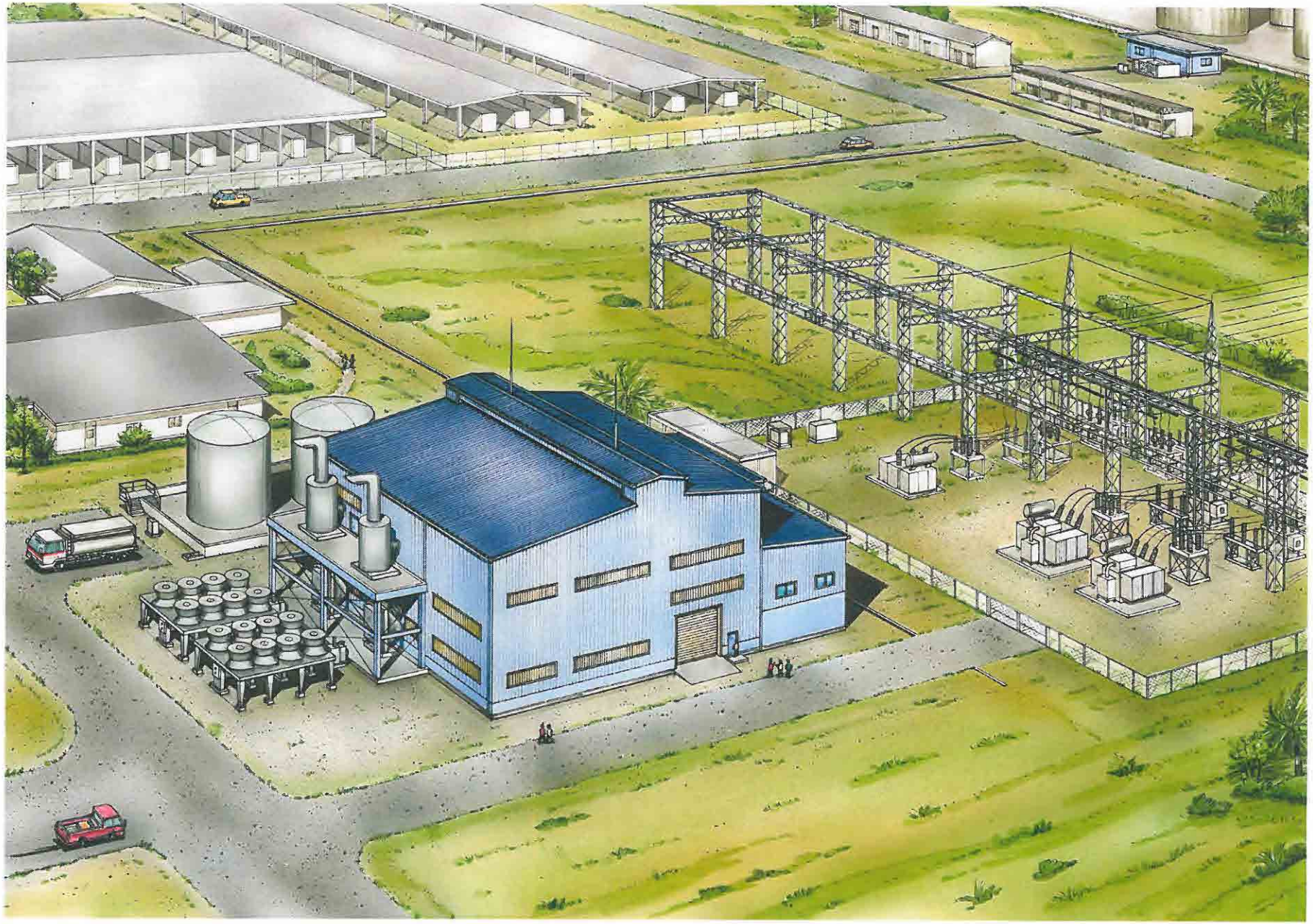
1.1 Overall View of the Aid Receiving Country





1.2 Location of the Site





Conceptional Drawing of the Bushrod Power Plant in Liberia

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ABBREVIATIONS

A/P	Authorization to Pay
AFREA	Africa Renewable energy Access trust fund
AIJ	Architectural Institute of Japan
ASTM	American society of Testing and Materials
AfDB	African Development Bank
BADEA	Arab Bank for Economic Development in Africa
BRE	Buchanan Renewable Energy
CLSG	CÔTE D' IVOIRE - LIBERIA - SIERRA LEONE - GUINEA
E/N	Exchange of Notes
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EPA	Environmental Protection Agency
EPP	Emergency Power Plan
EU	European Union
G/A	Grant Agreement
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GNI	Gross National Income
GPOBA	Global Partnership for Output Based Aid
IDA	International Development Association
IEC	International Electrotechnical Commission
IPP	Independent Power Producer
ISO	International Organization for Standards
JCS	Japanese Electrical Wire and Cable Maker's Association Standards
JEC	Japanese Electrotechnical Committee
JEM	Standards of Japan Electrical Manufacturer's Association
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
KfW	Kreditanstalt für Wiederaufbau
LBDI	Liberian Bank for Development &Investment
LEC	Liberia Electricity Corporation
LESEP	Liberia Electricity System Enhancement Project
LESSP	Liberia Energy Sector Support Program
MHI	Manitoba Hydro International
MLME	Ministry of Lands, Mines and Energy
NECOLIB	National Environmental Commission of Liberia
NEP	National Energy Policy

NGO	Non-Governmental Organizations
NORAD	The Norwegian Agency for Development Cooperation
O&M	Operation and Maintenance
OJT	On the Job Training
PPA	Power Purchase Agreement
PPP	Public Private Partnership
REA	Rural Electrification Agency
SEA	Strategic Environmental Assessment
SPC	Special Purpose Company
UBA	United Bank of Africa
UNICEF	United Nations Children's Fund
UNOPS	United Nations Office for Project Services
USAID	United States Agency for International Development
WAPP	West African Power Pool

Chapter 1 Background of the Project

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The grant portion of the Project compiled based on the survey findings targets the procurement and installation of two of 5MW diesel generators, the construction of a power house and the procurement of distribution line maintenance vehicles.

1-1 Environmental and Social Consideration

1-1-1 Environmental impact assessment

1-1-1-1 Outline of project component that affect environmental and social

The summary of the Project components are shown as below.

(1) Installation of 2 x 5MW HFO-fired medium speed diesel generator in Bushrod Power Plant and Construction of new power house in Bushrod Power Plant

(2) Supply of maintenance vehicle

Among the items, it is unlikely that the project component of (2) adversely impacts on the environmental and social conditions owing to its characteristics and size. Therefore, the environmental and social consideration under this study focuses on the project component (1) "Installation of 5MW x 2 HFO-fired medium speed diesel generators Bushrod and Construction of new power house in Bushrod Power Plant".

For this project, the plant site is already been reserved. It is, however, new 10 MW class power generation facilities and there is not significant, some environmental and social impact is assumed. Therefore, this project is classified as Category B project. In addition, "GUIDELINES FOR ENVIRONMENTAL AND SOCIAL CONSIDERATIONS, JICA (April 2004) "is applied for this project.

1-1-1-2 Environmental and Social Condition of the Sites

Bushrod Power Station locates at approximately 7 km north from the city center of Monrovia City. The station has been operated by LEC. Yet, all facilities were destroyed during the civil wars. The ex-generation

facilities locate at the northern part of the site and the existing generation facilities funded by USAID and NORAD locates at the north-western part of the site. The oil storage tanks and pipelines, which were also destroyed during the war, locate at the southern side of the site. Due to destruction of such facilities, there is soil contamination observed in these areas. It is predicted Word Bank would conduct decontamination of the soil. World Bank participates as a part of Liberia Electricity System Enhancement Project (LESEP) and committed to fund US$2.6 million for HFO storage tank repair and HFO contaminated soil treatment. Regarding this project, bidding for the repair and decontamination was implemented in August 2012 and three companies tendered. The contractor selection will be completed by the end of October 2012 and the work will complete in December 2013. 2The site for this Project locates at approximately the center of the site. The site has been currently served as a stock yard for wood poles. Bushrod Power Station has been secured by Liberia Electricity Corporation (LEC) as a power station since the pre-war period. There is no resident inhabiting identified at the site. The Bushrod power station project layout is shown in Figure 1-1-1-1. The surrounding conditions of Bushrod power station are shown in Table 1-1-1-1.

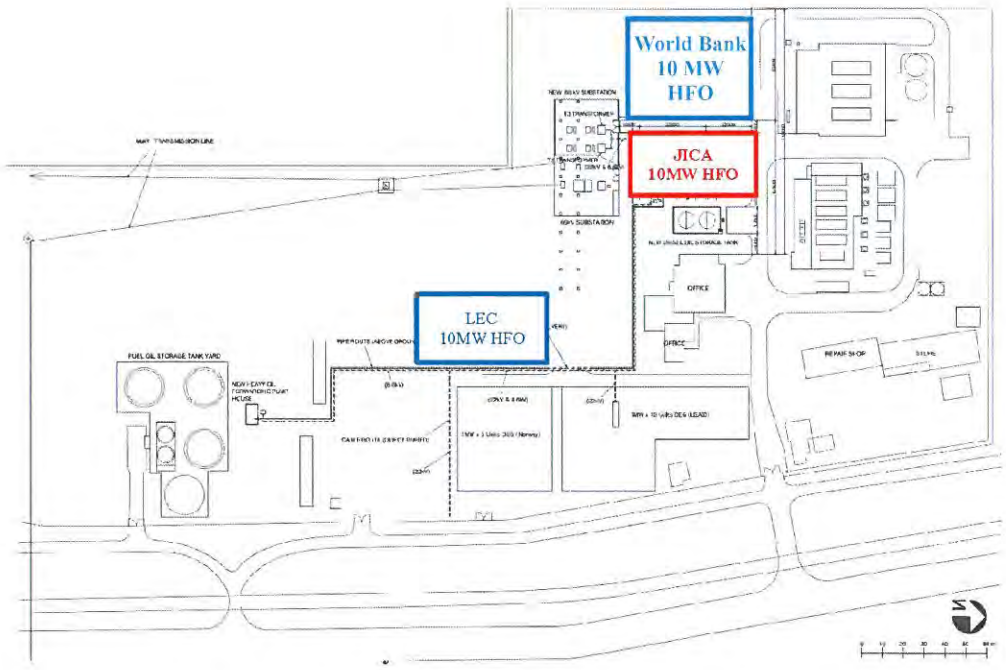


Figure 1-1-1-1 Layout of Bushrod Power Station

Table 1-1-1-1 Surrounding Environment of Bushrod Power Station

Item		Feature
North Side	:	The northern side is adjacent to residential area. The distance to the nearest house is approximately 150 m.
East Side	:	Across the 4 lane road, there are some houses scattered in the eastern side. Because there are port facilities in the near areas, a number of large scale tracks passing the 4 lane road.
West Side	:	UNMIL, consisting of Chinese military, base locates across the small ditch.
South Side	:	Port facilities such as storage exist at the southern side.

Current environmental condition at Bushrod Power Station is shown in Table 1-1-1-2.

Table 1-1-1-2 Site Condition of Bushrod Power Station

Land Use	• The land has been used by LEC as a Power Plant than before civil war. • The candidate components site is used as a material yard.
Biological Environment	• Grass covers the candidate components site. • No valuable fauna/flora identified during the field survey. • No nest of avian found during the field survey.
Physical Environment	• Flat area partially covered with gravels. • No river stream and water environment exists. • No subsidence / soil erosion observed. • The geological conditions are under examination in the second field survey.
Human/Social Environment	• No resident inhabits at the site. • No cultural/historical monument exists.
Conservation Area	• The site is not designated as a conservation area. • Mesurado Wetlands, a Ramsar treaty designated site, locates approximately 4 km south-east from the site.

1-1-1-3 Laws and Regulations relating to the Environmental and Social Consideration

(1) Organizations for Environmental and Social Consideration

1) Environmental Protection Agency (EPA)

Prior to the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, the Liberian environmental policy rather focused on the conservation of the nature and natural resources. The National Environmental Commission of Liberia (NECOLIB) was established in 1997. In accordance with the set of the Environment Protection Agency Act of Liberia in 2002, NECOLIB was promoted to EPA.

Article 5 of the law for establishment of environmental protection agency grants the authority to EPA to supervise environmental management, monitoring, auditing and discussion among relevant

institutions for coordination of environmental management. Therefore, EPA is responsible for review and approval of Project Brief and environmental impact assessment in this Project.

2) Liberia Electricity Corporation (LEC)

Although there is no specific section dealing with the environmental and social issues in LEC, the Planning Department was appointed as the main section for environmental and social consideration including obtaining environmental permit.

(2) Laws, Regulations and Policy for Environmental and Social Consideration

1) National Environmental Strategy

The first national environmental strategy was set in 2003. The strategy provides all national institutes, private sectors and individuals shall have obligation in appropriate management of natural resources and environment for avoiding irreversible impact on the environment caused by the activities.

2) Environment Protection and Management Law

The law became in effectuation in 2002 for the objectives of sustainable development and promotion of environmental management. The chapter 3 provides environmental impact assessment, environmental auditing and monitoring. The clause 6 and annex 1 provides the activities required for implementation of environmental impact assessment and obtaining environmental permit. Among energy sectors, such activities as production and distribution of electricity, gas, steam and hot water, solar power generation and nuclear power generations are the activities required for implementation of environmental impact assessment and obtaining environmental permit whereas there is no description on the capacity or size of the projects.

3) Environmental Impact Assessment Procedural Guidelines

The guidelines were issued in 2006 for providing the methodology of implementation of environmental impact assessment and review. Figure 1-1-1-2 shows the flow for granting environmental permit. The executing agency who intends to implement the activities as listed under the environmental protection and management law is required to submit application and the project brief. EPA will review and evaluate such documents submitted from the executing agency, and may grant environmental permit or may instruct implementation of further detailed survey or environmental impact assessment study. In accordance with the instruction by EPA, sorely certified Liberian consultants are allowed to prepare application documents.

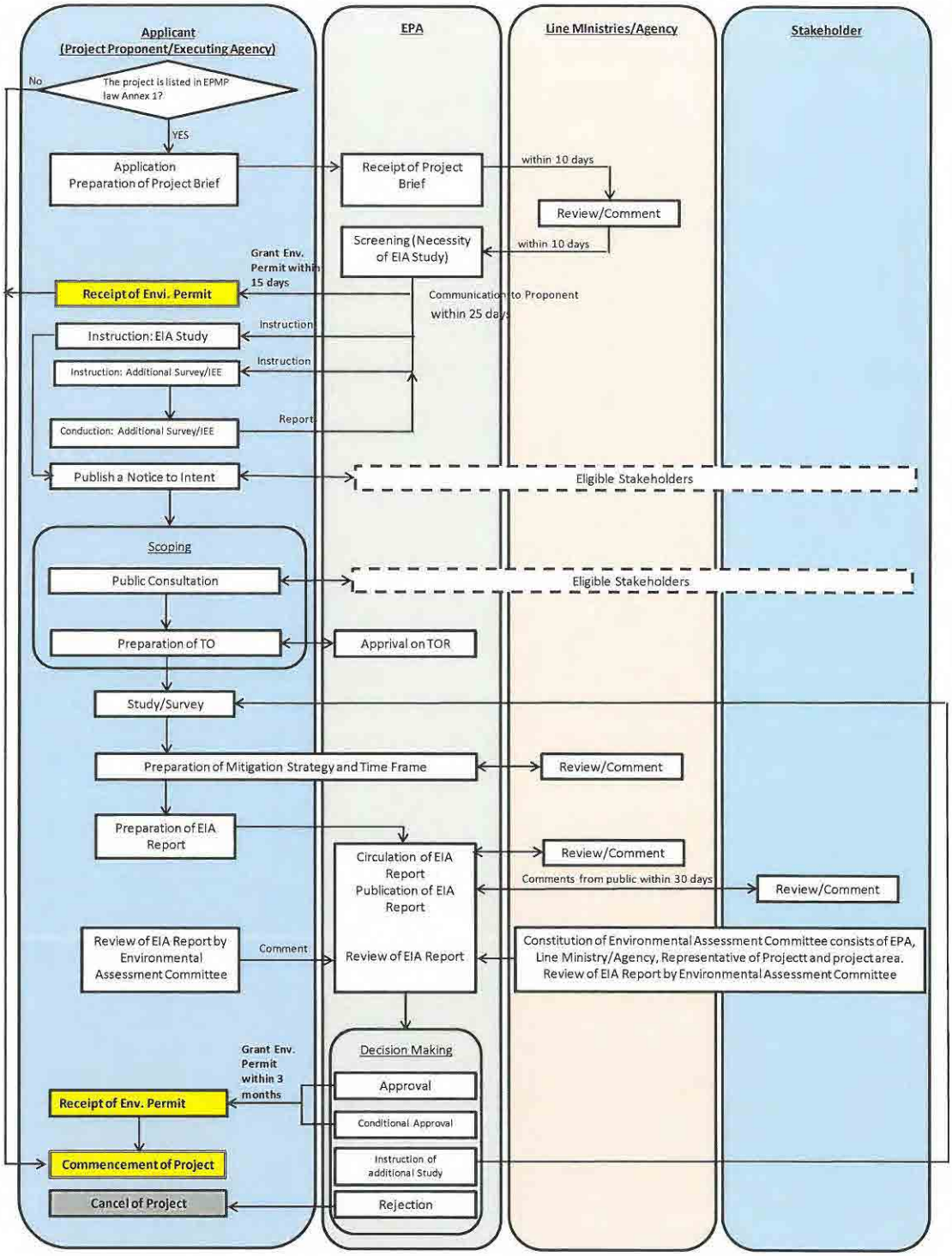


Figure 1-1-1-2 EIA Process in Liberia

4) Consistency with the JICA's Environmental and Social Consideration Guidelines

JICA's Environmental and Social Consideration Guidelines dated in April 2004 is applied to this Project. Comparing to the JICA's Guidelines and relevant Liberian regulations, laws and guidelines, Liberian EIA regulations includes such activity as public participation and information disclosure, therefore, the consistency with the JICA's guidelines was confirmed. Although the term, Strategic

Environmental Assessment (SEA) is not provided in the relevant Liberian guidelines, Liberian EIA procedures require comparison of the subject project with alternative options including zero option (without project case). This point is also consistent with the JICA's guidelines.

5) Status of Environmental Permit for the Project

In accordance with the Environmental Protection and Management Law and Environmental Impact Assessment Procedural Guidelines, the Project is required to obtain an environmental permit from the EPA.

Besides this Project, there are plans to construct a 10 MW of HFO fired medium speed diesel generator under the assistance of the World Bank and a 10 MW of medium speed diesel generator under financed by the LEC's own budget as shown in Figure 1-1-1-3 From the point of view of rationality, LEC aims to obtain one environmental permit combining three projects in one and will perform environmental impact assessment using LESEP budget supported by World Bank. A consultant will be assigned in August 2012, who will conduct Environmental and Social Impact Assessment (ESIA) for the HFO diesel generator projects (Total 30 MW, supported by World Bank, Liberian government funds and Japan's Grant Aid) and HFO storage tank repair related works. After establishing contract, the consultant will perform ESIA for 36 weeks including grant the environment permit (estimated to complete in April 2013).

