| No. |
|---|

# BASIC DESIGN STUDY REPORT
# ON
# THE PROJECT
# FOR
# RURAL ELECTRIFICATION
# IN
# THE REPUBLIC OF GHANA

**JULY 2006**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

**YACHIYO ENGINEERING CO., LTD.**

| GM |
|---|
| JR |
| 06-132 |

# PREFACE

In response to a request from the Government of the Republic of Ghana, the Government of Japan decided to conduct a basic design study on the Project for Rural Electrification and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Ghana a study team from January 29 to February 24, 2006.

The team held discussions with the officials concerned of the Government of Ghana, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Ghana in order to discuss a draft basic design, and as this result, 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.

I wish to express my sincere appreciation to the officials concerned of the Government of Ghana for their close cooperation extended to the teams.

July, 2006

Masafumi Kuroki
Vice-President
Japan International Cooperation Agency

# LETTER OF TRANSMITTAL

July, 2006

We are pleased to submit to you the basic design study report on the Project for Rural Electrification in the Republic of Ghana.

This study was conducted by Yachiyo Engineering Co., Ltd., under a contract to JICA, during the period from January to July, 2006. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Ghana and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

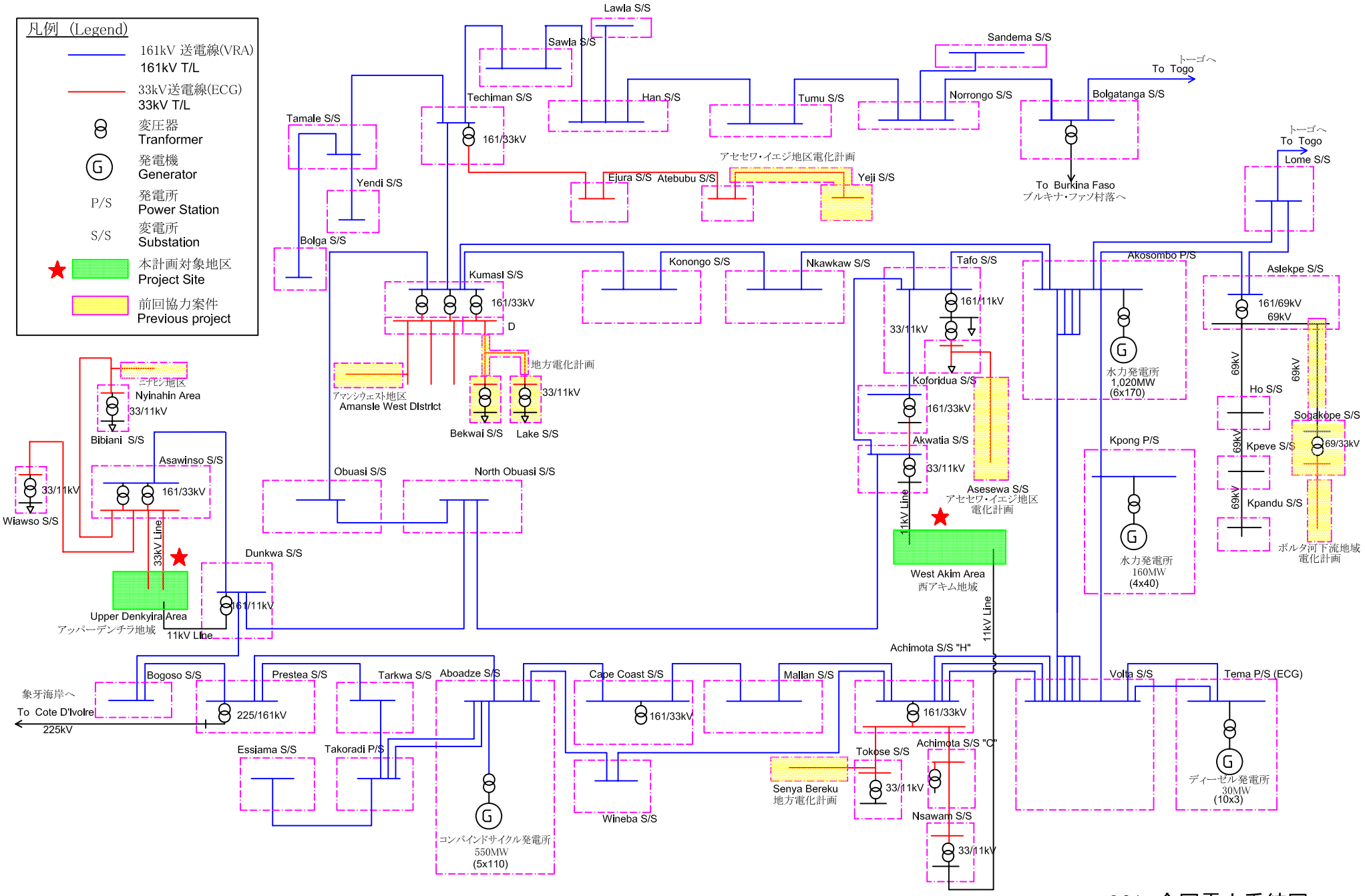
Very truly yours,

Hirohito Seto
Chief Consultant,
Basic design study team on the Project for Rural Electrification in the Republic of Ghana
Yachiyo Engineering Co., Ltd.

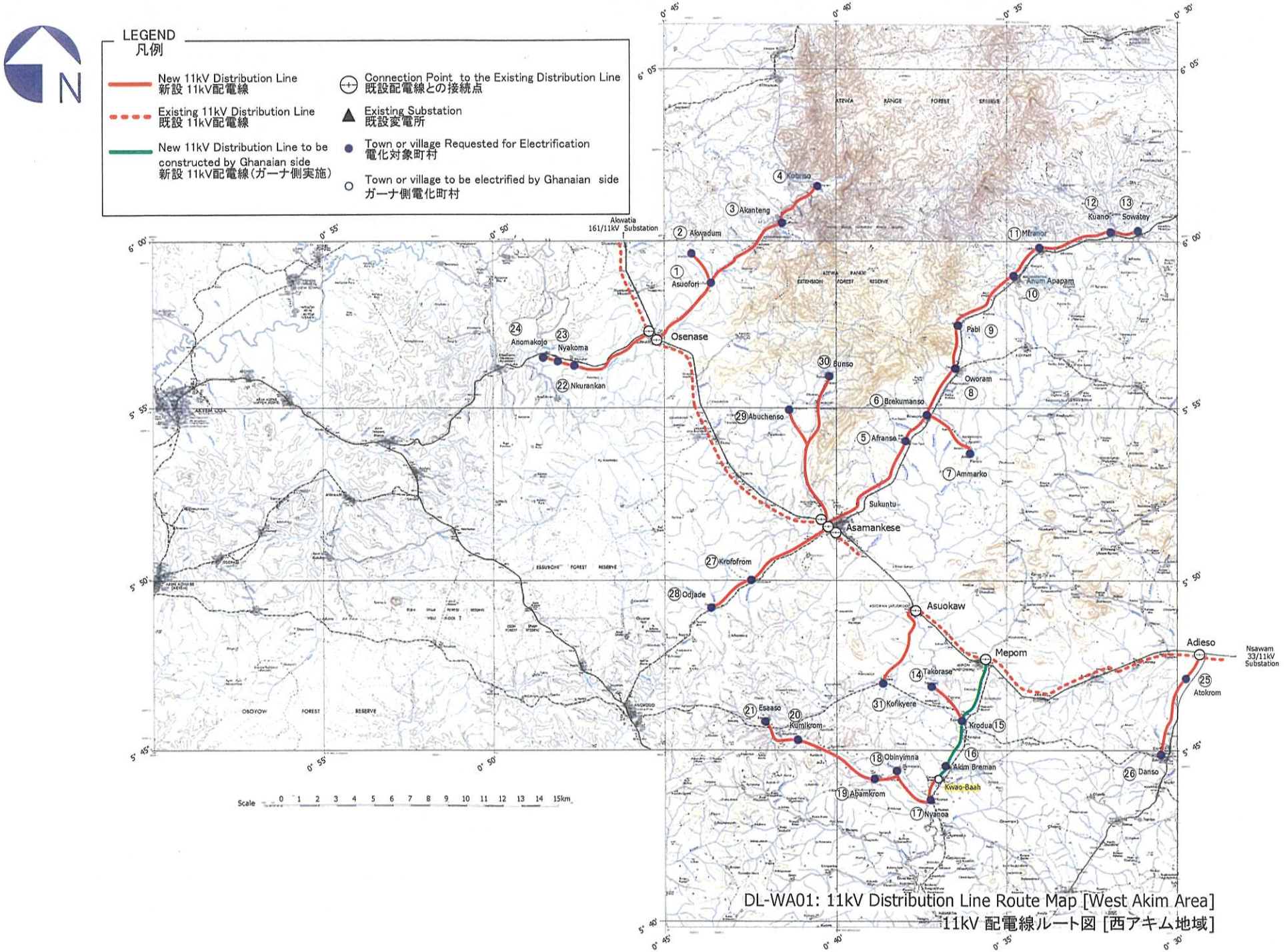


備考：★印は、本計画対象地域を示す。
★Shows the Project Sites.

ガーナ共和国全図
Map of the Republic of Ghana

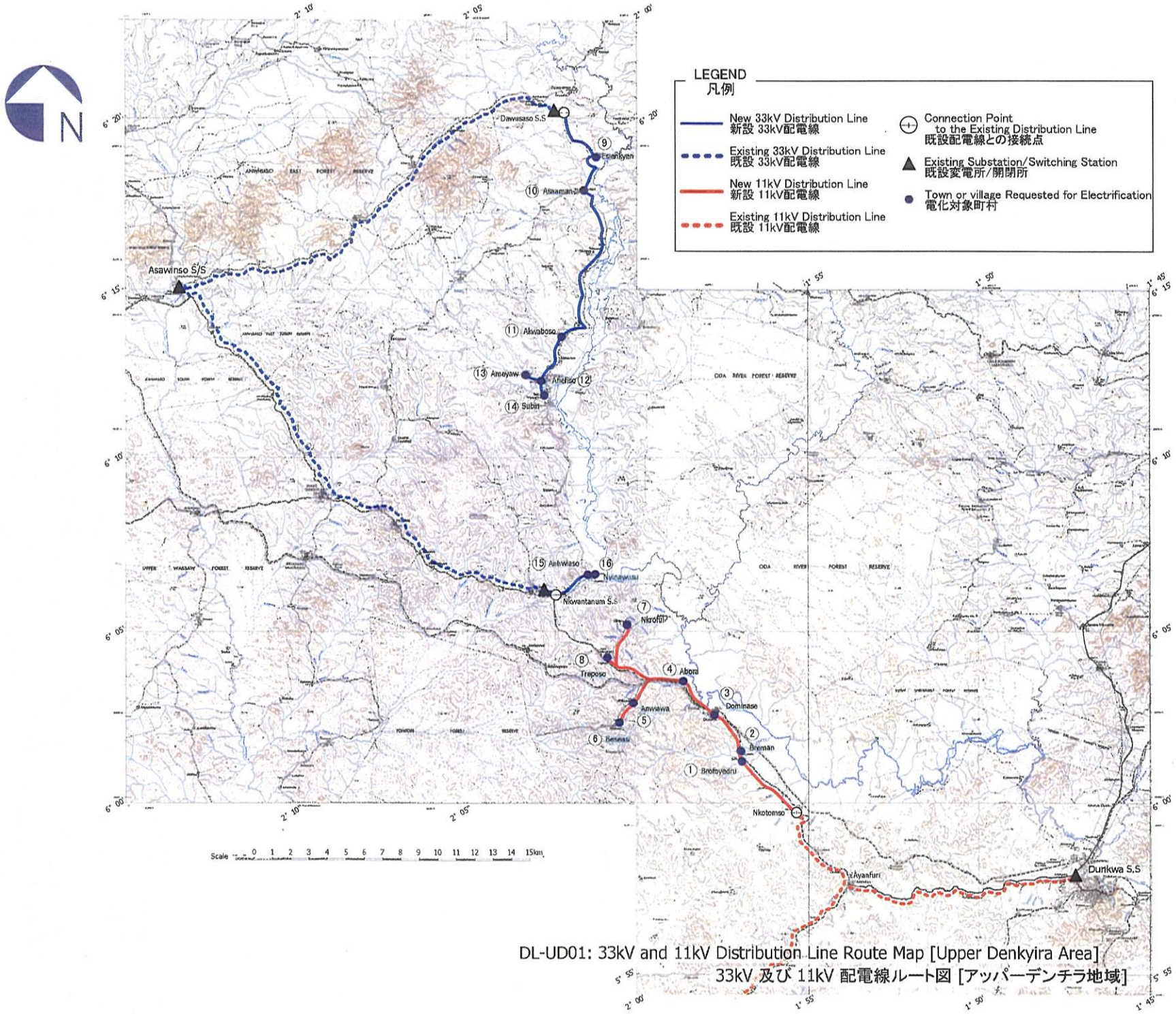



G01 全国電力系統図
National Power Network




DL-WA01: 11kV Distribution Line Route Map [West Akim Area]

11kV 配電線ルート図 [西アキム地域]




DL-UD01: 33kV and 11kV Distribution Line Route Map [Upper Denkyira Area]
33kV 及び 11kV 配電線ルート図 [アッパーデンチラ地域]

# LIST OF FIGURES AND TABLES

# ABBREVIATIONS

| | |
|---|---|
| AAC | All Aluminum Conductor |
| DANIDA | Danish Development Agency |
| EC | Energy Commission |
| ECG | Electricity Company of Ghana |
| E／N | Exchange of Notes |
| EPA | Environmental Protection Agency |
| EU | European Union |
| GDP | Gross Domestic Product |
| GNI | Gross National Income |
| GPRS | Growth and Poverty Reduction Strategy |
| HIPC | Heavily Indebted Poor Country |
| IEC | International Electrotechnical Commission |
| IMF | International Monetary Fund |
| ISO | International Organization for Standards |
| JCS | Japanese Electrical Wire and Cable Maker's Association Standards |
| JEAC | Japan Electric Association Code |
| JEC | Japanese Electrotechnical Committee |
| JEM | Standards of Japan Electrical Manufacturer's Association |
| JICA | Japan International Cooperation Agency |
| JIS | Japanese Industrial Standards |
| MDB | Main Distribution Board |
| MOE | Ministry of Energy |
| NDF | Nordic Development Fund |
| NED | Northern Electricity Department |
| NEP | National Electrification Project |
| NES | National Electrification Scheme |
| O&M | Operation and Maintenance |
| ODA | Official Development Assistance |
| OJT | On the Job Training |
| ORET | Development Related Export Transactions |
| PRSP | Poverty Reduction Strategy Paper |
| PURC | Public Utilities Regulatory Commission |
| SHEP | Self Help Electrification Project |
| SIDA | Swedish International Development Authority |
| SNEP | Strategic National Energy Plan |
| VRA | Volta River Authority |

# SUMMARY

# SUMMARY

The Republic of Ghana (hereinafter referred to as “Ghana” has a large economic gap between urban and rural areas where approximately 70% of the population resides continues to persist. As a result, people in relatively poor rural areas flock to the cities thus creating more slums. Poverty is still a serious concern. Accordingly, the Government of Ghana introduced “Vision 2020”, a long-term program of guidelines for development in 1995 and the “Ghana Poverty Reduction Strategy (GPRS) Paper” in 2003 with the goal of attaining sustainable economic growth, poverty reduction and democratic strategy. Ghana places a high priority on rural electrification programs, projects which are considered to be indispensable for improving social living standards and poverty reduction in rural areas.

