Volta River Authority (VRA)
Ministry of Energy (MOE)
Republic of Ghana

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR
IMPROVEMENT OF POWER
DISTRIBUTION SYSTEM
IN
THE REPUBLIC OF GHANA

MARCH 2012

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YACHIYO ENGINEERING CO., LTD.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey on the project for Improvement of Power Distribution System in the Republic of Ghana, and organized a survey team headed by Mr. Masatsugu KOMIYA of Yachiyo Engineering Co., Ltd. between November 2010 and March 2012.

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

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

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

March 2012

Kyoko KUWAJIMA
Director General,
Industrial Development and
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SUMMARY

① Overview of the Country

The Republic of Ghana (hereinafter referred to as "Ghana") located in central western Africa between 4° and 11° north latitude, and 3° west and 1° east longitude, Ghana faces the Gulf of Guinea to the South, and is bordered by Togo to the east, the Republic of Cote d'Ivoire to the west, and the Republic of Burkina Faso to the north. The population of Ghana is about 24.2 million (FY2010). Its territory is approximately 238,000 km^2 — about 0.6 times of the area of Japan — and is almost completely flat land less than 300 meters above sea level. Its climate is tropical and humid throughout the year with an annual average temperature of about 23Cº to 35Cº. The rainy season extends from May to July and from September to November, and its annual rainfall reaches more than 1400mm.

In 1995, the Government of Ghana formulated the "Vision 2020" which comprises comprehensive long-term development guidelines for the purpose of promoting sustainable economic growth, poverty reduction and democratic policies and actively pursued the economic development of the country. Especially, such subjects as development of human resources, economic growth, agricultural development and provision of circumstances for these developments are prioritized. For power sector development, "to achieve sure access to electricity in villages holding population more than 500" is adopted as the final objectives.

However, economy of Ghana is dependent on the primary industry, as its main exporting materials are cacao, gold and timber materials. Ghana is exposed to fluctuation of their international market prices. As the result, Ghana is designated as the heavily-indebted poor country (HIPC).

② Background of the Project

Aiming at boosting the domestic economy to break free from the HIPC status, the Government of Ghana has placed emphasis on the development of the electricity sector to form the foundation for the country's economic development. The Energy Commission (EC) of Ghana which is the body responsible for the planning of policies to utilise energy resources prepared the Strategic National Energy Plan (SNEP) in 2005. In addition, there has been a strong drive for electrification in Ghana based on the National Electrification Scheme (NES) and the Self Help Electrification Project (SHEP). Results of these endeavours have achieved an electrification rate of 66% (2010) which is the third highest among Sub-Saharan African countries. The Growth and Poverty Reduction Strategy II (GPRS II) formulated in 2006 calls for the modernisation and expansion of the power infrastructure as a service sector underpinning economic growth and poverty reduction.

The electricity sector in Ghana has been experiencing a severe financial situation and the expansion and renewal of the system and equipment have been insufficient despite an increase of the power demand and ageing of the equipment. Because of this, the power distribution grid in Ghana suffers from a high level of distribution loss and the poor reliability of the power supply has been hampering the development of the local economy and improvement of the daily lives of the people, particularly those living in rural

areas. Under these circumstances, the Government of Ghana made a request to the Government of Japan to conduct a master plan study for the power distribution sector with a view to formulating a master plan for the nationwide power distribution sector incorporating the renewal and enhancement of the distribution equipment and extension of the grid to rural areas. In response to this request, the Government of Japan completed the said study under its technical cooperation scheme.

Based on this master plan, the Government of Ghana then made a further request for improvement of the power distribution system as a Japanese grant aid project to improve the situation of power distribution through reduction of the distribution loss and improvement of the power supply reliability, thereby achieving accelerated economic growth and improvement of the living conditions.

③ Outline of the Study Findings and Project Contents

In response to the request, JICA dispatched the Study Team to Ghana from November 20 to December 18, 2010 (first field survey) and from January 23 to February 25, 2011 (second field survey) in order to reconfirm the contents of the request and discuss the contents for implementation with related agencies on the Ghanaian side (responsible government agency: Ministry of Energy (MOE), and implementing agency: Volta River Authority(VRA)), survey the Project sites and gather related materials and data.

On returning to Japan, the Study Team examined the necessity, social and economic impacts and validity of the Project based on the field survey materials and compiled the findings into the draft preparatory study report. Furthermore, JICA dispatched the Study Team to Ghana for the third field survey from May 21 to May 30, 2011 in order to explain and discuss the draft preparatory study report and reach a basic agreement with the Ghanaian counterparts.

The Project plan compiled based on the survey findings targets procurement and installation of new 34.5 kV sub-transmission lines, including extension work of 34.5 kV switchgears in Bulk Supply Points, and new 11.5 kV distribution lines and construction of new substations (34.5/11.5 kV) in Tamale Area (Northern Region) and Sunyani Area (Brong Ahafo Region)

Outline of the Basic Design

Category	Improvement of Distribution System in Tamale Area (Northern Region)	Improvement of Distribution System in Sunyani Area (Brong-Ahafo Region)
Procurement and Installation of Equipment	1. Construction of UDS Primary Substation (1) Transformer (34.5/11.5 kV, 7.5 MVA): 1 set (2) 34.5 kV Switchgear Cubicle: 2 sets (3) 11.5 kV Switchgear Cubicle: 5 sets (4) Station transformer (11.5/0.43 kV, 100 kVA): 1 set (5) Substation building (single story, floor area of some 260 m^2) 2. 34.5 kV Sub-transmission line (between Tamale	1. Construction of Kotokrom Primary Substation (1) Transformer (34.5/11.5 kV, 7.5 MVA): 1 set (2) 34.5 kV Switchgear Cubicle: 2 sets (3) 11.5 kV Switchgear Cubicle: 5 sets (4) Station transformer (11.5/0.43 kV, 100 kVA): 1 set (5) Substation building (single story, floor area of some 260 m^2) 2. 34.5 kV Sub-transmission line (between Sunyani BSP to new Kotokrom Primary Substation):

	BSP and the UDS Primary Substation): approx. 19 km (including underground section: approx.. 5 km) 3. 11.5 kV distribution lines (from new UDS Primary Substation to the existing distribution lines) (1) UDS feeder: approx. 0.2 km (2) Tolon feeder: approx. 0.7 km (3) Cheshegu feeder: approx. 0.3 km 4. Extension 34.5 kV Switchgear at Tamale BSP: 3 sets	approx. 8.5 km (including underground section: approx.. 0.5 km) 3. 11.5 kV distribution lines (from new Kotokrom Primary Substation to the existing distribution lines) (1) Hospital feeder: approx. 4.3 km (2) New Dormaa feeder: approx. 0.6 km (3) Chiraa feeder: approx. 0.7 km 4. Extension 34.5 kV Switchgear at Sunyani BSP: 3 sets 5. Ring main unit (RMU): 1 set
Procurement of Equipment and Other	1. Testing Instruments (including Cable Failure Point Detector) 2. Maintenance Tools (including Aerial Platform Vehicle) 3. Replacement Parts 4. Emergency Spare Parts	1. Testing Instruments (including Cable Failure Point Detector) 2. Maintenance Tools (including Aerial Platform Vehicle) 3. Replacement Parts 4. Emergency Spare Parts

④ Project Implementation schedule and Cost Estimation

In the event where the Project is implemented based on the Japan's Grant Aid scheme, the total cost of the Project will be (*confidential*). The contents and costs to be borne by the Ghanaian side will primarily be provision of ground levelling and preparation, weeding and removal of obstacles at the Project sites (approximately 14 million yen), auxiliary work for new substation (water supply and drainage work) (approximately 9 million yen), and construction of permanent fencing and gate at the new substations (approximately 7 million yen). The implementation schedule for the Project including the detailed design will be approximately 16 months.

⑤ Project Evaluation

(1) Relevance

The relevance of the Project to the spirit of Japan's grant aid scheme is judged to be strong as it not only contributes to the realisation of the development programme and energy policy of Ghana but also benefits the people of Ghana, including the poor.

(2) Efficiency

The following effects are expected as a result of the implementation of the Project.

1) Quantitative Effects (Size of Population Directly Benefitting: 114,000)

Indicator	Reference Value (2010)	Target Value (2018)
Voltage Drop (%)	Tamale : -25% Sunyani : -37%	Tamale : -10% or less Sunyani : -10% or less
Annual Total of Outage Duration	Tamale : 125	Tamale : 88

(hours/year)	Sunyani : 27	Sunyani : 19
Improvement of Electrification (households)	Tamale : - Sunyani : -	Tamale : ➢ Existing Customers: 5,084 households ➢ Waiting: 3,916 households ➢ Total: 9,000 households (Approx. 66,600 persons) Sunyani : ➢ Existing Customers: 4,577 households ➢ Waiting: 4,380 households ➢ Total 8,957 households (Approx.47,500 persons)

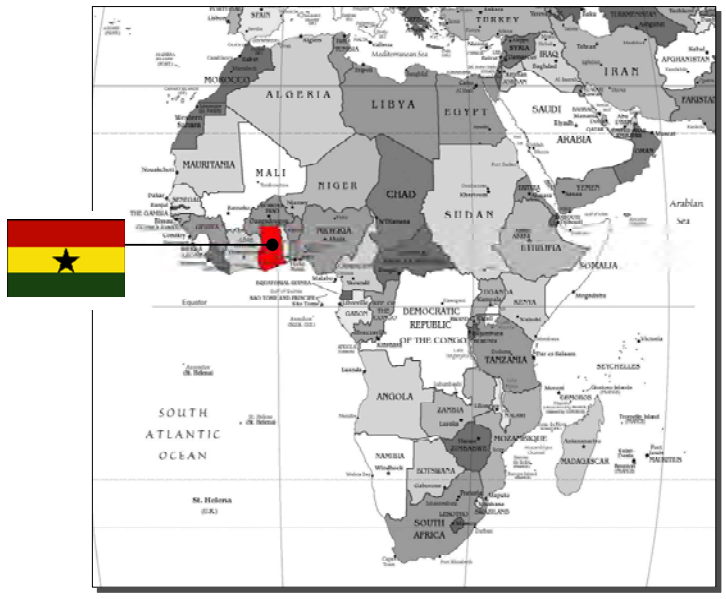
2) Qualitative Effects (Size of Population Indirectly Benefitting: 675,000)

Current Situation and Problems	Improvement Measures Under the Project	Project Effects and Degree of Improvement
< Large-Scale Medical Facility > 1. Sunyani is a main local city in which the Sunyani Regional Hospital is located for the treatment of seriously ill inpatients and outpatients from not only Brong-Ahafo Region but also from other nearby regions. There have been incidents where the emergency power generating system at the time of an outage has not properly functioned during an operation, threatening patient safety. The poor power quality (voltage drop or fluctuations) impede efficient medical treatment as precision medical equipment can be badly affected. ● Sunyani Regional Hospital This hospital is ranked fourth in the country after only the university hospitals in Accra, Kumasi and Tamale. It currently experiences outages some six times a month with a total duration of eight hours. There have been breakdowns of its medical equipment due to voltage fluctuations.	< Improvement of the Distribution System in Sunyani > Following the master plan for the distribution sector, equipment and materials for the Kotokrom Primary Substation (7.5 MVA), 34.5 kV sub-transmission lines (5 km) and 11.5 kV distribution lines (three feeders) will be procured and installed. Other items to be procured under the Project include such maintenance equipment as a cable failure point detector and aerial platform vehicle and spare parts for distribution equipment.	The implementation of the Project will improve the quality and supply reliability of power in Sunyani and the resulting avoidance of outages during operations will enable safe medical treatment. The overall medical care conditions for urgent patients and other outpatients from the local area and other regions will be greatly improved. The improved power supply will prevent failures of the X-ray and other important medical equipment and treatment based on accurate data will be consistently provided. Through such improvements, the Project will contribute to the achievement of the MDGs: "lowering of infant mortality" and "improvement of the health of pregnant women". ● Sunyani Regional Hospital <u>Patients: approx. 20,000/month</u> An exclusive feeder to the hospital will be installed under the Project and the availability of two supply sources will improve the power supply reliability. The normal use of an exclusive line will mean better power quality. <u>169 communities (with a population of some 600,000) in the service area will benefit.</u>
< Small Medical Facilities > 2. At health centres and other small medical facilities used	< Improvement of the Distribution System in Tamale > Following the master plan for the	The implementation of the Project will improve the power quality and supply reliability, ensuring the

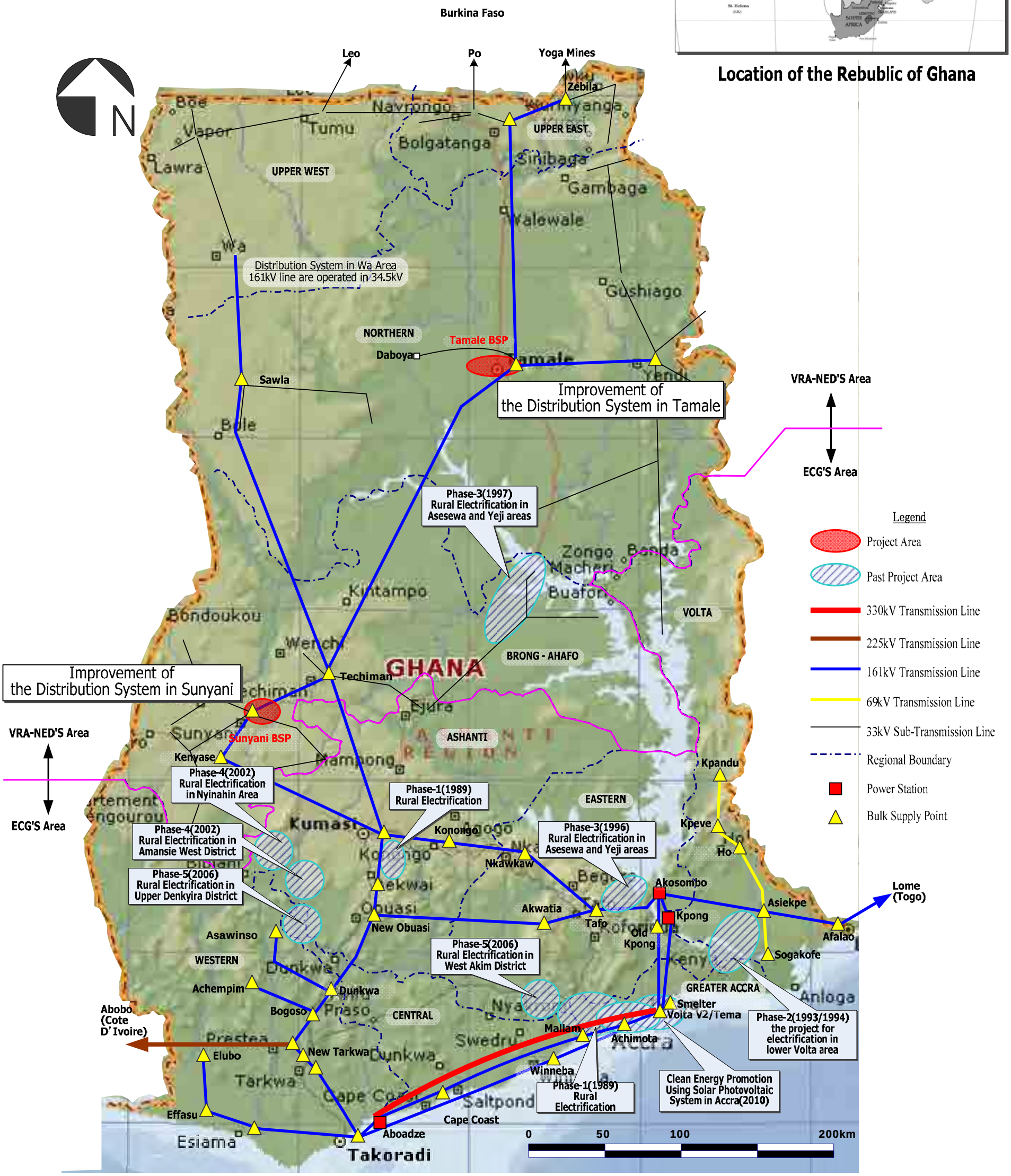
Current Situation and Problems	Improvement Measures Under the Project	Project Effects and Degree of Improvement
by local residents, refrigerators to store medicines and vaccines, sterilisers and other electrical equipment play an important role in medical care. An outage means that such equipment cannot be used as well as a lack of lighting, hampering the medical care provided by these facilities.	distribution sector, equipment and materials for the UDS Primary Substation (7.5 MVA), 34.5 kV sub-transmission lines (19 km) and 11.5 kV distribution lines (three feeders) will be procured and installed. Other items to be procured under the Project include such maintenance equipment as a cable failure point detector and aerial platform vehicle and spare parts for distribution equipment. < Improvement of the Distribution System in Sunyani > Following the master plan for the distribution sector, equipment and materials for the Kotokrom Primary Substation (7.5 MVA), 34.5 kV sub-transmission lines (5 km) and 11.5 kV distribution lines (three feeders) will be procured and installed. Other items to be procured under the Project include such maintenance equipment as a cable failure point detector and aerial platform vehicle and spare parts for distribution equipment.	proper functioning of refrigerators to store medicines and vaccines, sterilisers and other medical equipment. These improvements will result in assured medical treatment at the facilities and the vaccination of children in communities. As the local patients include many infants and pregnant women, their health will be improved. The proper treatment of patients at night will also be possible. Through such improvements, the Project will contribute to the achievement of the MDGs: "lowering of infant mortality" and "improvement of the health of pregnant women". < Improvement of the Distribution System in Tamale > ● God Cares Community Hospital ● Tolon Health Center ● Nyamkpala Health Center Patients: 4,500/month The Project will benefit 79 communities (some 75,000 people) in the service areas of these medical facilities. < Improvement of the Distribution System in Sunyani > ● Chiraa Health Center Patients: 1,000/month
< Educational Facilities > 3. Universities, vocational schools and senior high schools for the education of those who will become major players in future industries and the economy experience poor teaching efficiency as the use of electrical equipment is often prevented by outages or voltage fluctuations or drops. Outages at night also affect not only the work of students in dormitories but also the preparation of lessons by teachers.	As above	The Project will enable the steady use of lighting systems, PCs, laboratory equipment and others, vitalising educational activities. The homework of students in the dormitories, etc. at night will not be disrupted by outages, improving their learning efficiency. With these improvements, the Project will contribute to the "achievement of universal primary education", a MDG, and educational activities at higher levels. < Improvement of the Distribution System in Tamale > ● UDS University ● Grich Computer and Secretarial School ● Tamale Technical Institute ● Bisco Senior High School

Current Situation and Problems	Improvement Measures Under the Project	Project Effects and Degree of Improvement
		● Tolon Senior High School ● Other primary and junior high schools Students: approx. 23,000 < Improvement of the Distribution System in Sunyani > ● Sunyani Nurses' Training College ● Catholic Technical Institute ● Sunyani Business and Secretarial School ● Chiraa Senior High School ● Twene Amanfo Senior High School ● Other primary and junior high schools Students: approx. 27,000
< Local Industries > 4. Local industrial facilities at the Project sites, including sawmills, raw cotton factories, agricultural equipment manufacturing factories and corn mills, suffer from a low level of productivity due to the malfunctioning of processing equipment caused by voltage drops or equipment breakdowns due to voltage fluctuations.	As above	The Project will improve the power supply quality (fewer voltage drops or fluctuations) and the power supply reliability at the Project sites, improving the operating rate of processing equipment and thereby vitalising local industries.