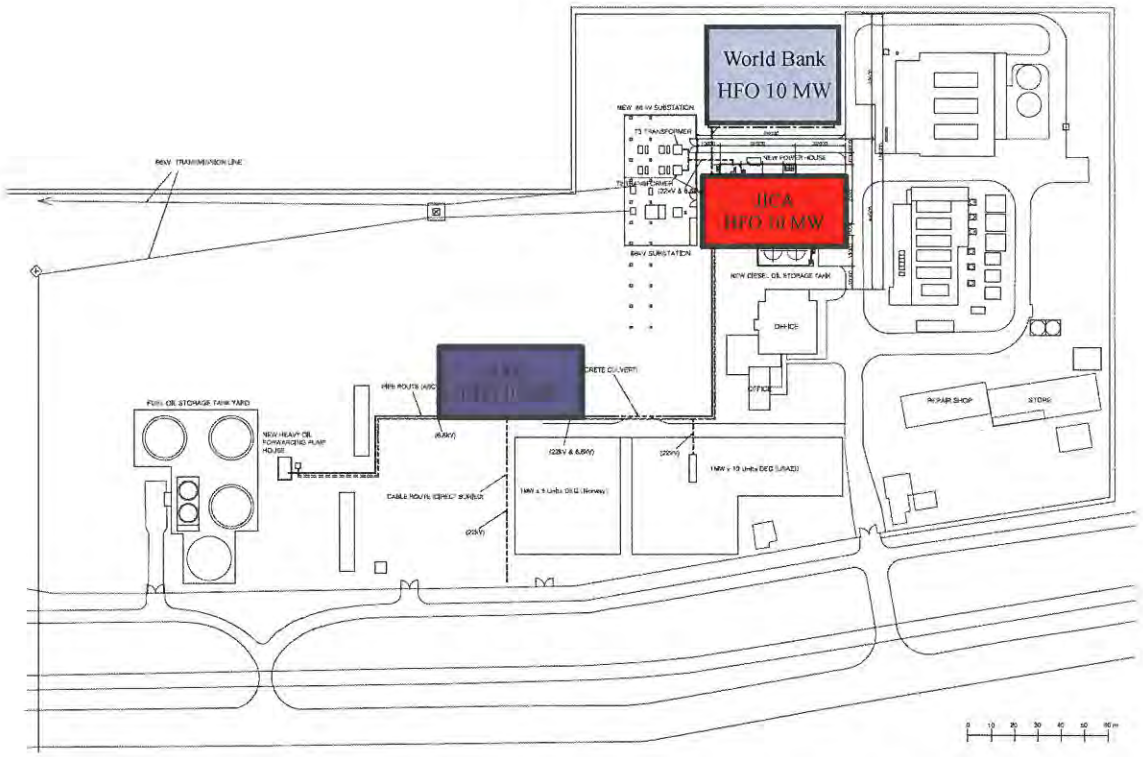


Figure 1-1-1-3 Power Plant Construction Plan by own fund, World Bank and Japanese aid

1-1-1-4 Comparison of the Substitute Plan

Zero Option （without project） Alternative Project Option

Two substitute plans against this Project was compared, one is zero option (not perform this project) and the other one is alternative project option (Solar Power Generation). The evaluation is shown in Table 1-1-1-3 below. Zero option case would result no improvement of power supply in Monrovia and would result negative effect on social economy. Though Solar Power Generation is advantage in environmental point of view, 10 MW class facility has is technical difficulties and power supply is not stable. In addition to this, the estimated budget is five times from planned Project, it is not realistic. From this evaluation, this Project is most realistic and the best solution.

Table 1-1-1-3 Alternative Project Option

Component	Diesel-HFO Power Generator	Renewable Energy (Solar Power Generator)	Zero Option (without project)
Description	Requested components.	Solar power panel is deployed for generating 10 MW.	No generator is install and the land remain as the present status
Capacity	5 MW x 2 units	Total 10 MW	0 MW
Technical Aspect	5MW generator is available to procure in the market. Constant power supply is available.	The maximum generation capacity is approximately 2 MW in common practice and it is not technically feasible at this moment. Generation depends on weather and day/night time, and then generating power varies.	-
(Evaluation)	++	--	0
Land Use	As shown in this Project plan, LEC and the other donor facility construction is available on the same site.	Approx. 200,000 m^2 of land required for 10 MW generation and affects new power station construction plan significantly.	The land can be used for the future plan.
(Evaluation)	+	--	++
Approximate Cost*	JPY 1.5~2.0 billion	Approx. JPY 6 billion	JPY 0
(Evaluation)	0 (as this Project)	-	++
Environmental Aspect	ight environmental impact esumed but limited at the te.	Clean and renewable energy and almost no impact for environmental condition.	No environmental deterioration is expected.
(Evaluation)	-	++	++
Social Aspect	Contributing economic development	Unstable energy supply is disadvantage for economic development.	Zero option will delay economic growth due to lack of energy supply.
(Evaluation)	+	0	--
Overall Evaluation	Cost effective and most optimum plan in technical aspect.	This option is not recommended due to cost and technical feasibility.	Lack of power supply lead to delay in economic growth in Monrovia. Therefore, this idea is not recommendable.
(Evaluation)	+	-	--

1-1-1-5 Scoping

Based on the requested contents and site reconnaissance results and following GUIDELINES FOR ENVIRONMENTAL AND SOCIAL CONSIDERATIONS, scoping was implemented. It was confirmed that the implementation of this project does not cause irreversible and significant environmental influence. In addition, it has been confirmed that there will not occur involuntary resettlement. On the other hand, it has been confirmed that considerations for air pollution, water pollution, waste material, noise and vibration, infectious disease such as HIV/AIDS, working environment, accident and climate change are required.

Table 1-1-1-4 Scoping (Primary Site Survey)

Item	No.	Parameter	Evaluation		Evaluation / Reason
			Construction	Operation	
Pollution	1	Air Pollution	C-	C-	**Construction** : Due to operation of construction machine/vehicles, temporal air pollution is forecasted. **Operation** : Operation of the power plant may cause deterioration of air quality. However, considering the size of the facility, the degree of the deterioration is limited at the Project site.
	2	Water Pollution	C-	C-	**Construction:** Due to excavation at the project site, some turbid water may be generated. However, the quantity is limited and it is planned appropriate turbid water treatment system will be installed. **Operation:** Cooling water circulates the power generation system. However, this water runs in a closed system. Therefore, no continuous discharge of water is expected.
	3	Waste Materials	C-	C-	**Construction:** No operation for replacement of the existing transformer, etc. is expected. However, a special attention for appropriate treatment of waste materials should be paid.

					Operation: Ash generated from Heavy Fuel Oil should be appropriately treated.
	4	Soil Contamination	D	D	The project will not trigger soil contamination.
Pollution (Cont'd)	5	Noise / Vibration	C-	C-	**Construction:** Increase number of construction machine and vehicles may cause noise and vibration temporally. **Operation:** Noise generated from the power generator is expected. However, the generator units are installed in the building. Considering the size of Bushrod Power Station, the impact will be limited at the site.
	6	Subsidence	D	D	No project components cause subsidence.
	7	Odor	D	D	No project components cause odor.
	8	Sediments	D	D	No project components cause deterioration on sediments.
Natural Environment	9	Protected Area	D	D	The project site is not located at protected areas designated by the laws. The Ramsar site is approximately 4 km south-east from the site.
	10	Ecosystem	D	D	**Construction:** Since the project site is the existing power station, no valuable creature is expected. **Operation:** The project components will not impact on local ecosystem.
	11	Hydrology	D	D	No river / ocean / reservoir / moor exist at the project site. In addition, no work and facility construction is planned that will cause any impact on site.
	12	Geology	D	D	Large scale excavation is not planned. Therefore, no project component impact on geological condition.

Social Environment	13	Resettlement	D	D	**Construction:** The Bushrod Power Station already exists and no resettlement is required. **Operation:** Operation of the facilities will not cause resettlement.
Social Environment (Cont'd)	14	Poverty	D	B+	**Construction:** The Bushrod Power Station already exists and no poverty exists on site. **Operation:** The LEC master plan aims to expand the supply of electricity to poverty areas on a priority basis. Electricity supply will contribute to expansion of social services and capacity of capital market. Therefore, it gives positive effect.
	15	Minority Race	D	D	No minority race inhabits near the project site.
	16	Employment	C+	B+	**Construction:** Construction works may lead to employment of local residents. **Operation:** Electricity supply will improve social services and expansion of market. Therefore, it gives positive effect.
	17	Land Use	D	D	No project components impact on land use of the project site.
	18	Water Right	D	D	No project components impact on water right.
	19	Existing Social Infrastructure	D	B+	**Construction:** Since the Project site has sufficient capacity for construction vehicles, any social impacts such as traffic jam are not forecasted. **Operation:** Electricity supply will improve the existing social infrastructure such as medical facilities and schools.
	20	Society / Capital Market	D	D	No project components impact on Society / Capital Market.

Social Environnement (Cont'd)	21	Unbalance of Benefit	D	D	Project component will not effect on social benefit.
	22	Interests in the Region	D	D	Project component will not effect on interests in the region
	23	Heritage	D	D	No heritage exists at the project site.
	24	Landscape	D	D	The surrounding areas, there is no point of view and landscape resources and the project area. The power generation facility is a low layer building, no effect on the landscape
	25	Gender	D	D	Project component will not effect on gender issue.
	26	Right of Children	D	D	Project component will not effect on right of children.
	27	Infection such as HIV / AIDS	C-	D	There is a possibility of the spread of infectious diseases due to inflow of construction workers and who will not receive adequate EHS training.
	28	Labor Environment	C-	D	**Construction:** Complying with the Liberian Labor regulation is required. **Operation:** Operation of the facility will not cause adverse effect on labors.
Others	29	Accident	C-	C-	**Construction:** Construction works may cause accidents. **Operation:** Appropriate training is required for avoiding accidents.
	30	Climate Change	D	C-	Considering the size of the power station, the project will not significantly impact on the climate change.

A± : Significant Impact is expected
B± : Some Impact is expected
C± : Minor Impact is expected
D: No Impact is expected

1-1-1-6 TOR for Environmental and Social Consideration

Based on scoping results, Terms of Reference (**TOR**) for environmental and social considerations was studied and the results are shown in table below.

Table 1-1-1-5 Terms of References for Environmental and Social Consideration Study

No	Item	Evaluation	Survey Contents	Methodology
1	Air Pollution	Con: C- Oper: C-	• Understanding present air quality • Ambient air quality standard • Impact of the project activity on the air pollution	• Field survey at and near the site • Interview with relevant organization • Analysis based on the previous studies
2	Water Pollution	Con: C- Oper: C-	• Impact of turbid water	• Field survey at and near the site • Analysis of the existing measurement methods and design
3	Waste Materials	Con: C- Oper: C-	• Treatment methods of construction waste materials and soils • Treatment methods of generated wastes from the facility	• Interview with relevant organization • Study on the similar facility cases
5	Noise and Vibration	Con: C- Oper: C-	• Detection of present noise level • Environmental standards • Impact of the Project activity on noise and vibration	• Field survey at and near the site • Interview with relevant organization • Concept and design study • Calculation of the future noise level
27	HIV/AIDS	Con: C-	• Present level of infection disease and governmental policy	• Study on similar cases (national policy and strategy) • Interview with relevant organization • Interview with surrounding residents
28	Labor Environment	Con: C-	• Measure for protection of labor environment	• Literature survey • Study on similar cases
29	Accident	Con: C- Oper: C-	• Accident cases	• Literature survey • Study on similar cases
30	Climate Change	Oper: C-	• Impact of greenhouse gases generated from the facility	• Literature survey • Simple examination of the impact (volume of greenhouse gas emission)

Con: construction phase. Oper: operation phase

[Source] : JICA investigation team

1-1-1-7 Analysis of Impact for Environmental and Social Consideration

(1) Air pollution

No periodical air quality monitoring has been conducted in Liberia. There is no specific source of air quality pollutants except the existing Bushrod Power Station in the Project area. Below table shows the tentative air quality standard adopted by EPA and applied for the Project evaluation. Considering the characteristics of the Project site as the existing power plant station and surrounding areas as port facilities including warehouses, etc., it is appropriate in this Project to apply the standards applicable for industrial areas.

Table 1-1-1-6 Tentative Air Quality Standard.

Pollutants	Time-weighted average	Concentration in ambient air		
		Industrial Areas	Residential, Rural & other Areas	Sensitive Areas
Sulfur Dioxide (SO_2)	Annual Average	80 μg/m³	60 μg/m³	15 μg/m³
	24 hours	120 μg/m³	80 μg/m³	30 μg/m³
Oxides of Nitrogen (NO_2)	Annual Average	80 μg/m³	60 μg/m³	15 μg/m³
	24 hours	120 μg/m³	80 μg/m³	30 μg/m³
Suspended Particulate Matter (SPM)	Annual Average	360 μg/m³	140 μg/m³	70 μg/m³
	24 hours	500 μg/m³	200 μg/m³	100 μg/m³
Respirable Particulate Matter (RPM) (size less than 10 microns)	Annual Average	120 μg/m³	60 μg/m³	50 μg/m³
	24 hours	150 μg/m³	100 μg/m³	75 μg/m³
Lead (Pb)	Annual Average	1.0 μg/m³	0.75 μg/m³	0.50 μg/m³
	24 hours	1.5 μg/m³	1.00 μg/m³	0.75 μg/m³
Ammonia	Annual Average	0.1 mg/ m³	0.1 mg/ m³	0.1 mg/m³
	24 hours	0.4 mg/ m³	0.4 mg/m³	0.4 mg/m³
Carbon Monoxide (CO)	8 hours	5.0 mg/m³	2.0 mg/m³	1.0 mg/ m³
	1 hour	10.0 mg/m³	4.0 mg/m³	2.0 mg/m³

【Construction Phase】

Several construction machines will be operated during the construction phase temporally. . Therefore, minor impact on the surrounding air quality is anticipated.

For mitigating the impact, the following measures will be applied for the construction machines.

- By flattening the construction schedule, avoid concentration of machinery works.
- During construction machinery works at Project site, consider stop idling as much as possible.
- Try to use lower gas emissions type construction machinery as much as possible.
- At the dust-prone work place, prevent the scattering of dust by spraying or the like as appropriate. In addition, consider the use of the dustproof net as necessary.

The distance from the Project site to the nearest house is approximately 150 m and there is no resident within boundary of the Project site. The above-mentioned protection measures will be taken with considering the wind direction. Therefore, the impact on the construction activity on the environment is not significant and is limited to the Project site.

2) Operation Phase

According to LEC, there has been no complaints from local residents concerning to the air pollution caused by the existing power plant. The design condition of generators in this Project is as shown in Table 1-1-1-7. The generator is intended to introduce a small and emission standards have not been established in Liberia. By comparison of environmental standards, this Project is planning to select equipment that complies with the more stringent emission standards in Japan

As a mitigation plan in this Project, the height of chimney will be increased as much as structural design allows for enhancing the diffusion. Therefore, the impact of operation of the facility onto the surrounding environment is limited and is not significant.

Table 1-1-1-7 Design Conditions for Generators

Items	Components
Generation Capacity and Numbers of Sets	5MW x 2 sets
Exhaust Gas Amount	31,600Nm^3/h per one generator
Exhaust Gas Temperature	365 °C
Nitrogen Oxides Concentration in the exhaust gas	950ppm
Sulfuric Oxides Concentration in the exhaust gas	500 ppm (Sulfur contents: 2% in HFO)
Height of Chimney	Approximately 17 m
Diameter of Chimney	0.85m
Environmental standards in Liberia Descriptions in parentheses are Japanese environmental standards	NOx : 0.08ppm (Japan: 0.04 ~ 0.06 ppm) SOx : 0.08ppm (Japan: 0.04 ppm)

(2) Water Pollution

There is no periodical monitoring and measurement for water quality, such as rivers, lakes and seas in Liberia

【Construction Phase】

Civil and generator installation work for this Project plans small scale underground excavation. This may cause impact on water quality surrounding waters with muddy water, the sediment discharge from the plant site. Following countermeasures are considered for such impact. Since there are no rivers for live use by residents, the impact of water pollution caused by construction work will be limited.

- There are dry and rainy seasons in Liberia, civil and excavation works will be minimized to reduce the effects of sediment runoff.
- To prevent direct runoff of high concentration muddy water, provide turbid water treatment facilities such as settling basin.

【Operation Phase】

When the generator is placed in service, cooling water is required. Plant design for this site plans to adopt closed cooling water recirculation system. Therefore, permanent and large-scale drainage is not planned. Though it is presumed impact of water pollution by discharging waste oil such as fuel oil and lubrication oil, this plant will equip waste oil treatment unit (design capacity: oil concentration less than 5 mg/litter) and the treated water will be discharged to sea through water discharge trench on site, the impact will be slight.

(3) Waste Materials

【Construction Phase】

During construction, waste soil due to underground excavation occur about 1,600 m^3 and the treatment needs to be considered.

The waste soil produced by the excavation work is planned to utilize for backfill or re-use on site. Also, not re-usable waste soil will be carried out to disposal site by local company that is licensed from EPA and Monrovia city to dispose adequately. Therefore, the impact caused by waste treatment on site during construction period will be small.

【Operation Phase】

When the generator is placed in service, sludge (residual oil) treatment is a concern. There is a plan to install sludge treatment unit and waste oil incineration unit to handle waste adequately. Therefore, the impact caused by waste treatment on site during construction period will be small. Noise and Vibration

(4) Noise and Vibration

【Construction Phase】

No environmental standard on noise and vibration has been established in Liberia.

It is anticipated noise may be generated during the construction due to operation of heavy machine and construction works. The following measures shall be adopted for mitigation of the impact.

- Low-noise type of machines shall be employed if applicable
- Temporary enclosure of the site (approximately 3m) shall be adopted during the construction works
- Construction method and schedule will be carefully examined for minimizing noise and vibration generations
- Encouragement of idling reduction to the workers

The nearest residential area locates approximately 150 m from the Project site. In addition to the above-mentioned mitigation measures, it is expected the concrete wall surrounding the existing Project site (20 cm in thickness and 3 m in height) acts as sound insulation structure. Therefore, the impact of the Project is not significant and is limited to the Project site.

【Operation Phase】

The generators, which are the main sources of noise, are planned to be installed inside the power plant. The JICA Study Team identified the nearest house locates approximately 150m north side from the Project site. Between the Project site and the nearest house, there are two existing plants with the height of approximately 20 m and 40 m, respectively. Additionally, there is a concrete wall with the height of approximately 3m along the boundary of the station. Such existing buildings and walls act as noise insulation structures. Therefore, it is expected that the impact of the noise caused by operation of the generators is minor and negligible.

Besides, LEC is expected to regularly inspect and repair the generators and other facilities for minimizing any unexpected noise generation as a measure for noise due to lack of appropriate maintenance works.

(5) Infection such as HIV/AIDS

【Construction Phase】

Though large scale construction is not planned for this project on site, there is a possibility of the spread of infectious diseases due to inflow of construction workers and who will not receive adequate EHS training.

According to the statistic report by the UNICEF （At a glance: Liberia, UNICEF）, as of 2009 the HIV positive/infected percentage in Liberia is approximately 1.5% of the entire nation.