In promoting rural electrification, the Government of Ghana formulated the National Electrification Scheme (NES) in 1989 with the aim of supplying electricity to all communities with a population of 500 or greater by the year 2020. The scheme is divided into 6 phases. In Phase 1 (1991 to 1995) and Phase 2 (1996 to 2000), electrification in all district capitals (110 locations) was completed through the electrification of all district capitals and key municipalities in rural areas through the cooperation of donors including Japan and through the initiatives of the World Bank. In parallel with the rural electrification of key municipalities, the Ministry of Energy (MOE) is currently pushing ahead with the Self Help Electrification Program (SHEP) in response to requests for electrification by communities where the level of electrification falls short despite being targeted by the NES. The SHEP is designed for electrification of municipalities that satisfy certain conditions, for example, it should be located within 20km of the existing distribution lines, it should bear the cost of electric poles for low voltage distribution lines, and more than one-third (1/3) of its residents who own a house wiring system and desire electrification.

Although it is difficult to sufficiently secure necessary funding for facility investments under current financial situation in the electric power sector, revenue and expenditure of the Electricity Company of Ghana Ltd (ECG) have been improved through a reduction in distribution power loss, a rise in electricity tariffs and a reinforcement of electricity tariffs collection, etc. However, the electrification rates in rural areas where approximately 70% of the total population reside still remains at 20% compared to 43% which is the national average (population rate: 2000 Population Census), so that rural un-electrified areas are unable to provide electricity in public facilities such as medical and educational institutions. Rural electrification has become important task in securing the quality of public services and improving the living standards of local residents.

Under such circumstances, as part of the NES, the Ghanaian government plans to electrify three districts in the mid-southern region (Upper Denkyira District in Central region, West Akim District in

Eastern Region and Jaman District in Brong Ahafo Region) where economic growth through electrification is anticipated since it is one of the largest farm producing regions. Accordingly, the Ghanaian government submitted a request for Japan's grant aid for the procurement and installation of equipment and materials 33/11kV and low voltage power distribution necessary to improve its power distribution network in July 2004.

In response to this request, in 2005 the Government of Japan through JICA collected information on proposed sites and examination based on a comparison from the viewpoints of (1) cost effectiveness, (2) ripple effects on economic development and (3) improvement in social living conditions through electrification of public facilities, etc. As the result, the beneficial effects in Jaman District in Brong Ahafo Region were confirmed to be smaller than those in the other two districts due to the wide distribution of communities. After the results of the examination were obtained, and after reviewing the proposed sites with the aim of promoting an effective electrification project through the grant aid scheme, the Ghanaian side selected two districts in two regions (Upper Denkyira District in the Central Region and West Akim District in the Eastern Region) aside from Brong Ahafo Region as project sites and in August 2005 made a request to Japan again for rural electrification through the grant aid scheme.

In response to this request, the Government of Japan decided to implement a Basic Design Study and the JICA dispatched a Basic Design Study Team to Ghana between January 29 and February 24, 2006 in order to verify the contents of the request with related Ghanaian authorities and to discuss the contents of the implementation. Simultaneously a survey of project sites was conducted and related materials were collected.

After returning to Japan, the Study Team examined the necessity, economic effects and relevance of the project based on data collected in the field survey and the results were compiled in the results in the Draft Basic Design Study Report. The JICA dispatched the Study Team to Ghana between June 1 and 9, 2006 in order to explain the Draft Basic Design Study Report and obtain basic consent from the Government of Ghana.

The scope of the requested Japanese assistance formulated from the study completely covers the components requested for the project in order to procure and install equipment and materials for 33kV and 11kV power distribution lines necessary to electrify non-electrified areas in Upper Denkyira District in the Central Region and West Akim District in the Eastern Region (47 communities in total) and to procure equipment and materials for low voltage trunk distribution lines.

The Basic Plan of the requested Japanese assistance compiled based on the results of the field survey and discussion with the Ghanaian side is summarized in the following table.

## Basic Plan Overview

| No. | Item | Unit | West Akim District in the Eastern Region | Upper Denkyira District in the Central Region |
|---|---|---|---|---|
| A. | Procurement and installation of equipment and materials for 33 kV and 11 kV power distribution lines | | | |
| (1) | 33 kV distribution lines | | | |
| | 1) 33 kV/ 433-250 V transformers | | | |
| | a) 50 kVA | [unit] | | 2 |
| | b) 100 kVA | [unit] | | 7 |
| | 2) Auto reclosers | [unit] | | 1 |
| | 3) Load isolators | [unit] | | 5 |
| | 4) Lightning arrestors | [unit] | | 16 |
| | 5) Cutout Switches with Fuses | [unit] | | 9 |
| | 6) Conductor: AAC 120 $mm^2$ | [km] | | 28.9 |
| | 7) Steel poles（11m） | [pole] | | 275 |
| (2) | 11 kV distribution lines | | | |
| | 1) 11 kV/ 433-250 V transformers | | | |
| | a) 50 kVA | [unit] | 22 | 3 |
| | b) 100 kVA | [unit] | 16 | 8 |
| | c) 200 kVA | [unit] | 4 | 0 |
| | 2) Auto reclosers | [unit] | 1 | 0 |
| | 3) Load isolators | [unit] | 9 | 2 |
| | 4) Lightning arrestors | [unit] | 53 | 13 |
| | 5) Cutout Switches with Fuses | [unit] | 42 | 11 |
| | 6) Electrical wire: AAC 120 $mm^2$ | [km] | 98.6 | 21.3 |
| | 7) Steel poles（11m） | [pole] | 1,108 | 233 |
| (3) | Main distribution board (MDB) | [set] | 42 | 20 |
| B. | Procurement of equipment and materials for low voltage distribution lines | | | |
| (1) | Low voltage trunk distribution lines | [km] | 455.8 | 183.4 |
| (2) | Pole fitting materials for distribution lines (such as insulators and terminals) | [set] | 1 | 1 |
| (3) | Procurement of maintenance tools and emergency spare equipment | [set] | 1 | 1 |

In the case of implementing the project through Japan's grant aid, the project cost is estimated to be approximately ¥1,423 million (approximately ¥1,079 million to be borne by the Japanese side and ¥344 million to be borne by the Ghanaian side). Of these, components to be mainly borne by the Ghanaian side include the installation of low voltage distribution facilities in targeted communities to be electrified. The term of the project will be approximately 15 months for West Akim District in the eastern Region and 14 months for Upper Denkyira District in the Central Region including a detailed design, procurement of equipment and materials and installation work.

The implementing and responsible agency for the Project will be the Ministry of Energy (MOE); whereas, operation and maintenance of equipment and facilities after completion of the Project will be the responsibility of the Electricity Company of Ghana (ECG), the state-owned entity responsible for power distribution undertakings in six regions in southern Ghana and with 4,889 employees (as of 2005), approximately 40% of the employees are technical staff, so that a sufficient number of engineers has been assigned. Since the specifications of power distribution facilities to be procured under the Project will be the same level as the previous grant aid projects which are also being in favorably operated and maintained, so the Ghanaian side is judged to have no particular problems with the technical competency in implementing the Project.

The following direct and indirect effects can be expected through the implementation of the Project. A total population of approximately 111,000 (approximately 76,000 in West Akim District and approximately 36,000 in Upper Denkyira District) will benefit directly from the Project. Economic ripple effects from both districts to neighboring areas can be also expected.

(1) Direct Effects

(i) The present municipality electrification rate in 16 municipalities (6%) out of 272 in West Akim District will be increased to 47 municipalities (17%); whereas, that in Upper Denkyira District in 15 municipalities (7%) out of 226 will be increased to 31 municipalities (13%).

(Remark) Municipality electrification rate: The ratio of electrified municipalities in the total number of municipalities in the relevant district

(ii) The present household electrification rate in West Akim District will be increased from 15% to 35%; whereas, that in Upper Denkyira District will be increased from 22% to 44%.

(Remark) Household electrification rate: The ratio of electrified households in the total number of household in the relevant district

(2) Indirect Effects

(i) It will be possible to introduce medical equipment and refrigerators for pharmaceuticals, so that improvement in public health and sanitation will be improved.

(ii) It will be possible to utilize electric pumps, so that local residents, in particular, women and girls who have to draw water will reduce the severity of their labor.

(iii) By utilizing electric appliances, business hours can be extended and productivity can be improved, which is expected to revitalize the regional economy.

(iv) Incandescent and/or fluorescent lamps can be utilized through the electrification, so it will be possible to reduce the harmful health effects of smoke discharge by kerosene lamps.

The Project will contribute extensively to improving basic human needs (BHN) for residents, at the same time; a great number of effects can be expected. Accordingly, the implementation of the Japan's grant aid for a portion of the requested Japanese assistance is judged to be relevant.

The following undertakings should be implemented by the Ghanaian side for exercising sustainable effects of the Project:

(1) The Ghanaian should smoothly implement installation of low voltage trunk distribution lines to be procured and supplied by the Japanese side in time for the construction of 33/11kV power distribution lines to be procured and installed by the Japanese side under the Project;

(2) The Ghanaian side should properly operate existing substations and distribution facilities in order to ensure a stable supply of electric power to the project sites, and strictly enforce preventive maintenance through periodical patrol inspections and maintenance or felling of trees alongside transmission and distribution lines;

(3) The Ghanaian side should improve the revenue and expenditures of electric power companies by promoting on-going measures to reduce power distribution loss and also create a reasonable electricity tariff system.

# CONTENTS

# CHAPTER 1

# BACKGROUND OF THE PROJECT

# CHAPTER 1
# BACKGROUND OF THE PROJECT

In 1989 the Government of Ghana formulated the National Electrification Scheme (NES) with the aim of supplying electricity to all communities with a population of 500 or greater by the year 2020. The scheme is divided into six phases. In Phase 1 (1991 to 1995) and Phase 2 (1996 to 2000), district capitals and key municipalities in rural areas were electrified through the National Electrification Project (NEP), with the cooperation of donors, including Japan, and through initiatives of the World Bank. As the result, electrification of 110 district capitals nationwide was completed in 2000. At present, the Self Help Electrification Program (SHEP), which burdens part of the public cost for electrification, is also implemented in areas close to existing transmission and distribution lines through the financial assistance of donors.

However, the financial deficit of the electric power sector has become a serious problem due to the increase in electricity cost resulting from a decline in the Ghanaian currency, the cedi, a surge in crude oil prices, and electricity tariffs left in arrears, which has had a negative impact on progress made by the NES. The average electrification rate in rural areas, primarily in the northern regions, is extremely low at 20% (approximately 60% in metropolitan areas). So mitigating the gap in living standards between urban and rural areas becomes an urgent task. Under such circumstances, as part of the NES, the Ghanaian government plans to electrify three districts in the mid-southern region (Upper Denkyira District in Central region, West Akim District in Eastern Region and Jaman District in Brong Ahafo Region) where economic growth through electrification is anticipated since it is one of the largest farm producing regions. Accordingly, in July 2004 the Ghanaian government submitted a request for Japan's grant aid funding necessary to extend its power distribution network.

In response to this request, in 2005 the Government of Japan through JICA collected information on proposed sites and examination based on a comparison from the viewpoints of (1) cost effectiveness, (2) ripple effects on economic development and (3) improvement in social living conditions through electrification of public facilities, etc. As the result, the beneficial effects in Jaman District in Brong Ahafo Region were confirmed to be smaller than those in the other two districts due to the wide distribution of communities. After the results of the examination were obtained, and after reviewing the proposed sites with the aim of promoting an effective electrification project through the grant aid scheme, the Ghanaian side selected two districts in two regions (Upper Denkyira District in the Central Region and West Akim District in the Eastern Region) aside from Brong Ahafo Region as project sites and in August 2005 made a request to Japan for rural electrification through the grant aid scheme.

# CHAPTER 2

# CONTENTS OF THE PROJECT

# CHAPTER 2
# CONTENTS OF THE PROJECT

## 2-1 Basic Concept of the Project

### 2-1-1 Overall Goal and Project Objective

Annual economic growth of approximately 5% was accomplished in the late 1980s through economic liberalization in accordance with the structural adjustment policy initiative of the World Bank and the International Monetary Fund (IFM). Despite this, more than 30% of Ghana's GDP remains dependent on agriculture, forestry and fisheries, so poverty in rural communities is still a major concern. Consequently, the Government of Ghana has misgivings about continuing slump in economic, social and welfare activities associated with poverty in rural areas and the lagging social infrastructure development and is placing a high priority on the rural electrification projects as a means of redressing the disparity between urban and rural areas by acting to reduce poverty and the "Vision 2020" national development plan.

In response to the above-mentioned policy, the Ministry of Energy formulated the National Electrification Scheme (NES) in 1989 with the goal of "supplying stable electricity to all communities with 500 residents or more by the year of 2020". The aim of the scheme is to "improve the living conditions of rural residents" which is a goal of the Poverty Reduction Strategy Paper (PRSP) and to contribute to "improving the living standards of rural residents and vitalize regional industries" which is taken up in the NES.

### 2-1-2 Outline of the Project

To achieve the above-mentioned goal, the Project will construct a low voltage distribution network in each district by extending 33kV and 11kV distribution lines to targeted sites.

## 2-2 Basic Design of the Requested Japanese Assistance

### 2-2-1 Design Policy

#### 2-2-1-1 Basic Concept

In order to extend existing power distribution facilities and to provide stable electric power to the targeted sites, the Project will procure and install equipment and materials for 33kV and 11kV power distribution lines to be newly constructed and procure materials for low voltage lines needed to supply

power to consumers in target communities. The route of 33/11kV distribution lines to be newly installed is shown in the figure on the first page of the report.

### 2-2-1-2 Natural Conditions

(1) Temperature and Humidity

The temperature at the Project sites is a constant 25C° to 29C° throughout the year, the hottest month being March and the coolest August. Humidity is greater than 85% year round, so it is hot and muggy.