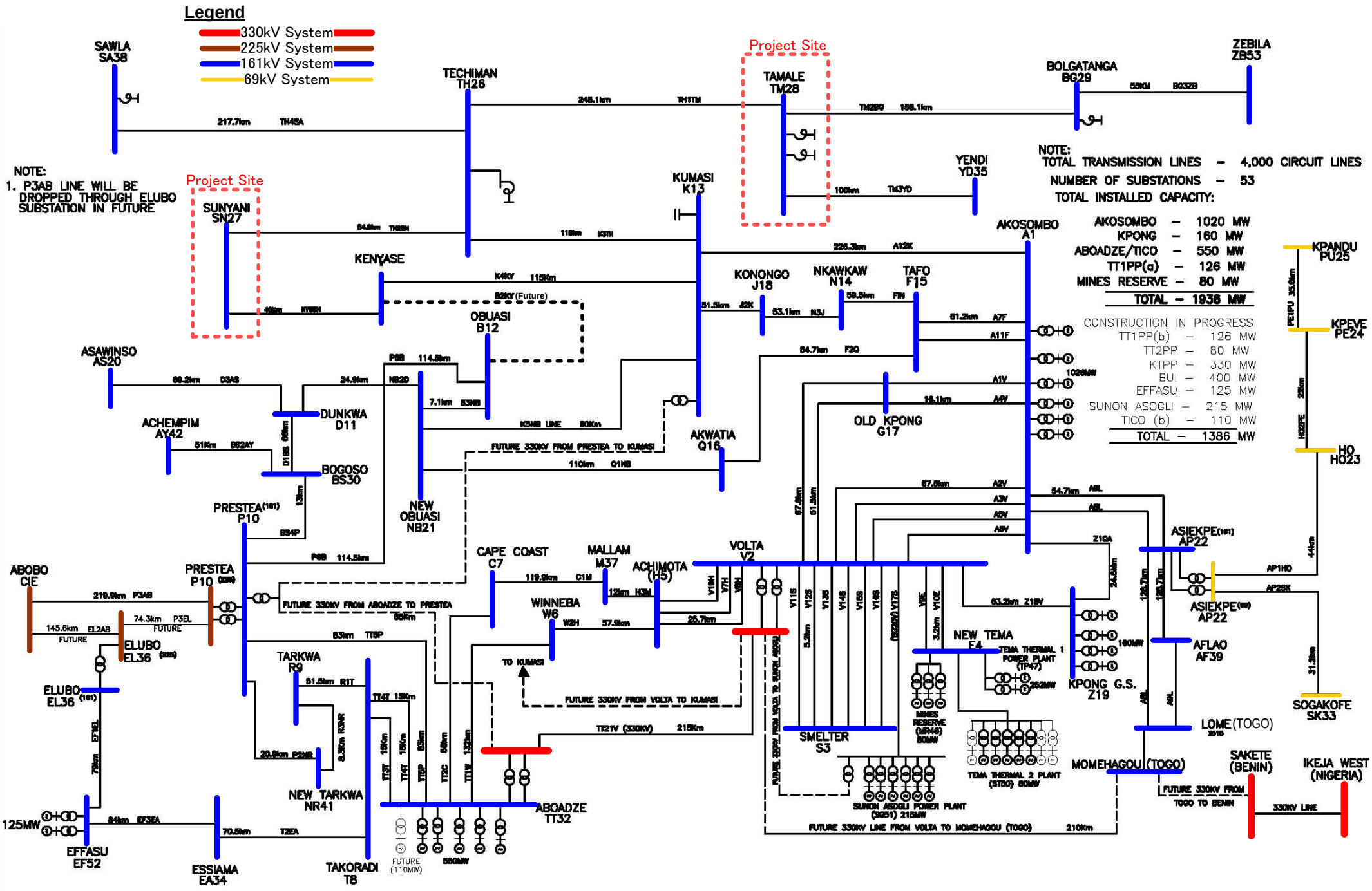
CONTENTS



Location of the Rebublic of Ghana



Location Map of the Project Site



Transmission System Diagram in Ghana（as of Feb., 2011）

Rendering of Primary Substation of the Project

LIST OF FIGURES & TABLES

(Figures)

Abbreviations

AAAC	All Aluminum Alloy Conductor
ACGF	African Catalytic Growth Fund
AFD	Agence Francaise Developpment
AfDB	African Development Bank
A/P	Authorization to Pay
ASEAN	Association of South-East Asian Nations
B/A	Banking Arrangement
BSP	Bulk Supply Point
CHPS	Community-Based Health Planning & Services
DAC	Development Assistance Committee
EC	Energy Commission
ECG	Electricity Company of Ghana
EIA	Environmental Impact Assessment
EIB	European Investment Bank
E/N	Exchange of Notes
EP	Environmental Permit
EPA	Environmental Protection Agency
ESA	Environmentally Sensitive Areas
EU	European Union
G/A	Grant Agreement
GDP	Gross Domestic Product
GEDAP	Ghana Energy Development and Access Project
GEF	Global Environmental Facility
GHS	Ghana Health Service
GNI	Gross National Income
GPRS	Ghana Poverty Reduction Strategy
GRIDCo	Ghana Grid Co. Ltd
GSGDA	Ghana Shared Growth and Development Agenda
HIPCs	Heavily Indebted Poor Countries
IDA	International Development Association
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IMF	International Monetary Fund
ISO	International Organization for Standards
JCS	Japanese Electrical Wire and Cable Maker's Association Standards
JEC	Japanese Electrotechnical Committee
JEM	Standards of Japan Electrical Manufacturer's Association
JICA	Japan International Cooperation Agency

JIS	Japanese Industrial Standards
KfW	Kreditanstalt für Wiederaufbau
LED	Light Emitting Diode
MDGs	Millennium Development Goals
MOC	Ministry of Communication
MOE	Ministry of Energy
MP	Master Plan
NED	Northern Electricity Department
NEP	National Electrification Project
NES	National Electrification Scheme
NREL	National Renewable Energy Laboratory
O&M	Operation and Maintenance
ODA	Official Development Assistance
OJT	On the Job Training
PEA	Preliminary Environmental Assessment
PER	Preliminary Environmental Report
POGE	Poverty Oriented Grid Extension Program
PRSP	Poverty Reduction Strategy Paper
PURC	Public Utilities Regulatory Commission
PVC	Polyvinyl Chloride
RMU	Ring Main Unit
SECO	Swiss State Secretariat for Economic Affaires
SHEP	Self Help Electrification Project
SNEP	Strategic National Energy Plan
UDS	University of Development Studies
UN	United Nations
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
VRA	Volta River Authority
WAPP	West Africa Power Pool
WB	World Bank
XLPE	Cross Linked Polyethylene

CHAPTER 1 BACKGROUND OF THE PROJECT

1-1 Background of the Japanese Assistance

In 1995, the Government of Ghana formulated the "Vision 2020" which comprises comprehensive long-term development guidelines for the purpose of promoting sustainable economic growth, poverty reduction and democratic policies and actively pursued the economic development of the country. The domestic economy was typically dependent on primary products which were vulnerable to price fluctuations in the international market and Ghana was identified as a heavily-indebted poor country (HIPC) under the HIPC programme of the IMF and the World Bank in 2001. Aiming at boosting the domestic economy to break free from the HICP status, the Government of Ghana has placed emphasis on the development of the electricity sector to form the foundation for the country's economic development. The Energy Commission (EC) of Ghana which is the body responsible for the planning of policies to utilise energy resources prepared the Strategic National Energy Plan (SNEP) in 2005. There has been a strong drive for electrification in Ghana based on the National Electrification Scheme (NES) and the Self Help Electrification Project (SHEP) aiming at achieving an electrification rate of 66% (2010) which is the third highest among Sub-Saharan African countries. The Growth and Poverty Reduction Strategy II (GPRS II) formulated in 2006 calls for the modernisation and expansion of the power infrastructure as a service sector underpinning economic growth and poverty reduction.

The electricity sector in Ghana has been experiencing a severe financial situation and the expansion and renewal of the system and equipment have been insufficient despite an increase of the power demand and ageing of the equipment. Because of this, the power distribution grid in Ghana suffers from a high level of distribution loss and the poor reliability of the power supply has been hampering the development of the local economy and improvement of the daily lives of the people, particularly those living in rural areas. Under these circumstances, the Government of Ghana made a request to the Government of Japan to conduct a master plan study for the power distribution sector with a view to formulating a master plan for the nationwide power distribution sector incorporating the renewal and enhancement of the distribution equipment and extension of the grid to rural areas. In response to this request, the Government of Japan completed the said study under its technical cooperation scheme. Based on this master plan, the Government of Ghana then made a further request for improvement of the power distribution system as a Japanese grant aid project to improve the situation of power distribution through reduction of the distribution loss and improvement of the power supply reliability, thereby achieving accelerated economic growth and improvement of the living conditions.

1-2 Natural Conditions

(1) Overview

The Tamale area of the Northern Region is located in the savannah zone of northern Ghana and the local elevation ranges from 150 m to 240 m. Meanwhile, the Sunyani area of the Brong Afaho Region is located in the transitional zone between the tropical rain fore zone (high forest

zone) in southern Ghana and the savannah zone in northern Ghana and the local elevation ranges from 290 m to 325 m.

(2) Climate

1) Temperature

According to observation data of the Tamale and Sunyani municipal meteorological bureaus (hereinafter referred to as "observation data"), the highest mean monthly maximum temperature in Tamale is 38.6°C in February and March when the temperature exceeds 40°C some days. The lowest mean monthly minimum temperature is 17.4°C in December. In December and January, the daily temperature range of around 20°C is quite large. The mean monthly maximum temperature is the lowest in July at 30.1°C while the mean monthly minimum temperature in July is 23.0°C, indicating a relatively small temperature fluctuation. The mean annual temperature of 28.8°C is high.

In Sunyani, the highest mean monthly maximum temperature is 35.4°C in February while the lowest mean monthly minimum temperature is 20.1°C in January. However, the mean monthly minimum temperature is fairly constant throughout the year, ranging from 20°C to 22°C. In January and February, the daily range of around 15°C is fairly large. The mean annual temperature of 26.4°C is fairly high.

2) Humidity

Observation data for the humidity in Tamale shows a large seasonal fluctuation between the rainy season and the dry season. In January, the average humidity in the morning is 45.0% and then drops to as low as 17% in the afternoon. In September, however, the average humidity in the morning is very high at 95% and the average humidity in the afternoon is still high at 73.0%. The average annual humidity is 62.8%. In Sunyani, the humidity in the morning is fairly constant throughout the year at around 85%. The highest and lowest mean monthly humidity in the afternoon occurs in August at 77.0% and in January at 32.0% respectively. The mean annual humidity is high at 75.8%.

3) Rainfall

There are two wet seasons lasting from May to July and from September to November at the Project sites, and the dry season lasts from December to April. According to observation data, the mean monthly rainfall in Tamale from June to October is high at 206.7 mm. In contrast, the mean monthly rainfall in the dry season of 39.0 mm is quite low. The annual rainfall exceeds 1,300 mm. In Sunyani, the mean monthly rainfall from April to October is 168.5 mm. The mean monthly rainfall in the dry season of 82.1 mm is relatively low. The annual rainfall exceeds 1,400 mm.

4) Wind Velocity

According to observation data, the highest mean monthly wind velocity in Tamale is 9.7 km/hr in April while the lowest mean monthly wind velocity is 4.3 km/hr in November. The mean annual wind velocity is 6.7 km/hr. In Sunyani, the highest and lowest mean monthly

wind velocities are 11.0 k/hr in July and 5.4 km/hr in November respectively. The mean annual wind velocity is 8.8 km/hr. In both cities, the mean monthly wind velocity is relatively constant throughout the year.

Table 1-2.1 Weather Data for Tamale (2010)

Month		1	2	3	4	5	6	7	8	9	10	11	12	Mean
Temperature (°C)	Max.	37.9	38.6	38.6	37.3	35.3	32.3	30.1	30.6	30.3	32.6	35.2	36.2	34.6
	Min.	18.4	23.9	26.3	26.3	25.8	23.7	23.0	22.8	22.8	23.0	22.3	17.4	23.0
Humidity (%)		26.5	46.5	48.3	60.3	66.8	75.5	80.0	80.8	83.5	77.5	66.0	42.3	62.8
Rainfall (mm)		0.0	58.8	26.8	176.6	10.3	199.3	107.6	287.2	255.0	184.4	0.8	0.0	108.9
Wind Velocity (km/hr)		7.6	7.5	7.7	9.7	8.3	6.7	7.9	6.1	4.6	5.0	4.3	5.2	6.7

Source: Tamale Weather Bureau

Table 1-2.2 Weather Data for Sunyani (2010)

Month		1	2	3	4	5	6	7	8	9	10	11	12	Mean
Temperature (°C)	Max.	34.0	35.4	33.9	33.4	32.2	30.4	29.0	28.3	29.3	30.3	31.0	31.7	31.6
	Min.	20.3	21.6	22.4	22.1	22.1	21.2	20.3	20.6	20.7	20.8	20.9	20.6	21.1
Humidity (%)		65.6	63.8	71.6	73.8	77.1	80.6	80.3	82.9	81.3	80.6	78.2	73.6	75.8
Rainfall (mm)		0.0	28.5	115.8	203.5	141.7	293.4	158.8	91.5	151.4	139.2	64.9	20.0	117.4
Wind Velocity (km/hr)		6.5	9.6	9.9	10.7	9.8	8.9	11.0	10.7	9.0	7.3	5.4	6.6	8.8

Source: Sunyani Weather Bureau

(3) Harmattan

As in the case of the rest of Ghana, the Project sites experience the harmattan, which is a dry and dusty trade wind from the Sahara, from January to March. The heavy amount of dust in the air can reduce visibility to some 200 m.

(4) Geology

The soil of the planned substation construction sites under the Project is laterite which is a typical soil in the tropics. It originates from weathered rock and is a rusty-red due to iron oxides.

1-3 Environmental and Social Considerations

1-3-1 Environmental Impact Evaluation

1-3-1-1 Project Components

The Project components are summarized as follows.

(1) Improvement of the Distribution System in Tamale

- Construction of the UDS primary substation (34.5/11.5 kV, 7.5 MVA), including the construction of a control building (single story with some 260 m^2)
- Procurement and installation of cables for a 34.5 kV sub-transmission line (from the Tamale BSP substation to the UDS primary substation; approximately 19 km including 5km underground cable)
- Procurement and installation of cables for 11.5 kV distribution lines (for connection to the existing distribution line; three feeder lines)
- Procurement and installation of a 34.5 kV distribution panel (for interconnection with the BSP system; one set)

(2) Improvement of the Distribution System in Sunyani

- Construction of the Kotokrom primary substation (34.5/11.5 kV, 7.5 MVA), including the construction of a control building (single story with some 200 m^2)
- Procurement and installation of cables for a 34.5 kV sub-transmission line (from the Sunyani BSP substation to the Kotokrom primary substation; approximately 8.5 km including 0.5km underground cable)
- Procurement and installation of cables for 11.5 kV distribution lines (for connection to the existing distribution line; three feeder lines of which one is exclusively used by a regional hospital)
- Procurement and installation of a 34.5 kV distribution panel (for interconnection with the BSP system; one set)

1-3-1-2 Outlines around the Project Sites

The Project sites have mostly flat lands in suburbs of Tamale and Sunyani urban areas. There are no protected areas, national parks, specific cultural heritages and subjects to be resettled are located in the Project sites. The natural conditions are described in the section 1.2. In the Project sites which include some built-up areas in the suburbs of regional cities, the plans were designed to avoid resettlement.

(1) Tamale

Potential beneficiaries can be expected at around 9,000 households and 66,600 populations around the Project route. They usually live together with multiple families and on farming in the suburbs of Tamale urban area. They produce maize as a food crop, rice and groundnut as cash

crops. Most households also breed goats or chickens, and peddle agricultural products or beverages to earn hard cash.

Farmer's dwelling places consist of small cylindrical or square-shaped huts built in mud wall with raftered roof and a square-shaped main house built in mud wall with zinc roof. Similar houses can be seen even in Tamale urban area. Most unelectrified households use kerosene lamps in the suburbs. Flashlights or electric bulbs with dry butteries are also used in households around Tamale outlying area. They mostly use fire woods collected from neighbouring bushes for cooking fuels. Domestic water can be supplied by pipe in the urban area but the other water sources are public wells, holding ponds, and purchased water. The public wells and holding ponds can dry in the dry season.

(2) Sunyani

Potential beneficiaries can be expected at around 9,000 households and 47,500 populations around the Project route. They usually live together with multiple families and on two income sources. Most households except in Sunyani urban area are farming to grow maize for personal consumption and groundnut as a cash crop.

Most unelectrified households use LED miniature bulbs with dry butteries attaching a compact disc as a reflector, flashlights, candles or kerosene lamps. The kerosene lamps are used fewer than Tamale. They mostly use fire woods collected from neighbouring bushes or purchased charcoals for cooking fuels. Domestic water can be supplied by pipe in the urban area but the other water sources are public wells and purchased water.

1-3-1-3 Institution and Organization of Environmental and Social Considerations in Ghana

(1) Legal Framework for Environmental and Social Considerations in Ghana

Table 1-3-1.1 shows the legal framework for environmental and social considerations in Ghana. The Environmental Assessment Regulations 1999 (LI 1652) in particular stipulate the types of projects subject to environmental impacts assessment and the procedure for the said assessment, forming the basis for environmental impacts assessment in Ghana.

Table 1-3-1.1 Legal Framework for Environmental and Social Considerations in Ghana

Category	Title	Year of Enforcement	Competent Body
Environmental Impacts Assessment	The Environmental Protection Agency Act 1994 (Act 490)	1994	EPA
	Environmental Assessment Regulations 1999, LI 1652	1999	EPA
Protected Areas	Wildlife Reserves Regulations	1971	FC
	Wildlife Conservation Regulations	1971	FC
	Wetland Management (Ramsar Sites) Regulations	1999	FC
Land Acquisition and Resettlement	The Land Title Registration Law 1986 (PNDCL. 152)	1986	MOL
	The Lands Act 1963 (Statutory Way Leaves Act)	1963	MOL
Cultural Heritage	The Cultural Policy of Ghana	2004	NCC

Category	Title	Year of Enforcement	Competent Body
Guidelines	Environmental Assessment in Ghana, A GUIDE	1996	EPA
	Environmental Impact Assessment Procedures	1995	EPA
	Environmental Guidelines for Energy Sector	2007	EPA

Source: Environmental Protection Agency (EPA), Master Plan Study for the Power Distribution Sector (2008)

(2) Organizational Structure for Environmental Impacts Assessment in Ghana

Environmental impacts assessment in Ghana falls under the jurisdiction of the Environmental Protection Agency (EPA) which was established in 1994 based on the Environmental Protection Agency Act 1994 (Act. 490). As shown in Fig. 1-3-1.1, the Environmental Audit and Assessment (EAA) Section belonging to the Environmental Compliance and Enforcement (ECE) Division is in charge of environmental impacts assessment.