Liberia has a strong policy against HIV/AIDS especially upon inauguration of the President Saarif in 2005 in cooperation with U.N. agencies such as WHO or UNDP. LEC is expected to strongly encourage the contractor(s) to conduct HIV/AIDS measures including education programs during the construction period in accordance to the present governmental policy. Therefore, the impact of the Project is considered as minor and negligible.

(6) Labor Environment (Including occupational safety)

【Construction Phase】

At this Project, no large scale construction is assumed, however, when performing construction work, there is a need to consider the labor environment of construction workers.

As the countermeasure, formulate the construction plan that consider safety concerns and assign safety management responsible person and perform EHS training for newly employed workers and conduct periodical safety meeting. Also consider the countermeasure for compliance with labor laws in Liberia (including issue of child labor etc.), the environmental impact during the construction work will be negligible.

(7) Accident

【Construction Phase】

According to the LEC, no major accidents have been recorded in previous construction works of similar facilities. However, Heinrich's law indicates considerable numbers of potential accidents are behind one serious and major accident. Under this Project, the LEC will strongly encourage the contractors to take necessary safety measures for avoiding accidents during the construction phase including;

- Appointing safety officer or person in charge for safety of construction works
- Encouraging to hold periodic safety meeting and safety/hygiene education to temporary workers if required
- Preparation of construction plan with consideration of safety aspects
- Periodic inspection of construction machinery and vehicle

【Operation Phase】

With in-service of power generation facilities, care must be taken against accidents.

LEC is expecting to comply with its safety management manual for avoiding any accidents. Besides, training will be implemented by the contractors for usage of the equipment upon installation and consultant will provide a soft-component for operation of the new generators under the Project.

(8) Impact of cross-border and Climate Change

【Operation Phase】

With in-service of power generation facilities, it is concerned increase of the amount of Greenhouse gas generation

Based on the formula in the report "the final report for project for formulation in electricity and energy sector as a measure against climate change" (2008, Japan Bank for International Cooperation (JBIC)), the amount of carbon dioxide emitted from the generators will amount to approximately 44,000 t-CO2 per year. However, in comparison with the global CO2 emission amount is approximately 32 billion t-CO2 per year. The quantity of emission from the Project site is far small.

Table 1-1-1-8 Prediction of Greenhouse Gases Emission

Items	Parameter
Annual Power Generation (GWh)	72
Heat Efficiency (Ratio) *	0.435
Carbon Emission factor for fuels **	20
CO_2 (t-CO_2)	43,697

* Interview with manufactures

** Formulation of Climate Change Research Project Guidelines in the Electric Energy Sector (August 2008, Japan Bank for International Cooperation (JBIC))

In addition, form the greenhouse gas reduction point of view, below mentioned countermeasures are planned. Therefore, this project considers the greenhouse gas reduction. From the perspective of reducing greenhouse gas emissions, it is planned to take the following measures. Therefore, this project has been considered to reduce the impact of greenhouse gas.

- Try to reduce HVAC load with structural considerations such as adopting adequate thermal insulation and air tightness.
- Try to adopt higher energy efficiency equipment and thoroughly perform periodical maintenance work.

1-1-1-8 Impact Assessment

Table 1-1-1-9 summarizes the evaluation of the impact forecasted on the course of the Project.

Table 1-1-1-9 Evaluation of the Impact

Item	No	Parameter	Scoping		Evaluation		Evaluation / Reason
			Const	Oper	Const	Oper	
Pollution	1	Air Pollution	C-	C-	B-	B-	Although minor impact may remain, impact can be eased by mitigation measures during the construction. The impact of operation of the facility is limited.
	2	Water Pollution	C-	C-	B-	B-	The impact can be minimized with mitigation measures including setting of sedimentation basin during construction phase and oil treatment system during operation.
	3	Waste Materials	C-	C-	B-	B-	Reuse of soil and waste materials will mitigate the impact during the construction. The waste generated during operation will be appropriately treated.
	4	Soil Contamination	D	D	N/A	N/A	-
	5	Noise / Vibration	C-	C-	B-	B-	Noise during the construction can be mitigated by applying mitigation measures. The impact of noise level during operation phase is forecasted as minor since there is approximately 150m of distance to the nearest house, existence of two existing building structures and walls with a height of 3m between the plant and the nearest house.
	6	Subsidence	D	D	N/A	N/A	-
	7	Odour	D	D	N/A	N/A	-
	8	Sediments	D	D	N/A	N/A	-
Natural Environment	9	Protected Area	D	D	N/A	N/A	-
	10	Ecosystem	D	D	N/A	N/A	-
	11	Hydrology	D	D	N/A	N/A	-
	12	Geology	D	D	N/A	N/A	-
	13	Resettlement	D	D	N/A	N/A	-
	14	Poverty	D	B+	N/A	N/A	-
	15	Minority Race	D	D	N/A	N/A	-
	16	Employment	C+	B+	N/A	N/A	-
	17	Land Use	D	D	N/A	N/A	-
	18	Water Right	D	D	N/A	N/A	-
	19	Existing Social Infrastructure	D	B+	N/A	N/A	-
	20	Society / Capital Market	D	D	N/A	N/A	-
	21	Unbalance of Benefit	D	D	N/A	N/A	-
	22	Interests in the Region	D	D	N/A	N/A	-
	23	Heritage	D	D	N/A	N/A	-
	24	Landscape	D	D	N/A	N/A	-

Item	No	Parameter	Scoping		Evaluation		Evaluation / Reason
			Const	Oper	Const	Oper	
	25	Gender	D	D	N/A	N/A	-
	26	Right of Children	D	D	N/A	N/A	-
	27	HIV / AIDS	C-	D	B-	N/A	Appropriate hygiene and HIV/AIDS education by the contractors will mitigate the impact.
	28	Labour Environment	C-	D	B-	N/A	LEC will encourage compliance of relevant laws, regulations and acts to the contractors.
Others	29	Accident	C-	C-	B-	B-	LEC will encourage compliance of safety regulations to the contractors. As a specific measure, trainings by the supplier and the consultant will be provided. Therefore, it is evaluated appropriate measures for accident is taken.
	30	Climate Change	D	C-	N/A	D-	Although an increase of CO_2 is forecasted, the impact is minor and will not cause climate change in consideration of the scale of the facility and emission amount.

Legend:

A± : Significant Impact is expected
B± : Some Impact is expected
C± : Minor Impact is expected
D: No Impact is expected

1-1-1-9 Cost for Mitigation Measures

With respect to social environment, natural environment and pollution, the evaluation is shown in Table 1-1-1-9 above, "Environmental and social impact assessment table" and the results are not impacting environmental conditions. Therefore, no special costs for the mitigation planning and the mitigation implementation is required.

1-1-1-10 Monitoring Programs

The monitoring programme was prepared for those items which require mitigation measures for minimizing the impact based on the LEC's capacity for environmental monitoring including technical and financial aspects as well as practical availability of resources. There is no additional cost appropriated for environmental protection purposes because those facilities such as turbid water treatment system, sludge treatment facility and waste oil incinerator are recognized as a part of standard power generation facilities and will be constructed under the Grant Aid scheme. On the other hand, the Liberian side is responsible for monitoring activities after commission and, therefore, the cost relating to monitoring activities shall be borne by the Liberian side. However, majority of the monitoring parameters set by the Project can be conducted as a part of ordinal route inspection, operation and maintenance. Therefore, no large scale additional budget is necessary for the Liberian side.

Table 1-1-1-10 Environmental management plan and monitoring plan (Construction phase)

No.	Impact items	Items	Management/Monitoring methods	Location	Timing and Frequency	Responsible Organization
1	Air pollution	Dust scattering situation	Visual confirmation	Within and around the project	During construction/ 2 times per month	LEC Subcontractor
2	Water pollution	Condition of muddy water	Visual confirmation	Within and around the project area	During construction/ 1 time per week	LEC Subcontractor
3	*Waste material*	Quantity of waste Treatment method/Transport destination	Visual confirmation/Confirmation of Monthly progress report	Within the project area	During construction/ 1 time per month	Subcontractor
5	Noise, Vibration	Complaints of residents of surrounding area	Interview	Around the project area	construction/2 times per month	LEC Subcontractor
27	Infection such as HIV/AIDS	Implementation status of EHS training	Confirmation of Monthly progress report	Around the project area	construction/1 time per month	LEC Subcontractor
28	Working environment (Including occupational safety)	Implementation status of EHS training	Confirmation of Monthly progress report	Around the project area	During construction/ 1 time per month	LEC Subcontractor
29	Accident	Implementation status of EHS training	Confirmation of Monthly progress report	Around the project area	During construction/ 1 time per month	LEC Subcontractor

Source : JICA investigation team

Table 1-1-1-11 Environmental management plan and monitoring plan (In-service)

No.	Impact items	Items	Management/Monitoring methods	Location	Timing and Frequency	Responsible Organization
1	Air pollution	Extent of the exhaust gas diffusion	Interviews with residents (Complaints (at any time))	In the project area and its vicinity	Time: After half a year in service Frequency/1 time/year	LEC
2	Water contamination	Presence or absence of oil spill	Visual confirmation of drainage channels	Drainage channels in the project area	Time: After half a year in service Frequency/ 1 time/week	LEC
3	Waste	Waste oil incineration operating condition	Record operating conditions of small waste oil incinerator	Around the project area	Time: After half a year in service Frequency/1 time/month	LEC
5	Noise and vibration	Opinion of local residents	Interviews with residents (Complaints (at any time))	In the project area and its vicinity	Time: After half a year in service Frequency/1 time year	LEC
29	Accident	Inspection and conforms to the safety Management Manual and Safety meeting implementation	Verifying safety control record	In the project area	Time: After half a year in serve Frequency: 2 times/month	LEC
30	Climate change and the impact of cross-border	Air-conditioning equipment operation and maintenance status Regular servicing status of equipment	Confirmation of equipment maintenance and inspection records	In the project area	Time: After half a year in service Frequency: 1 time/month	LEC

Source : JICA investigation team

1-1-2 Land Acquisition and Resettlement

Bushrod Power Station has been owned by LEC since the pre-civil water period. There is no formal and informal residents exist within the site of the station. Therefore, land acquisition and resettlement is not required for the Project.

1-1-3 Others

1-1-3-1 Monitoring Form (DRAFT)

The Monitoring Form (Draft) applied for this project is as follows.

(1) Monitoring Form (Construction)

1. Permit and Licensing, Explanation for the residents

Monitoring Items	Status during Reporting Period
Receiving complaints from local residents and stakeholders (At any time)	

2. Pollution Countermeasures

－Air quality (dust scattering situation)

Monitoring Items	Monitoring Results	Management/Monitoring methods	Location
Dusts		Visual Verification	Within the project area and Near the project area

－Water Quality (Conditions of Muddy water)

Monitoring Items	Monitoring Results	Management/Monitoring methods	Location
Muddy water		Visual Confirmation	Within the project area and Near the project area

－Waste Material

Monitoring Items	Monitoring Results	Management/Monitoring methods	Location
Waste Material	The amount of waste generated (Present month) Treatment Method Transport destination (place of final disposal)	Visual Confirmation Verification of monthly report, etc.	Within the project area

－Noise/ Vibration

Monitoring Items	Monitoring Results	Management/Monitoring methods	Location
Noise and vibration	Complaints Yes / No In case Yes, the contents of complaints	Interviews with residents	Near the project area

(2) Mentoring Form in This Project (In-service)

1. Permit and Licensing, Explanation to the residents

Monitoring Items	Situation during the reporting period
Receiving complaints from local residents and stakeholders (At any time)	

2. Pollution Countermeasures

－Air quality (Exhaust gas diffusion conditions)

Monitoring Items	Monitoring Results	Management/Monitoring methods	Location
The extent of the exhaust gas diffusion		Interviews with residents and reception at any time of the complaint	Near the project area

－Water Quality (Conditions of Oil/ Waste Oil)

Monitoring Items	Monitoring Results	Management/Monitoring methods	**Location**
Presence or absence of oil spill		Visual confirmation of discharge canal	Discharge Canal on the project area

－Waste Material

Monitoring Items	Monitoring Results	Management/Monitoring methods	Location
Sludge Treatment	Numbers of Startup (Present month)	Record confirmation of the operational status of small waste oil incinerator	Within the project area

－Noise/ Vibration

Monitoring Items	Monitoring Results	Management/Monitoring methods	Location
Noise and Vibration	Complaints Yes / No In case Yes, the contents of complaints	interviews with residents and reception at any time of the complaint	Near the project area

1-1-3-2 Environment Check List

The environment check list applied for this Project is as follows.

Category	Environmental item	Major check items	Yes: Y No: N	Concrete environmental and social considerations (Reasons for yes/no, grounds, mitigation measures, etc.)
1 Permit and explanation	(1) EIA and environmental permit	(a) Have the Environment Impact Assessment (EIA) Report etc. been created? (b) Have EIA Report etc. been approved by the central government of the partner country? (c) Does approval of the EIA Report etc. have collateral conditions? If yes, are the conditions satisfied? (d) In case any other permit or license is required, has such permit or license been obtained from the local competent authority?	(a) Y (b) N/A (c) N/A (d) N/A	(a), (b), (c) & (d) With the support of the World Bank (LESEP, Liberia Electricity System Enhancement Project), LEC is currently carrying out environmental analysis using a consultant approved by the Environmental Protection Agency (EPA) of Liberia. As part of the analysis, Environmental Impact Statement (EIS) is being developed. Approval of EIS and environmental permit are expected to be obtained by April 2013.
	(2) Explanation to local stakeholders	(a) Concerning the contents and impacts of the project, have the local stakeholders been provided with information and proper explanation? Do they understand? (b) Have comments from local residents and such been reflected on the contents of the project?	(a) Y (b) N/A	(a) & (b) Underway as part of the above-mentioned analysis
	(3) Consideration of alternatives	(a) Are more than one alternatives for the project plan considered? (Study items should include environmental and social items.)	(a) Y	(a) Based on JICA's Guidelines for Environmental and Social Considerations, alternatives including a zero option are considered in JICA's research.
2. Measure against Pollution	(1) Air quality	(a) For power generation facilities where biomass or other type of energy is burned, does the level of air contaminants such as sulfur oxides (SOx), nitric oxides (NOx) and dust released from the plant meet the country's emission standards and other environmental standards? (b) Does the level of other air contaminants from the facilities meet the country's emission standards etc.? Will measures for air quality be taken?	(a) N/A (b) Y	(a) N/A (b) Equipment that meets the strict emission standards of Japan is selected to prevent air pollution, and there are also other measures such as designing chimneys as high as possible.
	(2) Water quality	(a) Does effluent (including heated effluent) from power generation facilities etc. satisfy the country's effluent standards etc.? (b) Does leachate from the waste disposal sites satisfy the country's effluent standards and other environmental standards? Will there be measures to prevent such leachate from polluting soil, groundwater, ocean, etc.?	(a) Y (b) Y	(a) & (b) There will not be constant and large-scale discharge as a closed system will be adopted for cooling water. Such measures as installation of waste oil disposal equipment (design capacity below 5 mg of oil/ℓ) have been taken.
	(3) Wastes	(a) Will wastes from the facilities be properly treated and disposed of according to the country's regulations (especially for biomass energy)?	(a) Y	(a) It is expected that there will be some sludge. It will be properly treated in a small-scale incinerator that will be installed within the facilities.
	(4) Soil contamination	(a) Has the soil at the site been contaminated before? Will there be measures to prevent soil contamination?	(a) N	(a) There is no evidence to show the construction site for the project facilities has been contaminated before. However, in the property of the Bushrod Power Plant, there is soil contamination because heavy oil tanks and pipelines were destroyed during the civil war. Soil decontamination will be conducted with the support of the World Bank.
	(5) Noise and vibration	(a) Does the level of noise and vibration satisfy the country's standards? (b) In case of wind power generation, does the level of low frequency sound satisfy the country's standards?	(a) Y (b) N/A	(a) With about 150 m to the closest house, distance decay of more than 40 dB can be expected. Moreover, as noise will probably be intercepted by the building that will be constructed, existing buildings, concrete walls located on the border of the property (about 3 m high and 20 cm thick), etc., the impact of noise is going to be small. (b) N/A
	(6) Ground subsidence	(a) Is there a risk of ground subsidence caused by excessive extraction of groundwater?	(a) N	(a) Extraction of groundwater is not planned.
	(7) Odor	(a) Are there any odor sources? Will measures be taken against odor?	(a) N	(b) Generation of odor is not expected.

Category	Environmental item	Major check items	Yes: Y No: N	Concrete environmental and social considerations (Reasons for yes/no, grounds, mitigation measures, etc.)
3 Natural environment	(1) Sanctuary	(a) Is the site located in a sanctuary designated by the country's domestic law or international law? Will the project have impact on the sanctuary?	(a) N	(a) The project will be carried out in the property of the existing Bushrod Power Plant. The plant site is not a designated sanctuary and impact on any sanctuary is not expected.
	(2) Ecosystem and biota	(a) Does the site include virgin forests, natural tropical forests, or ecologically-important habitats (such as coral reefs, mangrove coasts and dry beaches)? (b) Does the site include habitats of precious species of which protection is required under the country's domestic law and/or international law? (c) In case there is concern for serious impact on the ecosystem, will measures be taken to reduce such impact? (d) Will change in micrometeorological phenomena caused by wind power generation have impact on the precious vegetation in the area? (Is there precious vegetation near the wind power plant?) If yes, will appropriate measures be taken? (e) Are the wind power generation facilities (windmills) going to be installed in consideration of habitats of precious bird species and courses of migratory birds?	(a) N (b) N (c) N (d) N/A (e) N/A	(a), (b) & (c) The designed site will be in the existing Bushrod Power Plant. The plant site is not a designated sanctuary and impact on any sanctuary is not expected. (d) & (e) N/A
	(3) Hydrometeor	(a) Will the establishment of the facilities cause change in the water system? Will it have adverse impact on stream regime, ocean waves, tidal currents, etc.?	(a) N	(a) There are no rivers or such in the designed site. The project is not expected to have impact on hydrometeor.
	(4) Geography and geology	(a) Will the project cause major changes in the topographic or geological features around the designed site?	(a) N	(a) In the project, large scale excavation or such is not planned and no alteration of topographic/geographical features is expected.
4 Social environment	(1) Relocation of local residents	(a) Will the project implementation involve involuntary relocation of the local residents? If yes, will there be efforts to minimize the impact of such relocation? (b) Will the residents to be relocated get proper explanation in advance concerning compensation and measures to rebuild life? (c) Will there be a research for relocation of the residents? Will a relocation plan be developed, covering compensation based on reacquisition price and reconstruction of base for living? (d) Will compensation be paid before relocation? (e) Is the compensation plan documented? (f) When the plan was developed, was due consideration given to the residents to be relocated, especially the socially vulnerable such as women, children, elderly people, ethnic minorities and indigenous people? (g) Will the prior consent of the residents to the relocation be gained? (h) Will a framework be developed for proper implementation of the relocation? Will there be sufficient capacities and budget? (i) Will monitoring of the impact of the relocation be planned? (j) Is there an established system to handle complaints?	(a) N (b) N/A (c) N/A (d) N/A (e) N/A (f) N/A (g) N/A (h) N/A (i) N/A (j) N/A	(a) As the designed site is in the existing Bushrod Power Plant, there are not residents. (b), (c), (d), (e), (f), (g), (h), (i) & (j) N/A
	(2) Lives and livelihoods	(a) Will the project have any negative impacts on the life of the residents? Will measures be taken to mitigate such impacts when necessary? (b) Will the water intake for the project (surface water and/or ground water) and/or discharge of effluent have impact on the use of existing water resources and water areas?	(a) N (b) N	(a) It is expected that stable power supply will have positive impact on the life of the residents. (b) Permanent and large-scale discharge is not planned.
	(3) Cultural assets	(a) Is there a possibility that the project will damage archaeologically, historically, culturally or religiously precious assets or sites? Will the measures designated by domestic law of the country be considered?	(a) N	(a) The designed site does not have cultural assets or such.
	(4) Landscape	(a) If there is a particular landscape that extra consideration should be given to, will there any negative impact on it? If yes, will necessary measures be taken?	(a) N	(a) There is no landscape that requires particular consideration.