Since the power distribution facilities to be adopted under the Project will be of an outdoor design, consideration should be given to maintaining a normal operating temperature for power distribution equipment and safeguard against increases in outside air temperature and direct sunlight, and to prevent any structural and functional disruption in operation and maintenance. At the same time, space heaters will be installed inside sealed distribution panels in order to prevent condensation from forming due to a drop in temperature.

(2) Precipitation and Lightning Damage

Although the average monthly rainfall during the rainy season (May to June, and September to October) is approximately 400mm at the Project sites, some areas experience heavy squalls. Therefore, waterproofing should be included for power distribution equipment. Since it is sometimes difficult to access 33kV and 11kV distribution lines during the rainy season, auto reclosers or load isolators should also be installed for relatively long lines to ensure safe operation of equipment, to minimize the scale of a power blackout during an accident, to improve the efficiency of recovery work, and for easy maintenance and inspections.

In addition, since thunderstorms occur more than 100 days annually at many of the Project sites, appropriate lightning arresters should be installed.

(3) Other Cautionary Notes

The Project sites are often hit by dust storms called “hamatan” during the dry season. If dust sticks to insulators, insulation performance may deteriorate. Electric poles could also be damaged by fires created through field burning methods. Adequate consideration should be given in the selection of creepage distance of insulators etc. and electric pole specifications so that stable power supply is maintained.

### 2-2-1-3 Socio-economic Conditions

The social infrastructure of municipalities along the route for 33kV and 11kV distribution lines to be newly constructed for the Project is still inadequate and there is no accommodation for Japanese engineers (building contractors) without feeling inconvenience. Accordingly, a construction schedule commuting from the nearest cities (such as Accra and Kumasi) to the sites should be prepared and then used in order to secure safe lodgings and an emergency contacting system during the construction period of the Project.

### 2-2-1-4 Construction and Procurement Conditions

In large cities such as Accra, the capital, and Kumasi, the construction industry is flourishing. Many new commercial office buildings are being built by only a handful of general contractors (builders) and electrical firms, so working conditions are favorable. However, the infrastructure has fallen behind and implementing conditions are very poor at the Project sites. In formulating a construction plan, special attention should be given to a method to transport and store construction machinery and materials and the environment in which a field office is to be built.

Of equipment and materials to be procured under the Project, the equipment for power distribution lines has already been introduced at the existing facilities. Japanese products that are familiar to the Ghanaian side will be mainly examined taking economic efficiency into consideration, and the products of a third country will be also examined.

Conductor for power distribution lines that can be locally procured and others that can be procured from a third country will be examined. Electric poles (steel pipe) and other electric materials are not produced in Ghana, so procurement from Japan and a third country will be examined. However, electric poles are available in Ghana so local procurement will be also examined. Considering the damage caused to electric poles due to field burning and insect biting, and at the request on the Ghanaian side, safe and durable steel poles will be used.

Table 2.2.1-1 Possible Source of Countries to Procure Equipment and Materials

| Equipment and materials | Place of Procurement | | |
|---|---|---|---|
| | Ghana | Japan | Third Country |
| 1. Transformers for Power Distribution | - | ○ | ○ |
| 2. Auto Reclosers | - | - | ○ |
| 3. Load Isolators | - | ○ | ○ |
| 4. Cutout Switches with Fuses | - | ○ | ○ |
| 5. Lightning Arresters | - | ○ | ○ |
| 6. Main Distribution Boards | - | ○ | ○ |
| 7. Aluminum Conductor | ○ | ○ | ○ |
| 8. Steel Poles | ○ | ○ | ○ |
| 9. Other Electrical Materials (such as insulators, cross arms & stay wires) | - | ○ | ○ |
| 10. Maintenance Tools & Emergency Spare Parts | - | ○ | ○ |

### 2-2-1-5 Effective Use of Local Construction Companies

Since on-site (local) procurement of workers, transportation vehicles and construction work equipment and materials in Ghana is relatively easy, local construction companies will be effectively utilized in the construction work for 33kV and 11kV distribution lines and civil engineering work for the Project.

### 2-2-1-6 Operation and Maintenance Capacity of Project Implementing Agency

In the addition to the first four rural electrification projects implemented through Japan's grant aid, many power distribution works at the same level of voltage by SHEP have been implemented in Ghana since 1989. Since the specifications of all distribution facilities to be improved and procured under the Project will be the same level as equipment procured through previous grant aid, the ECG who is in charge of operation and maintenance of the Project is deemed to have the competency to install, operate and maintain distribution equipment to be procured under the Project.

However, the existing distribution facilities have deteriorated and are malfunctioning, and there is a shortage of spare parts due to the financial difficulties at the ECG. In addition, engineers, operators and maintenance personnel may not fully understand the latest power distribution equipment. Japanese engineers will therefore provide on-the-job training (OJT) for operation, maintenance and inspection of the relevant equipment during the construction period of the Project. Simultaneously, special consideration will be given in order to effectively and efficiently operate the facilities to be constructed by providing necessary spare parts, testing instruments, maintenance tools, operation and maintenance manuals, and recommendations on an operation and maintenance system after the commencement of in-service training will be given.

### 2-2-1-7 Scope of Facilities and Equipment, Grade-Setting

In due consideration of the various conditions mentioned above, the scope of procurement and installation of equipment and materials and technical level will be formulated through the following basic policy.

(1) Scope of Facilities and Equipment

Since the target year of the Project is considered to be five years for completion of construction, the minimum but necessary configuration and specifications of facilities will be selected for construction of new distribution lines and procurement of materials for trunk low voltage distribution lines by extending the existing 33kV and 11kV distribution network in order to supply stable electric power for residents and for social and public facilities such as hospitals and schools at the Project sites. In addition, since the capacity of distribution lines is generally

selected based on a long-term plan in due consideration of economical efficiency and its impact on consumers, the capacity will be decided in due consideration of the demand 10 years following the scheduled year of the completion of the construction under the Project.

For a technically and economically appropriate design, the minimum but necessary configuration and specifications of facilities will be selected by applying products that conform to international standards with regards to specifications of materials as much as possible and by keeping the types of materials and equipment to a minimum. The facility scale will be selected based on the following.

1) Capacity of transformer for power distribution : Capacity meeting demand five years after the commencement of service

2) Capacity of distribution line : Capacity for demand ten years after the commencement of service

(2) Grade-Setting

In designing 33kV and 11kV power distribution lines and low voltage distribution lines to be constructed and procured under the Project, special attention will be given as to not to deviate from the technical standards of the ECG which will responsible for the operation and maintenance of the facilities after the completion of construction. Simultaneously, the equipment and materials that comply with the technical level of the Ghanaian side should be selected as equipment and materials for low voltage distribution lines which will be installed by the Ghanaian side.

### 2-2-1-8 Procurement and Construction Period

On the assumption of implementing the Project in accordance with the Japan's grant aid scheme, its construction should be completed in a single year. In order to complete the Project within the scheduled construction period and to effectively display the expected effects through the electrification, a construction schedule should be formulated in conjunction with the work process borne by the Japanese side and that borne by the Ghanaian side in due consideration of inland transportation, period and various procedures, etc.

### 2-2-1-9 Environmental and Social Considerations

According to the Environmental Assessment Regulations [1999, Legislative Instrument (LI) 1652] in Ghana, in the case of constructing electric power facilities, an Environmental Impact Assessment (EIA) must be carried out if the facility falls under any one of the following five forms:

① Construction of a steam power plant
② Construction of a dam and hydroelectric power plant
③ Construction of a combined cycle power plant in a national park
④ Construction of a nuclear power plant
⑤ Construction of power transmission lines

However, according to a letter submitted by the Ghanaian Environmental Protection Agency (EPA) to the JICA Ghana office on August 10, 2005, the 33kV distribution lines to be constructed under the Project are regarded to have a slighter impact on the environment than ultra voltage transmission lines such as 330kV or 161kV, so it may be acceptable to submit a Preliminary Environmental Report (PER) instead of a full-scale EIA. The ministry of Energy submitted a PER for the Project to the EPA in March 2006. Necessary approval for implementation of the Project was obtained from the EPA on June 2nd, 2006. However, if the Project is not completed within the validated date of the approval, special attention should be given to obtaining approval necessary for the implementation of the Project.

As mentioned above, environmental and social considerations will be given for the Project in accordance with the environmental legislation in Ghana. A basic plan will be formulated by observing the Ghanaian environmental regulations and standards.

## 2-2-2 Basic Plan

### 2-2-2-1 Preconditions

(1) Power Demand Forecast for Project Sites

The power demand at the Project sites was estimated through the following procedures. The power demand by 2018, which is ten years after the commencement of service, was estimated based on the number of the present consumers, basic consumption units and annual increase rate of demand.

1) Calculating Number of Consumers

Based on the Ghana 2000 Population Census, the number of consumers was compiled by adding data submitted by the MOE, and a hearing survey and questionnaire survey at the Project sites.

2) Increase Rate in Peak Demand

The increase rate in peak demand for the Rural Electrification Project may be examined by classifying the increase in power demand by (i) the entry rate of consumers to be connected to the power system after commencement of the power supply service, (ii) the growth rate of general households at the Project sites and (iii) the increase in power demand unit mainly resulting from the income effects after electrification.

① Entry Rate of Consumers

In rural electrification projects (NES and SHEP) in Ghana, when applying for electricity supply service 18 months or more after electrification, a consumer is required to pay 1 million Ghana Cedi per single household (approximately ¥19,000; 2 million Cedi in three phases) for a connection charge (in the case of applying for electricity supply service within 18 months after electrification, 5,000 Cedi or approximately ¥80). In previous rural electrification projects, the majority of consumers applied for electricity supply services immediately after the implementation of electrification. Accordingly, even with power demand forecasting for the Project, it is assumed that all consumers (100%) will have applied for electricity supply services by 2008, which will mark the commencement of service.

② Natural Increase Rate in Population at the Project Sites before Electrification

The estimated growth rate of general households by 2008 which will mark the commencement of service is 2.5% cited from the actual growth in the previous assistance, on the basis of the number of general households obtained through the Study which is regarded to be the number of consumers at the end of 2005.

③ Increase Rate in Power Demand after Commencement of Electricity Supply Service

Based on the numerical values mentioned in the Business Plan prepared by each branch office of the ECG which will maintain the power distribution lines for the Project, the annual increase rate of power demand after the commencement of service is estimated to be 5% on average based on the data of the MOE, etc.

3) Basic Units of Power Demand Forecast

The basic units for power demand forecast are as follows. Although the units are based on those adopted in previous ECG rural electrification projects, almost all similar units are adopted in rural electrification projects of other African nations and are therefore judged to be relevant. The average power factor will be 90%.

• Unit Demand Electricity (including demand and diversity factors):

| | | |
|---|---|---|
| General residences | : | 150W/household |
| Schools | : | 1,000W/building |
| Clinics | : | 2,500W/building |
| Other public facilities | : | 500W/building |

In addition, as for the breakdown of the above-mentioned load for general households from the results of an interview survey at the Project sites, the following electrical appliances necessary to daily life and feasible for use immediately after electrification are anticipated.

• Breakdown for electrical appliances of general housing (per single household):

| | | |
|---|---|---|
| Lighting | : | 80W (40W × 2) |
| Iron | : | 750W |
| Radio cassette recorder | : | 20W |
| Total | : | 850W |

When 30% of the demand factor and 1.7 of the diversity factor are applied to the above-mentioned total load, power demand in general household becomes 150W/household (850W × 0. 3 ÷ 1.7 = 150).

4) Power Demand Forecast for the Target Year

Since the target year of the Project is regarded to be five years after the commencement of service in the year of completion of construction, the demand forecast at the Project sites, assuming the number of households subject to electrification at the sites and various conditions such as the above-mentioned increase in rate of power demand, is shown in Appendix 6. As shown in the said table, the peak demand necessary at the Project sites is assumed to be approximately 3.6MW five years from the commencement of service, which is approximately 0.4% of 831MW of the ECG's peak demand at the end of 2005. The Project is therefore considered to have an extremely small impact on the power demand and supply balance on the national scale.

5) Voltage Drop

Distribution lines will be designed so that voltage drop at consumer ends in year 2013 can meet the allowable range which is specified in the ECG's technical standards.

6) Scale of Power Distribution Facilities

The specifications of transformers and distribution lines in the Project will be decided in due consideration of demand in the target year as follows.

a) Capacity of transformer for power distribution: The demand in 2013 is being considered.
b) Capacity of distribution lines:

| | | |
|---|---|---|
| 33/11kV | : | The demand in 2018 is being considered. |
| Low voltage (433 - 250V) | : | The demand in 2018 is being considered. |

(2) Electric Power System Plan

By using 120mm$^2$ all aluminum conductors (AAC) for all 33kV and 11kV distribution lines to be newly constructed in the Project, electricity will be supplied to consumers by extended lines from the existing 33kV and 11kV distribution system using the method shown in Table 2.2.2-1 by T-branching or extending the terminal to each target site and by lowering voltage through pole mounted transformers (33kV and 11kV/433 - 250V).

In due consideration of line extension and load capacity, since the 33kV and 11kV distribution lines are a radial system, the system should be designed so that faults can be easily spotted and separated by installing auto reclosers. If lateral lines exceed 10km from the trunk line, easy maintenance should be secured by installing a load isolators at branching points. Cutout switches with fuses will be installed to protect the pole-mounted transformer. Lightning arresters will be installed to protect distribution equipment from lightning.

Table 2.2.2-1 Connection Method between New and Existing 33kV and 11kV Distribution Lines

| Project Site | Connection Method |
|---|---|
| West Akim District | 1) T-branching from section or terminal poles of existing 11kV distribution lines |
| Upper Denkyira District | 1) Dunkwa line: T-branching from terminal pole of existing 11kV distribution line<br>2) Dawusaso line: Branching with a cable from lead-in line at the existing 33kV switching station and installation of a load isolator and an auto recloser on the first power distribution pole to be newly constructed<br>3) Nkwantanum line: Branching with a cable from lead-in line of the existing 33kV switching station and installation of a load isolator and an auto recloser on the first power distribution pole to be newly constructed |

### 2-2-2-2 General Plan

The following conditions have been set to determine the scope and specifications of facilities, equipment and materials for the Project.