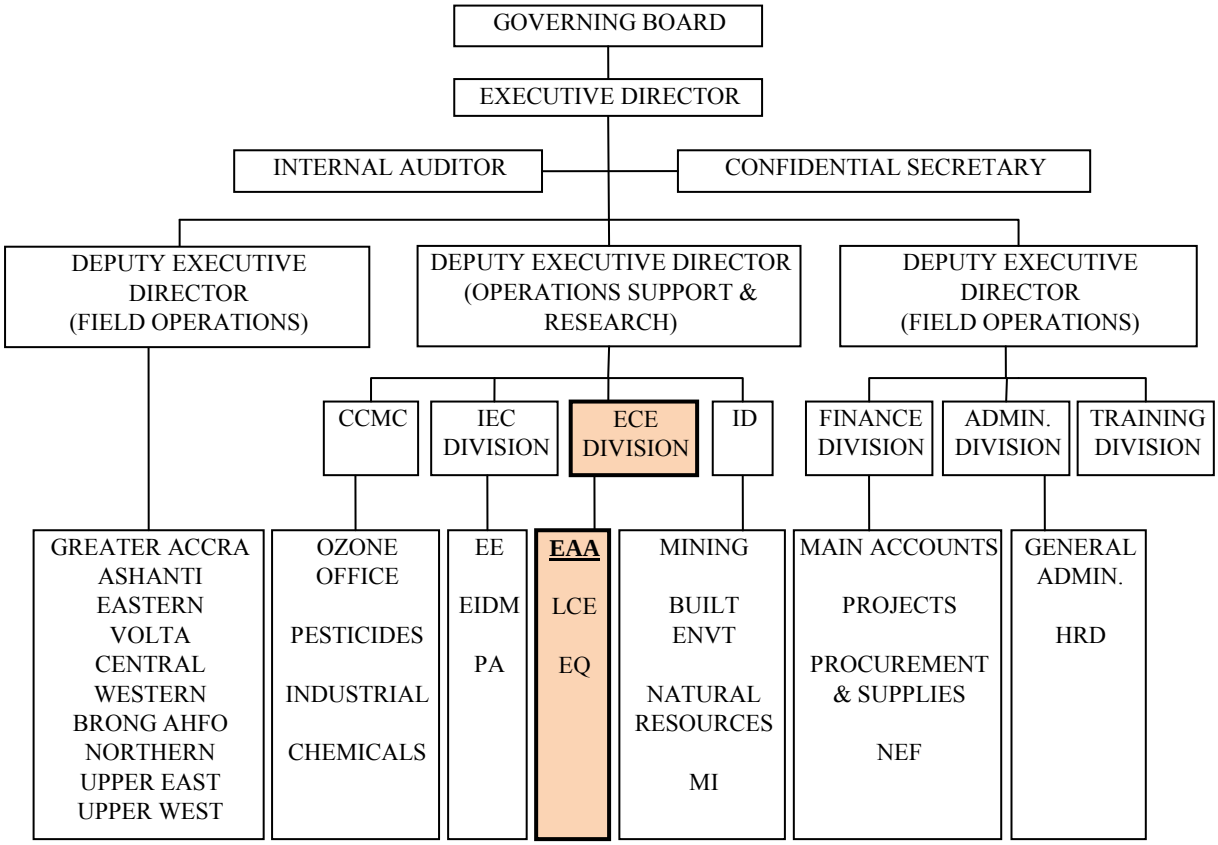
(3) EIA Procedure in Ghana

1) Procedure to Obtain an Environmental Permit

In Ghana, the Environmental Assessment Regulations 1999, LI 1652 stipulate the types of projects subject to an EIA and the EIA procedure. According to these regulations, anyone planning to implement a project which may have an impact on the environment must register the project with the EPA in advance and obtain an environmental permit (EP) for the project.

In such a case, the person concerned must firstly complete the environmental assessment registration form designated by the EPA and must submit this form to a local office of the EPA along with the project drawings and other documents demanded by the EPA. After this registration, the project in question is reviewed by the Technical Screening Committee within 25 working days of the date of registration and one of the following judgements is made.

- Issue of an EP
- Demand for the submission of a preliminary environmental report (PER)
- Demand for the implementation of an EIA
- Rejection of the project



CCMC-Chemical Control and Management
IEC-Information Education and Communication
ECE-Environmental Compliance and Enforcement
EE-Environmental Education
EIDM-Environmental Information and Data Management
PA-Public Affairs
EAA-Environmental Audit and Assessment
LCE-Legal Compliance Enforcement
EQ-Environmental Quality
HRD-Human Resources Development
ID-Intersectoral Division
MI-Manufacturing Industries

Source: Environmental Protection Agency (EPA), the Master Plan Study for the Power Distribution Sector (2008)

Fig.1-3-1.1 Organizational Structure of the Environmental Protection Agency in Ghana

Fig. 1-3-1.2 shows the overall process for an EP in Ghana. For the Project, it is assumed that the submission of a PER rather than the implementation of EIA will be demanded. As the VRA-NED is the implementing body for the Project, it will meet any obligations under the EP procedure.

Assumed Procedure to Obtain an EP for the Project

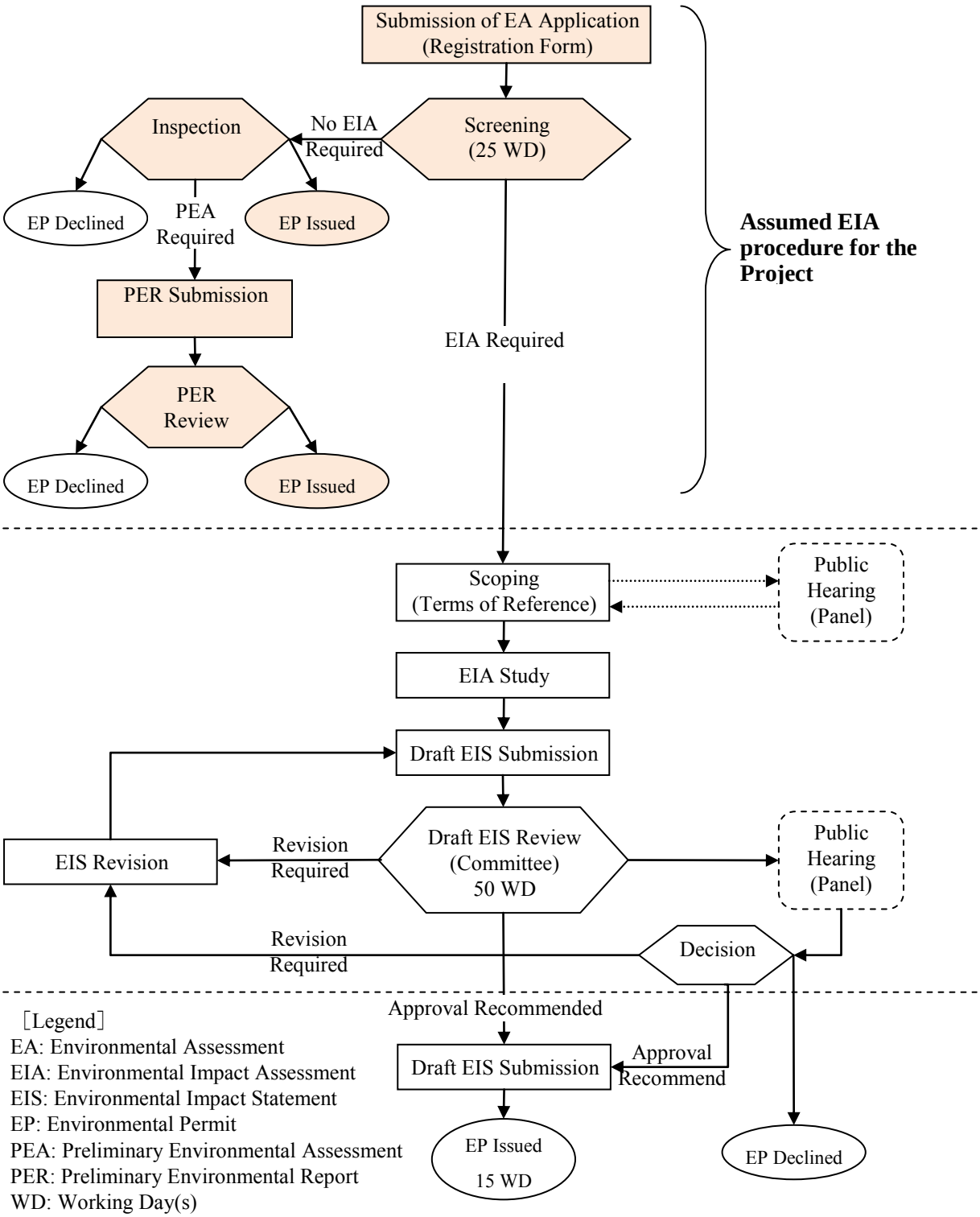
① Registration of the Project with the EPA and application for environmental screening
② Screening of the Project by the EPA within 25 working days to determine whether or not an EIA is required for the Project
③ When an EIA is found to be unnecessary, the necessity for a preliminary environmental assessment (PEA) is reviewed.
④ When a PEA is found to be unnecessary, an EP is issued.

⑤ When a PEA is found to be necessary, the EPA proposes the assessment items to the VRA.

⑥ The VRA-NED conducts the EPA and submits a preliminary environmental report (PER) to the EPA.

⑦ The EPA examines the PER and issues and EP if it does not find any problems with the PER.

⑧ If the EPA does find any problems with the PER, it returns the PER to the VRA-NED for revision.



Source: Environmental Protection Agency (EPA), the Master Plan Study for the Power Distribution Sector (2008)

Fig. 1-3-1.2 Procedure to Obtain Environmental Permit in Ghana

2) Screening

The Environmental Assessment Regulations demand an EIA for the following categories of work in the power generation and transmission fields. As the project components, i.e. the construction of primary substations (7.5 MVA) and the procurement and installation of 34.5 kV sub-transmission lines and 11.5 kV distribution lines, do not fall in any of these categories, it is safe to assume that an EIA will not be required for the Project.

- Construction of a thermal power station
- Construction of a dam and hydropower station
- Construction of a combined cycle power station inside a national park
- Construction of a nuclear power station
- Construction of a transmission line

Source: Environmental Assessment Regulations, Schedule 2 (Regulation 3), Paragraph 13

3) Environmental Guidelines for the Energy Sector

The Project plans the construction of 7.5 MVA primary substations, 34.5 kV sub-transmission lines and 11.5 kV distribution lines. The EPA's Environmental Guidelines for the Energy Sector demand the registration of any project involving the construction of a medium high voltage transmission line between 11 kV and 36 kV which does not pass through an environmentally sensitive area (ESA) with the EPA. In contrast, a PEA is required for the construction of a substation with a capacity of 1 MVA or higher on a transmission/distribution grid. As the construction of distribution lines under the Project is combined with the construction of a substation in each project area, a PEA is assumed to be necessary to obtain an EP for the Project.

Attached Table 5 of the Environmental Assessment Regulations of Ghana lists the different types of ESAs as shown below. However, there is no definitive information on the locations of ESAs and it is essential to check the existing of any local ESAs in the project areas. Each of the planned new substation sites is located at unused public land while the sub-transmission and distribution liens will be constructed on road reserve zones of existing roads. On this basis, it is judged that no ESAs exist in the project areas.

Environmentally Sensitive Areas (ESAs)

1. All areas declared by law as national parks, watershed reserves, wildlife reserves and sanctuaries, including sacred groves
2. Areas with potential tourist value
3. Areas which constitute the habitat of any endangered or threatened species of indigenous wildlife (flora and fauna)
4. Areas of unique historic, archaeological or scientific interest
5. Areas which are traditionally occupied by cultural communities
6. Areas prone to natural disasters (geological hazards, floods, rainstorms, earthquakes, landslides or volcanic activities)

7. Areas prone to bushfires
8. Hilly areas with critical slopes
9. Areas classified as prime agricultural land
10. Recharge areas of aquifers
11. Water bodies characterised by one or any combination of the following conditions
    a) Water tapped for domestic purposes
    b) Water within controlled and/or protected areas
    c) Water which supports wildlife and fishery activities
12. Mangrove areas characterised by one or any combination of the following conditions
    a) Areas with primary pristine and dense growth
    b) Areas adjoining the mouth of major river systems
    c) Areas near or adjacent to traditional fishing grounds
    d) Areas which act as natural buffers to shore erosion, strong winds or storm floods

(4) Procedure to Obtain an Environmental Permit (EP)

To proceed with the Project, the VRA-NED must firstly register the Project with the Environmental Protection Agency by submitting an application form together with project drawings and the written permissions issued by the Urban Planning Bureaus of the municipalities involved. After reviewing these documents, the Environmental Protection Agency will decide whether to issue an environmental permit (EP) for the Project, to request the implementation of an EIA or to request the implementation of a preliminary environmental assessment (PEA). As described earlier, the Project is likely to receive a request for a PEA rather than an EIA in view of the EIA screening criteria of the Environmental Assessment Regulations and the Environmental Guidelines for the Energy Sector. It is understood that the Environmental Department of the VRA-NED will obtain an EP for the Project in accordance with the relevant instructions by the Environmental Protection Agency.

1-3-1-4 Comparison of the Alternatives

Three alternative routes including the zero option (the case without the Project) were compared for Tamale and Sunyani in Table 1-3-1.2 and Table 1-3-1.3. For designing the alternatives, the public lands were considered as the first priority for the locations of primary substations and routes of feeder lines in order to avoid resettlement. The difference of alternatives is the totally shorter route passing more residential area as Alternative-2 and a totally longer route passing less residential area as Alternative-1.

The zero option will not solve the existing electrical problems: blackout, voltage fluctuations and voltage drop by over load and long distanced feeder lines. The risks on the beneficiaries cannot be reduced, which includes the existing consumers, waiting consumers, patients and medical staffs of hospitals, students of schools and rural communities. Consequently, improvements cannot be expected for socio-economic activities, living environment and social surveices. Moreover, those risks can increase in the near future.

In the Alternative-2 of Tamale, the 34.5kV sub-transmission line passes in front of the built-up area along Tamale – Nyampala Rd. at about 1.5km. The Alternative-1 was proposed to avoid the built-up area once bypassing there and an abandoned runway to back to Tamale – Nyampala Rd. The Alternative-1 has longer total length but the length of underground cable is shorter than the Alternative-2, and the construction cost of Alternative-1 can be either equalling or a little lower than the Alternative-2. Therefore, the Alternative-1 is more appropriate for the Project in Tamale.

In the Alternative-1 of Sunyani, the 34.5kV sub-transmission line has longer total length with higher construction cost but less impact on the residential area than the Alternative-2. In the Alternative-2, the 34.5kV sub-transmission line passes the residential area and parallel to the planed 11.5kV distribution line in the road reserve of Sunyani – Techiman Rd. The construction spaces are not enough and the Alternative-2 can affect the residential area more than the Alternative-1. Therefore, the Alternative-1 is more appropriate for the Project in Sunyani.

Table 1-3-1.2 Comparison of the Alternative Routes (Tamale)

No.	Item	Alt.-1	Alt.-2	Alt.-3 (Zero Option)
①	34.5kV sub-transmission line	Length: 19km (underground cable 5km) Main route: in the road reserves of Sutadium Rd. and Tamale – Nyampala Rd. once bypassing the built-up area and abandoned runway to back to Tamale – Nyampala Rd.	Length: 17.5km (underground cable 6km) Main route: in the road reserves of Sutadium Rd. and Tamale – Nyampala Rd.	－
②	11.5kV distribution line	Length: 1.2km For connections from UDS primary substation to the existing 11.5kV distribution lines	Same as on the left	－
③	Primary substation	UDS primary substation	Same as on the left.	－
④	Benefits to the existing and waiting consumers	◎	◎	×
		The existing blackout, voltage fluctuations and voltage drop will be improved by the Project. A stable power supply will improve self-employed business environment, operating environment of small factories, opportunities to obtain new livelihoods, children's learning environment, and living environment.	Same as on the left.	No benefits to the existing and waiting consumers.
⑤	Benefits to public facilities	◎	◎	×
		The stable power supply will also improve qualities of core and rural medical service and increase benefits to patients, infants and parturient. Educational environment will be also improved in schools.	Same as on the left.	No benefits to the existing public facilities.
⑥	Cost	○	△	◎
		The construction cost can be either equalling or a little lower than the Alt.-2 as the underground cable of 34.5kVsub-transmission line is shorter than the Alt.-2 although total length is longer.	The construction cost can be either equalling or a little higher than the Alt.-1 as the underground cable of 34.5kVsub-transmission line is longer than the Alt.-1 although total length is shorter.	No cost.
⑦	Social environment	○	△	◎
		Less impacts on the built-up area along Tamale – Nyampala Rd. than the Alt.-2 because the Alt.-1 avoids passing in front of the area.	More impacts on the built-up area along Tamale – Nyampala Rd. than the Alt.-1 because the Alt.-2 passes in front of the area.	No impacts on social environment.
⑧	Natural environment	○	○	◎
		Little impacts on natural environment as the sites are located along the road and in the public land in the suburbs of Tamale urban area, which has residential, cultivated or unused lands.	Same as on the left.	No impacts on natural environment.
⑨	Evaluation	◎	○	×
		Less impact on the built-up area and the construction cost is either equalling or a little lower than the Alt.-2.	More impact on the built-up area and the construction cost is either equalling or a little higher than the Alt.-1.	The risks on living environment, socio-economic activities and social services by the existing electrical problems will not decrease and can increase more.

Table 1-3-1.3 Comparison of the Alternative Routes (Sunyani)

No.	Item	Alt.-1	Alt.-2	Alt.-3 (Zero Option)
①	34.5kV sub-transmission line	Length: 8.5km (underground cable 0.5km) Main route: in the existing 161kV transmission line wayleave, on the border of public land	Length: 6.5km (underground cable 0.5km) Main route: in the existing residential area, in the road reserve of Sunyani – Techiman Rd.	－
②	11.5kV distribution line	Length: 5.6km For connections from Kotokrom primary substation to the existing 11.5kV distribution lines	Same as on the left.	－
③	Primary substation	Kotokrom primary substation	Same as on the left.	－
④	Benefits to the existing and waiting consumers	◎	◎	×
		The existing blackout, voltage fluctuations and voltage drop will be improved by the Project. A stable power supply will improve self-employed business environment, operating environment of small factories, opportunities to obtain new livelihoods, children's learning environment, and living environment.	Same as on the left.	No benefits to the existing and waiting consumers.
⑤	Benefits to public facilities	◎	◎	×
		The stable power supply will also improve qualities of core and rural medical service (Sunyani Regional Hospital) and increase benefits to patients, infants and parturient. Educational environment will be also improved in schools.	Same as on the left	No benefits to the existing public facilities.
⑥	Cost	△	○	◎
		The construction cost is higher than the Alt.-2 as the 34.5kVsub-transmission line is longer than the Alt.-2.	The construction cost is lower than the Alt.-1 as the 34.5kVsub-transmission line is shorter than the Alt.-1.	No cost.
⑦	Social environment	○	△	◎
		Less impacts on the residential area than the Alt.-2 because the Alt.-1 uses the lands in the existing wayleave of 161kVtrasmission line and on the border of public land.	More impact on residential area because the route passes in the residential area, in the road reserve of Sunyani – Techiman Rd. parallel to the 11.5kV distribution line	No impacts on social environment
⑧	Natural environment	○	○	◎
		Little impacts on natural environment as the sites are located along the road and in the public land in the suburbs of Sunyani urban area, which has residential, cultivated or unused lands	Same as on the left	No impacts on natural environment
⑨	Evaluation	◎	○	×
		Less impact on the residential area although the construction cost is higher than the Alt.-2.	More impact on the residential area although the construction cost is lower than the Alt.-1.	The risks on living environment, socio-economic activities and social services by blackout, voltage fluctuations and voltage drop will not decrease and can increase more.

1-3-1-5 Evaluation of Anticipated Environmental and Social Impacts

The principal components of the Project are the construction of one primary substation (site size of approximately 40 m x 30 m (1,200 m^2) each in Tamale and Sunyani, the construction of a 34.5 kV sub-transmission line totalling some 19 km and 11.5 kV distribution lines stretching approximately 1.2 km in Tamale and the construction of a 34.5 kV sub-transmission line totalling some 8.5 km and 11.5 kV distribution lines stretching approximately 5.6 km in Sunyani.

In reference to these project components, their anticipated environmental and social impacts were evaluated as shown in Table 1-3-1.4 incorporating the findings of the field reconnaissance and interviews with various stakeholders. Both of the substation sites in Tamale and Sunyani are currently not used and are owned by public bodies. There are no private houses or any other structures at these sites. The planned work at each of these sites includes levelling of the ground, foundation work for equipment, construction of a small building and installation of a transformer. While some parts of the planned 34.5 kV sub-transmission lines and 11.5 kV distribution lines are located in the suburbs, the electric poles and cables (either overhead or underground) will be installed on the road reserves, i.e. areas reserved for such infrastructure facilities as electricity supply, water supply, sewerage and communication facilities. For either case, VRA-NED will obtain the permissions to use those sites.