Category	Environmental item	Major check items	Yes: Y No: N	Concrete environmental and social considerations (Reasons for yes/no, grounds, mitigation measures, etc.)
4 Social environment	(5) Ethnic minorities and indigenous people	(a) Are there any measures taken to ease the impact on the culture and lifestyle of ethnic minorities and/or indigenous people? (b) Will the land and resource rights of ethnic minorities and/or indigenous people be respected?	(a) N/A (b) N/A	(a) & (b) There are no ethnic minorities or indigenous people around the planned site.
	(6) Labor environment	(a) Will the project comply with the country's labor environment related laws that the project should observe? (b) Will there be tangible safety measures concerning accident prevention for those involved in the project, such as installation of safety equipment and hazardous material management? (c) Will intangible measures be planned and carried out for those involved in the project, such as development of a safety and health plan and provision of safety training (including traffic safety and public health) to workers and such? (d) Will appropriate measures be taken to prevent the security staff for the project from threatening the safety of those involved in the project and the local residents?	(a) Y (b) Y (c) Y (d) Y	(a) Concerning labor and health, Liberia's relevant laws will be observed. (b), (c), & (d) Design was conducted in compliance with Japanese and international standards as well as Liberia's relevant laws. Sufficient safety measures have been taken to the extent possible.
5 Others	(1) Impact during construction	(a) Will measures be prepared to mitigate pollution during the construction (noise, vibration, murky water, dusts, emission, wastes, etc.)? (b) Will the construction have negative impact on the natural environment (ecosystem)? Will measures be prepared to mitigate such impact? (c) Will the construction have negative impact on the social environment? Will measures be prepared to mitigate such impact?	(a) Y (b) N (c) N	(a) Appropriate mitigation measures have been taken to the extent possible. (b) & (c) Monitoring is expected to ease negative impact.
	(2) Monitoring	(a) Out of the above-listed environmental items, will monitoring of the business operator be planned and carried out for the items that may have impact? (b) How are the items, methods, frequency, etc. determined in the plan? (c) Will there be an established system (organization, staff, equipment, budget, etc., and continuity of such) to monitor the business operator? (d) Are there established rules concerning the method, frequency, etc. of the reports from the business operator to the competent authorities?	(a) Y (b) Y (c) Y (d) Y	(a) & (b) It is planned to the extent that LEC can implement. (c) & (d) Monitoring will be conducted as part of regular operation maintenance.
6 Points to	Reference to other environmental check lists	(a) Relevant items on the check list concerning power transmission, transformation and distribution should be added for evaluation when necessary (e.g., in case there is construction of facilities for power transmission, transformation or distribution facilities).	(a) N/A	(a)
	Notes for the use of the environmental check list	(a) Impact on cross-border or global environmental issues should also be checked when necessary (e.g., in case there are some elements concerning cross-border waste treatment, acid rain, ozone layer destruction or global warming).	(a) N/A	(a)

1-1-3-3 Others

LEC is to follow up below items in accordance with Consultations Minutes signed between JICA, MLME, and LEC on the 26th of January, 2012.

- Environmental survey sponsored by the World Bank
- Acquisition of environmental permits by April 2013

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Purpose

National Energy Policy (NEP, January 2009), which is situated as the higher strategy to the electric power sector policy addresses the following four principal policy objectives. The Project will contribute to realize ① and ② of the following policy objectives of NEP.

Four Pillars of the National Energy Policy

① **Establish universal access to energy including establishment of an energy master plan**
② **Protect vulnerable customers and minimize energy production cost**
③ **Apply world-class best practices to the energy sector**
④ **Promote public private partnership (PPP) in the energy sector**

In addition, NEP sets the policy target that 30% of the urban and peri-urban population shall have access to reliable modern energy services enabling them to meet their basic needs by 2015. On the other hand, the LEC's Electric Master Plan aims to improve electricity access in Monrovia from current 1% to 14% by 2015. The Project will help realize the LEC's Electric Master Plan which entails the achievement of NEP's policy objectives.

2-1-1 Outline of the Project

In order to achieve the objectives described above, the Project shall install power generating equipment in the Liberian capital of Monrovia. By shouldering a part of building a stable power supply system by strengthening supply capabilities, the socio-economic stimulation of Monrovia and improvement of citizens' lives is envisaged.

The contents of the Project are (i) procurement and installation of 2x5MW, HFO fired diesel generators at existing Bushrod power station and (ii) procurement of maintenance vehicles for distribution network.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Design Policy

(1) Design Policy for the Temperature and Humidity

This region has a tropical monsoon climate, with mostly unvarying temperatures throughout the year between 24.7°C and 27.5°C. The annual average humidity is 88.4%. Since the engines and generators procured for the Project will be installed within a building structure, special measures are

not necessary for outside air humidity. However, in terms of design for combustion air for the engine and ventilation for the engine room, the design temperature will be set at 40°C and at 35°C for the electrical room. In addition, steps will be taken to ensure that the outdoor equipment is functional at 40°C.

(2) Seismic Conditions

As there is no record of earthquakes in Liberia, no considerations shall be made regarding earthquakes.

2-2-1-2 Concept regarding Social and Economic Conditions

In Liberia, there is no custom for observing Ramadan, thus no effect on the construction period, etc. is anticipated. However, prior to beginning construction on the powerhouse, it is necessary to notify the neighboring residents in advance, as well as to gain their understanding regarding implementation of the Project.

2-2-1-3 Concept regarding Construction Situation

The primary industries of Liberia are mining (iron ore) and agriculture/forestry (natural rubber, timber), but there are also approximately 50 construction companies within Monrovia. Although construction work has been done for reinforced concrete block structures of 3~4 floors in the city, building construction for the steel structures planned for the Project has not been observed. Therefore, other than unskilled laborers, it will be difficult to secure local technicians with a certain level of skill to accommodate the Project.

2-2-1-4 Concept regarding Utilization of Local Contractors and Local Equipment and Materials

(1) Utilization of Local Contractors

For power generation equipment installation work and facility construction work for this cooperation project, local construction companies will primarily be used for providing construction work equipment and labor. It will also be necessary to dispatch engineers from Japan for quality control, schedule control, safety management, and commissioning, etc.

(2) Utilization of Local Equipment and Materials

Local procurement is possible for materials and equipment for concrete work such as aggregate and cement, as well as for foundation work materials. However, since local procurement is not possible for reinforcing steel, structural steel framing, roof/wall materials for steel structures, wall material, facility materials, pipes for power generation equipment, and materials and equipment for mechanical/electrical work such as cables, procurement from Japan or a third country will be considered.

(3) Procurement of third country products

When procuring materials and equipment from the third country, the following should be thoroughly considered: price, quality, delivery time, ease of procuring spare parts, etc. after beginning operations, after-sales service system, and compatibility with existing equipment, etc.

Additionally, all of Liberia's power generation equipment and materials are imports, with mostly European products used. Therefore, in regard to equipment such as circuit breakers for generation facilities installed for the Project, procurement from a third country will be thoroughly considered.

(4) Concerning architecture

Within Liberia, unskilled labor, transport vehicles, and construction work equipment can be locally procured with relative ease. Securing local labor for civil engineering/foundation work and construction of the powerhouse structure for the Project can also be done with relative ease. However, since equipment for piling work is not available in Liberia, procurement from a third country will be considered.

In contrast, for setting up the power generation equipment and for constructing the relatively tall, steel-frame structure powerhouse for the Project, it would be difficult to use local contractors for anything other than laborers due to the necessity of using technicians with a high level of skill. Therefore, it is necessary to dispatch engineers from Japan or a third country to perform quality control, technical advice, and work supervision.

2-2-1-5 Concept regarding Setting of Facilities and Equipment Grades

For a design that is both technically and economically appropriate, standard grade materials with specifications that conform as closely as possible to international standards such as ASTM shall be used. Equipment compatibility shall be improved by using a smaller variety, and specification/quantity that meets minimum requirements shall be selected. However, since consistent quality control for materials, processing, and assembly is necessary for construction work on large-scale steel structures, procurement from Japan will be considered.

2-2-2 Basic Plan

2-2-2-1 Preconditions

In the Monrovia power system, generation capacity is insufficient for the power demand. Even when considering the development of power sources done with the assistance of other donors, the short and medium-term generation capacity is insufficient. Power generation equipment to be procured in this Project for Liberia needs to consider optimal selection of single unit capacity and numbers to compensate combining conditions of the shortage of emergency power supply by FY 2015 countermeasure (in-service of this generator), Mount Coffee hydroelectric power plant renovation, which is expected to occur after 2016 (First unit start-17MW in FY2016, 64MW at completion of all units) and power import from the West Africa Power Pool (18 MW in FY2016).

The peak demand of Monrovia city area in FY 2015 is predicted approx. 67 MW. When this Project is not implemented, with existing high speed diesel generator (available power output 15 MW), HFO fired diesel generator (10 MW) by World Bank and Liberian government own funds diesel generator (10 MW), the total is only 35 MW and the shortage is 32 MW. On the other hand, first unit of the Mount Coffee hydraulic starts commercial in FY 2016, and import from the West Africa Power Pool is realized, capable of supply will be 70MW in FY 2016. However, Mount Coffee Hydropower output power of the dry season can be reduced to about 5MW, stable supply capacity is about 58 MW. Compared to maximum supply in FY 2015, there will be still 9 MW shortages.

Installation of two 5MW generators by the implementation of this Project will bring stable power supply capacity 45MW in FY 2015 and 68MW in FY 2016 and this contributes to mitigate the lack of generation capacity in the power system Monrovia. Figure 2-2-2-1 and Table 2-2-2-1 shows the power supply and demand balance of power system of Monrovia by 2015.

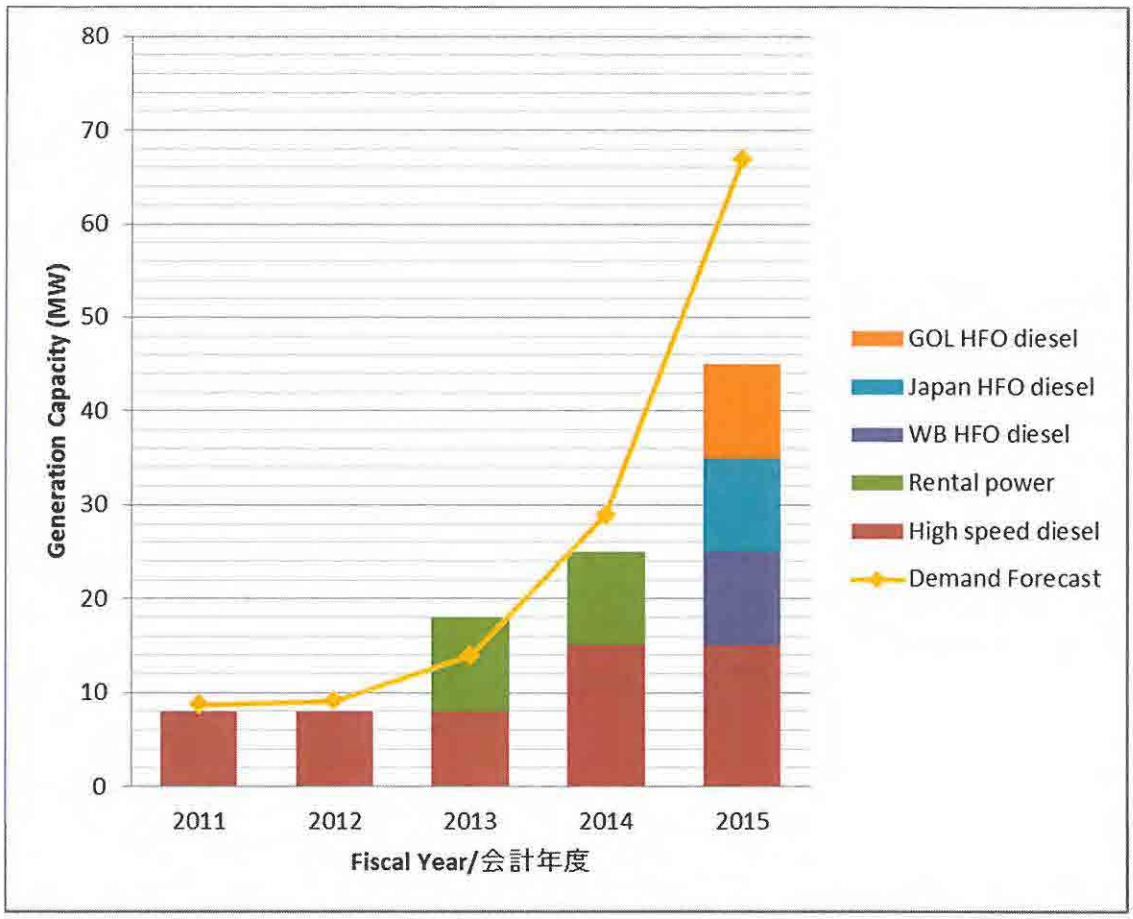
Table 2-2-2-1 Power supply and demand balance in the power system Monrovia

Unit: MW

Fiscal year (July ~ Next June)	2011	2012	2013	2014	2015
1.Bushrod Power Station					
(1) High Speed Power generation (USAID, Norway)	8	8	8	15	15
(2) Rental Power			10	10	
(3) World Bank, Diesel fuel oil-fired					10
(4) Japan heavy oil-fired diesel (this project)					10
(5) Liberian government funds Diesel fuel oil-fired Generator					10
2. Kru Town Substation	(5)	(5)	(5)	(5)	(5)
3. Congo Town Substation	(2)	(2)	(2)	(2)	(2)
4. Paynesville Substation	(O.64)	(O.64)	(0.64)	(O.64)	(O.64)
5. Total generation capacity	8	8	18	25	45
6.Power demand forecast(Base case)	8.70	9.08	13.96	28.93	66.85
7. Electric power supply and demand balance (5. - 6.)	-0.7	-1.1	4.0	-3.9	-21.9

Number of connected consumers (houses)	6,253	8,660	20,047	50,910	86,999
Annual growth rate (%)	-	38.50%	131.50%	154.00%	70.90%

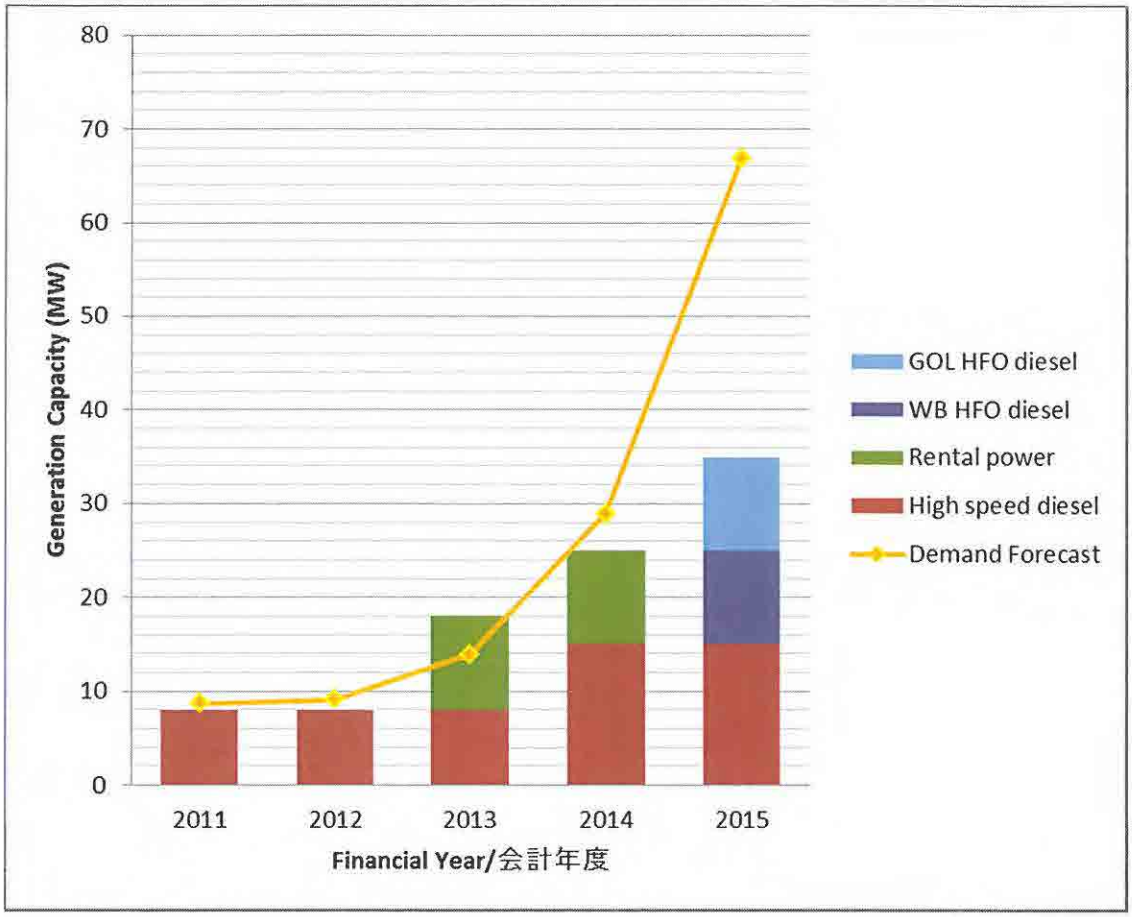
[Source] Prepared by investigation team based on LEC master plan,



［Source］ Prepared by investigation team based on LEC master plan,

Figure 2-2-2-1 Electric power supply and demand balance at Supply and demand balance in Monrovia Power System

If this project were not implemented provisionally, as shown in Figure 2-2-2-2, significantly insufficient power supply will continue after 2014.



［Source］ Prepared by investigation team based on LEC master plan,

Figure 2-2-2-2 Supply and demand balance in Monrovia Power System without the Project

2-2-2-2 Overall Plan

(1) Design Criteria

In order to design the facility and equipment for this Project needs to consider conditions such as below mentioned international standards, climatic and other natural conditions in Liberia, specifications of existing units.