(1) Climatic and Site Conditions

| | | | West Akim District | Upper Denkyira District |
|---|---|---|---|---|
| (a) Altitude | Site average | : | 60 ～ 460 m | 250 m |
| (b) Climate | Dry season | : | November to April | November to April |
| | Rainy season | : | May to October | May to October |
| (c) Relative humidity | Maximum | : | 98% | 98% |
| (d) Rainfall | (Annual) | : | 1,700 mm | 2,000 mm |
| (e) Average wind direction | | | | |
| | Northeast | : | September to March | September to March |
| | Southwest | : | April to August | April to August |
| (f) Gusts | | : | 120km/h | 120km/h |
| g) Thunderstorm days as annually (IKL) | | : | 100 days | 100 days |
| (h) Seismic factor | | : | 0.1 | 0.1 |
| (i) Soil bearing capacity (Long-term allowable bearing capacity) | | : | 10 ton/$m^2$ | 10 ton/$m^2$ |
| (j) Hamatan | | : | December to January | December to January |

(2) Electrical System Conditions

① Distribution voltage : 33 kV and 11 kV, three phase three wire (max.: 36 & 12 kV), Low voltage (433 - 250V), three phase four wire (maximum: 438 - 253V)

② Frequency : 50Hz

③ Interrupting capacity : 33 kV system: 25kA (1sec), 11kV system: 20kA (1sec)
Low voltage system: 15 kA (1sec)

④ Earthing system : 33 kV and 11 kV systems: effectively earthed
Low voltage system: effectively earthed

⑤ Basic insulation level (BIL) : 33 kV/11 kV systems: 170/75kV

⑥ Nominal Power Frequency withstand voltage:
33 kV/11 kV systems: 70/28 kV
Low voltage system: 3kV

⑦ Creepage distance : 25 mm/kV

⑧ Line capacity (per circuit) : 33 kV and 11 kV distribution line: 455 A
Low voltage distribution line: 165 A

⑨ Color coding : IEC standards (red, yellow, blue, black)

⑩ Insulator material and color : Ceramic, brown

⑪ Protection class and plate thickness for distribution panels:

Table 2.2.2-2 Protection Class and Plate thickness for Distribution Panels

| Usage | Plate thickness | Protection Class |
|---|---|---|
| Outdoor use | No less than 2.3 mm | No less than IP54 |

⑫ Safety factor:

Table 2.2.2-3 Safety Factor for Distribution Equipment and Materials

| Item | Safety Factor |
|---|---|
| Supports, support foundations | 2.0 |
| Conductors, cross arms | 2.5 |
| Insulators, connectors & terminals | 2.0 |

Remark: Based on the ECG standards

⑬ Clearance for distribution lines:

Table 2.2.2-4 Clearance for Distribution Lines

| Item | Unit | 33 kV Distribution Lines | 11 kV Distribution Lines | Low Voltage Distribution Lines |
|---|---|---|---|---|
| 1. Minimum Clearance | | | | |
| 1) Phase to Phase | [mm] | 370 | 315 | 300 |
| 2) Phase to Earth | [mm] | 320 | 220 | 200 |
| 2. Minimum Height | | | | |
| 1) Road crossing | [m] | 7 | 7 | 6 |
| 2) Roadside | [m] | 6 | 6 | 5 |
| 3. Clearance on same Pole High & Low Voltage Lines | [mm] | 1,500 | | |

(3) Applicable Codes/Standards and Units

With regard to the Project design, as shown below, in due consideration of conformity with existing facilities in Ghana, relevant international standards such as IEC and ISO and the Japanese standards will be applied to major equipment and facilities. Since the ECG standards are regarded to be applied to electrical work, Japanese standards will be supplementary applied. In addition, the International System of Units (SI) will be utilized.

① International Electrotechnical Commission (IEC) : Applied to major functions of electrical products in general
② International Standardization Organization (ISO) : Applied to units
③ Japanese Industrial Standard (JIS) : Applied to industrial products in general
④ Japanese Electrotechnical Commission (JEC) : Applied to electrical products in general
⑤ Standards for Japan Electrical Manufacturer's Association (JEM) : Applied to electrical products in general

⑥ Japanese Electrical Wire and Cable Marker's Association Standards (JCS) : Applied to electrical wires and cables

⑦ Other related Japanese and international standards : Applied to electrical works in general

⑧ Standards of Ghana Standard Board : Applied to electrical works in general

⑨ Electricity Company of Ghana (ECG) Standards : Applied to electrical works in general

(4) Overview of the Basic Plan

The Basic Plan for the Project in accordance with the above-mentioned basic design concept (Refer to 2-2-1) is outlined in Table 2.2.2-5.

Table 2.2.2-5 Overview of the Basic Plan

| No. | Item | Unit | West Skim District in the Eastern Region | Upper Denkyira District in the Central Region |
|---|---|---|---|---|
| A. | Procurement & Installation of Equipment & Materials for 33 kV & 11 kV Power Distribution Lines | | | |
| (1) | 33 kV Distribution Line | | | |
| | 1) 33 kV/ 433 - 250 V transformer | | | |
| | a) 50 kVA | [unit] | | 2 |
| | b) 100 kVA | [unit] | | 7 |
| | 2) Auto recloser | [unit] | | 1 |
| | 3) Load isolator | [unit] | | 5 |
| | 4) Lightning arrester | [unit] | | 16 |
| | 5) Cutout Switch with Fuse | [unit] | | 9 |
| | 6) Conductor: AAC 120 $mm^2$ | [km] | | 28.9 |
| | 7) Steel pole (11m) | [pole] | | 275 |
| (2) | 11 kV Distribution Line | | | |
| | 1) 11 kV/ 433-250 V transformer | | | |
| | a) 50 kVA | [unit] | 22 | 3 |
| | b) 100 kVA | [unit] | 16 | 8 |
| | c) 200 kVA | [unit] | 4 | 0 |
| | 2) Auto recloser | [unit] | 1 | 0 |
| | 3) Load isolator | [unit] | 9 | 2 |
| | 4) Lightning arrester | [unit] | 53 | 13 |
| | 5) Cutout Switch Fuse | [unit] | 42 | 11 |
| | 6) Conductor: AAC 120 $mm^2$ | [km] | 98.6 | 21.3 |
| | 7) Steel pipe pole (11m) | [pole] | 1,108 | 233 |
| (3) | Main Distribution Board (MDB) | [set] | 42 | 20 |
| B. | Procurement of Equipment & Materials for Low Voltage Distribution Lines | | | |
| (1) | Low voltage trunk line | [km] | 455.8 | 183.4 |
| (2) | Pole fitting materials for distribution lines (such as insulators and terminals) | [set] | 1 | 1 |
| (3) | Procurement of maintenance tools and emergency spare parts | [set] | 1 | 1 |

Remarks: The Quantity of equipment and materials indicated is the design quantity.

### 2-2-2-3 Equipment and Materials Plan

(1) 33 kV and 11 kV Distribution Lines Plan

Procuring and installing equipment and materials for 33kV and 11kV distribution lines to be implemented by the Japanese side for the Project will be planned in accordance with the following basic issues and the outline of facilities.

1) Fundamental Issues

The facilities will be designed in accordance with the ECG standards and supplemented by Japanese technical standards. In addition, whenever possible specifications for equipment and materials to be procured by the Japanese side should be compatible with existing equipment owned or utilized by the ECG in order to ensure unified management.

2) Overview of Distribution Lines Plan

① Selection of Routes

After examining a preliminarily route map of distribution lines and map, routes for each distribution line were determined through actual field surveys together with ECG engineers and by confirming any obstructions, target objects and unique natural conditions at the site. Since most of the distribution lines lie parallel with major trunk roads, spot crossings will be kept to a minimum to prevent broken wires caused by large-scale vehicles. The basic routes are shown in the opening page.

② Selection of Pole Spans

Spans between electric poles will be determined based on line sizes, line tensile loads and strength of electric poles in accordance with the ECG design standards.

| Description | Unit | Designed Value | Remarks |
|---|---|---|---|
| 1. Standard Span for 33 kV & 11 kV Electric Poles | | | |
| 1) Suburbs<br>2) Inside of town/village areas | [m]<br>[m] | 100<br>90 | |
| 2. Standard interval arrangement for section poles | | | |
| 1) Suburbs<br>2) Inside of town/village areas | [m]<br>[m] | 1000<br>900 | Maximum 10 span |

③ Type of Conductors for Overhead Distribution Lines

With regards to specifications for conductors used for overhead distribution lines for the Project, all aluminum conductors (AAC) and the following size will be adopted in accordance with ECG standards.

• 33 kV and 11 kV distribution line: AAC 120mm$^2$

With respect to the quantity of conductors for overhead distribution, design quantity (line sag length: 3% is included) will be determined by multiplying the plane distance as three phases and then procurement quantity will be forecasted multiplying the design quantity by 1.1 of the margin rate (construction supplementing quantity rate: 10%). The following table indicates the quantity of distribution lines at each site.

Table 2.2.2-6 Quantity of 33kV and 11kV Distribution Lines

| Item | | West Akim District | Upper Denkyira District | Total |
|---|---|---|---|---|
| 33 kV & 11 kV Distribution lines (AAC 120mm$^2$) | ① Distribution line length | 98.6 km | 50.2 km | 148.8 km |
| | ② Designed quantity [for 3 phases, ① × 3 × 1.03 (sag)] | 304.7 km | 155.1 km | 459.8 km |
| | ③ Planned quantity (②× 1.1) | 335.2 km | 170.6 km | 505.8 km |

Remark: Standard 2km drums will be adopted. XLPE cable with copper conductor which is specified in the ECG's technical standards will be used at branch points from the existing switching station.

④ Type and Shape of Electric Poles

Steel poles requested by the Ghanaian side will be utilized. The length of the steel poles will be 11m as a 33kV and 11kV standard class.

In due consideration of environmental factors such as harmattan (hamatan), 25mm/kV, which is the ECG standard, will be applied to pin insulators and dead-end (strain) insulators used for 33kV and 11kV distribution lines. In addition, iron L-shape galvanized cross arms for installing insulators meeting ECG standard specifications will also be adopted.

⑤ Capacity and Quantity of Distribution Transformers

(a) Selection of Capacity and Quantity

Distribution transformers will be installed to lower the voltage of 33kV and 11kV distribution lines to a low distribution voltage for connecting to individual consumers at the Project sites. Assuming that the peak demand for the target year must be satisfied, the capacity and the number of units of transformers to be procured under the Project will be selected from ECG standard transformer capacity and the optimum number of units will be selected based on distribution conditions at the sites. In addition, the distribution transformers should be located in the center of the load in order to minimize distribution loss and voltage drops. Total number and capacity of the selected transformers are 62 and 5,250kVA, respectively. Table 2.2.2-7 shows the number and capacity of the transformers.

Furthermore, in order to keep voltage fluctuation for low voltage consumers within ±7.0%, distribution transformers to be procured under the Project will have ±2 x 2.5 % taps (no-load tap changer) on the primary side, while the secondary (low voltage) side will use a three-phase, four-wire system for economy and efficiency of distribution lines. The area covered by each distribution transformer will be a radius of 400m taking into consideration voltage drops; whereas the maximum area for distribution transformers will be 1km in principle.

(b) Specifications

In order to reduce technical loss and enhance efficient operation of the distribution system, low-loss type transformer which is standardized in Japanese Industrial Standards will be applied for the Project.

(c) Installation Method

All distribution transformers will be installed using the existing pole-mounted method (pole transformers) for optimum safety.

⑥ Installation of Load Isolators

For maintenance and inspection of 33kV and 11kV distribution lines at the Project sites, load isolators to allow a break in the current will be installed at an appropriate distance for long-distance lines, and at the connecting points and junctions for the existing 33kV and 11kV distribution lines.

⑦ Installation of Cutout Switches with Fuses

Cutout switches with fuses, which are the existing method, will be installed on the high voltage side of distribution transformers (33kV and 11kV) in order to protect circuits from overloading and short-circuits and to open the primary circuits for maintenance and distribution transformers to be procured under the Project.

Table 2.2.2-7 Capacity and Number of Transformer at Project Sites

| Area | No. | Municipality Name | Population | Number of Households | Quantity & Capacity of Transformers | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (11kV/433-250V) | | | | (33kV/433-250V) | | | |
| | | | | | 200kVA | 100kVA | 50kVA | (kVA) | 200kVA | 100kVA | 50kVA | (kVA) |
| West Skim District in the Eastern Region | 1 | Asuofori | 1,700 | 170 | | 1 | | 100 | | | | |
| | 2 | Akwadum | 700 | 100 | | | 2 | 100 | | | | |
| | 3 | Akanteng | 4,000 | 400 | | 2 | 1 | 250 | | | | |
| | 4 | Kobriso | 1,040 | 214 | | | 1 | 50 | | | | |
| | 5 | Afranse | 4,000 | 400 | | 1 | | 100 | | | | |
| | 6 | Brekumanso | 1,010 | 176 | | | 2 | 100 | | | | |
| | 7 | Ammarko | 3,000 | 200 | | | 2 | 100 | | | | |
| | 8 | Oworam | 7,000 | 700 | | 2 | | 200 | | | | |
| | 9 | Pabi | 3,000 | 300 | | 1 | | 100 | | | | |
| | 10 | Anum Apapam | 6,500 | 615 | 1 | | 1 | 250 | | | | |
| | 11 | Mfranor | 1,500 | 100 | | | 1 | 50 | | | | |
| | 12 | Kuano | 3,800 | 449 | 1 | | | 200 | | | | |
| | 13 | Sowatey | 1,135 | 190 | | 1 | | 100 | | | | |
| | 14 | Takorase | 1,500 | 100 | | | 1 | 50 | | | | |
| | 15 | Krodua | 4,000 | 400 | | | 2 | 100 | | | | |
| | 16 | Akim Breman | 4,390 | 440 | 1 | | | 200 | | | | |
| | 17 | Nyanoa | 1,450 | 347 | 1 | | | 200 | | | | |
| | 18 | Obinyimna | 1,230 | 170 | | 1 | | 100 | | | | |
| | 19 | Abamkrom | 2,042 | 270 | | 1 | | 100 | | | | |
| | 20 | Kumikrom | 4,000 | 400 | | 1 | 1 | 150 | | | | |
| | 21 | Esaaso | 1,000 | 100 | | | 1 | 50 | | | | |
| | 22 | Nkurankan | 690 | 110 | | | 1 | 50 | | | | |
| | 23 | Nyakoma | 1,600 | 160 | | | 1 | 50 | | | | |
| | 24 | Anomakojo | 1,400 | 210 | | 1 | | 100 | | | | |
| | 25 | Atokrom | 1,200 | 100 | | | 1 | 50 | | | | |
| | 26 | Danso | 1,647 | 350 | | 1 | | 100 | | | | |
| | 27 | Krofofrom | 1,200 | 100 | | | 1 | 50 | | | | |
| | 28 | Odjade | 2,750 | 280 | | 1 | | 100 | | | | |
| | 29 | Abuchenso | 1,500 | 100 | | | 1 | 50 | | | | |
| | 30 | Bunso | 4,000 | 400 | | 2 | | 200 | | | | |
| | 31 | Kofikyere | 1,800 | 120 | | | 2 | 100 | | | | |
| | | Subtotal | 75,784 | 8,171 | 4 | 16 | 22 | 3,500 | 0 | 0 | 0 | 0 |
| Upper Denkyira District in the Central Region | 1 | Brofoyedru | 1,000 | 200 | | | 1 | 50 | | | | 0 |
| | 2 | Breman | 2,500 | 250 | | 1 | | 100 | | | | 0 |
| | 3 | Dominase | 6,000 | 1,200 | | 3 | | 300 | | | | 0 |
| | 4 | Abora | 1,500 | 350 | | 1 | | 100 | | | | 0 |
| | 5 | Anwiawa | 1,500 | 300 | | 1 | | 100 | | | | 0 |
| | 6 | Beseasi | 4,200 | 500 | | 1 | 1 | 150 | | | | 0 |
| | 7 | Nkroful | 1,500 | 200 | | | 1 | 50 | | | | 0 |
| | 8 | Treposo | 1,800 | 250 | | 1 | | 100 | | | | 0 |
| | 9 | Esienkyen | 2,000 | 350 | | | | 0 | | 1 | | 100 |
| | 10 | Asaaman | 2,500 | 300 | | | | 0 | | 1 | | 100 |
| | 11 | Akwaboso | 2,500 | 450 | | | | 0 | | 1 | | 100 |
| | 12 | Afiefiso | 1,500 | 400 | | | | 0 | | 1 | | 100 |
| | 13 | Ameyaw | 2,500 | 400 | | | | 0 | | 1 | | 100 |
| | 14 | Subin | 2,000 | 340 | | | | 0 | | 1 | 1 | 150 |
| | 15 | Anhwiaso | 800 | 80 | | | | 0 | | | 1 | 50 |
| | 16 | Nyinawusu | 1,800 | 300 | | | | 0 | | 1 | | 100 |
| | | Subtotal | 35,600 | 5,870 | 0 | 8 | 3 | 950 | 0 | 7 | 2 | 800 |
| Total | | | 111,384 | 14,041 | 4 | 24 | 25 | 4,450 | 0 | 7 | 2 | 800 |