In Tamale and Sunyani, a crane and other heavy machinery will be used for the ground levelling work, foundation work and transformer installation at the new substation sites. However, the installation of the electric poles and cables for the sub-transmission and distribution lines will be manually conducted, making the occurrence of severe adverse impacts on the natural environment, social environment and pollution highly unlikely because of the Project.

Meanwhile, the Project will provide an enhanced power supply capacity as well as reliable power supply and the beneficiaries will not be confined to existing users, including households, stores and business places but will also include hospitals and schools. The power supply to hitherto unelectrified households will possibly provide new means of livelihood and extend night-time learning for children at home. At hospitals and schools, their public services will be more accessible and reliable for people in a wider area.

Table 1-3-1.4 Environmental and Social Impacts Evaluation Sheet: Tamale and Sunyani

No.	Item	Planning Stage	Construction Stage	Operating Stage	Anticipated Impacts
[Social Environment]					
1.	Involuntary resettlement	D	D	D	① Tamale The planned site for the UDS primary substation is unused land owned by the Animal Research Institute which is a public body and no private houses or other structures exist on this land. The earmarked sites for the installation of sub-transmission and distribution lines are along existing roads and there are some dwelling areas along the planned routes. However, as these new power lines are designed to be located inside the designated road reserves so that existing houses will not be affected, there will be no involuntary resettlement of residents.

No.	Item	Planning Stage	Construction Stage	Operating Stage	Anticipated Impacts
		D	D	D	② Sunyani The planned site for the Kotokrom primary substation is unused land owned by the military and no private houses or other structures exist on this land. The planned 34.5 kV sub-transmission line from the Sunyani BSP substation will run along the boundary between the wayleave for the existing 151 kV transmission line and the military-owned land. The planned 11.5 kV distribution line from the Kotokrom primary substation to the Sunyani Regional Hospital is designed to be located on the road reserve along the Sunyani-Techiman road to avoid any negative impacts on local residents and there will be no involuntary resettlement of residents.
2	Local economy, such as employment and livelihood	D	$B^{+/-}$	A^{+}	① Tamale • Planning stage: The acquisition of land for the UDS primary substation has been agreed in writing between the Animal Research Institute, the owner, and the VRA-NED. In the case of the sub-transmission and distribution lines, the planned routes use publicly-owned road reserves that VRA-NED will obtain the use permit from Town and Country Planning Department and no serious negative impacts are anticipated. • Construction stage: Temporary stalls and shops exist on the road reserves from the Tamale BSP substation to the stadium and their partial and/or temporary relocation may be necessary because of the introduction of the sub-transmission line and its electric poles. As the construction work will be mostly manually conducted, its impacts on economic activities in the area will be minimal. The manual work means a high likelihood of a temporary boost for local employment. • Operating stage: The increased and more reliable power supply will generate positive effects for households, public facilities and manufacturing and other industries. The new power supply to hitherto unelectrified households will enhance the scope of developing new livelihoods using electricity and will provide a longer time for homework by children at night.
		D	$B^{+/-}$	A^{+}	② Sunyani The acquisition of land for the Kotokrom primary substation has been agreed in writing between the Sunyani Barracks, the owner, and the VRA-NED. In the case of the distribution line, the planned route uses publicly-owned road reserves that VRA-NED will obtain the use permit from Town and Country Planning Department and no serious negative impacts are anticipated. • Construction stage: Temporary stalls and stores exist on the road reserves in the section from the Kotokrom primary substation to the Sunyani Regional Hospital along the Sunyani-Techiman Road and their partial and/or temporary relocation may be necessary because of the introduction of the distribution line and its electric poles. As the construction work will be mostly manually conducted, its impacts on economic activities in the area will be minimal. The manual work means a high likelihood of a temporary boost for local employment. • Operating stage: The increased and more reliable power supply will generate positive effects for households, public facilities and manufacturing and other industries. The new power supply to hitherto unelectrified households will enhance the scope of developing new livelihoods using electricity and will provide a longer time for homework by children at night. Better and more reliable public services will be provided by the hospital and schools for people in a wider area.

No.	Item	Planning Stage	Construction Stage	Operating Stage	Anticipated Impacts
3	Land use and utilisation of local resources	D	D	D	Each of the UDS primary substation and Kotokrom primary substation will occupy an area of some 1,200 m^2 at publicly-owned unused land (currently grassland). Meanwhile, the new sub-transmission and distribution lines will use the road reserves of existing roads, etc. As the scale of the project sites is small, the Project is not expected to have any significant impact on the land use and utilisation of local resources.
4	Social infrastructure, such as social infrastructure and local decision-making institutions	D	D	D	The scale of the Project is small and the geographically affected areas are very limited. As the Project aims at improving the power supply which is a public service, no negative impacts on social institutions are anticipated.
5	Existing social infrastructure and services	D	B^-	A+	① Tamale • Construction stage: As the work to construct the sub-transmission and distribution lines will take place along existing roads, the movement of local residents may be hampered at this stage. However, the work will be mostly conducted manually and its scope is limited. The short construction period means that the impacts of the work on the social infrastructure and services will also be limited. There is a chance that the existing infrastructure, such as water supply and communication lines, on the road reserves could be damaged by the construction work. • Operation stage: Better and more reliable public services improved by stable electricity supply will be provided by the health centers and schools for people in wider area.
		D	B^-	A+	② Sunyani • Construction stage: As the work to construct the distribution lines will take place along existing roads, the movement of local residents may be hampered at this stage. However, the work will be mostly conducted manually and its scope is limited. The short construction period means that the impacts of the work on the social infrastructure and services will also be limited. There is a chance that the existing infrastructure, such as water supply and communication lines, on the road reserves could be damaged by the construction work. The wayleave site for the 161 kV transmission line next to the Sunyani BSP substation is the site of a Wednesday market run by the Sunyani municipal authority and temporary stalls are situation at this site, albeit illegally. With the introduction of the sub-transmission line and electric poles, some of these stalls may require permanent or temporary relocation. • Operation stage: Better and more reliable public services improved by stable electricity supply will be provided by the hospital and schools for people in wider area. Particularly, the benefit for medical services of Sunyani Regional Hospital will cover broad area.
6	Traffic congestion	D	D	D	• Construction stage: As the work to construct the sub-transmission and distribution lines will be conducted along existing roads, the local traffic may be affected by the delivery of materials, etc. to the sites. However, the work will mostly be manually conducted in relatively confined areas. The short construction period means limited impact on the local traffic.
7	Segmentation of communities	D	D	D	As the distribution lines will use either overhead or underground cables, they will not cause any geographical segmentation of communities.
8	Poor, indigenous people and ethnic minorities	D	D	D	There are no indigenous people or ethnic minorities in the areas affected by the Project.

No.	Item	Planning Stage	Construction Stage	Operating Stage	Anticipated Impacts
9	Uneven distribution of benefits or damage	D	D	D	The Project will improve the local electricity supply as a public service. This item is, therefore, irrelevant.
10	Cultural heritage	D	D	D	As there is no cultural heritage in the project areas to be considered, no impacts will occur in regard to cultural heritage.
11	Local conflict of interests	D	D	D	The Project will improve the local electricity supply as a public service. This item is, therefore, irrelevant.
12	Water use, water rights and rights of common	D	D	D	As there are no rivers, lakes or reservoirs in the vicinity of the planned project sites, this item is irrelevant.
13	Health and sanitation	D	D	D	As the scale of the expected construction work, which is mostly manual work, is small, no impacts will occur on local health and sanitation.
14	Risks of disasters and infectious diseases, such as HIV/AIDS	D	D	D	As the scale of the construction work is small and local labourers will be employed, there is no tangible risk of a disaster or the occurrence of infectious diseases due to the mass inflow of labourers from other areas.
[Natural Environment]					
15	Topography and geology	D	D	D	As the planned project sites are generally flat, the construction work will not involve any major alteration of the topography or civil engineering work. As the foundations for the electric poles, etc. are shallow, no impacts are anticipated on the local topography or geology.
16	Soil erosion	D	D	D	As the planned project sites are generally flat, the construction work will not involve any major alteration of the topography or civil engineering work, causing no impact on soil erosion.
17	Groundwater	D	D	D	The foundations for the building and transformer at the primary substation sites will be some 1 m deep while the foundations for the electric poles will be some 2.5 m deep. In both cases, these shallow foundations mean that there will be little impact on groundwater.
18	Lakes and rivers	D	D	D	As there are no lakes or rivers near the planned project sites, this item is irrelevant.
19	Coastal zone	D	D	D	As the planned project sites are not near a coastal zone, this item is irrelevant.
20	Flora and fauna	D	D	D	The planned project sites are located along existing roads or on public land without any endangered species in the vicinity. No negative impacts are, therefore, anticipated on the local flora and fauna.
21	Climate	D	D	D	The scale of the construction work is small and the work will be mostly conducted manually. Therefore, no impacts on the local climate will occur.
22	Landscape	D	B-	D	• Construction stage: There is no rare natural or cultural landscape in the vicinity of the planned project sites and no negative impacts will occur on the local landscape. However, there is a possibility of the cutting down of valuable trees (Mango, Shea Butter) or those branches along the planned routes for the distribution lines.
23	Global warming	D	D	D	The scale of the construction work is small and the work will be mostly conducted manually. Therefore, hardly any impact on global warming will occur.
[Pollution]					
24	Air pollution	D	D	D	As the use of heavy construction machinery is very limited with manual work accounting for the bulk of the construction work, air pollution due to the Project, if any, will be negligible.
25	Water pollution	D	D	D	There are no lakes or rivers in the vicinity of the planned project sites. As no large-scale alteration of the topography or civil engineering work is planned, water pollution due to soil runoff will not occur.

No.	Item	Planning Stage	Construction Stage	Operating Stage	Anticipated Impacts
26	Soil contamination	D	D	D	The electric poles to be erected for the distribution lines will be steel poles and no soil contamination will occur due to copper chromated arcenate, a chemical substance used as a preservative for wooden poles.
27	Waste	D	D	D	The Project aims at the construction of new primary substations and distribution lines and does not involve the replacement of existing transformers or wooden poles. Therefore, no abandonment of chemical substances contained in existing facilities will occur. Only a minimum amount of surplus soil will be generated by the construction work. Therefore, no significant negative impact by waste materials is anticipated.
28	Noise and vibration	D	D	D	Noise at a level of approximately 60 dB will occur at the 1 m point from the transformers at the primary substations but there will be sufficient space around the transformer for the noise to dissipate. Given the fact that there are no houses near the planned substation sites, no noise or vibration pollution will occur.
29	Ground subsidence	D	D	D	As the scale of the planned primary substations is small, no ground subsidence is anticipated to occur.
30	Offensive odour	D	D	D	No offensive odour is anticipated to originate from the distribution facilities.
31	Bottom sediment	D	D	D	As there are no lakes or rivers in the vicinity of the project sites, this item is irrelevant.
32	Accidents	D	D	D	• Construction stage: Although the scale of the planned construction work is small, the manual nature of the work means that there is the opportunity for accidents involving workers to occur. Besides, the construction work will abide by the labour laws of Ghana and ensure good and safe working conditions in accordance with contractor's and VRA-NED's construction manuals which are required in the contract. • Operating stage: The new primary substations will be fenced off, making it unlikely that accidents involving local residents will occur. Although rare, the overhead cables may be cut and dangled due to an accident or disaster.

Legend

$A^{+/-}$: Significant negative impacts are anticipated

$B^{+/-}$: Considerable negative impacts are anticipated

$C^{+/-}$: Minor negative impacts/possibility of negative impacts are anticipated depending on further planning

D : No or negligible negative impacts are anticipated

1-3-1-6 Mitigation Measures

As the environmental items which may experience negative impacts of the Project and their evaluation scores are identical for both the Tamale and Sunyani sites based on the evaluation results, their common mitigation measures are identified as shown in Table 1-3-1.5.

Table 1-3-1.5 Environmental Impacts Mitigation Measures (Tamale and Sunyani)

No.	Item	Possible Negative Impacts	Mitigation Measures	Organization
Construction stage				
1	Local economy, such as employment and livelihood	Construction stage: Stalls and other simple structures may require temporary removal or relocation during the work to construct the sub-transmission and distribution lines on the road reserves.	• The relocation of these structures will be arranged by the VRA-NED through negotiations with the owners. • The installation work will not affect stalls' businesses because the installation of poles and distribution lines require little space and they can move in short distance during short time of the work. However, VRA-NED will negotiate compensation with them if they cannot do businesses.	VRA - NED
2	Existing infrastructure and services	Construction stage: The work to construct the sub-transmission and distribution lines on the road reserves may damage the existing infrastructure (utility lines).	• The existing providers of water supply, communication and other services will be consulted on the locations of their service lines at the planned work sites before construction. • The site supervisors will issue instructions to be followed to avoid any unintentional damage to the existing infrastructure.	VRA - NED, Supervising Consultant, Contractor
		Construction stage: The work to construct a sub-transmission line on the wayleave zone for the existing 161 kV transmission line may make the temporary relocation of stalls necessary.	• The Sunyani municipal authority will move these stalls within a market area.	VRA - NED, Sunyani municipality
3	Landscape	The work to construct the new sub-transmission and distribution lines can involve the cutting of trees or their branches along the routes.	• The planned routes for the new sub-transmission and distribution lines will avoid large trees and Mango/Shea butter trees with economic value as much as possible.	Supervising Consultant, Contractor

1-3-1-7 Stakeholder Meetings

The VRA-NED Sunyani and VRA-NED Tamale organized a stakeholder meeting on 4th February, 2011 and 18th February, 2011 respectively. These meetings were attended by representatives of the Urban Planning bureau and Road Bureau of the respective municipal authority as well as local chiefs representing local residents. Other attendants included representatives of the UDS Nyankpala Campus and the Animal Research Institute at the Tamale meeting and a representative of the Sunyani Regional Hospital at the Sunyani meeting.

At the meetings, the VRA-NED explained the background, objectives and components of the Study, followed by a Q & A session. There was general enthusiasm among the attendants for improvement of the power supply. In particular, the representative of the Sunyani Regional Hospital expressed the hospital's expectation that improvement of the power supply would mean the steady use of medical equipment and improvement of the medical services at the hospital through the elimination or

significant reduction of power outages and voltage fluctuations. The hospital expects a positive impact of the improved power supply on the infant mortality rate and general health of pregnant women. Meanwhile, requests were made by the attendants for sufficient coordination and liaison with other providers of infrastructure services, such as communication and water supply, as well as the municipal planning bureau, local chiefs and communities. Another request for the use of local labour for the construction work was also made.

Bothe Sunyani and Tamale VRA-NEDs are under taking the coordination and liaison with relevant organizations through the process of project approval in the municipalities. They will further communicate with the local chiefs and communities after the Project is approved by the grant agreement. Besides, they will announce the local people with radio before the installation works are started. A supervising consultant and a contractor will suggest the local contractors to hire the local labour as many as possible.

1-3-2 Land Acquisition and Resettlement

The lands for sub-stations in Tamale and Sunyani Areas are public lands and unused lands. There are no houses or structure in the sites. The 34.5 kV sub-transmission lines and the 11.5 kV distribution lines will be installed with aerial and underground cables within the road reserves allocated for infrastructure (electricity, water supply, drainage, communication) in the suburban areas. Those lines are designed not to affect the structures in the road reserves and no resettlement is required for the Project. However, VRA-NED is processing the following procedures described in the section 1.3.2.1 to obtain those land-use permits from the authorities. The scales of those lands are summarized as follows.

- Tamale: the UDS primary substation site area (about 1,200 m^2), 34.5 kV sub-transmission line (about 19 km), 11.5 kV distribution lines (about 1.2 km)
- Sunyani: the Kotokrom primary substation site area (about 1,200 m^2), 34.5 kV sub-transmission line (about 8.5 km), 11.5 kV distribution lines (about 5.6 km)

1-3-2-1 Land Acquisition

(1) Tamale Area

1) UDS Primary Substation

Under the Project, the construction of the new UDS primary substation (1,200 m^2) is planned using land owned by the Animal Research Institute[1] near the UDS Nyankpara Campus. The VRA-NED has already sent a letter requesting permission to use the land in question to the Animal Research Institute. On receipt of a letter of intent to grant such permission from the Institute, the VRA-NED plans to conclude an agreement on the use of this land with the Institute. The VRA-NED also intends to obtain permission for the construction of the UDS Primary substation from the Municipal Urban Planning Bureau.

[1] The Animal Research Institute belongs to the Council for Scientific Industrial Research which is controlled by the Ministry of Environment, Science and Technology.

2) 34.5 kV Sub-Transmission Line and 11.5 kV Distribution Lines

The plan for the Project includes the construction of a 34.5 kV sub-transmission line on the road reserve of the existing road over some 19 km from the Tamale BSP Substation to the UDS primary substation (including an underground cable section of some 5 km). According to the Tamale Municipal Urban Planning Bureau, the total road width, including the roadbed and road reserve, of the said section is 15 m on each side of the centre line. The VRA-NED intends to obtain a permit to use the road reserve from the said Urban Planning Bureau for the 34.5 kV sub-transmission line. Part of the underground cable section runs through the boundary zone of disused military-owned land. A letter requesting permission to use this zone has already been sent to the military and a letter granting the requested permission is expected.

(2) Sunyani Area

1) Kotokrom Primary Substation

Under the Project, the construction of the new Kotokrom primary substation (1,200 m^2) is planned using unused land owned by the Sunyani Barracks. The VRA-NED has sent a letter requesting permission to use this land to the Sunyani Barracks and has already received a letter granting the requested permission. The VRA-NED now plans to conclude a formal agreement on the use of this land with the Sunyani Barracks, presenting the drawings for the planned substation.

2) RMU (Ring Main Unit) at the Sunyani Regional Hospital

Under the Project, one RMU will be installed on the premises of the Sunyani Regional Hospital. The VRA-NED has sent a letter requesting a permit to use the land to install this RMU and has already received a letter granting the requested permission.

3) 34.5 kV Sub-Transmission Line

Under the Project, the construction of a new some 8.5 km long 34.5 kV sub-transmission line is planned using the wayleave for the existing 161 kV transmission line stretching eastwards from the Sunyani BSP substation. This wayleave extends for 15 m on both sides of the line linking the centre points of the pylons and should be sufficient to accommodate the new sub-transmission line. Given the fact that the existing 161 kV transmission line is controlled by GRIDCo, the VRA-NED has already sent a letter requesting permission to use the wayleave and expects to receive the said permission soon.

Part of the planned 34.5 kV sub-transmission line will run along the boundary of land owned by the military. The VRA-NED has sent a letter requesting permission to use the land to the Sunyani Barracks along with a similar letter concerning the new Kotokrom primary substation site and has already received written permission.

4) 11.5 kV Distribution Lines

Under the Project, the construction of a new some 4.3 km long 11.5 kV distribution line is planned from the new Kotokrom primary substation to the Sunyani Regional Hospital using the road reserve of the Sunyani-Techiman Road. According to the Sunyani Municipal Urban Planning Bureau, the total road width, including the roadbed and road reserve, for this section is 15 m on each side of the centre line in urban areas and 30 m on each side of the centre line in suburban areas. As in the case of the Tamale area, the VRA-NED plans to obtain permission for use of the road reserve to accommodate the planned 11.5 kV distribution line from the said Urban Planning Bureau.

1-3-2-2 Other: Sunyani Wednesday Market

There is a Wednesday market site next to the eastern edge of the Sunyani BSP substation premises. As its name suggests, a market is held every Wednesday. On other days, the skeletons of temporary stalls occupy the site. This market is run by the Sunyani municipal authority and the sellers pay a daily rent for a stall. There are no designated spaces for the products for sale. The sellers come from not only the municipal area but also from neighbouring towns, etc.