1) Generating facilities construction site, location and altitude

Inside the existing Bushrod Power Station, altitude 14 m

2) Climatic Conditions

① Design Temperature : 40 ℃
② Design Relative Humidity : Max. 88 %
③ Design Wind Velocity : 6 m/sec.
④ The amount of rainfall : Annual average 6,900 mm
⑤ Thunderstorm days per year (IKL) : 50～100 Days
⑥ Salt deposit density : 0.5 mg/cm^2
⑦ Earthquake power : No consideration
⑧ Bearing Capacity of Soil : 10 ton/m^2 (Refer Attachment A-5 surveying geological survey

3) Applicable Codes / Standards and Units

① Japanese Industrial Standard (JIS): Applied to industrial products in general
② International Electro-technical Commission (IEC): Applied to major functions of electrical products in general
③ Standards for Japan Electrical Manufacturer's Association (JEM): Same as above
④ Japanese Electrical Wire and Cable Maker's Association (JCS): Applied to electric wire and cables
⑤ Relevant Technical Standards on Electrical Installation: Applied to electrical work in general
⑥ International Electro-technical Commission (IEC): Applied to major functions of electrical products in general
⑦ International Standardization Organization (ISO): Applied to performance evaluation of industrial products in general
⑧ Architectural Institute of Japan (AIJ): Calculation and designing of building structure
⑨ American society of Testing and Materials (ASTM) : Test method for materials

4) Unit

As a general rule, design description uses the International System of Units (SI units).

5) Basic Electrical Design Conditions

In order to match the technical specification for electrical design with existing power generation facility, this Project applies design basis shown in Table 2-2-2-2 below.

Table 2-2-2-2 Basic Electrical Design Conditions

Items	High Voltage (HV)	Medium Voltage (MV)		Low Voltage (LV)	Direct Current (DC)
Nominal Voltage (kV)	66	22	6.6	400/230	110
Maximum Voltage (kV)	72.5	24	7.2	440/253	121
LIWV (kV) (See *)	325	145	60	-	-
Wiring Method	3 phase 3 wires			3 phase 4 wires	2 wires
Frequency (Hz)	50				-
Farthing Method	Direct	Direct	Generator neutral resistance	Direct	-
Insulation Protection (IP)	See Note 1				
Creepage Distance	See Note 2				

(Notes)
* LIWV: Lightning Impulse Withstand Voltage
1. Insulation Protection (IP): IP20 for Indoor switchgear and panel IP43 for Outdoor switchgear and panel
2. Creepage Distance: 25mm/kV for outdoor insulator

Source: JICA investigation team

6) Environmental protection criteria

When constructing new power generating facilities, since no related environmental standards are established in Liberia, Japanese criteria and the following standards in consideration of local conditions in Liberia will be established as design criteria:

① NOx discharge criteria: No more than 950 ppm (when residual oxygen concentration is 13%)
② SOx discharge criteria: No more than 500 ppm (when fuel sulfur content is 2%)
③ Oil discharge standard: No more than 50 ppm
④ Particulate matter discharge criteria: No more than 100 mg/Nm^3
⑤ Noise standard: No more than 110dB(A) when only the target generating equipment is operating (1 m from the machine side)
⑥ Vibration criteria: No more than 65 dB at the site perimeter when only the target generating equipment is operating

(2) Facilities Layout Plan

The diesel engine generators and their mechanical auxiliary equipment shall be located in the new powerhouse.

Their auxiliary electrical equipment shall be located in the electrical room of the powerhouse. The air blowers shall be located in the blower room of the powerhouse and the sludge treatment equipment and radiators shall be located outside for easy operation and maintenance work.

Diesel fuel oil will be procured locally and distributed by tanker truck. Unloading facility, oil storage tanks (335 m^3 x 2 sets) and transfer facility will be installed. HFO will be supplied from existing storage tanks and HFO transfer pump, pump building (6 m x 10 m = 60 m^2), transfer pipe (approx. 400 m) will be installed.

2-2-2-3 Outline of the Basic Plan

Table 2-2-2-3 shows an outline of the basic plan of the Project based on the basic design concept, design criteria and facilities layout plan described previously (see 2-2-1-1).

Table 2-2-2-3 Outline of the Basic Plan

	Contents of the Project Plan
Material/Equipment Procurement and Installation	**Equipment Procurement and Installation** (1) Diesel engine generators (5 MW×2sets) (2) Required mechanical equipment for power generation >Fuel oil supply unit >Lubrication oil unit >Cooling water unit >Air in-take and exhaust >Air compressor unit >Waste oil treatment unit >Piping (3) Required electrical equipment for power generation >Generator transformer >Generator control/ monitoring panel >Low voltage power panel >DC power supply unit >Station transformer (4) 22 kV switchgears
Procurement	**Procurement of spare parts /tools and vehicles** (1) Emergency spare parts (2) Replacing spare parts (3) Maintenance tools (4) Maintenance vehicles transmission and distribution >Truck: Double cab (5cars) >Aerial bucket truck (1car) >Auger and crane truck (1car) >Cargo crane truck (2cars)
Construction	Construction of power generation building (1) power generation building (Total floor area : Approx. 1,479 m^2) (2) HFO transfer building (Total floor area : Approx. 60 m^2)

(1) Expansion of Bushrod power station

The constituting items of power generation system for this Project at Bushrod power station is as follows. The outline of the system and equipment are defied in Table 2-2-2-4.

1) Basic Items

i) Selection of Generation System

A diesel engine generation system will be applied in due consideration of compatibility with the existing facilities in Liberia, easy operation and maintenance and economy

ii) Fuel Composition

① Diesel oil

At Bushrod power station, existing High-speed power generator 1MW x 10 sets (USAID) and 1MW x 5 sets (NORWAY) are in-service. Fuel is diesel oil and receives supply by a tanker truck from the local oil company. In this Project, presuppose to receive diesel oil supply by tanker truck from the local oil company as well. Therefore, this project plans to install diesel oil unloading facility, diesel oil storage tanks (335m3 x 2 sets), diesel oil transfer facility adjacent to new generator unit building area.

② Heavy oil

At Bushrod power station, there exists HFO tank yard and was utilized for power generation. There is a plan support from World Bank to repair HFO tanks. Predict that the oil tank repair ends by November 2014, same as our Project completion, we plan to install HFO transfer pump, pump building, transfer piping (6 inches dia. x approx. 400 m).

iii) Lubricating Oil Composition

Lubricating oil composition recommended by the engine manufactures varies. However, lubricating oil for the existing power station is purchased locally. Since the revolution speed of medium speed diesel engine is 750 rpm or less, SAE-40 is recommendable.

iv) Cooling Water

The city water in Monrovia is utilized as cooling water at the existing Bushrods Power Station. The demineralizer shall be installed so that tap water can be utilized as cooling water.

2) Planned Components

i) Engine Output and Generator Capacity

The output of the generating system to be installed under the Project shall be decided in due considerations of the following factors.

① The target Project completion year is 2015.

② Select adequate scale of power generation unit to ensure the supply-demand balance of power after the target year, including refurbishment of existing and hydropower facilities and power imports from West Africa Power Pool,

③ A generating system of 10MW which can be operated continuously as base load power plant (over 8,000-hour operation annually) will be selected.

Since engine specifications, etc. vary according to manufacturer and are not the same or are slightly different, for the time being the following formula will be used as a yardstick.

• Engine Output

$$Pe \geqq \frac{P}{0.7355 \times \eta} = 7{,}553 \text{ PS}$$

Pe: Engine output (PS, meter horsepower)
P : Generator-end output (5,000 kW)
η : Generator efficiency (assumed to be 90%)

• Generator Capacity

$$P_G = \frac{P}{Pf} = 6{,}250 \text{ kVA}$$

P_G : Generator capacity (kVA)
P : Generator-end output (5,000 kW)
Pf : Generator power factor (0.8)

④ For an engine with a base load of 5 MW, medium-speed equipment with rated speed of 750 rpm or less is generally adopted and much operational experience is available. Accordingly, a medium-speed engine with rated speed of 750 rpm or less will be used for the diesel generating system to be installed under the Project.

ii) Mechanical Equipment Plan

a) Fuel Supply Plan

① Diesel oil

In this Project, diesel fuel oil is procured from local oil company and supplied by tanker truck. Diesel oil is received at newly constructed unloading facility and stored at oil storage tanks ($334m^3$ x 2 sets) and forwarded to day tank. The fuel oil is fed from Day tank to the engine by fuel transfer pump. Fuel oil system diagram is shown in Basic Design Diagram G-M02.

The diesel oil day tank capacity is determined from two hours fuel oil consumption. Design volume calculation is as follows.

$Vs = V \times 5{,}000 \text{ kW} \times 2\text{hours} \fallingdotseq 2.47 \text{ m}^3$

Where,

Vs : Capacity of fuel oil service tank
V : Fuel consumption (210 g/kWh) per generator (rated output of 5,000 kW)

Set the specific gravity of diesel fuel oil to be 0.85.

Accordingly, the nominal capacity of the fuel oil service tank will be 3 m^3 taking into consideration 15 % dead space.

② Heavy Oil

World Bank will support HFO storage tank repair work. The HFO will be supplied from storage tanks and transferred to HFO day tank (volume:3.0m^3) through 4 inches dia. piping, buffer tank (volume:6.0m^3) , oil filter by newly install HO transfer pump.

b) Lube oil

Since there is no common use lubrication oil unit at Bushrod power station site, this Project plans to install unit unique lubrication unit. The lubrication oil is supplied from LO drum locating outdoor to engine by LO transfer pump. LO process diagram is shown in Basic Design Drawing (G-M03.)

c) Cooling Water System

City water is processed using a demineralizing unit and utilized as cooling water. The radiator method same as the existing system will be applied. Some of the water treated by the water treatment unit will also be transferred to the lubricating oil purifier units.

The cooling water system is shown in Basic Design Drawing No. G-M04.

d) Compressed Air System

One set of compressed air system will be installed for each diesel engine to start-up under the Project to start the engine. The two units are connected with crossing pipe to use as common spare for emergency.

The compressed air system is shown in Basic Design Drawing No. G-M05.

Since humidity is high at the project site area, an automatic drain valve shall be installed on an air receiver. By dividing the discharge piping into high and low pressure, an air dryer shall be installed in the low-pressure piping. The low pressure air system will provide compressed air to control system and the lubricant purifier units.

e) Air Intake and Exhaust Gas System

Combustion air is taken through dedicated duct and supplied to engine via super charger. After burning, the exhaust gas is released to outdoor through silencer. The air intake and exhaust gas system is shown in Basic Design Drawing No. G-M06.

Air intake blower will be installed in the blower room in order to cool generators and to prevent the temperature rising in the DEG room; whereas, exhaust air will be discharged from an exhaust louver installed on the roof of the powerhouse.

f) Sludge Treatment System

Currently Bushrod power station does not equip sludge treatment system and environmental impact is concerned. In this Project, Sludge Treatment and Waste Oil Incinerating will be

installed o reduce environmental impact. The sludge treatment system is shown in Basic Design Drawing No. G-M07.

g) Piping System

The piping necessary for the relevant generating system to be constructed outside includes the following types. Color coding should be applied to the piping for each operation and flow direction should be specified.

- Fuel oil piping
- Lubricating oil piping
- Cooling water piping
- Compressed air piping
- Waste oil piping
- Drainage piping

iii) Electrical Equipment Plan

The generator voltage is applied to 6.6kV. The 22kV system and 66kV system is applied to same as the existing system.

The planned contents of major electrical equipment are as follows.

Electrical Equipment for Engine and Generator

a) Generator transformer

Step-up Generator transformers that changes generator output from 6.6 kV to 22kV will be installed one set for one generator individually.

b) Local Control Panels

The local control panels are installed on the generator side for starting, stopping and controlling the generation system and annunciation, etc.

c) 22kV Switchgear Cubicles

One 22kV circuit breaker panel for generator synchronization, house transformer, HFO system and dispatching 66kV substation is installed in the electrical unit room at the power generation building. The breaker panel equips a static type protective relay.

d) Generator Neutral Earthing Cubicle

The generator neutral earthing cubicle (disconnecting switches and earthing resistance are mounted) is installed in the electrical room. As a mono earthing method is applied, only one disconnecting switch is closed. The static type protection relay is mounted on the cubicle.

e) Generator Control Panel

One generator control panel will be installed in the control room in order to monitor power generation, 22 kV generator circuit breaker, generator neutral grounding disconnector, auxiliaries etc.

A thyristor brushless excitation system control unit will be installed in the generator control panel and generator synchronization operation will be also performed at this panel.

f) Station Transformer

One oil fill type transformer will be installed outdoor in order to supply power for generator auxiliary facility and power generation building facility. Capacity of a transformer shall be to a minimum of 750 kVA and shall have enough capacity to supply a generator auxiliary unit (for two sets of generators) and a common (the power plant building facilities and so on).

g) Main LV Panels

The LV Panels (400/230V) for distribution of power to DEG No.1 MCC, DEG No.2 MCC and Common MCC are installed in the electrical room.

h) Motor Control Centers

The Motor Control Centers (MCC) for power supply to the engine generator auxiliaries and powerhouse facilities are installed in the electrical room. Necessary operation mechanism, measuring instruments and alarms are equipped on MCC. The MCC is both sides type to secure the space in the electrical room.

i) DC Power Supply Panel

The Direct Current (DC) power supply panel for starting, stopping, control, measuring and alarm of engine generator facilities and auxiliaries is installed in the electrical room. DC voltage is 110V. The type of battery is lead acid sealed type. The required capacity of battery is considered with 2 hours black out.

j) Low Voltage Panels

The low voltage panels for supplying power to the powerhouse facilities (lightings and power (air-conditioners, ventilators, etc.)) are installed in the electrical room.

Electrical Equipment for HFO Facility

A new building will be constructed near existing HFO tank and HFO transfer pump will be installed in the building.

a) HFO Transformer

One oil immersed type transformer (22/0.4-0.23kV) for HFO equipment and house facilities is installed in outdoor closed to a HFO pump house. The capacity of the transformer is minimum 630 kVA.

b) 22kV Disconnecting Switch Cubicle

The 22kV disconnecting switch cubicle (24kV disconnecting switch is mounted) for maintenance purpose of HFO transformer and Motor Control Center is installed in the HFO pump house.

c) HFO Motor Control Center

The Motor Control Centers (MCC) for power supply to the HFO equipment, DC 110V battery charger and house facilities is installed in the HFO pump house. The MCC is both sides type to secure the space in the house.

d) DC Power Supply Panel

The DC power supply panel for control source of 22kV disconecting switch and HFO supervisory panel are installed in the HFO pump house. DC voltage is 110V. The type of battery is lead acid sealed type. The required capacity of battery is considered with 2 hours black out.

e) Low Voltage Panel

The low voltage panel for supplying power to the HFO pump house facilities (lightings and power (air-conditioners, ventilators, etc.)) is installed in the HFO pump house.

f) HFO Supervisory Panel

The HFO supervisory panel which has status of HFO equipment and alarm is installed in the HFO pump house.

Supplementary Electrical Materials

a) Cable specification and Installation

22kV, 6.6kV and 1kV power cable: XLPE insulated, PVC sheathed, copper conductor.

Direct buried cable: steel wire armored (SWA) for 3-cores cable or aluminum wire armored (AWA) for single core cable.

22kV, 6.6kV cable termination: heat shrinkable type (Raychem or equivalent)

Inside of the power house and the HFO pump house, all cables are installed on the cable support in the concrete cable trench. Direct buried cable is installed in 60cm depth from ground surface.

Major 22kV and 6.6kV power cables are as follows.

No.	From	To	Specifications			No. of Cable
			Type	No. of Core	Size (mm^2)	
1	Generator (5MW)	6.6/22kV, 7.0MVA Generator Transformer	3.6/6(7.2)kV, XLPE/PVC	1	95	6sets (2wires/ 1Phase)
2	6.6/22kV, 7.0MVA Generator Transformer	22kV Generation Switchgear	12/20(24) kV, XLPE/SWA/PVC	3	95	
3	Generator (5MW)	Neutral grounding board	3.6/6(7.2)kV, XLPE/PVC	1	70	
4	22kV station transformer circuit breaker panel	Station transformer 22kV/400-230V 750kVA	12/20(24) kV, XLPE/PVC	3	70	
5	22kV HFO transformer circuit breaker panel	HFO transformer 22kV/400-230V 630kVA	12/20(24) kV, XLPE/AWA/PVC	1	70	
6	22 kV distribution circuit breaker panel	22kV substation circuit breaker panel (Norway side installation)	12/20(24) kV, XLPE/SWA/PVC	3	120	

Control Cable Specification and the Installation: Adopts PVC insulation, PVC sheathed, copper conductor. Control cable installation shall not adopt direct-buried installation but use cable support or conduit.

b) Earthing System

The following earthing system is connected to common earthing mesh in the ground.

- Ground equipment for the purpose of ground fault protection of power system
- Earthing system for earth fault protection and electrical shock
- Lightning protecting for the power house and electrical equipment

Earthing mesh around powerhouse and 66kV substation is connected to the existing 66kV substation earthing mesh. The expected combined earthing resistance is less than 5 ohm.

Earthing mesh is installed in 75cm depth from ground surface.

Earthing materials is same or more as the existing one which was used in the existing 66kV substation.