⑧ Installation of Lightning Arrestors

In a similar manner as with existing equipment, lightning arrestors will be installed on the 33kV and 11kV sides to protect the distribution transformers, auto reclosers and load isolators from lightning strikes.

(2) Low Voltage Distribution Lines Plan

In procuring equipment and materials for 433 - 250V low voltage distribution lines to be implemented by the Japanese side, the design will be based on the following basic issues and outline of equipment and materials.

1) Basic Issues

The equipment should be designed in accordance with relevant ECG standards, and whenever possible, the specifications of equipment and materials to be procured by the Japanese side should be compatible with existing equipment owned or utilized by the ECG for uniformity of management. Low voltage distribution lines should be designed so as to be easily maintained

2) Outline of Distribution Lines Plan

① Selection of Routes

The low voltage distribution routes map at the Project sites obtained from the ECG side will be applied for distribution line routes.

② Selection of Pole Spans

Although pole spans will be determined by conductor size, the tensile load and strength of electric pole, etc., wooden poles based on ECG standards and manufactured in Ghana will be used in principle. Accordingly, the design will be made by adopting spans in accordance with ECG standards.

- Standard span of low voltage distribution poles : 45m
- Standard interval arrangement of section poles : every 10 spans

③ Type and Shape of Electric Poles

Since residents of areas subject to electrification purchase electric poles for low voltage distribution and install them in the presence of the ECG through the Self Help Electrification Program (SHEP), wooden poles manufactured in Ghana are normally

used. Consequently, the height of wooden poles for low voltage distribution will be 8m or 9m from the ECG standard in principle.

The ECG standards will be adopted for the surface creepage distance of shackle insulators and spool insulators used for low voltage distribution lines. In addition, the type of clamps for insulators should conform to relevant ECG standard specifications and hot-dip galvanized mild steel will be adopted for materials.

④ Type of Conductors for Low Voltage Overhead Distribution Lines

The ECG standards for all aluminum conductors (AAC) will be adopted for the specifications of conductors utilized for low voltage overhead distribution lines in the Project and the size will be as follows.

• Trunk low voltage distribution lines : AAC 50mm$^2$

With respect to the quantity of the above-mentioned conductors for low voltage overhead distribution lines, design quantity (line sag length: 3% is included) will be calculated by multiplying the plain distance as three phases and then procurement quantity will be forecasted by multiplying the design quantity by 1.05 of the margin rate (construction supplementing quantity rate: 5%). The following table shows the quantity of electric lines at each site.

⑤ Low Voltage Distribution Method

Main Distribution Boards (MDB) which contain MCCBs (Molded Case Circuit Breaker) on low voltage side and various meters will be installed to transformer poles so that low voltage lines can be easily connected and maintained. The MDB should have four low voltage feeders.

Table 2.2.2-8 Quantity of Low Voltage Distribution Lines

| Item | | West Akim District | Upper Denkyira District | Total |
|---|---|---|---|---|
| Low Voltage Distribution Lines (AAC 50mm$^2$) | ① Distribution line length | 110.6 km | 44.5 km | 155.1 km |
| | ② Designed quantity [for 3 phase 4 wire, ① × 4 × 1.03 (sag)] | 455.8 km | 183.4 km | 639.2 km |
| | ③ Planned quantity (②× 1.05) | 478.6 km | 192.5 km | 671.1 km |

Remark: Standard 4km drum will be adopted.

(3) General Specifications of Equipment and Materials

General specifications of equipment and materials to be procured under the Project are shown in Table 2.2.2-9 and Table 2.2.2-10.

Table 2.2.2-9 General Specifications of Equipment and Materials Procured for the Project (33/11kV Distribution)

| No. | Name | Major Specifications or Configuration | | Unit | Installed Site & Quantity | | Total Quantity |
|---|---|---|---|---|---|---|---|
| | | | | | West Akim District | Upper Denkyira District | |
| 1. | Equipment | | | | | | |
| 1.1 | Distribution Transformers | (1) Applicable Standard | : IEC60076 or equivalent | | | | |
| | | (2) Type | : Outdoor, oil-filled self cooling (ONAN), pole-mounted | | | | |
| | | (3) Rated Voltage | : 33kV/433-250V (for 33kV): 11kV/433-250V (for 11kV) | | | | |
| | | (4) Tap Changer | : 2×±2.5%, No load | | | | |
| | | (5) Capacity | : 50kVA（33kV） | set | 0 | 2 | 2 |
| | | | : 100kVA（33kV） | | 0 | 7 | 7 |
| | | | : 50kVA（11kV） | | 22 | 3 | 25 |
| | | | : 100kVA（11kV） | | 16 | 8 | 24 |
| | | | : 200kVA（11kV） | | 4 | 0 | 4 |
| 1.2 | Auto Reclosers | (1) Applicable Standard | : IEC or equivalent | | | | |
| | | (2) Type | : Outdoor, 3 phase, vacuum type or SF6 gas circuit breaker | | | | |
| | | (3) Rated Voltage | : 36kV (for 33kV) | set | 0 | 1 | 1 |
| | | | : 12kV (for 11kV) | set | 1 | 0 | 1 |
| | | (4) Rated Current | : 630A | | | | |
| | | (5) Short Circuit Current | : 16kA, 1 sec. (for 33kV) : 12.5kA, 1 sec. (for 11kV) | | | | |
| 1.3 | Load Isolators | (1) Applicable Standard | : IEC or equivalent | | | | |
| | | (2) Type | : Outdoor, pole-mounted, 3 phase | | | | |
| | | (3) Rated Voltage | : 36kV (for 33kV) | set | 0 | 5 | 5 |
| | | | : 12kV (for 11kV) | set | 9 | 2 | 11 |
| | | (4) Rated Current | : 400A | | | | |
| | | (5) Short Circuit Current | : 25kA, 1 sec. (for 33kV) | | | | |
| | | | : 16kA, 1 sec. (for 11kV) | | | | |
| 1.4 | Cutout Switches with Fuses | (1) Applicable Standard | : IEC or equivalent | | | | |
| | | (2) Type | : Outdoor, pole-mounted type, single phase (3 units/set) | | | | |
| | | (3) Rated Voltage | : 36kV (for 33kV) | set | 0 | 9 | 9 |
| | | | : 12kV (for 11kV) | set | 42 | 11 | 53 |
| | | (4) Rated Current | : 100A | | | | |
| | | (5) Short Circuit Current | : 25kA (for 33kV) | | | | |
| | | | : 16kA (for 11kV) | | | | |
| 1.5 | Lightning Arrestors | (1) Applicable Standard | : IEC or equivalent | | | | |
| | | (2) Type | : Outdoor, single phase (3 units/set) | | | | |
| | | (3) Rated Voltage | : 36kV (for 33kV) | set | 0 | 16 | 16 |
| | | | : 12kV (for 11kV) | set | 53 | 13 | 66 |
| | | (4) Discharge Current Value | : 10kA | | | | |
| 1.6 | Main Distribution Boards (MDB) | (1) Applicable Standard | : IEC or equivalent | set | 42 | 20 | 62 |
| | | (2) Type | : Outdoor, pole-mounted type, IP54 | | | | |
| | | (3) Configuration | : ・Primary side, disconnecting switch, 400A, 4 pole<br>・Secondary side, MCCB 100AF x 1 (4 pole) & 50AF x 3 (4 pole)<br>・Thermal relay (variable)<br>・Digital meter W (with max), A, V & Wh display<br>・Current transformer (15VA, class 1.0) | | | | |

| No. | Name | Major Specifications or Configuration | | Unit | Installed Site & Quantity | | Total Quantity |
|---|---|---|---|---|---|---|---|
| | | | | | West Akim District | Upper Denkyira District | |
| 2. | Materials | | | | | | |
| 2.1 | 33/11kV Overhead Distribution Line Conductors | (1) Applicable Standard<br>(2) Type<br>(3) Size | : IEC or equivalent<br>: All aluminum conductor (AAC)<br>: 120mm$^2$ | km | 335.2 | 170.6 | 505.8 |
| 2.2 | Connector & Binding Wires for Eclectic Lines | | | | | | |
| (a) | Straight Sleeves | (1) Application<br>(2) Type<br>(3) Material | : For the above-mentioned 2.1 Conductor<br>: Crimp style<br>: Aluminum | piece | 168 | 86 | 254 |
| (b) | Connectors | (1) Application<br>(2) Type<br>(3) Material | Same as above | piece | 494 | 221 | 715 |
| 2.3 | Electric Poles | (1) Material<br>(2) Length/ Thickness<br>(3) Horizontal Load | : Steel pipe incorporated structure<br>: 11m/2.54mm<br>: Not less than 538.65kg (600mm spot from the top) | piece | 1,108 | 233 | 1,441 |
| 2.4 | Insulators | | | | | | |
| (a) | Dead-end (Strain) Insulator Set | (1) Unit Quantity | : 3 units/set (for 33kV)<br>: 2 units/set (for 11kV) | set<br>set | 0<br>1,476 | 360<br>408 | 360<br>1,884 |
| | | (2) Applicable Standard | : IEC or equivalent | | | | |
| | | (3) Type | : Porcelain insulator, disc shape | | | | |
| | | (4) Color | : Brown | | | | |
| | | (5) Creepage Distance | : 320mm | | | | |
| (b) | Pin Insulator Set | (1) Unit Quantity<br>(2) Applicable Standard<br>(3) Type<br>(4) Color<br>(5) Nominal System Voltage<br>(6) Creepage Distance (Minimum) | Quantity 1 piece/set<br>: IEC or equivalent<br>: pin type, porcelain insulator<br>: Brown<br>: 33kV<br>: 11kV<br>: 25mm/kV | set<br>set | 0<br>3,068 | 751<br>639 | 751<br>3,707 |
| 2.5 | Cross-arm set | (1) Cross-arm<br>1) Materials<br>2) Coating<br>3) Section Shape<br>4) Length | Quantity 1 piece/set<br>: Mild steel<br>: Hot-dipped galvanized<br>: L shape<br>: 33kV: 2,500mm<br>: 11kV: 2,200mm | set<br>set | 0<br>1,533 | 367<br>330 | 367<br>1,863 |
| 2.6 | Stay wire set | (1) Stay wire<br>1) Materials<br>2) Size<br>3) Coating<br>(2) Insulator<br>1) Voltage | Quantity 9 m/set<br>: Mild steel<br>: 45mm2 (2.9mm x 7) or equivalent<br>: Hot-dipped galvanized<br>Quantity 1 piece/set<br>: 33kV<br>: 11kV | set<br>set | 0<br>814 | 201<br>218 | 201<br>1,032 |
| 2.7 | Earthing Wire Set | | | | | | |
| (a) | For Equipment | (1) Earthing Rod<br>1) Material<br>2) Size<br>(2) Earthing Wire<br>1) Material<br>2) Size | Quantity 2 pieces/set<br>: Copper clad core rod<br>: D14mm× L1500mm<br>Quantity 15m/set<br>: 600V polyvinyl chloride wire, copper wire<br>: 100mm$^2$ | set | 52 | 28 | 80 |
| (b) | For Pole Fitting Hardware | (1) Earthing Rod<br>1) Material<br>2) Size<br>(2) Earthing Wire<br>1) Material<br>2) Size | Quantity 2 units/set<br>: Copper clad core rod<br>: D14mm× L1500mm<br>Quantity 15m/set<br>: 600V polyvinyl chloride wire, copper wire<br>: 16mm$^2$ | set | 1,091 | 495 | 1,586 |
| (c) | For Lightning Arrestors | (1) Earthing Rod<br>1) Material<br>2) Size<br>(2) Earthing Wire<br>1) Material<br>2) Size | Quantity 2 units/set<br>: Copper clad core rod<br>: D14mm× L1500mm<br>Quantity 15m/set<br>: 600V polyvinyl chloride wire, copper wire<br>: 100mm$^2$ | set | 52 | 28 | 80 |

| No. | Name | Major Specifications or Configuration | | Unit | Installed Site & Quantity | | Total Quantity |
|---|---|---|---|---|---|---|---|
| | | | | | West Akim District | Upper Denkyira District | |
| 2.8 | LV Cable Materials | | | Set | 42 | 20 | 62 |
| (a) | Between Distribution Transformer and MDB | (1) LV Cable | | | | | |
| | | 1) Type | 600/1,000V, PVC, single core, Cu | | | | |
| | | 2) Sectional Size | From TR to MDB: 95mm$^2$ (1 circuit) 30m<br>From MDB to LV trunk line: 50mm$^2$ (2 circuits) 80m | | | | |
| | | 3) Accessories | Insulation cap and terminal lugs | | | | |
| | | (2) Cable Support | Quantity 8m/ set (2 circuits) | | | | |
| | | 1) Type | Cable Rack | | | | |
| | | 2) Accessories | Rack support, bolts, nuts and cover | | | | |
| | | (3) Connector | Quantity 8 pieces/ set (2 circuits) | | | | |
| | | 1) Type | Bolt type, bimetal (copper and aluminum) | | | | |
| (b) | Between MDB and LV Cable | (1)~(3) | Same as above | Set | 42 | 20 | 62 |
| 2.9 | Plate set | | | Set | 1,091 | 493 | 1,584 |
| | | (1) Pole No. and Danger Plate | Quantity 1 piece/set | | | | |
| | | 1) Material | Aluminum | | | | |
| | | 2) Size | 200mm x 175mm x t1mm (ECG's standard) | | | | |
| | | (2) Japan's Flag Plate | Quantity 1 piece/set | | | | |
| | | 1) Material | Stainless Steel | | | | |
| | | 2) Accessories | Band | | | | |
| 2.10 | Connection Materials to existing distribution lines | | | Lot | 0 | 2 | 2 |
| (a) | Dawusaso | (1) Clamp | AAC 120mm$^2$ | | | | |
| (b) | Nkwantanum | (2) Conductor | AAC 120mm$^2$ | | | | |
| | | (3) Steel Pole | Mild steel, Hot-dipped galvanized coating, Height: approx. 2.5m | | | | |
| | | (4) Cross Arm | L-type, Mild steel, Hot-dipped galvanized coating | | | | |
| | | (5) HV Cable | XLPE 18/30(36), single core, 95mm$^2$, Cu | | | | |
| | | (6) Line post insulator | 33kV, Brown, Porcelain insulator | | | | |
| | | (7) Cable conduit | Hard PVC, flexible type Diameter 150mm | | | | |
| | | (8) Pin insulator | 33kV, Pin type, porcelain insulator | | | | |
| | | (9) Connector | Bolt type, aluminum alloy | | | | |
| | | (10) Lightning Arrester | Outdoor, Zinc oxide, gapless, single phase | | | | |
| | | (11) Earthing set | Copper clad core rod, D14mm x L1,500mm | | | | |