The existing 161 kV transmission line runs over this site. The regulations of the VRA-NED do not allow active land use on the wayleave zones of this transmission line. As the new 34.5 kV sub-transmission line will be constructed on the wayleave zone running through the market site, space will need to be secured for the erection of three new permanent electric poles on the market site. During the construction work, extra space will be required to allow the work without hindrance. However, no actual impacts on the market will occur if the work avoids Wednesdays and the stalls are moved during the work on other days and then moved back to their original places before Wednesday. The Sunyani municipal authority will move the existing stalls at the planned electric pole sites to other places on the market site.

1-3-3 Draft Monitoring Forms and Environmental Check List

1-3-3-1 Draft Monitoring Forms

Draft monitoring forms during the construction phase are shown in Table 1-3-3.1.

Table 1-3-3.1 Draft Monitoring Forms

Monitoring Item: 1. Explanation of the Project Schedule for the Local People - The local people on the Project routes will be informed the Project schedule before the installation work starts.					
No.	Date	Location	Method	Note	Frequency
1					6 months before the works, Every Community
2					
3					
1					Just before the works,
2					

Monitoring Item: 1. Explanation of the Project Schedule for the Local People - The local people on the Project routes will be informed the Project schedule before the installation work starts.					
No.	Date	Location	Method	Note	Frequency
3					Every 1.0km

Monitoring Item: 2. Stalls moved in the Road Reserve - The stalls on the Project routes in the road reserve will be informed the installation schedule before the work starts and they will be moved if necessary.					
No.	Location	Type of Stall	Condition	Reason	Frequency
1					Every 0.5km
2					
3					

Monitoring Item: 3. Trees felled - If the installation works affect on the trees on the Project routes, valuable trees (Mango, Shea Butter) and landmark trees will be left according to the communication with the local people along the Project routes.					
No.	Location	Type of Tree	Condition	Reason	Frequency
1					Every 0.5km
2					
3					

1-3-3-2 Environmental Check List

Based on the JICA's Guidelines for Environmental and Social Considerations (April, 2010 Version), the Study Team conducted an environmental review of the Project using the Environmental Checklist: Power Transmission and Distribution Lines with VRA-NED as shown in Table 1-3-3.2.

Table 1-3-3.2 Environmental Checklist: Power Transmission and Distribution Lines

Category	Environmental Item	Main Check Items	Yes:Y No:N	Confirmation of Environmental Considerations (Reasons for Yes/No, Mitigation Measures)
1. Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	Y	(a) According to the Environmental Assessment Regulations 1999, LI 1652, which stipulates the types of projects subject to an EIA and the procedure of EIA, the Project is not included in the EIA subjected projects. The Project plans the construction of 7.5 MVA primary substations, 34.5 kV sub-transmission lines and 11.5 kV distribution lines. The EPA's Environmental Guidelines for the Energy Sector demand the registration of any project involving the construction of a medium high voltage transmission line between 11 kV and 36 kV which does not pass through an environmentally sensitive area (ESA) with the EPA. In contrast, a PEA is required for the construction of a substation with a capacity of 1 MVA or higher on a transmission/distribution grid. Therefore, a PEA is necessary to obtain an EP for the Project. The Environment & Sustainable

Category	Environmental Item	Main Check Items	Yes:Y No:N	Confirmation of Environmental Considerations (Reasons for Yes/No, Mitigation Measures)
			N	Development Department of VRA has coordinated the preparation of the PER, and is currently under in-house review.
			Y	(b) The PER is expected to be submitted to EPA by the end of May 2011. EPA will assess the PER and give VRA instructions toward the EP. The EP is expected by the beginning of August.
			Y	(c) Conditions can be imposed especially for the construction activities and VRA will satisfy those conditions.
				(d) In order to use road reserves, VRA consulted with the Regional offices of the Town & Country Planning Departments for assistance in selecting the line routes. Both the Sunyani and Tamale offices of Town & Country Planning Department has formally submitted maps indicating the routes that VRA intends utilising for the distribution lines.
	(2) Explanation to Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	Y	(a) VRA-NED conducted stakeholder meetings at two Project sites of Sunyani and Tamale in February 2011. Following this, detailed community consultations were held in May 2011 in Choggu, Shishegu, Nyohini, Nyakpala, Kotokrom and New Dormaa. Consultations will be continued till when all issues regarding environmental management and compensation (if necessary) are successfully addressed.
			Y	(b) Comments made at the various community consultations have informed mitigation measures proposed in the PER.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	Y	(a) The Project consists of the installation of sub-transmission and distribution lines and the construction of primary substations. The locations of substations and the routes of feeder lines were studied from a technical perspective, geography (flat land), land use (unused land, no residence and permanent structures), land availability (public land, road reserve), consistency with urban plan.
2. Pollution Control	(1) Water Quality	(a) Is there any possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? If the water quality degradation is anticipated, are adequate measures considered?	N	(a) The planned installation of distribution lines and construction of primary substations will not involve any major alteration of the local topography or large-scale civil engineering work. Consequently, there will be no soil runoff to the extent of worsening the water quality.
3. Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	N	(a) The Project sites are not located in protected areas.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection	N	(a)-(f) Almost all of the project sites are located in suburbs and there are no special habitats for endangered fauna or flora.

Category	Environmental Item	Main Check Items	Yes:Y No:N	Confirmation of Environmental Considerations (Reasons for Yes/No, Mitigation Measures)
		measures taken to reduce the impacts on the ecosystem? (d) Are adequate measures taken to prevent disruption of migration routes and habitat fragmentation of wildlife and livestock? (e) Is there any possibility that the project will cause the negative impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystem due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered? (f) In cases where the project site is located in undeveloped areas, is there any possibility that the new development will result in extensive loss of natural environments?		
	(3) Topography and Geology	(a) Is there any soft ground on the route of power transmission and distribution lines that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed? (b) Is there any possibility that civil works, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides? (c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	N Y	(a)(b) All of the project sites are almost flat. No major alterations of the local topography or large-scale civil engineering work will occur under the Project, making slope failures, landslides or soil runoff highly unlikely. (c) The preparation of the substation sites could have an adverse impact on soils through excavation for the foundations of the site. This potential impact will, however, be short-lived on the flat land or temporary since it is expected that the exposed areas will be covered quickly by vegetative re-growth to stabilize the soil and minimize erosion. VRA will apply erosion control practices such as re-grading, compaction and early re-vegetation to promote soil conservation.
4. Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement?	N	(a)-(j) No involuntary resettlement is expected in the Project. There are no residence and structures at the sites of primary substations, which are unused in public lands. The sub-transmission lines and distribution lines will be installed within road reserve allocated for utilities along the present roads.

Category	Environmental Item	Main Check Items	Yes:Y No:N	Confirmation of Environmental Considerations (Reasons for Yes/No, Mitigation Measures)
		(j) Is the grievance redress mechanism established?		
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary? (c) Is there any possibility that installation of structures, such as power line towers will cause a radio interference? If any significant radio interference is anticipated, are adequate measures considered? (d) Are the compensations for transmission wires given in accordance with the domestic law?	Y N N N	(a) In construction phase, the construction works can affect residential properties, stalls and shops which are located within the road reserves. This category of people will have to be moved and may temporary lose their livelihoods. In the consultations by VRA, they were aware of occupying public land. However if necessary, appropriate compensation shall be paid in line with the conditions of the Land Acquisition & Resettlement Framework (LARF). VRA shall engage the Lands Valuation Division (LVD) to undertake a detailed survey of project-affected persons for the purposes of compensation payment. Information on modalities for compensation including grievance procedures is explained at the community consultations. Access to public services and traffic by the local people can be affected. However, the construction works will be done by humans at limited areas and in short-term. The adverse impact is not serious and limited. Construction observers will direct the local people and traffic passing safely. (b) The Project do not expect any adverse impact regarding infectious diseases because no massive influx of workers is expected as most labour s can be supplied locally for the small-scale projects and construction works by humans. However, with the introduction of some migrant workers into the communities along the proposed line route, mitigation measures will be required to minimize the potential danger of the spread of sexually transmitted diseases (STDs) including HIV AIDS. In line with VRA's "HIV&AIDS Policy", the VRA in collaboration with the Northern and Brong Ahafo Regional Health Services shall undertake HIV/AIDS education for the workforces of the contractors and consultants. (c) The planned construction of the 34.5 kV sub-transmission lines and 11.5 kV distribution lines will not cause any radio interference which will negatively affect local people. (d) The Project is not installation of transmission wires. The currently unused sites for the planed primary substation will need acquisition of public lands. 34.5kV sub-transmission lines and 11.5kV distribution lines will be installed within road reserve allocated for utilities. No permanent structures are observed except small temporary stalls. However in case of compensation, VRA will deal with the matters complying with the VRA's LARF.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures	N	(a) There are no prominent archaeological, historical, cultural or religious sites to consider at the Project sites. However, an unused cemetery belongs to the

Category	Environmental Item	Main Check Items	Yes:Y No:N	Confirmation of Environmental Considerations (Reasons for Yes/No, Mitigation Measures)
		considered to protect these sites in accordance with the country's laws?		New Dormaa Chief is located at the opposite side of the Kotokrom Primary Substation and the 11.5kV line can pass the land. Therefore, consultations have been held with the Municipal Chief Executive representative on follow-up with the New Dormaa Chief when project construction is about to commence.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	N	(a) No significant impact is expected on landscape because there are no special natural and cultural landscapes around the project sites although some street trees can be felled or their leaves can be cut for the construction of feeder lines in the road reserves. VRA-NED will avoid valuable trees to install feeder lines or just cut their leaves, consider replanting the existing trees or plant new trees at where the trees do not disturb the feeder lines.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	N	(a)(b) There are no settlements of ethnic minorities or indigenous peoples at the Project sites.
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	Y Y Y Y	(a) The Japanese contractor responsible for the construction work will abide by the labour laws of Ghana and ensure good and safe working conditions in accordance with their own and VRA-NED's construction manuals. The following laws shall be abided with Labour Act No (2003) Act 651 and the Factories, Offices and Shops Act (1970) Act 328. (b) Safety Rules, Protection Code & Safe Working Practice are in place in line with VRA's Safety Rules and are to be adhered to during project implementation. (c) Before the order to commence any works, the Contractor is required to prepare his own Environmental Management Plan and Safety & Health Plan (SHP) for each subproject. This will have to be approved by VRA. (d) Security guards on the project shall be trained on appropriate measures to take in handling and dealing with the general public. This shall be included in regular safety communications to be done by the contractor.
5. Others	(1) Impacts During Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	Y Y Y	(a) The Safety & Health Plan (SHP) shall be prepared by the contractor and approved by VRA and shall be in line with VRA's Corporate Safety Policy. (b) The project sites are located in suburbs and little adverse impacts on natural environment are expected. However, an Environmental Officer shall be assigned on the project to monitor project construction activities to ensure impacts on the ecosystem are reduced. (c) The construction works can affect shops, stalls and the residents in the road reserves. However, consultations will be continued during the construction when all issues are successfully addressed.
	(2) Monitoring	(a) Does the proponent develop and	Y	(a) As part of the environmental assessment

Category	Environmental Item	Main Check Items	Yes:Y No:N	Confirmation of Environmental Considerations (Reasons for Yes/No, Mitigation Measures)
		implement monitoring program for the environmental items that are considered to have potential impacts?		process, an Environmental Management & Monitoring Plan (EMMP) will be prepared in the PER and implemented by VRA.
		(b) What are the items, methods and frequencies of the monitoring program?	Y	(b) The following items are agreed and will be included in the EMMP: Explanation of the Project Schedule for the Local People, Stalls moved in the Road Reserve and Trees felled. The other items including contractor's matters will also be comprised in the EMMP in the coordination with EPA.
		(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?		
		(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	Y	(c) An organizational structure consists of the director, manager and officer in the Environmental & Sustainable Development Department of VRA. VRA and Contractor shall make budgetary allocations towards all environmental programmes.
			Y	(d) The Environmental Officer of VRA shall coordinate the production of internal monthly/quarterly reports for VRA, and an annual report for submitting to EPA.
6. Note	Reference to Checklist for Other Sectors	(a) Where necessary, pertinent items described in the Road checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	N	(a) The Project is irrelevant as it only involves the project components consist of small-scale and limited areas, which are installations of sub-transmission and distribution lines, constructions of two primary substations, and is planned within the road reserve allocated for utilities.
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	N	(a) The Project is irrelevant as it only involves the project components consist of small-scale and limited areas, which are installations of sub-transmission and distribution lines, constructions of two primary substations.

Source: VRA-NED, Study Team

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 Basic Concept of the Project

In the past, Ghana has pursued economic liberalisation policies based on structural adjustment policies led by the IMF and the World Bank and had achieved an annual economic growth rate of around 5% in the second half of the 1980's. The Government of Ghana continued its economic development efforts in the 1990's and formulated the "Vision 2020", comprehensive guidelines for the long-term development of the country, in 1995 with the aim of achieving sustainable economic growth, poverty reduction and the democratisation of society.

The Government of Ghana incorporated the Millennium Development Goals (MDGs) agreed at the UN Millennium Summit in 2000 in its Ghana Poverty Reduction Strategy II (GPRS II; 2006 – 2009). The Ghana Shared Growth and Development Agenda (2010 ~ 2013) which followed the GPRS II has adopted a strategy of economic reform through (i) infrastructure development and agricultural modernisation to create employment/income opportunities for poverty reduction and (ii) industrialisation with the active use of natural resources. However, the country is still facing the serious problem of a significant economic gap between urban and rural areas with severe poverty in rural areas.

Under these circumstances, the Ghanaian Ministry of Energy (MOE) formulated the National Electrification Scheme (NES) in 1989 and launched a nationwide electrification drive with the highest priority for electrification given to provincial capitals and key commercial cities because of the high investment effect in these cities. The MOE also introduced the Self-Help Electrification Programme (SHEP) to respond to demands for early electrification by communities in rural areas where the speed of electrification has been slow under the NES. Under the SHEP, government aid for electrification is provided when the self-help efforts of rural communities are judged to warrant such aid. Meanwhile, the National Energy Policy (NEP) adopted in 2009 aims at (i) making Ghana an exporting country of electricity through the development of new power sources and (ii) achieving 100% access to electricity nationwide by 2020.

Through these conscious efforts, Ghana's electrification rate of 66% in 2010 is the third highest among sub-Saharan countries. However, Ghana's distribution system is marred by such problems as a high distribution loss rate and low supply reliability. These problems are hampering the further improvement of the country's electrification rate. To solve these problems, the Government of Ghana has requested the Government of Japan to formulate a master plan for the distribution sector and the JICA produced such master plan, the contents of which include the necessary rehabilitation, augmentation and extension of the distribution grids, in 2008.

Japan has so far conducted five grant aid cooperation projects for electrification in Ghana and their positive effects are highly visible in the respective target areas. These effects include direct effects on residents as a result of an increased electrification rate and indirect effects, including improved public services by hospitals, schools and other public facilities. The positive contribution to the achievement

of the MDGs has been verified in the form of a reduced infant mortality rate and the improved health of pregnant women, for example.

The facilitation of electrification nationwide requires a huge amount of foreign currency. Even though the national average electrification rate in Ghana considerably increased from 43% in 2006 to 67% in 2009, the rate remains low at around 30% ~ 44% in poorer northern Ghana. This figure is far below the 58% ~ 96% in central and southern Ghana, causing a lingering huge socioeconomic gap between northern Ghana and central/southern Ghana.

The Project intends to improve the power distribution system in two areas, i.e. Tamale which is the capital city of the Northern Region and Sunyani which is the capital city of Brong-Ahafo in northern Ghana (to be more precise, the service area of the VRA-NED) by means of extending and augmenting the existing distribution grids. The ultimate objective to achieve such targets of the GSGDA as infrastructure development, improvement of the standard of living for the rural populace and vitalisation of local industries, thereby contributing to poverty development which is one of the MDGs.

The implementation of the Project is expected to stimulate socioeconomic activities and to improve local life with the provision of a reliable power supply, which is an essential component of modern social infrastructure, in the Project sites. The Japanese assistance for the Project is the construction of 34.5/11.5 kV primary substations and the procurement and installation of cables, etc. to construct new 34.5 kV sub-transmission and 11.5 kV distribution lines in the Project sites.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policies

2-2-1-1 Basic Policies

The principal project components are the construction of new 34.5/11.5 kV primary substations and the procurement and installation of cables, etc. for 34.5 kV sub-transmission and 11.5 kV distribution lines so that the new sub-transmission line extending from the existing 161/34.5/11.5 kV BSP substation and new distribution lines can provide reliable power supply at each Project site.

2-2-1-2 Natural Conditions

(1) Temperature and Humidity

At the Project sites, the wet season lasts from May to July and again from September to November and the periods between these two wet seasons constitute the dry seasons. Weather data for Tamale in 2010 indicate that the maximum temperature is 40°C (in the dry season while the minimum temperature is 17°C (in the wet season). The highest humidity exceeding 95% is recorded in the wet season. In general, both the wet and dry seasons are fairly distinctive. It is essential for the distribution and substation equipment to be procured under the Project to take these weather characteristics into consideration so that all of the equipment continually operates

normally in the face of a temporary sharp rise of its temperature due to a high ambient temperature and/or direct sunlight or high ambient humidity. In the case of sealed panels, a space heater will be provided to prevent condensation originating from large temperature fluctuations.

(2) Rainfall and Lightning

The mean monthly rainfall in the Project sites is some 160 mm although there is a significant difference between the dry and wet months. Given the likelihood of tropical squalls at some sites, the introduction of waterproofing measures is considered for some of the distribution equipment. There is also a chance of lightning incidents involving the electric poles during the construction work of especially the sub-transmission and distribution lines, making careful planning of the schedule of work in high places necessary. As a full-time operator will be assigned to each new substation, the installation of a lightning conductor will be necessary to prevent any personal injury as well as damage to the building by lightning.

(3) Other Important Matters

The Project sites are subject to the harmattan and the accumulation of sandy dust on the insulators will reduce the level of insulation performance. The local farming practice of burning fields could also damage the electric poles. Careful planning is, therefore, necessary in regard to the creepage distance for insulation and the selection of the electric pole specifications to ensure a steady power supply.

2-2-1-3 Socioeconomic Conditions

The planned substation construction work under the Project will include expansion work inside the 34.5 kV distribution switchboard room of the existing BSP substation and it will be necessary to temporarily switch off the electricity supply to connect a new 34.5 kV sub-transmission cable to the existing distribution switchboard. The schedule for this work must be carefully planned to make the duration of power outage as short as possible in order to minimise any negative impacts on power users.

The new 34.5 kV sub-transmission and 11.5 kV distribution lines will, in principle, be constructed in the wayleave zones of the existing transmission distribution routes. The Ghanaian side must undertake such work as weeding and the removal of rocks as well as the relocation of market stalls and farming fields along the planned routes. Some sections of the planned routes run on the road reserve of a trunk road or along the boundary between military land and private land. The Ghanaian side must fully explain the contents of the Project to the affected road department, land owners and local residents in advance to avoid any disputes after the commencement of the Project. At the stage of the foundation work and digging and the erection of the electric poles as part of the construction work for the new substations and sub-transmission and distribution lines, extra care will be required to avoid any damage to existing underground infrastructure (telephone, water supply and sewer lines). In the case of the overhead cabling work, a safety distance from the existing power line, telephone line, railway line and road must be established in accordance with the relevant laws and regulations in Ghana. In short, the construction work must be designed so as to not interfere with such existing infrastructure.

2-2-1-4 Local Construction Industry

Both of the cities targeted by the Project are key local cities in Ghana and local construction companies have been involved the construction of up to medium size commercial and office buildings. There are several local companies, including those which specialise in electrical installation. The local construction industry is, therefore, judged to be adequate for general construction work. However, there is no local company which is capable of installing the planned high voltage transformer, sub-transmission and distribution lines. In view of this, the company for the installation work under the Project will be selected from leading construction companies based in the Greater Accra Region along the coast.

2-2-1-5 Use of Local Construction Companies and Local Materials

The interview results with local construction companies and past records for construction orders by the VRA-NED have established that the recruitment of workers and the procurement of construction vehicles and construction materials are relatively easy in Ghana. As it is judged to be feasible to order the recruitment of technicians (skilled workers) and ordinary workers necessary for the construction work for the substations and sub-transmission and distribution lines to a local construction company, the use of local companies is planned for the construction work.