- Earthing wire: bare copper wire $50mm^2$ or more
- Earthing rod: copper clad steel rod 2.1 meter long or more

3) Outlines of Major Equipment

In due consideration of the above-mentioned design policy, design standard, facility and equipment layout plans, etc., the specifications for major equipment to be constructed under the Project will be formulated

Table 2-2-2-4 Outlines of Major Equipment for Power Generating Facility

No.	Major Equipment Name	Specifications
1.	Diesel Engine	Operation rating : Continuous (base load) Output : More than 5,000 kW at generator-end Revolution speed : Not more than 750 rpm Engine type : 4 stroke cycle, trunk piston type, water cooled, inter-cooled, V-type diesel engine with turbocharger Cooling method : Radiator cooling Fuel oil : Diesel oil and heavy fuel oil Other : Common bed with vibration damper
2.	Generator	Operation rating : Continuous Output : Not less than 6,250 kVA (5,000 kW) Frequency : 50 Hz Phase : 3 phase Rated voltage : 6.6 kV Revolution speed : Same as engine Power factor : 0.8 (lagging) Connection : Wye (Y) connection, neutral grounding Insulation class : F
3.	Mechanical System	
3.1	Fuel Oil Supply System	
(1)	Diesel Oil Supply System	
	a) Unloading System	Loading pump, flow meter, etc.
	b) Storage tanks	335 m^3 x 2 units
	c) Diesel Oil Transfer Pump	3m^3, 0.5MPa
	d) Diesel Oil Service Tank (Day tank)	3 m^3
(2)	Heavy Fuel Oil Supply System	
	a)HFO forwarding system	Transfer pump
	b)HFO forwarding pipe	6 innches dia., approx.400 m, with heat trace
	c)HFO Buffer Tank	6 m^3
	d) HFO Washing Unit	
	e) HFO Purifier Unit	
	f) Diesel Oil Service Tank (Day tank)	3 m^3
(3)	Common System	
	a) Fuel Oil Flow Meter	Accuracy Class more than 0.5, Including filter
	b) Fuel Oil Filter	Primary and Secondary bucket type
	c) Fuel Control Valve	Self-control type
	d) Fuel Oil Drain Tank	200 ℓ
	e) Fuel Oil Drain Pump	Motor driven gear pump, including filter
3.2	Lubricating Oil System	
	a) Lubricating Oil Transfer Pump	Motor driven gear pump, including filter
	b) Lubricating Oil Sump Tank	Approx. 7 m^3
	c) Lubricating Oil Priming Pump	Including motor & gear pump
	d) Lubricating Oil Cooler	Plate type, including automatic temperature regulating valve
	e) Lubricating Oil Main Filter	Bucket type 50μ, Incl. automatic backwashing unit
	f) Lubricating Oil Purifier Unit	Centrifuge type, automatic sludge discharge type included
	g) Pressure Regulating Valve	Air pressure operation type
	h) Turbo charger lubrication oil unit	Sump tank, Transfer Pump, filter and Cooler
3.3	Cooling Water System	
	a) HT/LT Buffer Tank	Steel-plate product, 0.5 m^3
	b) HT Cooling Water Pump	Motor, Centrifugal type
	c) Cooling Water Temperature Control Valve	Self-operating type
	d) Radiator	2-stage type, vertical air flow fan, copper cooling pipe
	e) LT Cooling Water Pump	Motor, Centrifugal type

No.	Major Equipment Name	Specifications
	f) Demineralizer	Ion exchange resin type
	g) Demineralized Water Supply Pump	Motor, Centrifugal type
3.4	Compressed Air System	
	a) Air Compressor	Pressure 25/kgcm^{3}electric motor driven
	b) Air Receiver	Capacity for continuous 3-time engine starts, with automatic drain valve equipped,
	c) Pressure Reducing valve	Self-operating type
	d) Air Dryer	Electric type
3.5	Air Intake & Exhaust Gas System	
	a) Intake Air Duct	Steel-plate product, cylindrical
	b) Intake Air Filter	Automatic cleaning type
	c) Intake Air Silencer	Horizontal type
	d) Exhaust Air Silencer	Equipped with roof ventilator (air stack)
	e) Exhaust Air Duct	Steel-plate product, cylindrical
	f) Intake Blower	Axial flow type
3.6	Sludge Treatment System	
	a) Oil-Water Separator Tank	Gravity type, about 2 m^3
	b) Waste Oil Pump	Motor driven screw pump, 0.5 m^3/hour
	c) Oily Water Separation Unit	Residual oil not more than 50 ppm
	d) Incinerator	0.5 m^3/hour, auxiliary fuel & waste oil tank equipped
4.	Electrical System	
4.1	Electrical Equipment for Engine and Generator	
	a) Generator Transformer	6.6/22kV 7.0MVA
	b) Local Control Panels	Indoor and self-standing type
	c) 22 kV Switchgear Cubicles	Indoor metal enclosed type Circuit breaker: VCB (withdraw type), 24 kV, 630A/1,000A/2,000A, 25 kA (1 sec.), Auxiliary voltage DC 110V Metering, protection relays and synchronizer are equipped.
	d) Generator Neutral Earthing Cubicle	Indoor metal enclosed type Disconnecting switches: 6.6/$\sqrt{}$3kV, 100A Resistance: 6.6/$\sqrt{}$3kV, 100 A, 38 ohm, 10 sec.
	e) Engine, Generator and Station Service Control Panels	Indoor and self-standing type AVR, synchronizer, metering, operating status and alarms are equipped.
	f) Station Transformer	Outdoor, Three-phase oil immersed type, Cooling: ONAN, 22+/-2x2.5%/0.4-0.23 kV (No-voltage tap changer), Dyn11, 750 kVA, %Z=5% MV and LV connections: both sides are cables with long skirt cable ducts
	g) Main LV Panel	Indoor metal enclosed type 400/230V, 3 phase 4 wires Circuit breaker: ACB (Air Circuit Breaker), 600V, 1,250/400A, 20kA (1 sec.)
	h) Motor Control Centers	Indoor and self-standing type, both sides type 400/230V, 3 phase 4 wires Circuit breaker: ACB (Incoming) and MCCB (Mold Case Circuit Breaker) (feeder), 20kA (1 sec.)
	i) DC Power Supply Panel	Indoor and self-standing type Battery: lead acid sealed type batteries, 110 V Capacity of batteries: 2hours black out DC distribution board: 110V
	j) Low Voltage Panels (Lighting and power (air-conditioner/ventilator))	Indoor and self-standing type 400/230V, 3 phase 4 wires Circuit breaker: MCCB

No.	Major Equipment Name	Specifications
4.2	Electrical Equipment for HFO Facility	
	a) HFO Transformer	Outdoor, Three-phase oil immersed type, Cooling: ONAN, 22+/-2x2.5%/0.4-0.23 kV (No-voltage tap changer), Dyn11, 630 kVA, %Z=5% MV and LV connections: both sides are cables with long skirt cable ducts
	b) 22kV Disconnecting Switch Cubicle	Indoor metal enclosed type Disconnecting Switch: Manual operation, 22 kV, 630A, 31.5 kA (1 sec.), Auxiliary voltage DC 110V Metering and protection relays are equipped.
	c) HFO Motor Control Center	Indoor and self-standing type, both sides type 400/230V, 3 phase 4 wires Circuit breaker: ACB (Incoming) and MCCB (Outgoing)
	d) DC Power Supply Panel	Indoor and self-standing type Battery: lead acid sealed type batteries, 110 V Capacity of batteries: 2 hours black out
	e) Low Voltage Panels (Lighting and power (air-conditioner/ventilator))	Indoor and wall mounted type 400/230V, 3 phase 4 wires Circuit breaker: MCCB
	f) HFO Supervisory Panel	Indoor and self-standing type Operation status of HFO and alarms are equipped.

2-2-3 Outline Design Drawing

Drawing No.	Drawing Title
G-01	General Layout in Bushrod Power Station
G-02	Power House Layout
A-01	Powerhouse Elevation
A-02	New Power House Finishing Schedule
G-M01	Key Flow Diagram
G-M02	Fuel Oil Flow Diagram
G-M03	Lubricating Oil Flow Diagram
G-M04	Cooling Water Flow Diagram
G-M05	Compressed Air Flow Diagram
G-M06	Air Intake and Exhaust Gas Flow Diagram
G-M07	Sludge Treatment Flow Diagram
G-M08	HFO Supply Flow Diagram
E-01	Single Line Diagram of Bushrod Power Station

2-2-4 Implementation Plan / Procurement Plan

2-2-4-1 Construction / Procurement Implementation Policy

The Project will be implemented based on the Government of Japan's Grant Aid scheme. According to this, the Project will receive approval by the Government of Japan, the Exchange of Notes (E/N) will be signed by the two countries' governments, and the Grant Agreement (G/A) will be concluded by JICA (Japan International Cooperation Agency) and the Government of Liberia before the Project progresses to the implementation stage. The following paragraphs describe the basic items and points requiring particular consideration in the event where the Project is implemented.

(1) Project Implementing Agency

The implementing agency for the Project is the Liberia Electricity Corporation (LEC). The implementing department in LEC will need to execute the Project works and undertake the operation and maintenance of the supplied equipment following completion. Moreover, in order to smoothly advance the Project, the LEC will need to liaise and communicate closely with the Japanese consultant and contractor and to appoint staff in charge of the Project in order to smoothly advance the Project.

The appointed LEC Project staff member will need to fully explain and secure understanding for the contents of the Project to employees of the LEC, related agencies and residents of the target area with a view to eliciting cooperation for Project implementation.

(2) Consultant

In order to implement the equipment and materials procurement and installation works and facilities construction works, the Japanese Consultant will conclude a Design Supervision Contract with the LEC and conduct the implementation design and supervision work for the procurement and installation works in the Project. Moreover, the Consultant will prepare the tender documents and act for the Project implementing agency, the LEC in conducting the tender work.

(3) Contractor

In accordance with the framework of Japan's Grant Aid scheme, the Japanese contractor that has been selected by the Liberian side in general open tender will implement the equipment and materials procurement and installation works and facilities construction works of the Project. Following completion of the Project, since it will be necessary to continue supplying spare parts and conducting post-installation service to resolve breakdowns and so on, it will be necessary to conduct thorough liaison and coordination after the handover of equipment and materials.

(4) Need for Dispatch of Engineers

Since the Project entails the procurement and installation of two diesel generating units with capacity of 5 MW, and the work will need to be conducted by multiple teams, it will be necessary to coordinate the work between each team. Moreover, as the works will largely be conducted

simultaneously, it will be essential to dispatch Japanese engineers and technicians who can conduct consistent management and guidance on schedule, quality, progress and safety throughout the works.

2-2-4-2 Construction and Procurement Implementation Conditions

(1) Important Points in Equipment and Materials Procurement

1) Concerning the country of equipment and materials procurement

Since Liberia depends on imports for major items of equipment such as motor engines, synchronous generators and switchgear, etc. and such items cannot be procured locally, it will be necessary to procure equipment from Japan or third countries. Moreover, since it depends on imports for wiring and piping materials and so on too and these items are also not available locally, they will be procured from Japan or a third country.

2) Safety measures

The Project target site has relatively few problems in terms of law and order, however, it will be necessary to display ample care for preventing theft of equipment and securing the safety of works personnel. Accordingly, not only is it essential that the Liberian side take safety measures, but also the Japanese side will need to take steps such as erecting fences (as temporary works) and assigning guards around equipment and materials storage areas and so on.

3) Tax exemption

In order to receive the exemption of customs and tariffs on materials and equipment to be procured in this Project, contractor shall submit the necessary documents such as a copy of the bill of lading to the Customs and taxation in Ministry of Finance. The application shall submit through LEC in advance.

4) Transportation

For materials and equipment transported to Liberia by sea, customs clearance procedures will be conducted at the Freeport of Monrovia (4 berths), which is the only international port in the country. These procedures will be done by the National Port Authority. The port is currently being renovated, and dredging work will secure a draught of 12m. Planned completion of construction is May 2012. After construction is complete, 8,000-ton cargo vessels will be able to berth sufficiently. However, the port is not equipped with 100-ton cargo handling equipment.

Heavy loads in the 100-ton weight class, such as the engines, will be loaded on the deck of bulk carriers in Japan and transported by sea. At Freeport, the crane mounted on the ship will be used to unload the freight directly on to a hydraulic low bed trailer. The 3 km road from the port to the Project Site at Bushrod Power Station is relatively well-maintained, and will not be a problem for transport. However, there are some power lines of approximately 3.5 m in height that cross this road. For this domestic segment of transport, thorough coordination in advance and cooperation with LEC is

essential. Unloading at the power station will be done by jacking up the cargo, and then extracting the trailer. The hydraulic low bed trailer can be procured within Monrovia.

In addition, procured materials transported from Japan must be packed using methods that can fully withstand long periods of sea transport, port unloading, domestic land transport to the Project Site, and storage.

2-2-4-3 Demarcation of execution/procurement and installation Scope of Works

According to the Grant Aid Scheme for General Project, Table 2-2-4-1 shows the detailed scope of works on the Japanese and Liberian sides.

Table 2-2-4-1 Work Demarcations for Both Parties

No.	Undertakings	To be covered by		Notes	
		Japan	Liberia		
*1	(1) Securing lands necessary for the implementation of the Project		○	Including area for the new powerhouse, HFO transfer and substation	
	(2) Demolition of the existing foundations, removal of obstacles, land leveling in the Project sites		○		
*2	Installation of fences and gates				
	(1) Temporary fences and/or safety barricades during construction period	○			
*3	Road works				
	(1) Road within the Project sites	○			
	(2) Access road to the Project sites		○	Maintaining existing road pavement.	
*4	Auxiliary facilities for the new power house				
	(1) Electrical works				
	a) Extension work to the new generation facilities		N/A	Not applicable due to house transformer installation	
	b) Internal wiring	○			
	(2) Drink water supply works				
	a) Primary connection work to the new generation facilities		○		
	b) Piping work after primary connection	○			
	(3) Drainage works				
	a) Outside New Power Station		○		
	b) Inside New Power Station	○			
*5	Transportation of the Equipment, customs procedures and tax procedures				
	(1) Marine/air transportation to a port of disembarkation in Liberia	○			
	(2) Procedures for tax exemption and customs clearance at the port of disembarkation		○		
	(3) Internal transportation from the port of disembarkation to the Project sites	○		Delivery point: On site temporary storage yard	
	(4) Exemption or payment of internal tax on locally procured items		○		
*6	Procedures necessary to obtain the following permits for the Japanese Consultant and Contractor: - Permits required for construction - Permits required for installation works - Permits to access restricted areas		○	The permits shall be obtained before project implementation, if necessary.	
*7	Proper operation and maintenance of facilities and the Equipment after the Project		○	Including future procurement of spare parts.	
*8	Other expenses that are not covered by Grant Aid		○		

No.	Undertakings	To be covered by		Notes	
		Japan	Liberia		
*9	Payment of the following fees based on the Banking Arrangement:				
	(1) A/P advising commission		○		
	(2) Payment commission		○		
*10	Giving due environmental and social considerations in the implementation of the Project.		○		
11	Securing of land of temporary material storage yard		○	Land area : Approx. 50 m x 50 m	
12	Securing parking space during construction period		○		
13	Site offices	○		For the Japanese Consultant and Contractor	
14	Proper storage and safety management of the Equipment at temporary material storage yard	○			
15	Obtaining permissions for underground cabling and plumbing work (power, telephone, drink water, drain, etc.)		○	If necessary	
16	Obtaining permissions on road crossing works.		○	If necessary	
17	Providing of disposal site of soil and discharged water caused by the construction work		○		
18	Manufacturing and procurement of the Equipment	○		Equipment and materials that are procured for this Project.	
19	Installation of the Equipment, adjust and testing	○		The Liberian side is required to lend test equipment and tools to be provided on the Project to the Japanese Contractor during construction.	
20	Temporary power cut during construction		○		
21	Final connection to the existing Facilities				
	(1) Final connection to the power system		○	LEC witness	
	(2) Final connection to the existing fuel system		○	LEC witness	
	(3) Final connection to the existing water system		○	Match point on site and incl. secure connecting valve. LEC witness	
22	Provision of materials for the above mentioned final connection	○			
23	Provision of trainings for Initial operation and maintenance of the Equipment	○			
24	Assuring security for personnel in the Project sites		○	When necessary	
25	Managing any dispute from customers regarding temporary black out due to construction work including compensation for customers		○	If necessary	
26	Public notice of scheduled power cut and safety measures for the consumers during the implementation stage		○		

Source : JICA investigation team

Remarks:

○ Indicates parties concerned "*" is described in the M/D

2-2-4-4 Consultant Supervision for Construction and Procurement

Based on the scheme of the Government of Japan's Grant Aid, the Consultant will organize a consistent project team to smoothly conduct the implementation design and construction supervision work according to the principles of the outline design. The Consultant will assign at least one full-time engineer to the Project site during the construction supervision stage in order to conduct schedule control, quality control, performance control and safety control. Furthermore, an expert in Japan will attend plant inspections and pre-shipping inspections of equipment and materials manufactured in Japan as needed with a view to ensuring that no troubles occur following delivery of materials and equipment to Liberia.

(1) Basic Concept of Execution Supervision

The basic concept of construction supervision by the Consultant will be as follows: to supervise the works progress to ensure they finish within the designated period, and to supervise and instruct the contractor to ensure that the quality, performance and delivery times specified in the contract are secured and that the site works are executed safely. The important points to consider in Consultant supervision are described below.

1) Schedule control

The contractor will compare progress with the implementation schedule decided in the contract every month or every week in order to adhere to the delivery deadline given in the contract. In cases where delays are predicted, the contractor will warn the subcontractors, present and instruct a plan of countermeasures and offer guidance to ensure that the works and equipment delivery are completed within the contract period. The comparison of the planned schedule and actual progress will mainly be carried out according to the following items.

① Confirmation of works performance (manufacture of equipment and materials at factory and performance of wiring works on site)
② Confirmation of equipment and materials delivery (power generation equipment and materials)
③ Confirmation of temporary installation works and construction machinery preparations
④ Confirmation of yield and actual numbers of engineers, skilled workers and laborers, etc.

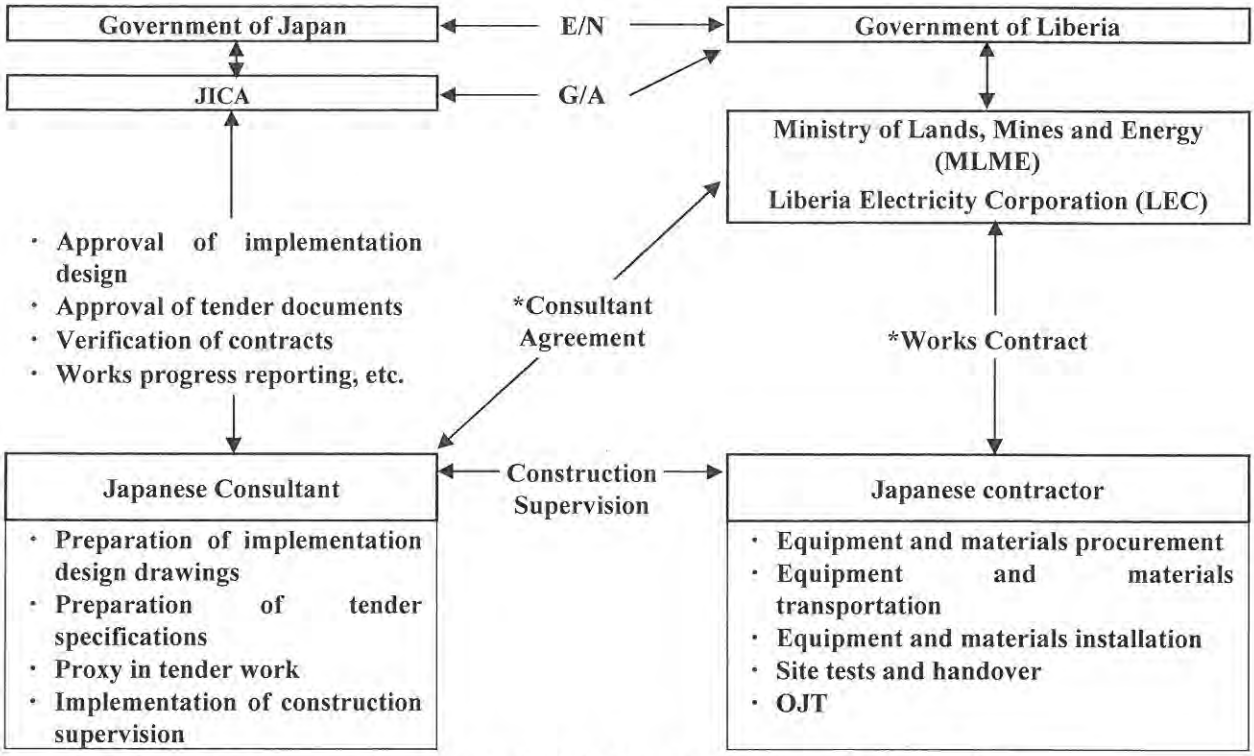
2) Safety control

Discussions will be held and cooperation sought with responsible officers of the contractor and safety control will be exercised during the construction period in order to prevent industrial accidents and accidents affecting third parties. Important points to consider in safety control on the site are as follows:

① Establishment of safety control regulations and appointment of manager
② Prevention of accidents through implementation of periodic inspections of construction machinery
③ Planning of the works vehicles and construction machinery operating routes and thorough enforcement of slow driving
④ Encouragement of laborers to utilize welfare measures and vacations

(2) Overall Relationships concerning Project Implementation

Figure 2-2-4-1 shows the mutual relationships between Project parties including the construction supervision.



＊Note: The Consultant Agreement and Works Contract require verification by JICA.