Table 2.2.2-10 General Specifications of Equipment and Materials Procured for the Project (Low Voltage Distribution)

| No. | Name | Major Specifications or Configuration | | Unit | Installed Site & Quantity | | Total Quantity |
|---|---|---|---|---|---|---|---|
| | | | | | West Akim District | Upper Denkyira District | |
| 1.1 | LV overhead line conductors | (1) Applicable Standard<br>(2) Type<br>(3) Size | : IEC or equivalent<br>: All aluminum conductor (AAC)<br>: 50mm$^2$ | km | 478.6 | 192.5 | 671.1 |
| 1.2 | Bracket set | (1) Quantity<br>(2) Material<br>(3) Coating | : 1 piece/set<br>: Mild steel<br>: Hot-dipped galvanized | set | 16,756 | 6,444 | 23,200 |
| 1.3 | LV shackle insulators | (1) Applicable Standard<br>(2) Type<br>(3) Color<br>(4) Nominal System Voltage | : IEC or equivalent<br>: Porcelain insulator<br>: Brown<br>: 3kV | set | 16,756 | 6,444 | 23,200 |
| 1.4 | Bolt nut and Washer set | (1) Materials<br>(2) Coating | : Mild steel<br>: Hot-dipped galvanized | set | 16,756 | 6,444 | 23,200 |
| 1.5 | Connector set for LV lines | (1) Type<br>(2) Coating | : Crimp style, AAC50mm$^2$<br>: Aluminum alloy casting | piece | 7,700 | 2,952 | 10,652 |
| 1.6 | Stay wire assembly | (1) Stay wire<br>1) Material<br>2) Size<br>(2) Stay Insulator<br>1) Line Voltage<br>2) Material<br>3) Creepage Distance<br>4) Tensile Strength | Quantity 6m/set<br>: Stranded galvanized steel<br>: 38mm$^2$ or equivalent<br>Quantity 1 piece/set<br>: 425V<br>: White glazed porcelain<br>: 85mm<br>: About 65kN | set | 2,183 | 830 | 3,013 |
| 1.7 | LV neutral earthing assembly | (1) Earthing Wire<br>1) Material<br>2) Size<br>(2) Earthing Rod<br>1) Material<br>2) Size | Quantity 10m/set<br>: 600V polyvinyl chloride wire, copper wire<br>: 16mm$^2$<br>Quantity 1 unit/set<br>: Copper clad core rod<br>: D14mm× L1500mm | set | 323 | 161 | 484 |
| 1.8 | Binding wire | (1) Materials<br>(2) Size (diameter) | : Aluminum<br>: 4.0mm or equivalent | piece | 50,268 | 19,332 | 69,600 |
| 1.9 | Bracket support set (for combination pole) | (1) Quantity<br>(2) Material<br>(3) Coating | : 1 piece/set<br>: Mild steel<br>: Hot-dipped galvanized | set | 916 | 312 | 1,228 |

(4) Spare Parts Purchase Plan

1) Items to be Periodically Inspected

The most important service for consumers is to maintain distribution lines by detecting any accident, damage or failure and immediately restore such spots through daily patrol inspection. In addition, if a line-to-ground fault is anticipated due to distribution lines contacting with trees, preventive measures such as tree trimming should be taken in advance. Major inspection items during daily patrols are as follows.

① Presence of disconnection of electric lines
② Presence of insulator breakage
③ Presence of electric lines contacting with trees, etc.

④ Presence of electric pole damage and leaning
⑤ Installation condition of distribution transformers, oil leakage
⑥ Confirmation of various switch conditions

2) Spare Parts

(a) Equipment subject to Spare Parts

Spare parts subject to the Project will include equipment necessary for 33/11kV distribution lines during an emergency or accident which may lead to disruption in the distribution system.

(b) Specific Factors in the Project

Since the following are specific to the Project, spare parts should be procured at both targeted sites.

① Distribution facilities at both targeted sites will be separately maintained by the ECG office.

② Both targeted sites are separated geographically (approximately 3 hours by car), travel is quite difficult, and they are located away from the capital and previous project sites.

(c) Selecting Spare Parts

Emergency spare parts will include equipment which may hinder the stable supply of electricity and which are difficult to repair locally in the early stages in the case of damage from some kind of phenomenon not normally assumed or anticipated.

The reasoning behind the selection of emergency spare parts for the Project is as follows.

① Since “protectors and switches” such as lightning arrestors and cut-out switches with fuses play a role in protecting transformers from abnormal electric current and voltage from lightning surges and grounding faults, should a breakdown occur, these should be replaced immediately. Due to frequent occurrence of thunderstorms at the Project sites, if the system is operated continuously without replacing broken protectors during periods of frequent thunderstorms, there is a risk that a transformer which is key equipment may breakdown and subsequently may create a fire. Therefore, there is a fear that this may lead to extensive power blackouts.

② Since a radial design is applied to the distribution network instead of a ring (loop) design, if a load isolator breaks down, consumers after the point of fault (load side of the transformer) will not receive any electricity. If a distribution transformer breaks down all consumers connected to the dmaged transformer will not receive any electricity until the transformer is restored. If the supply of electricity stops for an extended period after consumers have started to utilize it, it will have a serious social impact. Early treatment should therefore be taken in order to reduce such an impact.

The Ghanaian side should replace it with new equipment and restore electric power as soon as possible. However, the ECG who will be responsible for maintenance under the Project does not have the appropriate equipment for such a replacement. Consequently, distribution transformers, protectors and switches, etc. should be procured as emergency spare parts for replacement. Broken down equipment will be brought to the factory of manufacturer to determine the cause of failure and repair the problem.

3) Maintenance Tools

Equipment necessary for appropriate maintenance of distribution lines will be procured for the Project. Various measuring instruments and simple maintenance tools necessary at the regular inspections are insufficient and are indispensable for proper maintenance, so the minimum amount of newly procured but necessary maintenance tools for the equipment to be procured under the Project is being requested.

Table 2.2.2-11 Spare Parts and Maintenance Tools Procured in the Project

| Item | | Unit | West Akim District | Upper Denkyira District |
|---|---|---|---|---|
| 1. Maintenance Tools | | | | |
| a | Hydraulic compression tool (including 60 to 150 $mm^2$ dice) | set | 1 | 1 |
| b | Hydraulic termination pliers (for 14 to 120$mm^2$) | set | 1 | 1 |
| c | Cable cutter | set | 1 | 1 |
| d | Wire stripper | set | 1 | 1 |
| e | Portable earth set (for 3 phase, with clamp) | set | 1 | 1 |
| f | Operating rod for cutout switch | set | 1 | 1 |
| g | Analogue-type tester (A, V, R) | set | 1 | 1 |
| h | Phase rotation meter (R-Y-B) | set | 1 | 1 |
| i | Voltage detector (for 33kV lines) | set | - | 1 |
| j | Voltage detector (for 11kVlines) | set | 1 | 1 |
| k | Voltage detector (for low voltage lines) | set | 1 | 1 |
| l | Insulation resistance tester (for 500V megger) | set | 1 | 1 |
| m | Insulation resistance tester (for 1,000V megger) | set | 1 | 1 |
| n | Portable earth resistance tester (0 to 2,000Ω) | set | 1 | 1 |
| o | Digital-type multi-tester (V, A, R) | set | 1 | 1 |
| p | Clip-on meter (A) | set | 1 | 1 |
| 2. Emergency Spare Parts | | | | |
| a | Distribution transformer（33kV/433-250V, 100kVA） | set | - | 1 |
| b | Distribution transformer（11kV/433-250V, 50kVA） | set | 1 | 1 |
| c | Distribution transformer（11kV/433-250V, 100kVA） | set | 1 | 1 |
| d | Distribution transformer（11kV/433-250V, 200kVA） | set | 1 | - |
| e | 33kV load isolator（horizontal installation, three phase, 400A） | set | - | 1 |
| f | 11kV load isolator（horizontal installation, three phase, 400A） | set | 1 | 1 |
| g | 33kV cutout switches with fuses (single phase, 100A) | unit | - | 3 |
| h | 11kV cutout switches with fuses (single phase, 100A) | unit | 3 | 3 |
| i | 33kV lightning arrestor (single phase, 10kA) | unit | - | 3 |
| j | 11kV lightning arrestor (single phase, 10kA)） | unit | 3 | 3 |
| 3. Spare Parts | | | | |
| a | 33kV fuse for cutout switch (single phase, 100A) | piece | - | 3 |
| b | 11kV fuse for cutout switch (single phase, 100A) | piece | 6 | 6 |

## 2-2-3 Basic Design Drawings

The basic design drawings for the Project are as follows. The route for 33kV and 11kV distribution lines is shown in the opening page. The system drawings and assembly drawings are shown in Appendix -5.

The low voltage distribution equipment and materials installation plan drawings are shown in Appendix -5.

## 2-2-4 Implementation Plan

### 2-2-4-1 Implementation Policy

In the case of implementing the Project in accordance with the Japan's grant aid scheme, the basic issues and points to note are described as follows.

(1) Project Implementation Body

The organization responsible for and implementing the Project on the Ghanaian side is the Ministry of Energy (MOE). Although the Electricity Department of the MOE will be directly responsible for the Project, the Electricity Company of Ghana (ECG) is scheduled to implement operation and maintenance of the relevant facilities after the commencement of electricity supply services (in-service). It will, therefore, be necessary for the Electricity Department of the MOE to maintain close contact and to consult with Japanese consultants and subcontractors (equipment suppliers) and to appoint a person responsible for the Project to ensure its smooth progress.

The appointed person responsible for the Project at the MOE will be required to explain fully the contents of the Project to staff concerned of the MOE, ECG and local residents at the Project sites in order to facilitate their understanding of the Project and to encourage their cooperation in its implementation.

(2) Consultants

A Japanese consultant will conclude a consulting services agreement with the MOE and will provide detailed design and work supervision for the Project to realize the planned procurement and installation of equipment and materials. The consultant will also prepare tender documents and provide necessary assistance for the MOE, the Project implementation body, and to conduct tenders.

(3) Equipment Suppliers

In accordance with the framework of the Japan's grant aid scheme, a Japanese equipment supplier selected by the Ghanaian side through competitive tendering will carry out the procurement and installation of equipment and materials.

When deemed necessary to provide aftercare services, including the supply of spare parts and an appropriate response to breakdowns, the equipment supplier should pay proper attention to adequate communication channels with the Ghanaian side after handing over equipment and materials.

(4) Necessity for Dispatching Japanese Engineers

The Project is to be implemented in a short period of time and will involve the construction of 33kV and 11kV distribution lines of line length that will be long and extensive from the foundation work associated with branching from existing distribution lines to installation work of transformers and distribution equipment. Since much of the various types of work will be conducted simultaneously, it is essential that a site manager capable of controlling and guiding all work in an integral manner be dispatched from Japan to ensure work progress, quality and safety.

Since highly skilled engineers are required for adjustment and testing when installing the equipment and materials at distribution facilities and after installation, it will be difficult to effectively utilize local companies other than workers. Accordingly, engineers should be dispatched from Japan to ensure quality, technical guidance and schedule control.

(5) Technical Guidance Plan

The Ghanaian side will carry out installation of equipment and materials for low voltage distribution to be procured by the Japanese side. Since the ECG will be responsible for operation and maintenance of the facilities and construction companies (builders) in Ghana as subcontractors and who appear to have similar construction of distribution networks and their own necessary machinery and materials, no particular difficulties in the case of implementing conventional installation work for overhead distribution lines will be observed.

However, 33kV and 11kV distribution line construction work is scheduled to be completed approximately 14 months after the contract agreement, including a trial run and adjustments. In addition, the equipment and materials for low voltage lines are expected to be handed over to the Ghanaian side approximately 9 months after the contract agreement taking into consideration the manufacturing and transportation period. Accordingly, in order to display the predetermined effects at the time of completion of the Project, the Ghanaian side should complete installation work for low voltage lines approximately 8 months after the handing over of low voltage distribution equipment and materials. However, whether or not the Ghanaian side can ensure schedule control and quality during the short-term construction period in several widely spread areas remains uncertain.

With respect to the installation of equipment and materials for low voltage distribution lines to be implemented by the Ghanaian side, the construction period will be ensured by installing service wires for consumers and confirming the distribution work process through the dispatching of short-term instructors by a Japanese consultant. Services wires for consumers will be installed and a distribution work process confirmed together with work supervisors from the ECG, and at the same time, the effectiveness of the electrification project will be secured.

(6) Soft Component (Technical Assistance) Plan

The necessity for a soft component (technical assistance) is not observed since the distribution voltage for the Project has been widely adopted and the ECG who operates and maintains related equipment is well-informed with regards to maintenance and inspection work.