Aggregates, cement, reinforcing bars and other materials for the construction of the substations can be locally procured in Ghana and these local materials will be used as much as possible for the Project. However, most of the transforming and distribution equipment of the scale planned under the Project is not manufactured in Ghana. This equipment will be procured in Japan and/or third countries in the light of past importation records of such equipment, the operation and maintenance capability of the VRA-NED and other relevant matters.

2-2-1-6 Operation and Maintenance Capability of the Project Implementing Body

Since 1989, a series of work to construct distribution lines has been conducted in Ghana under the five phases of the rural electrification project assisted by Japan's grant aid scheme and also under the SHEP involving similar voltage classes to those of the Project. As the specifications of the transforming, transmission and distribution equipment to be procured under the Project are similar to those procured under past grant aid projects, it can be safely assumed that the VRA-NED has sufficient capability to install, operate and maintain the new equipment. A note of caution here is the fact that the existing transforming, transmission and distribution equipment shows much deterioration as well as malfunctioning, partly because of the insufficient replacement of parts due to the financial difficulty of the VRA-NED. It is also possible that the engineers, operators and maintenance workers of the VRA-NED do not fully understand the technical details of the latest distribution equipment and systems. To ensure the proper operation of the new equipment, Japanese engineers will provide OJT on the operation and maintenance of the new equipment during the construction and installation work. In addition, the necessary spare parts, testing instruments, maintenance tools and operation and maintenance manuals will be provided as part of the Project. The desirable operation and maintenance

system after the commencement of operation of the new facilities and equipment will be proposed to the VRA-NED so that the new facilities and equipment are effectively and efficiently operated.

2-2-1-7 Scope and Grades of Facilities and Equipment

In consideration of the various conditions described above, the following policies are adopted in regard to the scope and technical grades of the equipment, etc. to be procured under the Project.

(1) Scope of Facilities and Equipment

The Project intends the improvement of the power supply system at the Project sites to ensure a stable power supply for residents and public facilities in these areas based on the assumed power demand in the target year of 2018. The Japanese side will procure and install the minimum but necessary range of equipment while requiring the Ghanaian side to procure and install the necessary equipment as is reasonably possible at its own expense with a view to encouraging self-reliant operation and maintenance by the Ghanaian side. The specifications of the new equipment will comply with the international standards as much as possible to ensure an economical design and compatibility with the existing facilities and equipment. The equipment will also have the minimum but necessary configuration to achieve the objectives of the Project.

(2) Grades

For the design of the transforming and distribution equipment and facilities to be procured and constructed under the Project, special care will be taken to ensure that the technical requirements of the equipment and facilities do not exceed the technical level of the VRA-NED which will be responsible for their operation and maintenance. For this purpose, the configuration of the existing facilities and the technical standards and work manuals of the VRA-NED will be taken into consideration at the design stage of the new equipment and facilities.

2-2-1-8 Construction and Procurement Methods and Schedule

As the Project will be implemented in accordance with the rules of the grant aid scheme of the Government of Japan, it must be completed within a single fiscal year. For the completion of the Project within the finalised schedule to ensure the achievement of the expected effects of electrification, the coordination of the work between the Japanese side and Ghanaian side is essential. The schedule must be carefully planned with proper consideration of suitable routes, methods, timing of and procedures to be followed for inland transportation.

Despite the long distance between the two Project sites (some 5 hour travelling distance by car), the construction work for the 34.5 kV sub-transmission and 11.5 kV distribution lines, totalling some 34.4 km (some 20.2 km in the Tamale area and some 14.2 km in the Sunyani area), will be simultaneously conducted in the two areas. The organization of appropriate construction teams and schedule is, therefore, essential to ensure the efficiency of the work. The construction methods should be those with which local construction companies and engineers are familiar and a carefully arranged work management system is required so that all of the planned work is safely and smoothly completed.

The equipment procured in Japan or a third country will be landed at the Port of Tema and will then be transported overland to the Project sites more than 400 km away, making careful packing of the equipment essential to avoid any problems at the transportation stage.

2-2-2 Basic Plan

2-2-2-1 Preconditions for Planning

(1) Estimation of the Power Demand at the Project Sites

The power demand in five years time from the commencement of operation of the new equipment and facilities introduced under the Project at each Project site is estimated in accordance with the following procedure based on the estimated current power demand.

1) Number of Connected Consumers and Those Awaiting Connection

There are many potential consumers at the Project sites awaiting connection to the distribution system even though a distribution line has already been extended to their vicinity. The number of applications by potential consumers for new connection has been rapidly increasing in the Tamale and Sunyani areas in recent years and it is inferred that most of these people will be connected to the distribution system in the next five years. For this reason, the power demand of those awaiting connection is included in the estimate of the likely power demand in the target year of the Project.

2) Annual Increase Rate of Demand and Power Factor

The annual increase rate of the demand of 5.4% is adopted as assumed by GRIDCo which controls the transmission grids, for these two areas. The power factor used for the present power demand estimation is 0.85 which is the average power factor at the Project sites.

3) Average Unit Demand per User and Load Utilisation Factor

Both of the Project sites have a household electrification rate of more than 50%. As the main loads of ordinary consumers and small shops are inferred to be lamps, television sets and refrigerators, the average unit demand is set at 400 kW/user. In the case of relatively large consumers for which an exclusive transformer is installed, the power demand is assumed to be the value obtained by multiplying the transformer capacity by a factor of 0.7. The load utilisation factor is also set at 0.7. Using these conditions, the current maximum power demand of existing consumers is estimated and the result is almost identical to the actual power demand value. The power demand in the target year of 2018, i.e. five years after the assumed commencement of operation of the new equipment, etc. in 2013, is estimated using the same conditions.

4) Estimation of the Power Demand in the Target Year

The target year of the Project is set at five years after the completion year of the construction work under the Project and the power demand in the target year is estimated

using the number of consumers at each Project site and the various conditions described above, including the rate of increase of the maximum power demand. The estimation results are shown in Table 2-2-2.1 and Table 2-2-2.2. As these tables show, the total maximum power demand at the Project sites in the target year is estimated to be approximately 11.5 MW (approximately 13.5 MVA). This value represents some 0.6% of the nationwide generating capacity as of 2010. As such, any impact of the Project on the nationwide balance of the power supply and demand is likely to be very small.

< Power Demand at the Project Sites in 2018 >

- Tamale (Northern Region) 5,770 kW (6,788 KVA)
- Sunyani (Brong-Ahafo Region) 5,683 kW (6,686 KVA)

Total approx. 11.5 MW (approx. 13.5 MVA)

Table 2-2-2.1 Estimated Power Demand at the Project Site (Tamale)

					Demand in 2010 (Estimated)					Demand Forecast (Projected)							
		A	B	C	①	②	③	④	⑤			Completion of the Project					Target Year for Demand Forecast
Feeder No. (Name)	Distribution Transformer	Existing Transformer Capacity	Existing Consumers	Waiting Consumers	Average Unit Demand per Consumer	Demand for Existing Consumers 【B x ①】	Demand for Waiting Consumers 【C x ①】	Total kW 【②+③】	Total Demand 【④ x Load Utilization Factor=0.7】	2011	2012	2013	2014	2015	2016	2017	2018
		kVA	Households	Households	kW	kW	kW	kW	k W	k W	k W	k W	k W	k W	k W	k W	k W
UDSF1B	UDS	315	1	0	220.5	220.5	0.0	220.5	154	163	171	181	190	201	212	223	235
(UDS)	UDS Annex	315	1	0	220.5	220.5	0.0	220.5	154	163	171	181	190	201	212	223	235
	UDS Hostel No.1	200	1	0	140.0	140.0	0.0	140.0	98	103	109	115	121	127	134	142	149
	UDS Hostel No.2	100	1	0	70.0	70.0	0.0	70.0	49	52	54	57	60	64	67	71	75
	Kpaliga	100	50	44	0.4	20.0	17.6	37.6	26	28	29	31	32	34	36	38	40
	Cheshegu	50	10	24	0.4	4.0	9.6	13.6	10	10	11	11	12	12	13	14	14
	Bagnegilu	100	85	80	0.4	34.0	32.0	66.0	46	49	51	54	57	60	63	67	70
	Nwogu	50	66	85	0.4	26.4	34.0	60.4	42	45	47	50	52	55	58	61	64
	Islamic JSS	100	86	143	0.4	34.4	57.2	91.6	64	68	71	75	79	83	88	93	98
	Nyamkpala Chief Palace	100	100	165	0.4	40.0	66.0	106.0	74	78	82	87	92	97	102	107	113
UDSF2B	Penti Cost	100	150	80	0.4	60.0	32.0	92.0	64	68	72	75	79	84	88	93	98
(Tolon)	Tingoli	100	90	107	0.4	36.0	42.8	78.8	55	58	61	65	68	72	76	80	84
	Nyankpala Bungalows	200	250	295	0.4	100.0	118.0	218.0	153	161	170	179	188	198	209	221	232
	Woribogu	50	65	89	0.4	26.0	35.6	61.6	43	45	48	50	53	56	59	62	66
	Tolon Sec	100	1	0	70.0	70.0	0.0	70.0	49	52	54	57	60	64	67	71	75
	Tolon Admin	100	100	120	0.4	40.0	48.0	88.0	62	65	68	72	76	80	84	89	94
	Tolon Mosque	100	100	125	0.4	40.0	50.0	90.0	63	66	70	74	78	82	86	91	96
	Tolon Chief Palace	100	135	186	0.4	54.0	74.4	128.4	90	95	100	105	111	117	123	130	137
	Dimobi No 1	50	80	100	0.4	32.0	40.0	72.0	50	53	56	59	62	66	69	73	77
	Dimobi No 2	50	80	100	0.4	32.0	40.0	72.0	50	53	56	59	62	66	69	73	77
	Dimobi No 3	50	60	35	0.4	24.0	14.0	38.0	27	28	30	31	33	35	36	38	41
	Yipalgu	100	98	130	0.4	39.2	52.0	91.2	64	67	71	75	79	83	88	92	97
UDSF3B	ECG	50	15	22	0.4	6.0	8.8	14.8	10	11	12	12	13	13	14	15	16
(Sheshegu)	Kasalugu	100	72	81	0.4	28.8	32.4	61.2	43	45	48	50	53	56	59	62	65
	Albasta	100	1	0	70.0	70.0	0.0	70.0	49	52	54	57	60	64	67	71	75
	Abattoir	200	192	108	0.4	76.8	43.2	120.0	84	89	93	98	104	109	115	121	128
	Sheshegu	50	100	150	0.4	40.0	60.0	100.0	70	74	78	82	86	91	96	101	107
	Gbambaya No.1	50	92	122	0.4	36.8	48.8	85.6	60	63	67	70	74	78	82	87	91
	Gbambaya No.2	50	98	116	0.4	39.2	46.4	85.6	60	63	67	70	74	78	82	87	91
	Bisco	50	1	0	35.0	35.0	0.0	35.0	25	26	27	29	30	32	34	35	37
	Sheshegu Chief Palace	100	193	180	0.4	77.2	72.0	149.2	104	110	116	122	129	136	143	151	159
	Social Welfare	100	113	99	0.4	45.2	39.6	84.8	59	63	66	70	73	77	81	86	90
	Remand Home	200	235	82	0.4	94.0	32.8	126.8	89	94	99	104	110	115	122	128	135
	Daboya	315	428	128	0.4	171.2	51.2	222.4	156	164	173	182	192	203	213	225	237
	Zoggbeli No.1	300	275	83	0.4	110.0	33.2	143.2	100	106	111	117	124	130	137	145	153
	Zoggbeli No.2	200	320	100	0.4	128.0	40.0	168.0	118	124	131	138	145	153	161	170	179
	Lamakara	100	188	60	0.4	75.2	24.0	99.2	69	73	77	81	86	90	95	100	106
	Cotton	500	1	0	350.0	350.0	0.0	350.0	245	258	272	287	302	319	336	354	373
	Gratis Fundation	315	1	0	220.5	220.5	0.0	220.5	154	163	171	181	190	201	212	223	235
	Oil Mill	500	1	0	350.0	350.0	0.0	350.0	245	258	272	287	302	319	336	354	373
	STC	800	634	190	0.4	253.6	76.0	329.6	231	243	256	270	285	300	316	333	351
	Street Lights	100	1	0	70.0	70.0	0.0	70.0	49	52	54	57	60	64	67	71	75
	Sadelmi	200	180	90	0.4	72.0	36.0	108.0	76	80	84	89	93	98	104	109	115
	Old Airport	315	58	52	0.4	23.2	20.8	44.0	31	32	34	36	38	40	42	45	47
	Nyankpala Agri. W/S	400	250	300	0.4	100.0	120.0	220.0	154	162	171	180	190	200	211	223	235
	Sari Quarters	100	25	45	0.4	10.0	18.0	28.0	20	21	22	23	24	25	27	28	30
	Total	7725	5084	3916		3845.7	1566.4	5412.1	3788	3993	4209	4436	4675	4928	5194	5475	**5770**

Notes:

1) "Average Unit Demand per Consumers" is based on actual record of VRA.
2) "Power factor" is based on the average of actual data of VRA. 0.85
3) "Load Utilization Factor" is based on the VRA Load Monitoring Survey (2010) 0.7
4) "Annual Increasing Ratio for Demand" is based on GRIDCo Demand Forecast 1.054

in the target year, 2018

Projected Demand	**[kW]**	**5770**
Required Capacity	**[kVA]**	**6788**

Table 2-2-2.2 Estimated Power Demand at the Project Site (Sunyani)

					Demand in 2010 (Estimated)					Demand Forecast (Projected)							
		A	B	C	①	②	③	④				Completion of the Project					Target Year for Demand Forecast
Feeder No. (Name)	Distribution Transformer	Existing Transformer Capacity	Existing Consumers	Waiting Consumers	Average Unit Demand per Consumer	Demand for Existing Consumers 【B x ①】	Demand for Waiting Consumers 【C x ①】	Total kW 【②+③】	Total Deman 【④ x Load Utilization Factor=0.7】	2011	2012	2013	2014	2015	2016	2017	2018
		kVA	Households	Households	kW	kW	kW	kW	k W	k W	k W	k W	k W	k W	k W	k W	k W
KTF1B (Hospital)	Brong-Ahafo Regional Hosp	1500	1	0	1050	1050	0	1,050	735	775	817	861	907	956	1,008	1,062	1,119
KTF2B	Low Cost	315	300	300	0.4	120	120	240	168	177	187	197	207	219	230	243	256
(New Dormaa	Postrial	100	250	200	0.4	100	80	180	126	133	140	148	156	164	173	182	192
	Low Cost Extension	315	300	200	0.4	120	80	200	140	148	156	164	173	182	192	202	213
	Low Cost Extension Annex	200	150	100	0.4	60	40	100	70	74	78	82	86	91	96	101	107
	Quarter Guard	200	140	120	0.4	56	48	104	73	77	81	85	90	95	100	105	111
	New Dormaa	315	400	250	0.4	160	100	260	182	192	202	213	225	237	250	263	277
	New Dormaa Extension	315	200	250	0.4	80	100	180	126	133	140	148	156	164	173	182	192
	Asuakwa	100	200	200	0.4	80	80	160	112	118	124	131	138	146	154	162	171
	Barracks No.2	200	1	0	140	140	0	140	98	103	109	115	121	127	134	142	149
	Barracks No.3	500	1	0	350	350	0	350	245	258	272	287	302	319	336	354	373
	Asuakwa Extension	50	150	200	0.4	60	80	140	98	103	109	115	121	127	134	142	149
	Barracks No.1	200	1	0	140	140	0	140	98	103	109	115	121	127	134	142	149
	Super A1	100	200	220	0.4	80	88	168	118	124	131	138	145	153	161	170	179
KTF3B	Kotokrom	100	150	100	0.4	60	40	100	70	74	78	82	86	91	96	101	107
(Chiraa)	Kotokrom West	100	120	250	0.4	48	100	148	104	109	115	121	128	135	142	150	158
	Kotokrom Aviation	100	110	240	0.4	44	96	140	98	103	109	115	121	127	134	142	149
	Yawhema	100	300	200	0.4	120	80	200	140	148	156	164	173	182	192	202	213
	Nana Gyedu	50	50	100	0.4	20	40	60	42	44	47	49	52	55	58	61	64
	GWCL Kobedi	100	1	0	70	70	0	70	49	52	54	57	60	64	67	71	75
	Kobedi Central	25	60	200	0.4	24	80	104	73	77	81	85	90	95	100	105	111
	Oti Sawmill	600	350	150	0.4	140	60	200	140	148	156	164	173	182	192	202	213
	Chiraa Presby	200	300	350	0.4	120	140	260	182	192	202	213	225	237	250	263	277
	Chiraa Central	315	200	200	0.4	80	80	160	112	118	124	131	138	146	154	162	171
	Chiraa Apostolic	100	250	200	0.4	100	80	180	126	133	140	148	156	164	173	182	192
	Asuakwa Chiraa	100	92	150	0.4	37	60	96.8	68	71	75	79	84	88	93	98	103
	Chiraa Clinic	100	300	200	0.4	120	80	200	140	148	156	164	173	182	192	202	213
	Total	6400	4577	4380		3,579	1752	5,331	3,732	3,933	4,145	4,369	4,605	4,854	5,116	5,392	**5,683**

Notes:

1) "Average Unit Demand per Consumers" is based on actual record of VRA.
2) "Power factor" is based on the average of actual data of VRA. 0.85
3) "Load Utilization Factor" is based on the VRA Load Monitoring Survey (2010) 0.7
4) "Annual Increasing Ratio for Demand" is based on GRIDCo Demand Forecast 1.054

in the target year, 2018

Projected Demand	**[kW]**	**5683**
Required Capacity	**[kVA]**	**6686**

(2) Distribution Plan

1) Construction of 34.5 kV Sub-Transmission Lines

At both Project sites, the existing BSP substation does not have an unused 34.5 kV feeder facility and the new 34.5 kV line for the new primary substation will be drawn in the following manner. In this way, the duration of power outages due to the work is likely to be shortened.

- Two 34.5 kV circuit breaker boards and one connecting board will be installed at the BSP substation.
- One of the existing 34.5 kV feeders will be detached from the existing 34.5 kV circuit breaker board and will be attached to one of the new circuit breaker boards.
- A feeder for the new primary substation will be attached to the other new circuit breaker board.
- The existing 34.5 kV circuit breaker board will be connected to the new connecting board to share the bus.

After drawing out a new 34.5 kV sub-transmission line from the existing BSP substation in the above manner, this sub-transmission line will be extended at each Project site as described in Table 2-2-2.3.

Table 2-2-2.3 New 34.5 kV Sub-Transmission Line Construction Plan

Project Site	Outline of the Construction Plan
Tamale (UDS Primary Substation)	As the Tamale BSP Substation is situated in an urban area, the new sub-transmission line will use underground cabling near the Tamale BSP Substation to avoid the need for the resettlement of residents (for approximately 5 km). This underground cabling will be laid along Stadium Road. However, an overhead line will be opted for at the section crossing Stadium Road to avoid any disruption to traffic due to the work. The underground line will continue along the former airport site and become an overhead line at the end of the former airport site. (The total length, including underground sections, will be approximately 19 km.)
Sunyani (Kotokrom Primary Substation)	The first pole will be located near the Sunyani BSP Substation and an overhead line will be constructed on the wayleave zone (15 m wide zone on each side of the line linking the centre of the pylons) of the existing 161 kV transmission line extending from the Techiman BSP Substation. This line runs northwards along the perimeter of the military site from the position of existing pylon No. 144 and then turns westwards after hitting Regional Hospital Road to reach the new Kotokrom Primary Substation. (The total length will be approximately 8.5 km.)