Figure 2-2-4-1 Project Implementation Relationships

(3) Works supervisor

When implementing the facilities construction works and equipment installation works based on the works contract, the contractor will bind a contract with and employ a local subcontractor. Therefore, since the contractor will need to ensure that the subcontractor complies with the works schedule, quality, performance and safety measures prescribed in the contract, it will dispatch an engineer who has experience of similar projects in overseas countries to provide guidance and advice on the site.

2-2-4-5 Quality Control Plan

The Consultant's construction supervisor will carry out supervision and checking based on the following items to ensure that the contractor secures the quality of Project equipment and materials and the execution and installation performance stipulated in the contract documents (technical specifications and implementation design drawings, etc.). In cases where doubts arise over quality and performance, the construction supervisor will immediately demand that the contractor make amendments, revisions or corrections.

① Verification of shop drawings and specifications of equipment and materials

② Witness the shop inspections of equipment and materials and the records
③ Verification of packing, transportation and on-site temporary storage methods
④ Verification of shop drawings and installation instruction of equipment and materials
⑤ Verification of test operation, adjustment and inspection procedures of equipment and materials for both shop and on site.
⑥ Supervision of equipment installation works, startup operations, adjustments and inspection witness on site.
⑦ Verification of facilities shop drawings and construction drawings on site.
⑧ Verification of as-built drawings

2-2-4-6 Procurement Plan

Because the equipment and materials and the construction materials targeted for procurement in the Project are not manufactured in Liberia, they will be procured from Japan or third countries. Some of the construction materials that can be procured locally (cement, rocks, sand, etc.) are available in Liberia and will be procured locally.

(1) Diesel Engine Generation Facilities

Procurement countries for diesel engines are Japan and European nations that are members of the DAC. There are many companies in Europe that manufacture generation equipment satisfying the specifications required by the Project. However, there is a large possibility that these companies cannot meet the delivery period corresponding to the work schedule of Japanese Grant Aid and also, their after-sales service systems are not reliable.

Due to the above conditions, Japanese-made diesel generator equipment will be provided for the Project.

For generation equipment auxiliaries such as radiators and lube oil purifiers, it is common for Japanese generator manufacturers to incorporate American and European-made parts into their systems. Therefore, DAC member countries will also be used as procurement countries for this project.

(2) Electrical Facilities

Ancillary facilities related with power generation unit such as synchronous generator, 6.6kV indoor distribution board、22kV switchgear, station transformers shall be made in Japan.

Table 2-2-4-2 Country of Origin of Equipment

Equipment and materials	Source		
	Liberia	Japan	Third country (see the note)
(Oil related)			
① Fuel oil, cooling water	○	-	-
② Lubricating oil	○	-	-
(Civil work materials)			
① Sand, gravel	○	-	-
② Cement	○	-	-
③ Steel material	-	○	○
④ Steel frame	-	○	○
⑤ Building equipment, finishing materials	○	○	○
(Construction machinery / Transportation vehicles)(*1)			
① General construction machinery	○	-	-
② Piping machine	-	○	○
(Diesel Generator Unit)			
① Diesel engine, synchronous generator	-	○	-
② Mechanical auxiliary equipment for diesel engine generator	-	○	○
(Fuel supply unit, cooling water supply unit, Compressor unit, etc.)			
③ Piping and accessories for above mentioned items.	-	○	○
④ Electrical auxiliary equipment for diesel engine generator	-	○	-
⑤ 22 kV switchgear	-	○	-
⑥ Electrical material (Medium voltage cable, Low voltage cable, conduit and attachment, etc.	-	○	○
⑦ Spare parts and maintenance tools	-	○	-

Note: Third countries will be DAC countries.
*1 Special construction machinery and transportation vehicles will be procured from neighboring countries.

2-2-4-7 Plan for Initial operation instruction/In-service Instruction Plan

In this Project, the electric generator output is 5MW and it is relatively large. In addition, there are many troubles at existing power generation plant, we propose OJT implementation plan.

(1) OJT plan during unit installation and startup testing period

1) Purpose of the OJT

Operation and maintenance technology related to procured and installed equipment, which is subject to cooperation in this project will be transferred to the Liberia-side counterpart during the installation and commissioning work.

The specifications and grade of Power generation facilities is chosen taking into account the existing level of technology involved in the LEC staff operation and maintenance of existing facilities. Regarding the operation and maintenance technology, LEC also had some experiences of Japanese diesel engines in the past. Now days, there is no experienced personnel at all by civil war. Also, the mechanical part of existing unit was stolen and only the foundation remains. The power generating system supplied in this Project has some modern technology. Therefore, during installation and start up testing period, dispatched engineers from the equipment supply companies will train Liberian

engineers about operation and maintenance technique. In addition, to minimize environmental impact, instruct about waste oil treatment including existing unit renovation. Various instruments usage essential to the operation and maintenance work will be also trained to ensure the effective operation of the equipment provided.

(2) Contents of the Plan

1) OJT implementation duration and location

- Classroom : approx. 1week (on site)
- Field training : approx.2months (on site)

2) Instructor

Japanese equipment supplier will dispatch installation engineer, pre-operation and startup engineer and they will perform training. Therefore,

3) Trainee

LEC operators and maintenance personnel who directly participate with unit operation after commissioning shall receive this training (OJT). As LEC is the executing agency of the country side, needs to assign trainee until starting the power generation facility

4) Contents of training

—Classroom

- Using operation and maintenance manual, focusing on the power generation, facilities below mentioned basic training will be implemented. Characteristics of the power generating unit and the structure, etc.
- The basis of unit operation and maintenance management (Schedule control, basic concept of preventative maintenance, functions of the unit, basics of accident/trouble shooting, spare parts and tools control, drawings and document control)
- Waste oil treatment system and its management method, etc.

—Field training

Focusing mechanical disassemble and repair related maintenance and inspection, Japanese suppliers will implement this training during equipment installation and startup testing period on site.

2-2-4-8 Soft Component (Technical Assistance) Plan

Diesel generator facilities of the same type as the HFO-fired medium speed diesel generators planned for the Project had been installed previously and were operating at the Bushrod Power Station. However, these facilities were destroyed due to the civil war more than ten years ago and the plant has not generated power with HFO-fired medium speed diesel generators since then. Therefore, this has caused a blank period in

terms of technology related to HFO-fired medium speed diesel engines. Since there has been no technology transfer within LEC, this transfer of technology for the operation and maintenance management of HFO-fired medium speed diesel generators are critical.

For the Project, on the job training (OJT) will be implemented mainly in the area of operating procedures. This will be taught by people from the contractors delivering the equipment during the construction period, during test operations, and at commissioning. However, this is insufficient for having only the local staff conduct overall operations and management of the power generation facilities, including maintenance management. For this, a series of technology transfers that covers everything from the structure of the equipment and system to maintenance management, patrol inspections, and preventive maintenance is necessary. This type of technology transfer will be conducted as a soft component of the Project.

(1) Soft Component Objectives

In addition to the lack of technology related to HFO-fired diesel generators, the daily inspections and periodic inspections conducted for the existing diesel generators cannot be described as satisfactory. Therefore, the soft component objectives are as follows.

- Technology transfer related to the structure, functions, and theories of diesel engines (mainly medium-speed)
- Technology transfer related to the structure, functions, and theories of various systems and their equipment (lube oil system, cooling water system, etc.)
- Technology transfer related to daily/periodic inspections and preventative maintenance for the diesel engine and various systems and their equipment

(2) Soft component results

Through the implementation of these soft components, the results of transfers of technology on daily/periodical inspections and preventative maintenance are as follows.

- Tests will be conducted to confirm the knowledge acquisition level on the structure, functions, and theories of diesel engines (mainly medium-speed).
- Tests will be conducted to confirm the acquisition level on the structure, functions, and theories of various systems and their equipment (lube oil system, cooling water system, etc.).
- Daily/periodic inspection and preventative maintenance implementation charts will be created based on the acquired technology related to malfunctions, daily/periodic inspections, and preventative maintenance related to diesel engines and various systems and their equipment.

(3) Soft Component Activities and Input Plan

1) Activities

As soft components, the following activities (mainly lectures and OJT) will be conducted to transfer technology related to maintenance management and preventative maintenance for medium speed diesel engines.

- Lectures on structure, theories and operations management of medium speed 4-cycle diesel engines.
- Lectures on structure, theories, and operations management for various systems and their equipment (fuel oil, cooling water, compressed air, air supply/exhaust, and waste oil treatment).
- Lectures on malfunctions, daily/periodic walkdown, and preventative maintenance for medium speed 4-cycle diesel engines and auxiliary systems.
- OJT for the items above.
- Creation of daily/periodic walk down and preventative maintenance implementation charts for medium speed 4-cycle engines and various systems and their equipment.

2) Implementation plan

As the instructing engineer for soft components, a Japanese engineer who has experience in the design of medium speed 4-cycle diesel engines and who is also well-versed in operations/maintenance management will be assigned. This engineer will prepare materials beforehand in Japan to transfer technology regarding the soft components to the local staff.

i) Domestic activities

The period for domestic activities is set at 0.75 months, and the content of the materials to be created in Japan are as shown in Table 2-2-4-3

Table 2-2-4-3 Activities in Japan

Categories	Activities in Japan (Preparation of materials for activities in Liberia)	Term
Diesel engine	● Composition and theory for four-cycle diesel engine	5 days
Mechanical equipment	● Fuel oil system (Outline, composition and theory of purifier unit, maintenance of thermal efficiency, management of exhaust gas and fuel oil characteristics) ● Lube Oil System (Outline, composition and theory of purifier unit, hydrodynamic lubrication, management of lube oil characteristics) ● Cooling water system (Outline, composition of radiator and water treatment unit, relation between cooling capacity thermal efficiency, corrosion inhibitor, management of cooling water characteristics) ● Intake and exhaust gas system (Outline, composition and theory of turbocharger and silencer, management of temperature of exhaust gas) ● Waste oil treatment system (Outline, composition and theory of waste oil treatment unit, effect to environment)	7 days
Preventive maintenance	● Preparation of documents for technical transfer for failure, daily maintenance, periodical maintenance and preventive maintenance ● Preparation of implementation schedule sheets for daily maintenance, periodical maintenance and preventive maintenance	10 days
Total		22 days (0.75 months)

ii) Local activities

The transfer of soft component contents will be conducted in the recipient country, and the timing for OJT will coincide with the test operation period and commissioning period of the Project.

The period for local activities is set at 2.0 months, and the content of these activities is as shown in Table 2-2-4-4.

Table 2-2-4-4 Activities in Liberia

Category	Activities in Liberia(Activity in class rooms and on-the-job training)	Term
Diesel engine	● Composition and theory of 4 cycle HFO fired diesel engine generator	0.4 months
Mechanical equipment	● Local stuf training about each system shown in the Table 3-2-4.	0.6 months
Preventive maintenance	● Training for discovering of failure, daily maintenance, periodical maintenance, prediction of failure ● Training for proper replacement work of spare parts and consumables ● Effective utilization of operation and maintenance records ● Management of noise and vibration and Prevention of environmental pollution ●	0.6 months
Implementation plan of preventive maintenance	● Preparation of implementation schedule sheets for daily maintenance, periodical maintenance and preventive maintenance ● Implementation of confirmation test of achievement after technical transfer	0.4 months
Total		2.0 months

2-2-4-9 Implementation Schedule

After the Project is approved by the Government of Japan, there will be an Exchange of Notes (E/N) will between the two countries. Based on the Grant Aid system of Japan, the Project will then begin. As the Project is large, it will be conducted in three steps: ① implementation design, ② contractor selection (preparation of tender documents, tender announcement, tendering, tender evaluation, contract), and ③ procurement of materials/equipment and installation work. Figure 2-2-4-2 shows the implementation schedule for the Project.

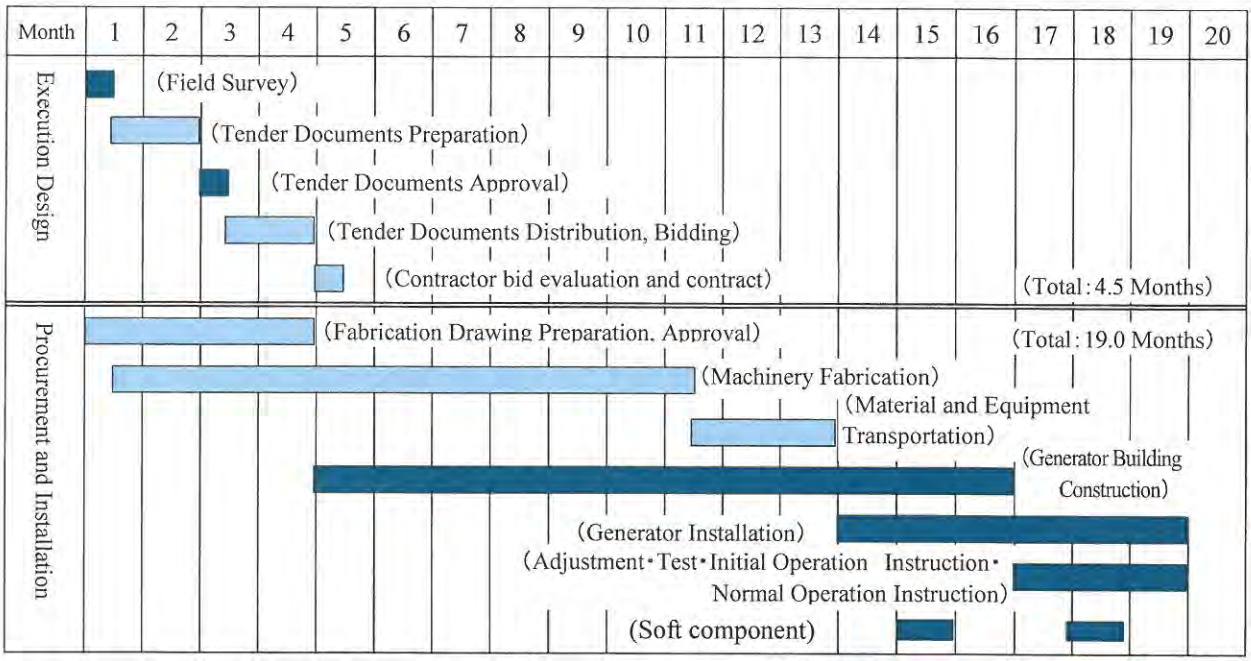


Figure 2-2-4-2 Implementation schedule of the Project

2-3 Obligations of Recipient Country

For implementation of the Project, in addition to the obligations of the Liberian side that are shown in Item 2-2-4-3 "Demarcation of execution/procurement and installation," Liberia will also be bear the responsibility for and shall implement the following items.

- They shall provide data and information necessary for implementing the Project.
- They shall appoint a professional engineer for the transfer of operations and maintenance management technology related to facilities installed for the Project, who shall also be present for work checks during the installation work period and for quality control inspections of materials and equipment.

2-4 Project Operation Plan

2-4-1 Basic Concept

Maintenance will be most important for the power generating equipment in the Project. In order to secure a stable supply of power, it will be essential to perform operation and maintenance (O&M) and preserve the equipment environment.

In order to maintain the performance and functions of the generating equipment and conduct sustained power supply, it is desirable to implement appropriate preventive maintenance and regular maintenance geared to enhancing the reliability, safety and efficiency of equipment.

Figure 2-4-1-1 shows the basic thinking regarding the maintenance of equipment.

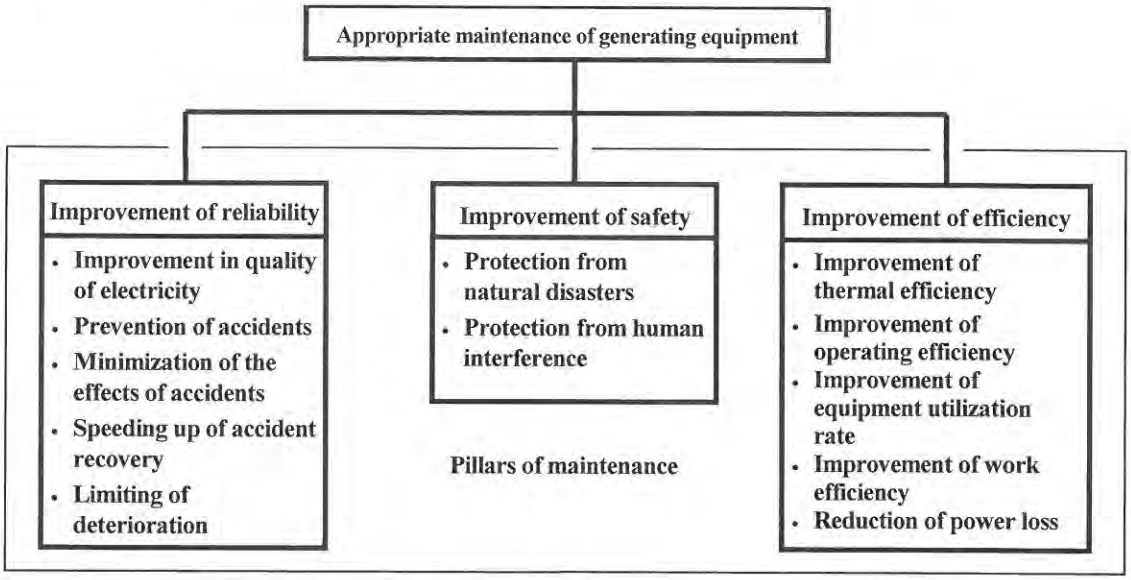


Figure 2-4-1-1 Basic Thinking on Maintenance of Generating Equipment

In the Project, bearing in mind the above points, it will be necessary for the Liberian side to implement operation and maintenance following completion of the Project in accordance with the O&M technology that was transferred by the expert engineers dispatched by the Japanese contractor during the works and the operation and maintenance manual, while always bearing in mind the basic items indicated above.

2-4-2 Periodic Inspection Items

(1) Generating equipment

The Project counterparts in Liberia will need to compile an operation and maintenance plan for the generating equipment based on the standard periodic inspection items shown in Table 2-4-1-1 and the operation and maintenance manual submitted by the equipment manufacturer, as well as prepare an economical operation plan that corresponds to demand.