### 2-2-4-2 Implementation Conditions

(1) Construction Industry Conditions in Ghana and Technology Transfer

As previously mentioned in 2-2-1-4, there are a few general contractors (builders) and electric firms in the cities of Accra and Kumasi, so it is possible to place orders at local companies for on-site recruitment and procurement of workers, transportation vehicles, construction work equipment and materials within Ghana for foundation work for distribution line construction. However, in due consideration of the procurement conditions, the Project should secure in order to meet the delivery date and the anticipated huge quantity of electric wire to be locally ordered, the dispatch of Japanese engineer is vital for schedule management, quality and safety control.

(2) Effective Use of Local Equipment and Materials

Although local procurement of aggregates, cement, reinforcing bars, etc. for foundation work, and bare conductors for distribution lines should meet delivery time and quality; they are locally available in Ghana and have been frequently adopted in similar projects. Consequently, in the formulation of a work plan, locally available materials will be utilized whenever possible as a means of promotion for local industries. On the other hand, power distribution equipment required for the Project is not manufactured and is entirely dependent upon importation, so equipment will be procured from Japan or a third country.

(3) Safety Measures

Public unrest in Ghana is relatively rare and the Projects sites have good access from the capital Accra and Kumasi, the second largest city. The Project sites are therefore situated in locations where monitoring, etc. can be easily carried out. However, special attention will still be necessary in order to prevent theft of equipment and materials and to ensure the safety of work-related personnel since some of the Project sites are out of range of cellular phones.

(4) Tax Exemption

The procedures for tax exemption (including value added taxes) for equipment and materials to be procured under the Project by the Ghanaian side are as follows. After a subcontractor (equipment supplier) submits an application for tax exemption to the MOE, the MOE requests a letter for tax exemption from the Ministry of Finance, which is sent to customs (copies are issued

simultaneously to the MOE and the subcontractors). When equipment and materials arrive at port or at an airport in Ghana, the subcontractor presents the prescribed shipment documents with an attached copy of the above-mentioned tax exemption letter to Customs. Tax is then exempted. Therefore, it is important to pay special attention to the process of acquiring tax exemption in order to prevent any delays which could have a negative impact on the progress of the Project.

#### 2-2-4-3 Scope of Work

With regards to the work demarcation between the Japanese side and the Ghanaian side, the Japanese side will conduct procurement of equipment and materials for 33kV and 11kV distribution lines to be newly constructed under the Project, installation work, testing and adjustment. Whereas, the Ghanaian side will implement construction of low voltage distribution lines and procurement and installation of necessary low voltage distribution materials for customer connection other than those for trunk lines such as electric wires, accessories for overhead lines, insulators, watt-hour meters and distribution boards. A detailed description of the work demarcation between the Japanese and Ghanaian sides is shown in Table 2.2.4-1.

Table 2.2.4-1 Work Demarcation between the Japanese and Ghanaian Sides

| Work Item | Procurement | | Installation | | Remarks |
|---|---|---|---|---|---|
| | Japan | Ghana | Japan | Ghana | |
| 1. Common Requirements | | | | | |
| (1) Securing ROW for distribution lines | | | | ○ | ROW: Right of Way |
| (2) Trimming trees on distribution lines route & removal of obstacles | | | | ○ | To be completed prior to commencement of Japanese work. |
| (3) Providing storage yard for materials & equipment | | | | ○ | To be prepared prior to the arrival of equipment and materials. |
| (4) Assuring worker security at the site | | | | ○ | |
| (5) PR on a power interruptions plan to consumers | | | | ○ | When the new line are connected to an existing line. |
| 2. 33 kV & 11 kV Distribution Lines | | | | | |
| (1) Distribution transformers | ○ | | ○ | | |
| (2) Cutout switches with fuses | ○ | | ○ | | |
| (3) Auto reclosers | ○ | | ○ | | |
| (4) Load isolators | ○ | | ○ | | |
| (5) Lightning arrestors | ○ | | ○ | | |
| (6) Materials for the above-mentioned equipment | ○ | | ○ | | |
| (7) Distribution lines | ○ | | ○ | | |
| (8) Electric poles, insulators & assembling hardware | ○ | | ○ | | |
| (9) Civil engineering work for electric poles & stay wires | ○ | | ○ | | Digging & backfilling, etc. |
| (10) Installation & maintenance manuals | ○ | | | ○ (Storage) | |
| (11) Emergency spare and spare parts | ○ | | | ○ (Storage) | |
| (12) Testing instruments & maintenance tools | ○ | | | ○ (Storage) | Testing instruments & maintenance tools will be utilized during installation work. |
| (13) Onsite testing before handing over | | | ○ | ○ (Presence) | |
| (14) Technical guidance (OJT) | | | ○ | ○ (Training) | To be implemented within the E/N period. |
| 3. Low Voltage Distribution Lines | | | | | |
| (1) Main distribution board (MDB) | ○ | | ○ | | To be installed on distribution transformer poles. |
| (2) Electric wires, insulators & assembling hardware for trunk lines | ○ | | | ○ | To be completed to install prior to testing of Japanese work. |
| (3) Electric poles for trunk lines | | ○ | | ○ | To be completed to install prior to testing of Japanese work. |
| (4) Connecting lines to consumers & watt-hour meters | | ○ | | ○ | To be completed to install prior to testing of Japanese work. |
| (5) Testing instruments & maintenance tools | | ○ | | ○ | |
| (6) Onsite testing before electric charging | | | | ○ | |

(Note) ○ Indicates work demarcation.

### 2-2-4-4 Consultant Supervision

The consultant will organize a reliable project team to conduct a detailed design and work supervision to ensure smooth implementation of the Project in due consideration of the objectives of the basic design and in accordance with the Japan's grant aid scheme. Given the dispersion of the Project sites, the planned parallel implementation of the 33kV and 11kV distribution line construction work by the Japanese side and low voltage distribution line installation work by the Ghanaian side, the consultant will appoint at least one full-time site engineer during the work period to supervise schedule control, quality control and finished work quality control and safety control. In addition, the consultant will dispatch other engineers in line with the progress of the equipment installation, trial run and adjustment and completion testing, etc. to supervise the relevant work to be conducted by the equipment suppliers. Furthermore, the consultant will assign Japanese experts to observe factory and pre-shipment testing of equipment manufactured in Japan so that any problems on the equipment after arrival in Ghana can be prevented in advance.

(1) Basic Principles of Work Supervision

The basic principles behind the work assigned to the consultant include supervision of the work progress in order to ensure completion within the established schedule, to ensure quality, quality of finished work and delivery dates of equipment and materials specified in the contract and to supervise the subcontractors so that the site work is carried out safely in accordance with Japan's Grant Aid Scheme.

Important points to note for work supervision are as follows.

1) Schedule Control

The implementation schedule planned at the conclusion of the contract and actual state of progress will be compared monthly or weekly to ensure that the equipment supplier meets the handing over date specified in the contact. If any delay of work is anticipated, the consultant will issue a warning to the subcontractor and will request that the subcontractor take steps to improve the situation so that the work is completed within the contract period. The above-mentioned comparison is mainly conducted by confirming the following items.

① Quantity of work completed (Quantity of equipment manufactured at the factory and equipment for completed civil engineering work on site)

② Quantity of equipment and materials delivered (substation, transmission and distribution equipment and materials for civil engineering work)

③ State of temporary work and preparation of construction machinery

④ Actual number of engineers, skilled workers and laborers and their ratio compared with the original plan

2) Quality and Finished Work Quality Control

The consultant will determine whether or not the equipment and materials to be manufactured, delivered and installed meet those set in the drawings of the contract, quality of the facilities and quality of finished work based on the following items. If any doubt in quality or specifications exists, the consultant will immediately ask the equipment supplier to rectify, alter or improve the situation.

① Checking of shop drawings and specifications of equipment and materials

② Observing of factory inspection of equipment and materials or checking of factory test results

③ Checking of packing, transporting and temporary onsite storage methods

④ Checking of equipment shop drawings and installation manuals

⑤ Checking of manuals on trial runs, adjustment, testing and inspection of equipment

⑥ Supervision of equipment onsite installation work and witnessing of trial runs, adjustment, testing and inspection

⑦ Checking of construction drawings, factory fabrication drawings, and checking of drawing specifications and quality of finished work against original drawings

⑧ Approval of as-build drawings

3) Safety Control

The consultant will provide safety supervision to prevent industrial accidents involving workers and third persons during the construction period through consultations and cooperation with subcontractor’s site managers. The following points regarding onsite safety control should be carefully noted.

① Establishment of safety control rules and appointment of a safety control manager

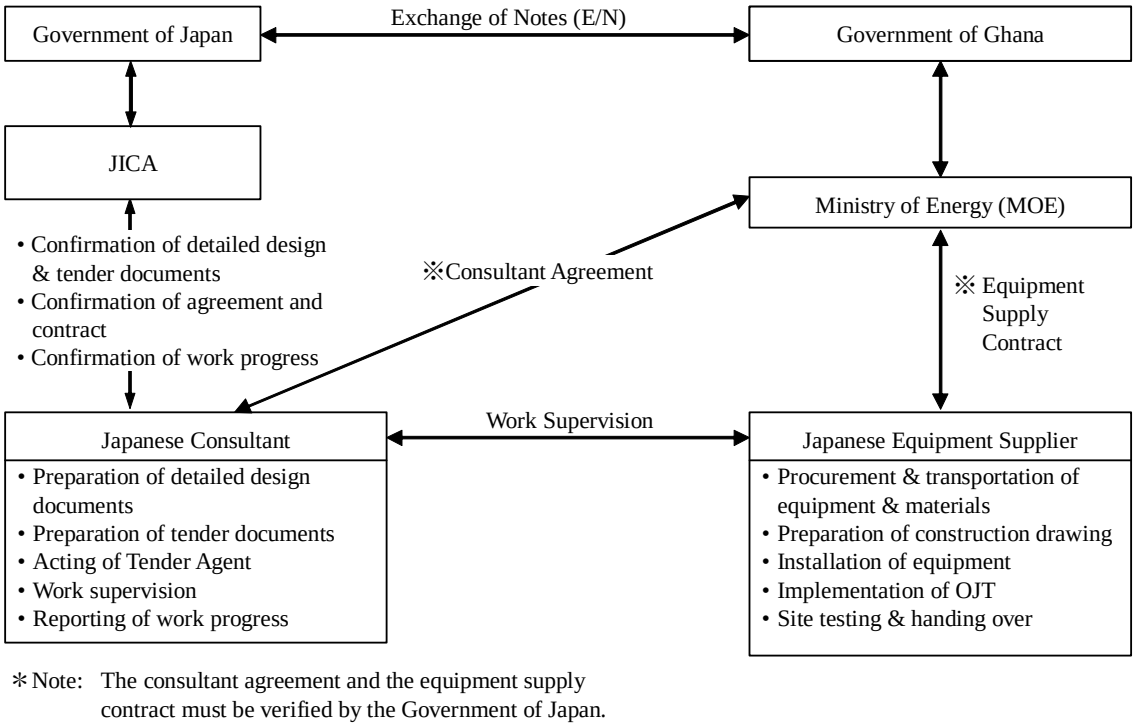
② Prevention of accidents through regular inspection of construction machinery

③ Establishment of travel routes for construction-related vehicles and construction machinery and strict enforcement of safe onsite driving speeds

④ Enforcement of welfare measures for workers and work holidays

(2) Project Implementation System

The inter-relationship between those involved in the implementation of the Project including the work supervision stage is shown in Figure 2.2.4-1.




＊Note: The consultant agreement and the equipment supply contract must be verified by the Government of Japan.

Figure 2.2.4-1 Project Implementation System

(3) Work Supervisors (Supervising Engineers)

Apart from 33kV and 11kV distribution lines construction and necessary civil engineering work, the equipment supplier will employ local construction companies in Ghana in accordance with the contract agreements. Since it will be necessary for the equipment supplier to fully understand the contents of the subcontract regarding the work schedule, work quality and compliance with the specifications and safety measures, the equipment supplier will dispatch Japanese engineers with oversees experience similar to the Project to provide guidance and training for local companies.

Given the scale and contents of the planned construction work under the Project, full-time engineers should be dispatched for at least those listed in Table 2.2.4-2.

Table 2.2.4-2 Engineers Dispatched by Equipment Supplier

| Type of Engineer | No. | Assign Work | Assignment Period |
|---|---|---|---|
| Site Manager | 1 | Overall construction work management, consultation & coordination with related organizations, obtaining of necessary permits, director to implement OJT, equipment procurement control, customs clearance, personnel management, account's business | Entire construction period |
| Electrical Engineers (Distribution) | 3 | Installation supervision of 33 kV & 11lV distribution lines | Relevant installation work period |
| Electrical Engineers (Transformer) | 2 | Supervision of auto reclosers, transformers & load isolators | Relevant installation work period |
| Testing & Adjustment Engineer (Distribution) | 1 | Testing & adjustment of distribution lines, implementation of OJT | Relevant testing & adjustment period |

### 2-2-4-5 Procurement Plan

Equipment and materials for substation facilities (including pole mounted transformers and fuses) to be procured under the Project will not be manufactured in Ghana. Accordingly, all substation equipment and related materials including transformers and distribution boards will be imported from a variety of sources such as various European nations as UK, France, Italy, Denmark, Germany and Japan. Although some European substation equipment manufacturers have agents in Ghana, few manufacturers provide local aftercare service or spare parts, etc. for high voltage substation equipment. Consequently, during the selection of supply sources for the substation equipment and materials for the Project, it is necessary to carefully examine the current situation when selecting sources. To be more precise, the ease of operation and maintenance of the equipment by the Ghanaian engineers and the availability of aftercare service and availability of spare parts in Ghana should be taken into consideration.

The ECG which will be responsible for operation and maintenance of equipment and materials after the completion of the Project, is quite familiar with the operation and maintenance methods of Japanese equipment since Japanese-manufactured transformers and other distribution transformers previously procured are still functioning well. The ECG is confident in the performance of the Japanese-manufactured main substation equipment and aftercare services provided by Japanese manufacturers. Therefore, they have requested Japanese substation equipment and materials for the Project.

With respect to equipment installation and construction machinery for transportation, 30ton-class cranes or trailers can be locally leased so that no specific problems are expected during the implementation of the Project.

(1) Equipment and Materials to be Locally Procured

1) Equipment and Materials for Construction Work

Cement, sand, aggregate for concrete, concrete blocks, reinforcing bars, timber, construction-related vehicles, cranes and other equipment and materials for temporary work.

2) Equipment and Materials for Distribution Lines

Since conductors are manufactured within Ghana and steel poles are imported mainly from Europe, which are distributed in Ghana, they will be locally procured.