Source: JICA Study Team

2) Connection Method Between the Existing and New Distribution Lines

Each new primary substation to be constructed under the Project will receive 34.5 kV power supply from the existing BSP substation. This 34.5 kV will be stepped down to 11.5 kV at the new substations to supply power to the connected distribution lines. The connection method between the existing and new distribution lines is described in Table 2-2-2.4 and Table 2-2-2.5.

While the final connection work will be undertaken by the Ghanaian side, the connecting equipment and materials will be provided by the Japanese side. Fig. 2-2-2.1 and Fig. 2-2-2.2 show the areas expected to directly benefit from the Project at Tamale and Sunyani respectively.

Table 2-2-2.4 Connection Method Between the Existing and New 11.5 kV Distribution Lines (Tamale)

Feeder Name	Connection Method
UDS	The first pole will be located on the USD Primary Substation site, an overhead line will be constructed (approx. 0.2 km) to the existing distribution line serving the USD and a jumper connection will be made to the existing distribution line.
Tolon	The first pole will be located on the USD Primary Substation site and an underground line will be constructed to a point near the existing distribution line heading towards Tolon after crossing UDS Road. The line will become an overhead line just before the section crossing the approach road to the Animal Research Institute and a jumper connection will be made to the existing distribution line. (Total length: approx. 0.7 km).
Sheshegu	The first pole will be located on the UDS Primary Substation site. After crossing Tolon-Cheshegu Road, the line will become an underground line near the existing distribution line heading for Cheshegu. Connection to the existing distribution line will be made after the terminal treatment of the new line. (Total length: approx. 0.3 km)

Source: JICA Study Team

Table 2-2-2.5 Connection Method Between the Existing and New 11.5 kV Distribution Lines (Sunyani)

Feeder Name	Connection Method
Dedicated Hospital	The first pole will be located on the Kotokrom Primary Substation site and an overhead line will be constructed to the regional hospital site (approx. 4.3 km). A new RMU will be installed near the terminal pole at the regional hospital site and the existing 11.5 kV line from the Sunyani BSP Substation and a new 11.5 kV line from the Kotokrom Primary Substation will be connected to this RMU to improve the reliability of power supply to the regional hospital. The normal operating mode of the RMU will be that the Kotokrom Primary Substation side will be off while power supply to the regional hospital will use a dedicated line.
New Dormaa	The first pole will be located on the Kotokrom Primary Substation site and an overhead line will be constructed to the nearest terminal pole of the distribution line heading for New Dormaa to the Kotokrom Primary Substation (approx. 0.6 km). The line will go underground from this connection point to connect to the existing distribution line after the terminal treatment of the new line.
Chiraa	The first pole will be located on the Kotokrom Primary Substation site and an overhead line will be constructed to the nearest dead-end pole of the distribution line heading for Chiraa to the Kotokrom Primary Power Station (approx. 0.7 km). The line will go underground from this connection point to connect to the existing distribution line after the terminal treatment of the new line.

Source: JICA Study Team

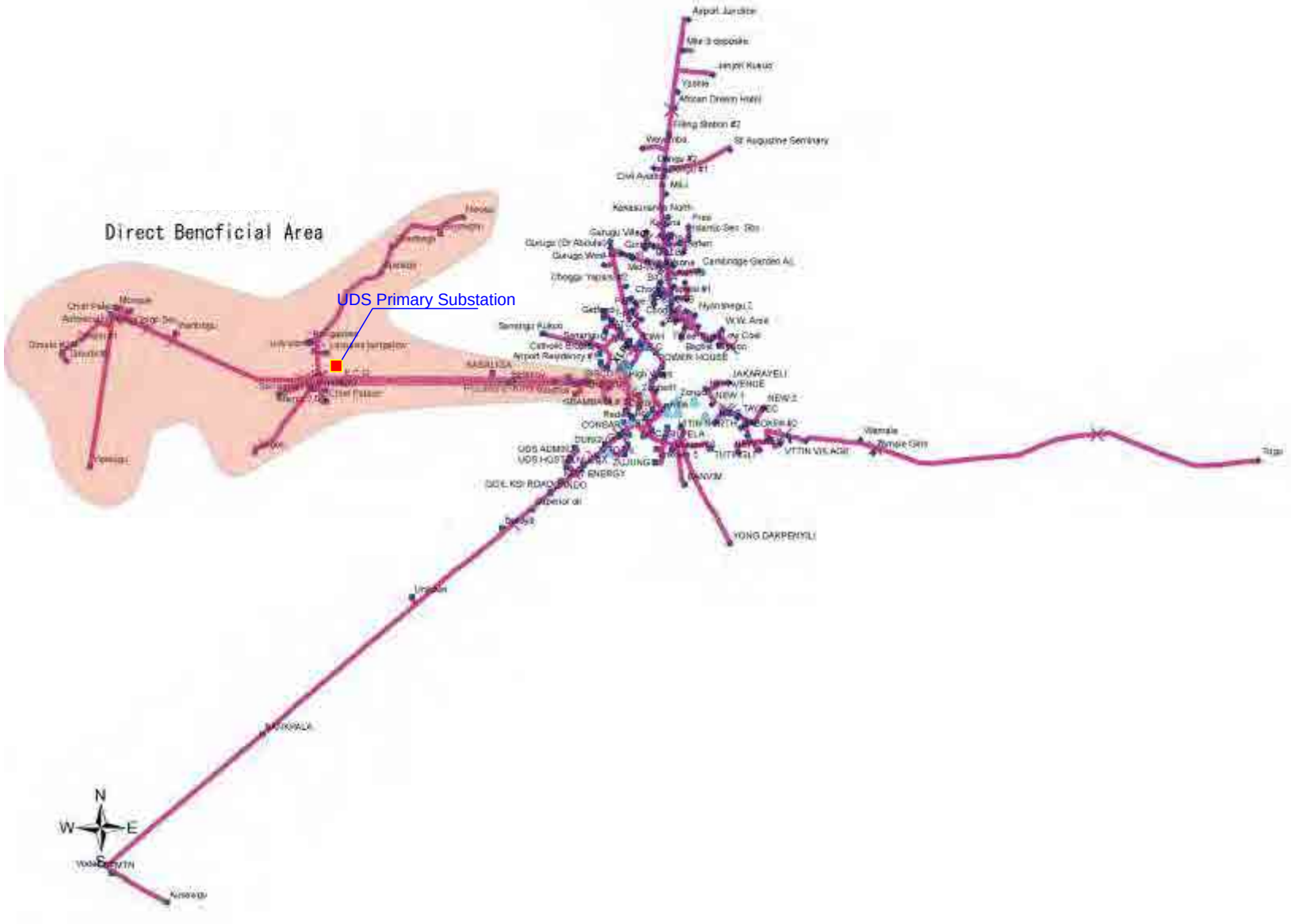


Fig. 2-2-2.1 Direct Benefitting Area of the Planned Distribution System Under the Project in the Tamale Area

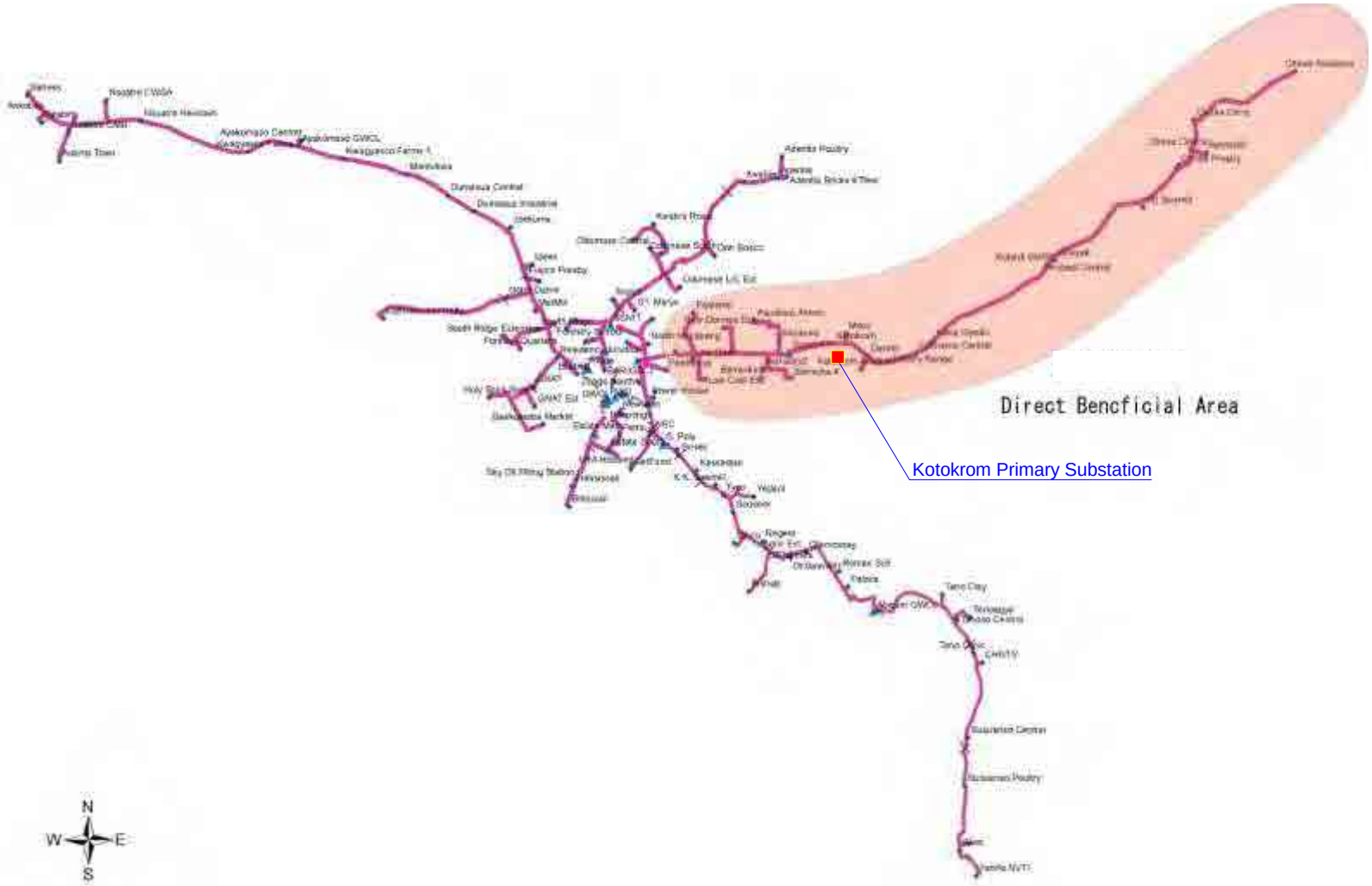


Fig. 2-2-2.2 Direct Benefitting Area of the Planned Distribution System Under the Project in the Sunyani Area

2-2-2-2 Design Conditions

The design conditions for the Project are described in this section.

(1) Meteorological Conditions

The meteorological conditions to be used for the design of the transformation and distribution facilities, substation buildings and foundations are shown in Table 2-2-2.6.

Table 2-2-2.6 Meteorological Conditions

Project Site		Northern Region and Brong-Ahafo Region
Elevation		≦ 500 m
Ambient Temperature	Maximum	40°C
	Minimum	10°C
	Mean	30°C
Maximum Humidity		85%
Maximum Wind Velocity		34 m/sec
Rainfall		1,400 mm/year
Seismic Force		
Soil Bearing Capacity		20 tons/m^2

(2) Electric Mode

The details of the electric mode to be used for the design of the transforming and distribution systems are shown in Table 2-2-2.7.

Table 2-2-2.7 Electric Mode

Item	Distribution System		Station Power Source	
Nominal Voltage	34.5 kV	11.5 kV	AC 415/240 V	DC 125 V
Maximum Voltage	36 kV	12 kV	AC 435/252 V	DC 131 V
Frequency	50 Hz		Irrelevant	
Short-Time Withstand Current	25 kA (1 sec)	12.5 kA (1 sec)	12.5 kA (1 sec)	Irrelevant
Lightning Impulse Withstand Voltage	170 kV	75 kV	Irrelevant	Irrelevant
Grounding System	Effective grounding system		Irrelevant	
Ingress Protection Rating	Outdoor: IP43 / Indoor: IP20			
Colour Coding	IEC standards (three phase; red/yellow/blue; neutral: black; grounding: green)			Positive: red Negative: blue
Cable Armour Colour	Black			
Minimum Creepage Distance	25 mm/kV	Irrelevant	Irrelevant	
Minimum Isolation Distance for Conductors				
Between Phase Conductors (mm)	370	315	Irrelevant	Irrelevant
Between Phase and Grounding Conductors (mm)	320	220	Irrelevant	Irrelevant
Height of Conductor for Distribution Line				
Ordinary Section (m)	6	6	Irrelevant	Irrelevant
Road Crossing Section (m)	7	7	Irrelevant	Irrelevant

(3) Applicable Codes/Standards and Units

Such international standards as IEC and ISO and the Japanese standards listed below will be applied for the design of the main functions of the equipment to ensure compatibility with existing equipment in Ghana.

- IEC : applied to electrical products in general
- ISO : applied to industrial products in general
- JIS : applied to industrial products in general
- JEC : applied to electrical products in general
- JEM : applied to electrical products in general
- JCS : applied to electrical wires and cables
- Technical Standards for Electrical : applied to electrical work in general Facilities in Japan

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

The outline of the basic plan for the requested Japanese assistance for the Project shown in Table 2-2-2.8 is based on the findings of the field survey as well as the results of consultations with the Ghanaian side and taking the design policies described in 2-2-1 into consideration.

Table 2-2-2.8 Outline of the Basic Design

Category	Improvement of Distribution System in Tamale Area (Northern Region)	Improvement of Distribution System in Sunyani Area (Brong-Ahafo Region)
Procurement and Installation of Equipment	1. Construction of UDS Primary Substation (1) Transformer (34.5/11.5 kV, 7.5 MVA): 1 set (2) 34.5 kV Switchgear Cubicle: 2 sets (3) 11.5 kV Switchgear Cubicle: 5 sets (4) Station transformer (11.5/0.43 kV, 100 kVA): 1 set (5) Substation building (single story, floor area of some 260 m^2) 2. 34.5 kV Sub-transmission line (between Tamale BSP and the UDS Primary Substation): approx. 19 km (including underground section: approx.. 5 km) 3. 11.5 kV distribution lines (from new UDS Primary Substation to the existing distribution lines) (1) UDS feeder: approx. 0.2 km (2) Tolon feeder: approx. 0.7 km (3) Cheshegu feeder: approx. 0.3 km 4. Extension 34.5 kV Switchgear at Tamale BSP: 3 sets	1. Construction of Kotokrom Primary Substation (1) Transformer (34.5/11.5 kV, 7.5 MVA): 1 set (2) 34.5 kV Switchgear Cubicle: 2 sets (3) 11.5 kV Switchgear Cubicle: 5 sets (4) Station transformer (11.5/0.43 kV, 100 kVA): 1 set (5) Substation building (single story, floor area of some 260 m^2) 2. 34.5 kV Sub-transmission line (between Sunyani BSP to new Kotokrom Primary Substation): approx. 8.5 km (including underground section: approx.. 0.5 km) 3. 11.5 kV distribution lines (from new Kotokrom Primary Substation to the existing distribution lines) (1) Hospital feeder: approx. 4.3 km (2) New Dormaa feeder: approx. 0.6 km (3) Chiraa feeder: approx. 0.7 km 4. Extension 34.5 kV Switchgear at Sunyani BSP: 3 sets 5. Ring main unit (RMU): 1 set
Procurement of Equipment and Other	1. Testing Instruments (including Cable Failure Point Detector) 2. Maintenance Tools (including Aerial Platform Vehicle)	1. Testing Instruments (including Cable Failure Point Detector) 2. Maintenance Tools (including Aerial Platform Vehicle)

	3. Replacement Parts 4. Emergency Spare Parts	3. Replacement Parts 4. Emergency Spare Parts

(1) Improvement of the Distribution System at the Tamale Site (Northern Region)

1) Basic Points and Plan Contents

① Construction of the UDS Primary Substation

a) Construction Site for the New Substation

The VRA-NED will secure part of the land owned by the Animal Research Institute which is controlled by the Ministry of the Environment, Science and Technology and the new substation will be constructed on a site of some 40 m x 30 m.

b) Installation of Transforming Equipment

One main transformer (34.5/11.5 kV, 7.5 MVA, oil-filled, self-cooling, with on-load tap changer), one station transformer (11.5/0.433 – 0.25 kV, 100 kV, oil-filled, self-cooling), one terminal pole for the 34.5 kV sub-transmission line (steel pole with a disconnecting switch and lightning arrester) and three terminal poles for the 11.5 kV distribution lines (steel poles with a disconnecting switch and lightning arrester) will be installed outdoors.

Two 34.5 kV distribution boards, five 11.5 kV distribution boards and a station power supply system (low voltage board and DC power supply unit) will be installed inside the substation building (approximately 260 m^2).

c) Main Transforming Equipment

Based on the estimated power demand in 2018, the main transformer to be installed at the new substation will be one transformer with a capacity of 7.5 MVA and an on-load tap changer (voltage adjustment range of 34.5 kV ± 10%) will be provided. The winding for this transformer will use the delta connection for the 34.5 kV side which is used as the standard connection by the VRA for primary substations and the star connection for the 11.5 kV side (vector symbol: Dyn11). The neutral point will be directly grounded. The impedance will be roughly 6% which is the standard value for transformers of this class.

Both the 34.5 kV and 11.5 kV distribution boards will use air insulation as in the case of the existing transformers. The circuit breakers will be operated from a distribution board and instruments and protection relays will be installed on the distribution board. The circuit breakers will be vacuum circuit breakers and will have a mechanism to allow their drawing out. The short-time withstand current value for the circuit breakers of the 34.5 kV distribution boards and 34.5 kV distribution equipment will be 25 kA (one second) which is the standard value adopted by Japanese manufacturers based on the relevant JIS and JEC standards. This decision is aided by the fact that the short-circuiting current value will be

approximately 4.2 kA for the current main transformer (161/34.5/11.5 kV, 20/12.5/12.5 MVA, %Z: 10% (161/34.5 kV)) at the Tamale BSP Substation when replaced by a new transformer (161/34.5/11.5 kV, 33/25/25 MVA, %Z: 10% (161/34.5 kV)) in 2012. The short-time withstand current value for the circuit breakers of the 11.5 kV distribution boards and 11.5 kV distribution equipment will be 12.5 kA (one second) which is the standard value adopted by Japanese manufacturers based on the relevant JIS and JEC standards. This is based on a three phase short-circuiting value of approximately 6.3 kA for the main transformer (34.5/11.5 kV, 7.5 MVA, %Z: 6%) at the UDS Primary Substation. An automatic reclosing relay will be installed for each distribution feeder from a 11.5 kV distribution board so that a circuit breaker will be automatically restored at the time of a minor grounding incident to improve the power supply reliability. The VRA standards will be used as the specifications for the instrument transformers for the 34.5 kV distribution boards and 11.5 kV distribution boards and instrument current transformers (secondary side current value: 5A) and instrument voltage transformers (secondary side voltage: 115/53 V) will be installed.

The station transformer will be an oil-filled type and will be installed outdoors. The capacity of this single transformer will be 100 kVA to operate the transforming equipment and to supply the station power. The primary/secondary voltages of the transformer will use the VRA standard of 11.5 kV/433 – 250 V (zero voltage switching). The neutral point on the secondary side will be directly grounded.

An alkali battery or lead battery may be used as the DC power source. As the cadmium contained in an alkali battery poses a problem for its disposal, a lead battery will be used. The capacity of this battery will be sufficient to cover a power outage lasting 12 hours. The voltage of the DC power source will be 125 V which is the standard voltage adopted by the VRA.

d) Auxiliary Electrical Installations

The 36 kV and 12 kV cables to be used at the new substation sites will be aluminium conductor, XLPE insulation, aluminium strand, armoured sheathed power cables in accordance with the VRA standards and will be buried approximately 1.2 m below the ground surface. The low voltage and control cables will be copper conductor cables and will be laid in conduits.