Table 2-4-1-1 Periodic Inspection Items in Standard Generating Equipment

	Inspection Category	Main Work Items
Diesel Engine	Routine (daily) inspections	- Fuel oil level, lubricating oil sump tank oil level - Confirmation of jacket water level - Confirmation of pressure in start air tank - Exterior appearance inspection of each part
	1,000 hour inspection	- Confirmation of tightening of nuts and bolts - Cleaning of fuel and lubricating oil filters
	2,500~3,000 hour inspection	- Confirmation of operating state and oil leaks, etc. in air intake and exhaust valves, starting valves, fuel valves, fuel pumps, pistons, and liners, etc., and analysis of oil in the lubricating oil sump tank
	7,500~8,000 hour inspection	- Confirmation of operating state and oil leaks, etc. in pistons and cylinder liners and replacement of gaskets - Replacement of piston rings, hydraulic rings and O-rings - Cylinder head disassembly and replacement of gaskets and O-rings - Inspection of air intake and exhaust valves and replacement of exhaust valve O-rings - Inspection of fuel injection valves and replacement of nozzles - Inspection of crank pin bearings and replacement where necessary - Disassembly and inspection of supercharger and replacement of bearings, etc. - Analysis of oil in the lubricating oil sump tank and replacement of lubricating oil where necessary
	16,000 hour inspection	- Above inspections every 7,500~8,000 hours - Inspection of main bearings and replacement where necessary - Inspection of exhaust valve rotator and replacement where necessary - Disassembly inspection of lubricating oil pump attached to engine and replacement where necessary
Generator	Routine (every day during operation) monitoring	- Visual inspection and confirmation of strange noise and temperature in each part
	Monthly inspection	- Existence of strange vibrations - Confirmation of lubricating oil flow conditions and oil leakage around bearings - Necessary cleaning of each part
	Annual inspection	- Insulation resistance measurement and inspection of lead wires and terminals - Visual inspection of space heater and other accessories - Visual inspection and cleaning where necessary of bearings

Incidentally, the rough number of days required for each standard periodic inspection is as follows:

- 2,500~3,000 hour inspection : 7~8 days per inspection
- 7,500~8,000 hour inspection :15~18 days per inspection
- 16,000 hour inspection : 20~25 days per inspection

(2) Electrical equipment

The standard periodic inspection items for electrical equipment to be procured and installed in the Project are as indicated in Table 2-4-1-2. As is indicated in this, inspections can be categorized into the following three types:

- Walkdown in which abnormal heating or noises, etc. are monitored everyday based on the five senses;
- Ordinary inspections in which inspections are conducted on energized sections that cannot be inspected in routine patrols, for example, heating and torque of bolts surface dirt on insulated objects etc.

- Detailed inspections on functions of interlocking mechanisms between instruments and for maintaining precision of measuring instruments.

Ordinary inspections are normally conducted once every one or two years, while detailed inspections are conducted around once every four years. Moreover, it is desirable to replace parts such as fuses, meters and relays, etc. fitted inside circuit breaker panels and distribution panels, etc. when they are found to have deteriorated performance, deteriorated insulation performance or altered characteristics in ordinary inspections and detailed inspection upon confirming the characteristics and frequency of use of parts.

Table 2-4-1-2 Periodic Inspection Items in Standard Electrical Equipment

Inspection Item	Inspection Contents (Method)	Patrol Inspection	Ordinary Inspection	Detailed Inspection
Equipment exterior	Display conditions of switching indicators, switching display lamps	○	○	
	Abnormal noise and odor	○	○	
	Heating discoloration of terminals	○	○	
	Cracking, damage and staining of bushing and porcelain tubes	○	○	
	Rust on installation booths and frames, etc.	○	○	
	Abnormal temperature (thermometer)	○	○	
	Bushing terminals torque (mechanical check)	○	○	
Operating device and control panel	Display conditions on measuring instruments	○	○	○
	Indications on operation counters		○	○
	Condensation, rust and dirt inside operating boxes and panels		○	○
	Lubrication and cleaning conditions		○	○
	Wiring terminals torque	○	○	○
	Confirmation of switching display status		○	○
	Air and oil leaks		○	○
	Pressure check before and after operation (air pressure, etc.)		○	○
	Operation check of operation meters		○	○
	Rust, deformation and damage of springs (repair)	○	○	○
	Abnormality of pins at tightening parts		○	○
	Inspection (repair) of auxiliary switches and relays		○	○
	Inspection of DC control power source	○		
Measurement and testing	Measurement of insulation resistance		○	○
	Measurement of contact resistance			○
	Heater disconnections		○	○
	Actuation test of relays		○	○

2-4-3 Spare Parts Purchasing Plan

The spare parts for generating equipment comprise standard accessory parts are replaced according to operating time and replacement parts that are urgently needed in the event of breakdowns. Therefore, the Liberian side will need to purchase these parts corresponding to the cycle of periodic inspections.

In the Project, it is planned to procure the minimum necessary spare parts for the first full-scale inspection implemented after 16,000 hours of fired operation (approximately after two years) and for the periodic inspections up to that point. The major items are the periodic inspection items shown in Table 2-4-1-3.

Therefore, it will be necessary for the Liberian side to budget for the purchase of standard accessory parts up to roughly two years ahead (approximately 3% of the generating and electrical equipment costs) and the purchase of the necessary emergency replacement parts.

It is defined that the diesel power plant is assumed that periodic overhaul performed according to cumulative operation time. From the experiences of the multiple engine production companies in Japan

Typical annual maintenance costs for the regular maintenance (including consumables, replacement parts and on-site supervisor expenses) is about 3%/year of the initial investment (approx. 40,000,000 JPY = US $ 500,000).

In neighboring Sierra Leone, there is a power generation site. The capacity and mechanical specification is as same as this Project (HFO fired, middle speed engine 5MW x 2 sets). At Sierra Leone, periodical diesel generator maintenance at 4000 and 8000 firing hours were implemented. Their total maintenance cost for the replacement parts, consumables and dispatched on-site supervisor is approximately 40,000,000JPY. For regular 8000 firing hour maintenance for this Project will be almost the same. This cost estimation is valid when the engine was operated appropriately conditions. When the generator is operated long-term and continuously knowing the mechanical failure or inadequate conditions, it may cause unpredicted major parts replacement large scale repair work due to accident,Due to the aging of the equipment, replacement parts fee tends to increase. In this Project, two years replacement parts are supplied in advance. At initial operation stage, the spare parts exceed and the maintenance budget accordingly. However, it is recommended reserve for the future for large-scale maintenance, such as an unexpected accident. Therefore, LEC needs to keep the cost of the above maintenance each year from electricity sales revenue after the start of operation of the equipment

In case LEC outsources periodic overhaul in a lump sum, LEC bears the risk of the contract. The power generation cost is estimated as 2~4 ¢ (cent). When power generation operation is 8,000 hours/year and average power output is 10MW x 70%, annual unit overhaul cost (including parts replacement, consumables, man-power fee) is estimated as 1.12~2.24 million USD.

Table 2-4-1-3 Replacement and Spare Parts of the Project

No.	Items	Quantity	Remarks
1	Cylinder cover		
	① O-rings for cylinder cover	2 sets × No. of cylinder × 2 units	
	② Packing for cylinder cover	2 sets × No. of cylinder × 2 units	
	③ Packing for cylinder cover (suction pipe)	2 sets × No. of cylinder × 2 units	
	④ Fully equipped cylinder cover (including valves)	1 set	Emergency Spare Parts
2	Intake value		
	① Load cap for intake valve	1 set × No. of cylinder × 2 units	
	② Valve shaft for intake valve	1 set × No. of cylinder × 2 units	
	③ O-ring for intake valve	2 sets × No. of cylinder × 2 units	
	④ Fully equipped intake value	2 sets	Emergency Spare Parts
3	Exhaust Valve		
	① Valve shaft for exhaust valve	1 set × No. of cylinder × 2 units	
	② Sleeve for exhaust valve	1 set × No. of cylinder × 2 units	
	③ Seat for exhaust valve	1 set × No. of cylinder × 2 units	
	④ O-ring for exhaust valve	2 sets × No. of cylinder × 2 units	
	⑤ Load cap for exhaust valve	1 set × No. of cylinder × 2 units	
	⑥ Fully equipped exhaust valve	1 set	Emergency Spare Parts
4	Fuel injection valve		
	① Nozzle cap for fuel injection valve	2 sets × No. of cylinder × 2 units	
	② O-ring for fuel injection valve	2 sets × No. of cylinder × 2 units	
	③ Fully equipped fuel injection valve	4 sets	Emergency Spare Parts
5	Piston		
	① Piston ring	2 sets × No. of cylinder × 2 units	
	② Oil ring for piston	2 sets × No. of cylinder × 2 units	
	③ Piston pin bearings	1 set × No. of cylinder × 2 units	
	④ Crown bolt for piston	1 set × No. of cylinder × 2 units	
	⑤ O-ring for piston	2 sets × No. of cylinder × 2 units	
	⑥ Fully equipped pistons	1 set	Emergency Spare Parts
6	Connecting bar		
	① Crank pin bearings for connecting bar	1 set × No. of cylinder × 2 units	
	② Tightening bolt for connecting bar	1 set × No. of cylinder × 2 units	
7	Main bearings		
	① Main bearings	1 set × No. of cylinder × 2 units	
	② Thrust bearings	2 sets × 2 units	
8	Cylinder liner	2 sets	Emergency Spare Parts
9	Fuel injection valve		
	① Plunger sleeve for fuel injection valve	2-sets × No. of cylinder × 2 units	

	② Full set of discharge valve	1 set × No. of cylinder × 2 units	Emergency Spare Parts
	② Deflector for fuel injection pump	2 sets × No. of cylinder × 2 units	
	③ O-ring for fuel injection pump	2 sets × No. of cylinder × 2 units	
	④ Fully equipped fuel injection pump	2 sets	Emergency Spare Parts
10	Supercharger		
	① Bearings for supercharger	2 sets × 2 units	
	② Thrust bearings for supercharger	2 sets × 2 units	
11	Air cooler		
	① Packing for air coolers	2 sets × 2 units	
12	Starting valve		
	① Packing for starting valve	2 sets × No. of cylinder × 2 units	
	② Fully equipped for starting valve	2 sets	Emergency Spare Parts
13	Cylinder safety valve		
	① Packing for cylinder safety valve	2 sets × No. of cylinder × 2 units	
	② Fully equipped for cylinder safety valve	2 sets	Emergency Spare Parts
14	Indicator valve	1 set × No. of cylinder × 2 units	
15	Intake expansion pipe	1 set × No. of cylinder × 2 units	
16	Exhaust expansion pipe	1 set × No. of cylinder × 2 units	
17	Fuel injection pipe	1 set × No. of cylinder × 2 units	
18	Filter element		
	① Air intake system	100%	
	② Fuel oil system	100%	
	③ Lube oil system	100%	
	④ Compressed air system	100%	
19	Lube oil purifier unit	Lube oil	
	① Mechanical seal for lubricating oil purifier pump	100% × 2 / 100% × 2	
	② Shaft seal packing for lubricating oil purifier pump	100% × 2 / 100% × 2	
	③ O-ring for lubricating oil purifier	100% × 2 / 100% × 2	
	④ Ring for lubricating oil purifier	100% × 2 / 100% × 2	
	⑤ Clamping for lubricating oil purifier	100% × 2 / 100% × 2	
	⑥ Valve plug for lubricating oil purifier	100% × 2 / 100% × 2	
	⑦ Maintenance tool for lubricating oil purifier	1 set / 1 set	
20	Softener (Ion exchange Resin)	100%	
21	Measuring instruments		
	① Pressure switches	1 set for each kind	Emergency Spare Parts
	② Temperature switches	1 set for each kind	Emergency Spare Parts
	③ Pressure gages	1 set for each kind	Emergency Spare Parts
	④ Thermometers	1 set for each kind	Emergency Spare Parts
22	Auxiliary Equipment		
	① Fuel oil circulating pump	1 set	Emergency Spare Parts

	② Lube oil priming pump	1 set	Emergency Spare Parts
	③ High temperature water circulating pump (HT)	1 set	Emergency Spare Parts
	④ Fuel oil drain pump	1 set	Emergency Spare Parts
	⑤ Sludge pump	1 set	Emergency Spare Parts
	⑥ Waste oil pump	1 set	Emergency Spare Parts
	⑦ Low temperature water circulating pump (LT)	1 set	Emergency Spare Parts
	⑧ Spare parts for auxiliary pump (Packing, O-ring)	1 set × 2 units	
	⑨ Spare parts for oil-water separator	1 set	
	⑩ Spare parts for pumps	100% × 2 units	
23	Spare Parts for Electrical Auxiliary Equipment		
	① Control circuit fuses	100% for each kind	
	② Display lamps (excluding LED)	100% for each kind	
	③ Auxiliary relays	1 set for each kind	
	④ Fluorescent lamps in panel and glow lamps	100% for each kind	
	⑤ MCCB	1 set for each kind	
24	Spare Parts for Maintenance Vehicle		—
	① Truck: Double Cab Truck	100% for 5 cars	—
	② Aerial Bucket Truck	100% for 1 car	—
	③ Auger and Crane Truck	100% for 1 car	—
	④ Cargo Crane Truck	100% for 2 cars	—

Table 2-4-1-4 Maintenance tools procured under the Project

No	Items	Quantity	Remarks
1.	Maintenance tools (Standard/ Special engine)	1 set	
2.	Special tools for generator	1 set	
3.	Wrenches for Generator	1 set	
4.	Intake and exhaust valve grinding machine	1 set	
5.	Intake and exhaust valve seat grinding machine	1 set	
6.	Lubricating oil analyzer	1 set	
7.	Cooling water analyzer	1 set	
8.	Tool box (steel)	1 set	
9.	Measuring Instruments	1 set	
	① Burning pressure gage	1 set	
	② Noncontact thermo meter	1 set	
	③ Fuel nozzle tip injection pattern tester	1 set	
	④ Anemometer	1 set	
	⑤ Vibration meter	1 set	
10.	Hand Pallet (1.5 t)	1 set	
11.	Ladder (2 stage)	1 set	
12.	Chain fall (0.5 ton×2.5 m, 1.0 ton×3 m)	1 set each	
13.	Wire Ropes		
	① 0.5 ton, 3 m, 2 sets, Shackle 4 sets	1 set	
	② 1.0 ton, 5 m, 2 sets, Shackle 4 sets	1 set	
	③ 1.5 ton, 8 m,2 sets, Shackle 4 sets	1 set	
14.	Test Equipment		
	① DC high voltage tester	1 set	
	② Relay Tester	1 set	
	③ Insulation Tester (1,000 V / 2,000 MΩ)	1 set	
	④ Insulation Tester (500 V / 1 ,000 MΩ)	1 set	
	⑤ Phase rotation meter	1 set	
	⑥ Voltage Detector (Middle and Low Voltage)	1 set	
	⑦ Digital multi meter (Digital type)	1 set	
	⑧ AC clamp meter (with noise filter)	1 set	
	⑨ Portable Earth resistance Meter	1 set	
	⑩ Temporary earthing wire (clamp, codes)	3 sets	

2-5 Project Cost Estimation

2-5-1 Estimated total project cost

In case this Project is implemented as Japanese Grant Aid, the Liberian side is expected to pay the costs of its undertakings as listed below.

(1) Expenses borne by the recipient country **US$ 429,000- (Approx. 33.56Million JPY)**

① Payment of a fee based on the following bank arrangements : US$ 29,000 (2.27Million JPY)

- Commission authorized A / P US$ 3,000-
- Commission B / A (0.1% of maximum amount of E/N、US$ 26,000-)

② Diesel oil initial charge : US$ 400,000- (31.29Million JPY)

- Tank volume Minimum required volume 500m^3×US$ 800- = US$ 400,000-

(2) Conditions for cost estimation

① Estimation Timing February 2012

② Exchange rate 1US$=78.23JPY ((Six-month average of January 2012 to August 2011)

③ The schedule for construction work procurement and its interval, detailed design and procurement of equipment and its installation duration are shown in the implementation schedule.

④ Others: This project will be carried out in accordance with the Japanese Government Grant Aid Scheme.

2-5-2 Operation and maintenance cost

Estimated maintenance costs of HFO fired medium-speed diesel generator (cost of purchasing replacement parts and consumables) in this cooperation Project is approximately 3% of equipment cost shown in breakdown of project cost summary. It amounts approximately US$570,000.- annually. Statutory useful life of diesel engine generator is 15years (Electricity Utilities Industry Law). Therefore, it is necessary to accumulate (depreciation expense) funds that can replace the equipment after 15 years. When the residual value is 10% of equipment procurement and installation costs, depreciation is the US $ 1,150,000 per year.

Current power sales unit price is 57.78 ¢/kWh, Medium speed generator in this Project can significantly reduce fuel cost, then the unit price is estimated at 46 ¢ /kWh which is 20% lower than current price.

Currently, only high speed diesel generator is operated at Bushorod power station.

Assumed balance of earnings and expenses with medium-speed engine generator operation, which is procured n this Project, is shown in Table 2-5-3-1.

As shown in Table 2-5-3-1, operating balance is positive under condition of more than 50% capacity utilization annually.

Table 2-5-3-1 Assumed balance of earnings and expenses in this Project

Item			Unit	Annual capacity utilization rate (%)						
				30	40	50	60	70	80	90
I Income										
1. Plant capacity	①		(kW)	10,000	10,000	10,000	10,000	10,000	10,000	10,000
2. Annual operating hours	②		(hr)	2,628	3,504	4,380	5,256	6,132	7,008	7,884
3. Generated energy	③		(kWh)	26,280,000	35,040,000	43,800,000	52,560,000	61,320,000	70,080,000	78,840,000
4. Power consumption in the plant	④	(③x 0.06)	(kWh)	1,576,800	2,102,400	2,628,000	3,153,600	3,679,200	4,204,800	4,730,400
5. Power loss through transmission, distribution and transformation	⑤	(③x0.30)	(kWh)	7,884,000	10,512,000	13,140,000	15,768,000	18,396,000	21,024,000	23,652,000
6. Electric power sales	⑥	(③-④-⑤)	(kWh)	16,819,200	22,425,600	28,032,000	33,638,400	39,244,800	44,851,200	50,457,600
7. Average electricity rate	⑦		(US$/kWh)	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Total income	⑧	(⑥x⑦)		$7,736,832	$10,315,776	$12,894,720	$15,473,664	$18,052,608	$20,631,552	$23,210,496
II. Expenditure										
1. Fuel	⑨	(③x(2)x(4))	(US$)	5,605,031	7,473,375	9,341,719	11,210,063	13,078,406	14,946,750	16,815,094
2. Lubricating oil	⑩	(③x(3)x(5))	(US$)	147,168	196,224	245,280	294,336	343,392	392,448	441,504
3. Labor	⑪	(6)x12	(US$)	240,000	240,000	240,000	240,000	240,000	240,000	240,000
4. Replacement parts	⑫	(7)x3%	(US$)	575,227	575,227	575,227	575,227	575,227	575,227	575,227
5. Overhead	⑬	(9)	(US$)	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
6. Depreciation	⑭	(8)	(US$)	1,150,454	1,150,454	1,150,454	1,150,454	1,150,454	1,150,454	1,150,454
Total expenditure	⑮		(US$)	8,917,880	10,835,280	12,752,679	14,670,079	16,587,479	18,504,879	20,422,278
III Operating balance			(US$)	($1,181,048)	($519,504)	$142,041	$803,585	$1,465,129	$2,126,673	$2,788,218

Assumptions for study

(1) Average electricity rate	0.46	USD/kWh	
(2) Unit price of fuel oil	0.78	USD/ℓ	One part diesel oil (0.90 USD/ℓ and four parts heavy oil (0.765 USD/ℓ)
(3) Unit price of lubricating oil	3.50	USD/ℓ	
(4) Fuel consumption	0.2734	ℓ/kWh	0.21 g/kWh, fuel ratio 0.96, average efficiency 80%
(5) Lubricating oil consumption	0.0016	ℓ/kWh	
(6) Unit labor cost	20,000	USD/month	40 people x 500 USD (20 people for power generation, 10 for transmission, 10 for management)
(7) Machinery cost	19,174,230	USD/10MW	1,500,000,000 yen (exchange rate I USD = 78.23)/10MW
(8) Depreciation cost	1,150,454	USD/year	15-year fixed-installment depreciation, remaining value after 15 years: 10%
(9) Overhead	1,200,000	USD/year	100,000 USD/month x 12 months
(10) Total power loss through transmission, distribution and transformation	30	%	Assumed to be 30%