(2) Equipment and Materials to be Procured from Japan or a Third Country

Since equipment and materials for distribution lines such as distribution transformers, insulators, lightning arrestors, load isolators, cutout switches with fuses are not manufactured in Ghana, all except for conductors and steel pipe poles, will be procured from Japan or a third country.

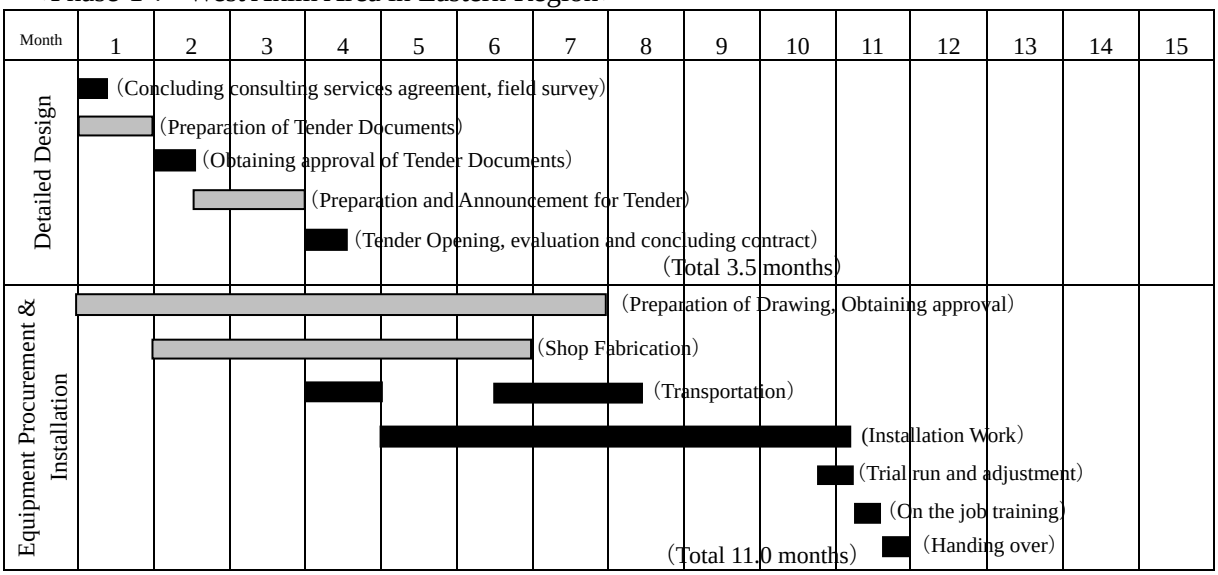
With regards to the transportation of the products to be procured from Japan, a packaging method which can sufficiently withstand long marine transportation, unloading at the port, inland transportation to the Project sites and storage should be adopted.

Tema Port appears to be the most convenient port of landing as its major loading and unloading facilities are best suited for equipment to be procured under the Project. The condition of major trunk roads from Tema Port to the Project sites is favorable. Although some branch roads at the Project sites are unpaved, they are still accessible by trailer at low speed.

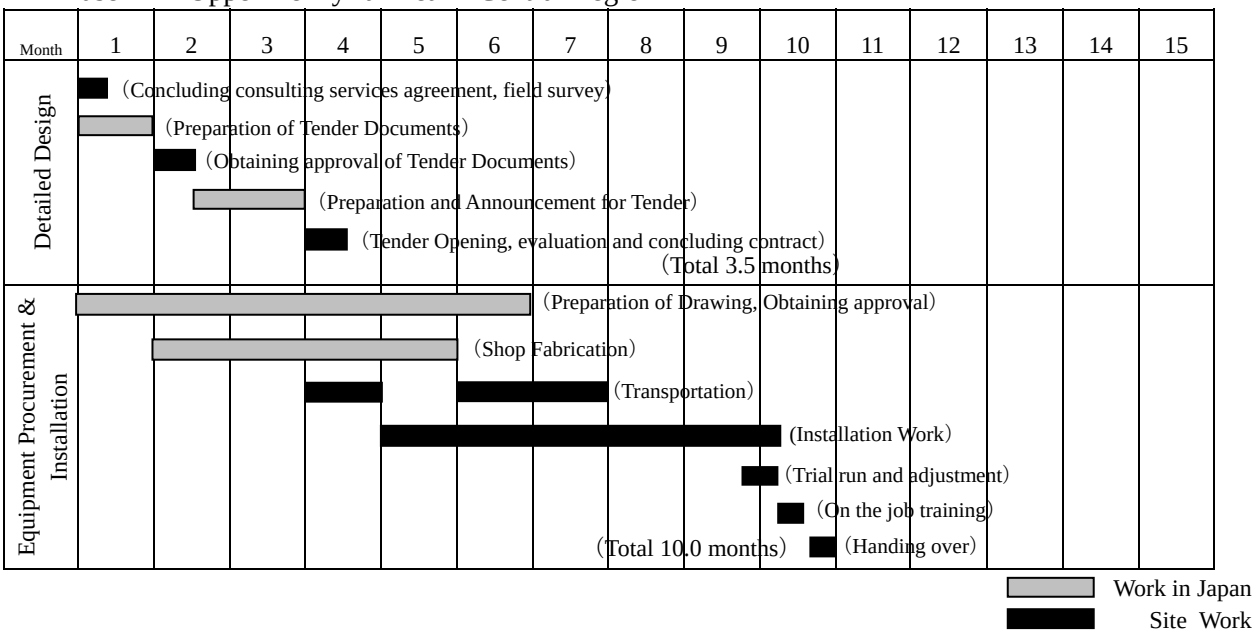
### 2-2-4-6 Implementation Schedule

The recommended project implementation schedule prepared in accordance with the Japan's grant aid scheme is shown as follows.

＜Phase-1： West Akim Area in Eastern Region＞




＜Phase-2： Upper Denkyira Area in Central Region＞




## 2-3 Obligations of the Recipient Country

During the implementation of the Project, apart from the work responsibilities of the Ghanaian side as outlined in 2.2.4-3 (Scope of Work), the Ghanaian side will be responsible for the following items.

(1) To provide necessary data and information for the Project

(2) To ensure speedy unloading, custom clearance and tax exemption of goods for the Project at ports and airports

(3) To accord Japanese nationals whose services may be required in connection with the supply of products and services under verified contracts for necessary entry and stay in Ghana therein in the performance of work

(4) To exempt Japanese nationals from custom duties, local taxes and other fiscal levies which may be imposed in Ghana with respect to the supply of products and services under verified contracts

(5) To bear service charges from a Japanese bank for banking services based on banking arrangements

(6) To bear all expenses other than those borne by grant aid necessary in the implementation of the Project

(7) To assign exclusive counterpart engineers and technicians for the Projects in order to witness overhaul work and quality of equipment and materials when inspections are conducted and to transfer operation and maintenance techniques under the Project

(8) To use and maintain appropriately and effectively all equipment and materials provided through the Japan's grant aid

(9) To provide proper disposal sites for excavated soil, waste water and waste oil discharged during the construction period

## 2-4 Project Operation and Maintenance Plan

Transformers, 33kV and 11kV distribution lines are the most important facilities to maintain in the Project. In the maintenance, it is important to ensure the operation and maintenance (O & M) of facilities and the equipment environment in order to ensure a stable supply of electric power, even during bad weather.

In order to maintain the performance and function of the relevant distribution facilities and to provide a stable and continuous supply of electricity, appropriate preventive measures for improving reliability, safety and efficiency of the distribution facilities and maintenance are strongly recommended.

Figure 2.4-1 demonstrates the basic concept of maintenance.

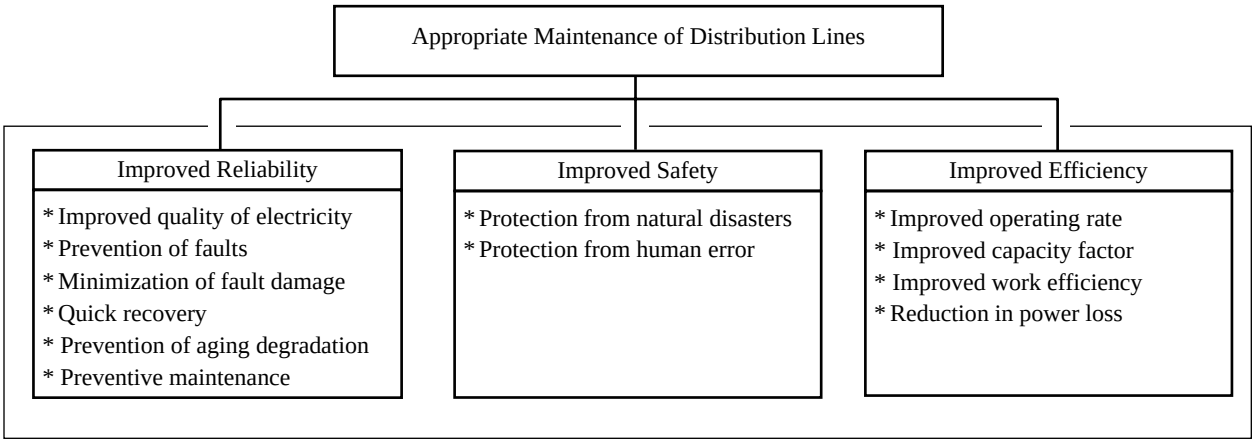



Figure 2.4-1 Basic Concept for Maintenance of Distribution Lines

In due consideration of the above-mentioned basic concept, the Ghanaian side should implement operation and maintenance after the completion of the Project in accordance with O & M skills transferred by expert engineers dispatched, operation and maintenance manuals.

## 2-5 Estimated Project Cost

### 2-5-1 Estimated Cost of the Requested Japanese Assistance

The total cost of the Project to be implemented in accordance with the Japan's grant aid scheme will be ¥1,423 million. This cost estimates is provisional and would be further examined by the Government of Japan for the approval of the grant. According to the following estimated conditions, the breakdown of expenses for both sides based on the scope of work between Japan and Ghana described earlier is estimated to be as follows.

Expenses to be taken by the Japanese side

| Item | | Amount | | |
|---|---|---|---|---|
| | | Phase-1 (West Akim) | Phase-2 (Upper Denkyira) | Total |
| Equipment | 33/11kV Distribution Facilities | ¥ 513 million | ¥ 302 million | ¥ 815 million |
| | Low Voltage Trunk Lines | ¥ 120 million | ¥ 59 million | ¥ 179 million |
| Detailed Design & Procurement Supervision | | ¥ 45 million | ¥ 40 million | ¥ 85 million |
| Total | | ¥ 678 million | ¥ 401 million | ¥ 1,079 million |

Expenses to be taken by the Ghanaian side Approx. US$ 2,945,000 (Approx. ¥ 344.9 million )

Major items to be borne by the Ghanaian side are as follows.

West Akim District in the Eastern Region

| | | |
|---|---|---|
| ① Trimming trees on 11kV distribution line route | Approx. US$ 99,500 | (Approx. ¥ 11.7 million) |
| ② Procurement (wooden poles) and installation of low voltage distribution facilities | Approx. US$ 526,600 | (Approx. ¥ 61.7 million) |
| ③ Procurement and Installation of consumer service lines, watt-hour meters and circuit breakers for service lines | Approx. US$ 1,187,600 | (Approx. ¥ 139.1 million) |
| Total expenses to be taken for West Akim District: | Approx. US$ 1,813,800 | (Approx. ¥ 212.4 million) |

Upper Denkyira District in the Central Region

| | | |
|---|---|---|
| ① Trimming trees on 33kV/11kV distribution line route | Approx. US$ 40,000 | (Approx. ¥ 4.7 million) |
| ② Procurement (wooden poles) and installation of low voltage distribution facilities | Approx. US$ 212,200 | (Approx. ¥ 24.9 million) |
| ③ Procurement and Installation of consumer service lines, watt-hour meters and circuit breakers for service lines | Approx. US$879,000 | (Approx. ¥ 103.0 million) |
| Total expenses to be taken for Upper Denkyira District: | Approx. US$ 1,131,200 | (Approx. ¥ 132.5 million) |

Estimated Conditions

The above-mentioned expenses to be taken by Japan and Ghana are estimated based on the following conditions.

Date of Estimation : March 2006

Exchange Rate : 1US$＝¥117.12 (TTS average value between September 2005 and February 2006)

1Euro＝¥140.76 (Save as above)

100 Ghana Cedi＝¥1.27（TTB average value between September 2005 and February 2006）

Implementation Period : Period of detailed design construction work and equipment procurement is shown in implementation schedule.

Other : The Project will be implemented in accordance with the Japan's grant aid scheme.

### 2-5-2 Operation and Maintenance Cost

Although equipment to be procured under the Project are basically maintenance free, consumables necessary for operation of the facilities and spare replacement parts for deterioration should be reserved. Accordingly, the Ghanaian side should prepare the necessary budget so that operation and maintenance of the relevant facilities will not be disrupted.

Maintenance cost of the equipment and materials to be procured under the Project is estimated to be 163 million cedi in West Akim District and 138 million cedi in Upper Denkyira District as shown in table 2.5-1. Annual maintenance cost of ECG's regional office in Eastern and Central Region is 2,832 million cedi (FY2004) and 2,444 million cedi (FY2004), respectively. In ECG's structure, Eastern controls West Akim and Central controls Upper Denkyira. After the completion of the Project, maintenance cost of both regions will increase by 5.6% which seems to be minimal to the total maintenance budget and there appear to be no specific problems with regards to allocating necessary maintenance budget.

Table 2.5-1 Maintenance Cost of the Equipment and Materials to be Procured under the Project

| Items | Units | Eastern | Central |
|---|---|---|---|
| **1.Maintenance cost for existing distribution lines** | | | |
| (1) Length of existing distribution lines (33/11 kV) | km | 1,708.4 | 887.5 |
| **(2) Annual maintenance cost (FY2004)** | Million cedi | **2,832** | **2,444** |
| (3) Maintenance cost per unit length of distribution lines | Million cedi /km | 1.66 | 2.75 |
| **2. Increment of maintenance cost after the Project** | | | |
| (1) Length of new distribution lines | km | 98.6 | 50.2 |
| **(2) Increment of maintenance cost** | Million cedi | **163.4** | **138.2** |
| 1) Distribution lines | Million cedi | 109.0 | 92.2 |
| 2) Transformers and circuit breakers | Million cedi | 54.5 | 46.1 |

Source: ECG Business Plan (2005-2007)

## 2-6 Other Relevant Issues

Major points are described as follows.

(1) To ensure a budget for items to be borne by the recipient country

(2) To energize Nkwantanum switching station

(3) To adjust protection relays of existing substations and distribution systems for proper functioning after the completion of the Project

(4) To formulate an appropriate maintenance plan

(5) To carry out trimming of trees on new distribution line routes as scheduled