The design grounding resistance at the new substations will be 1 ohm or less based on the relevant VRA standard. As the planned substation site has firm ground, it will be necessary to use grounding mesh and grounding electrodes (grounding poles, a grounding plate and grounding resistance reducer). The grounding wire to be used for the grounding mesh will be stranded bare copper wire. The lightning

rod of the substation building will be linked to the grounding mesh of the said substation.

e) Substation Building and Auxiliary Facilities

A building (260 m^2) and auxiliary facilities will be constructed at the UDS Primary Substation Site to house the 34.5 kV distribution board, 11.5 kV distribution board and station power supply system. The earmarked land for the UDS Primary Substation is some 70 m wide (east – west) and 60 m long (north – south) and is large enough to accommodate the planned new substation. The location of the substation building will be determined in view of the planned installation of one terminal pole for the 34.5 kV sub-transmission line and three terminal poles for the 11.5 kV distribution lines. This building is outlined below.

- Building : one single story building
- Structure : RC rigid structure and concrete block walls
- Area : building area of 260 m^2 and floor area of 260 m^2

The main features of the building and building services and other relevant aspects of its construction plan are described next.

f) Principal Rooms and Building Services

Table 2-2-2.9 List of the Main Rooms and Building Services for the Substation Building

Rooms	Area (m^2)	Systems/Specifications
Distribution Board Room	195	Lighting, air-condition and ventilation
Battery Room	15	Lighting and ventilation
Staff Office	23.5	Lighting, air-conditioning and ventilation
Spare Parts Storage	17.5	Lighting and ventilation
Toilet	9	Lighting, flush toilet, wash basin and ventilation
Exterior	-	Gravelled premises, concrete parking area and stormwater drainage ditches
Plumbing	-	Water supply tank, flush toilet, wash basin, septic tank and infiltration basin
Electrical Installations	-	Distribution boards, indoor lighting, outdoor lighting, lightning rod and grounding
Auxiliary Facility	-	Oil separator for the transformer
Total	260	

g) Specifications of the Principal Structural Bodies

Table 2-2-2.10 Specifications of the Principal Structural Bodies

Structural Body	Specifications
Foundations	RC, spread foundations
Floor and plumbing/cabling pits	RC
Pillars and beams	RC
Walls	Concrete block masonry

h) Exterior Finishes

Table 2-2-2.11 Exterior Finishes

Section	Type of Finish
Foundations	Exposed concrete
External walls	Mortar with a trowel finish and EP finish
Roof	Aluminium zinc alloy plated steel sheeting with a paint finish

i) Interior Finishes

Table 2-2-2.12 Interior Finishes

Area	Section	Type of Finish
Distribution Board Room	Floor	Mortar with trowel finish and non-slip paint finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joists and veneer gypsum board
Battery Room	Floor	Mortar with trowel finish and acid-resistant paint finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joists and veneer gypsum board
Staff Room	Floor	Mortar with trowel finish and P tile finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joists and veneer gypsum board
Spare Parts Storage	Floor	Mortar with trowel finish and non-slip paint finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joints and veneer gypsum board
Toilet	Floor	Ceramic tile finish
	Wainscoting	Earthenware tile finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joints and veneer gypsum board

The structural plan for the substation is outlined next.

j) Principal Building Structure

The principal structure of the new substation building will be a RC rigid structure with concrete block masonry employed for the walls. As this type of structure is commonly used in Ghana, all of the necessary materials can be easily procured. Its advantages include the existence of many engineers and technicians who are familiar with this type of structure and the building maintenance is easy.

k) Foundations

The geological survey results for the Project sites indicate that there is a 0.4 ~ 0.8 m thick sand gravel layer at the surface of which the allowable bearing capacity is 200 kN/m^2. Below this is a solid gravel layer to a depth of 1.6 m with an allowable bearing capacity of 400 kN/m^2. As the bearing capacity of the ground is sufficient, spread foundations will be employed.

The plan for the building services is outlined next.

l) Lighting and Power Outlet System

The relevant JIS standard will be used to determine the illuminance for indoor lighting and such lighting will, in principle, be provided by fluorescent lamps. Mercury lamps will be used for outdoor lighting.

m) Air-Conditioning System

An air-conditioning system will be installed in the distribution board room and staff room.

n) Ventilation System

The installation of a ventilation fan in every room will be considered.

o) Fire Extinguishing System

A fire extinguisher (10 kg) will be provided in the distribution board room and battery room for initial fire extinguishing activities.

p) Equipment Foundations

Separate foundations will be constructed to support heavy transforming equipment, etc.

② Construction of 34.5 kV Sub-Transmission Line (from the Tamale BSP Substation to the UDS Primary Substation)

a) Construction of 34.5 kV Sub-Transmission Line

To determine the route for the new 34.5 kV sub-transmission line, a route map was firstly prepared using a satellite image map of the area. This was followed by field reconnaissance by a Study Team member accompanied by a VRA-NED engineer to check any obstacles, special natural conditions and other relevant matters. The routes for the underground cable section and overhead cable section were then finalised.

This sub-transmission line using 36 kV cable will run underground from the 34.5 kV distribution board room of the existing Tamale BSP Substation for approximately 5 km along Stadium Road, Nyankpala Road and the former airport runway. It will become an overhead line at the end of the former airport runway, stretching some 14 km along Nyankpala Road to the UDS Primary Substation. At the two sites where the planned route crosses a trunk road, an overhead line will be constructed to avoid any disruption to traffic by underground cabling work. The flat ground along Nyankapala Road (some 5 km section before reaching the UDS Primary Substation) is often flooded during the wet season and, therefore, the

electric poles in this section will require a concrete lining for the underground portion.

In view of preventing damage due to open burning and preserving the urban landscape, steel electric poles will be used for this sub-transmission line. The height of these poles will be 15 m above ground and the new sub-transmission line will run above the existing 34.5 kV sub-transmission and 11.5 kV distribution lines. The standard span will be 90 m in consideration of the planned cable size, tensile load of the cable and pole strength. The overhead cable will be the VRA standard AAAC 120 mm. The creepage distance for the insulators will be 25 mm/kV in view of the likelihood of pollution due to the harmattan. The arms for insulator insulation will be made of zinc-plated steel.

The underground cables used for this sub-transmission line will be the VRA standard AAAC XLPE insulation single core 185 mm^2 sheathed cable with aluminium wire armour for underground application. This cable will be laid some 1.2 m below the ground surface.

b) Insulation of 34.5 kV Distribution Board (at the Tamale BSP Substation)

One 34.5 kV feeder will be required at the Tamale BSP Substation to feed the new 34.5 kV sub-transmission line heading for the UDS Primary Substation. Because of the absence of a drawing showing the bus structure for the existing some 20 year old 34.5 kV distribution board, it will be impossible to conduct the work to connect the bus of the existing 34.5 kV distribution board and the bus of the new 34.5 kV distribution boards. Because the existing 34.5 kV distribution board installed in the power room of the Tamale BSP Substation does not have an unused reserve feeder, a new 34.5 kV distribution board will be installed next to the existing board. Due to the difficulty to connect the buses of these two distribution boards, a cable link will be established between the existing 34.5 kV distribution board (Buipe/Yapei feeder) and the bus of the new 34.5 kV distribution board. This new 34.5 kV distribution board will be equipped with a UDS Primary Substation feeder and a Buipe/Yapei feeder. The connection of the bus between the two distribution boards will use cable of which the bus current is equivalent to 800 A (36 kV, copper conductor, XLPE insulation single core 240 $mm^2$with PVS jacket; two conductors per phase).

The short-time withstand current value for the circuit breakers of the 34.5 kV distribution boards and 34.5 kV distribution equipment will be 25 kA (one second) which is the standard value adopted by Japanese manufacturers based on the relevant JIS and JEC standards. This decision is based on the estimated 3-phase short-circuiting current value of approximately 4.2 kA when the current main transformer (161/34.5/11.5 kV, 20/12.5/12.5 MVA, %Z: 10% (161/34.5 kV)) at the Tamale BSP Substation is replaced by a new transformer (161/34.5/11.5 kV, 33/25/25 MVA, %Z: 10% (161/34.5 kV)) in 2012.

Each distribution feeder of the new 34.5 kV distribution board will be equipped with an automatic reclosing relay so that a circuit breaker is automatically restored at the time of a minor grounding incident to improve the power supply reliability. This new 34.5 kV distribution board will be the compact gas insulation type as the existing power room of the Tamale BSP substation does not have sufficient space for the additional installation of a conventional type distribution board. The power to operate the new 34.5 kV distribution board will be provided from the existing power board (AC 3-phase 4-wire 415/240 V, DC 125 V).

③ Construction of 11.5 kV Distribution Lines (between the connecting points to the existing 11.5 kV distribution lines and the UDS Primary Substation)

New 11.5 kV distribution lines will be constructed for the following three sections from the UDS Primary Substation to each of the existing three 11.5 kV feeders.

- UDS Primary Substation to the UDS feeder:
  overhead line of some 200 m long
- UDS Primary Substation to the Tolon feeder:
  overhead line of some 300 m long; underground line of some 400 m long
- UDS Primary Substation to the Cheshegu feeder:
  overhead line of some 300 m long

In view of preventing damage due to open burning and preserving the urban landscape, steel electric poles will be used for these distribution lines. The height of these poles will be 15 m above ground as the new distribution line will run above the existing 11.5 kV distribution line. The standard span will be 90 m. For overhead sections, a VRA standard AAAC 120 mm^2 cable will be used. Meanwhile, a VRA standard sheathed cable with aluminium conductor XLPE insulation 185 mm^2 single core aluminium strand armoured will be used for underground sections. The underground cable will be buried some 1.2 m below the ground surface.

2) Outline Specifications of the Main Equipment

Table 2-2-2.13 Outline Specifications of the Main Equipment
for the UDS Primary Substation

No.	Item	Specifications	Qty.
1	34.5/11.5 Transformer		1 set
	1) Type	Outdoor oil-immersed type with on-load tap changer	
	2) Rated voltage of primary side	34.5 kV	
	3) Rated voltage of secondary side	11.5 kV	
	4) Rated capacity	7.5 MVA	
	5) Cooling method	ONAN	
	6) Number of phases	3	
	7) Frequency	50 Hz	
	8) Tap voltage	34.5 kV ± 10%	
	9) Number of taps	17 taps	
	10) Step voltage	1.25%	
	11) Winding connection and vector symbol	Primary side: delta Secondary side: star (neutral lead out) Dyn11	
	12) % Impedance	approx. 6%	
	13) Cable cover	Elephant type cable duct with base plate	
2	34.5 kV Switchgear Cubicle		
	1) Type	Indoor distribution cubicle	
	2) Component of switchgear cubicles		
	2.1) Incoming feeder switchgear cubicle		
	a) Number of boards		1 set
	b) Circuit breaker (CB)		
	- Type	VCB, drawer type	
	- Rated voltage	36 kV	
	- Rated current	630 A	
	- Rated short-time withstand current	25 kA (one second)	
	c) Earthing switch (ES)		
	- Type	Mechanical or electrical interlock with CB	
	2.2) Transformer Metering Cubicle		
	a) Number of cubicle		1 set
	b) Current transformer for metering		
	- Current ratio	Primary side: 150 – 75 A / Secondary side: 5 A	
	- Accuracy class	CL: 0.2	
	- Burden	15 VA	
	c) Current transformer for protection relays		
	- Current ratio	Primary side: 150 – 75 A / Secondary side: 5 A	
	- Accuracy class	CL: 5P20	
	- Burden	15 VA	
	d) Potential transformer		
	- Voltage ratio	Primary side: 34.5/√3kV / Secondary side: 115/√3V	
	- Accuracy class	CL: 0.2	
	- Burden	25 VA	
	e) Metering	Multimeter (V, A, W, VA, VAR, PF, Hz, WH)	
	f) Protection relays	Under-voltage relay, over-current relay, ground fault over-current relay, percentage differential relay	

No.	Item	Specifications	Qty.
3	11.5 kV Switchgear Cubicles		
	1) Type	Indoor distribution board	
	2) Component of Switchgear Cubicles		
	2.1) Transformer feeder switchgear cubicle		
	a) Number of cucicle		1 set
	b) Bus bar current	800 A	
	c) Circuit breaker (CB)		
	- Type	VCB, drawer type	
	- Rated voltage	12 kV	
	- Rated current	630 A	
	- Rated Short-time withstand current	12.5 kA (one second)	
	d) Earthing switch (ES)		
	- Type	Mechanical or electrical interlock with CB	
	e) Current transformer for metering		
	- Current ratio	Primary side: 400 – 200 A / Secondary side: 5 A	
	- Accuracy class	CL: 0.2	
	- Burden	15 VA	
	f) Current transformer for protection relays		
	- Current ratio	Primary side: 400 – 200 A / Secondary side: 5 A	
	- Accuracy class	CL: 5P20	
	- Burden	15 VA	
	g) Potential Transformer		
	- Voltage ratio	Primary side:11.5/√3kV / Secondary side: 115/√3V	
	- Accuracy class	CL: 0.2	
	- Burden	50 VA	
	h) Metering	Multimeter (V, A, W, VA, VAR, PF, Hz, WH)	
	i) Protection relays	Under-voltage relay, over-voltage relay, ground fault over-current relay, automatic voltage regulating relays	
	2.2) 11.5 kV Distribution feeder cubicle		
	a) Number of cubicle		
	b) Circuit breaker (CB)		3 sets
	- Type	VCB, drawer type	
	- Rated voltage	12 kV	
	- Rated current	630 A	
	- Rated Short-time withstand current	12.5 kA (one second)	
	c) Earthing Switch		
	- Type	Mechanical or electrical interlock with CB	
	d) Current transformer for metering		
	- Current ratio	Primary side: 200 – 100 A / Secondary side: 5 A	
	- Accuracy class	CL: 0.2	
	- Burden	15 VA	
	e) Current transformer for protection relays		
	- Current ratio	Primary side: 200 – 100 A /Secondary side: 5A	
	- Accuracy class	CL: 5P20	
	- Burden	15 VA	
	g) Voltage transformer for instruments		
	- Voltage ratio	Primary side:11.5/√3kV / Secondary side: 115/√3V	
	- Accuracy class	CL: 0.2	
	- Burden	50 VA	
	f) Metering	Multimeter (V, A, W, VA, VAR, PF, Hz, WH)	
	h) Protection relays	Over-current relay, ground fault over-current	

No.	Item	Specifications	Qty.
		relay, automatic reclosing relay	
	2.3) Station transformer feeder switchgear cubicle a) Number of cubicle b) Circuit breaker (CB) - Type - Rated voltage - Rated current - Rated Short-time withstand current c) Earthing switch (ES) - Type d) Current transformer for metering - Current ratio - Accuracy class - Burden e) Current transformer for protection relays - Current ratio - Accuracy class - Burden f) Metering g) Protection relays	 VCB, drawer type 12 kV 630 A 12.5 kA (one second) Mechanical or electrical interlock with CB Primary side: 10 A / Secondary side: 5 A CL: 1.0 15 VA Primary side: 10 A / Secondary side: 5 A CL: 5P10 15 VA Multimeter (V, A, W, VA, VAR, PF, Hz, WH) Over-current relay, ground fault over-current relay	1 set
4	Station transformer (STR) 1) Type 2) Rated voltage of primary side and tap 3) Rated voltage of secondary side 4) Rated capacity 5) Number of phases 6) Frequency 7) Winding and vector symbol 8) % Impedance 9) Current transformer for protection relays - Current ratio - Accuracy class - Burden 10) Cable cover	 Outdoor oil-immersed 11.5 kV± 2.5%, ±5% taps (non-voltage tap change) 433 – 250 V 100 kVA 3 50 Hz Primary side: delta Secondary side: star (drawn from the neutral point) Dyn11 approx. 5% Primary side: 100 – 50 A / Secondary side: 5 A CL: 10P10 25 VA Elephant type cable duct with baseplate	1 set
5	LV Service panel 1) Number of panel 2) Type 3) Rated voltage (number of phases and wires) 4) Circuit breaker type 5) Current transformer for metering - Current ratio - Accuracy class - Burden 6) Metering 7) Protection relay	 Indoor self-contained AC 415/240 V (3-phase 4-wire) Earth leakage circuit breaker (ELCB), 4 poles, 225 AF/150 AT Primary side: 200 A / Secondary side: 5 A CL: 1.0 25 VA Ammeter (with changing-over switch) Ground fault over-current relay	1 set
6	DC Service panel and battery charger 1) Number of panel 2) Type 3) Rated voltage	 Indoor self-contained DC 125 V	1 set

No.	Item	Specifications	Qty.
	4) Circuit breaker type 5) Battery charger	Mold case circuit breaker (MCCB) With float charging functions	
7	Battery 1) Type 2) Rated voltage (voltage per cell) 3) Number of battery cells 4) Discharge duration (duration of commercial power outage) 5) Battery capacity	 Lead acid sealed type 125 V (2 V/cell) 63 cells 12 hours 150 Ah/10 hrs (the battery capacity shall be secured of an outage duration of 12 hours into consideration)	1 set
8	34.5 kV Disconnecting switch pole 1) Quantity 2) Type 3) Pole mounting equipment - Arrester - Circuit breaker	 Steel pole (x 2), arrester, circuit breaker 36 kV, 10 kA, zinc oxide gapless type 36 kV, 630 A, 25 kA (one second)	1 set
9	11.5 kV Disconnecting switch pole 1) Quantity 2) Type 3) Pole mounting equipment - Arrester - Circuit breaker	 Steel pipe (x 2), arrester, circuit breaker 12 kV, 10 kA, zinc oxide gapless type 12 kV, 630 A, 12.5 kA (one second)	3 sets
10	36 kV Cable 1) Type 2) Conductor, insulation, armour and jacket 3) Number of cores and conductor size	 Armoured cable for direct underground laying Aluminium conductor, XLPE insulation, aluminium strand-armoured power cable with ant-repellent PVC jacket Single core, 185 mm^2, single cable per phase (from the 34.5 kV disconnecting switch pole to the 34.5 kV distribution board; from the 34.5 kV circuit board to the 34.5 kV side of the transformer)	1 set
11	12 kV Cable 1) Type 2) Conductor, insulation, armour and jacket 3) Number of cores and conductor size	 Armoured cable for direct underground laying Aluminium conductor, XLPE insulation, aluminium strand-armoured power cable with ant-repellent PVC jacket ・ Single core, 185 mm^2, 3 cables per phase (from the 11.5 kV side of the transformer to the 11.5 kV distribution board) ・ Single core, 185 mm^2, single cable per phase (from the 11.5 kV distribution board to the 11.5 kV disconnecting switch pole) ・ Single core, 185 mm^2, single cable per phase (from the 11.5 kV distribution board to the 11.5 kV side of the station transformer)	1 set

Table 2-2-2.14 Outline Specifications of the Main Equipment for the 34.5 kV Sub-Transmission Line (from the Tamale BSP Substation to the UDS Primary Substation)

No.	Item	Specifications	Qty.
1	34.5 kV Sub-transmission line		1 set
	1) Electric pole types		
	a) 3A (intermediate pole)	0°~ 5°	
	b) 3B (light angle pole)	5° ~ 20°	
	c) 3C (medium angle pole)	20° ~ 60°	
	d) 3D (heavy angle pole)	60° ~ 90°	
	e) 3E (cross pole)	90°	
	f) 3F (section pole)		
	g) 3K (disconnecting switch pole)		
	2) Conductor type	AAAC120 mm^2	
2	34.5 kV Switchgear Cubicles in Tamale BSP		1 set
	1) Type	Indoor SF6 gas-insulation	
	2) Number of cubicle	・ One for connection with the existing distribution board (Buipe/Yapei feeder) ・ One for the distribution feeder (Buipe/Yapei feeder) ・ One for the distribution feeder (UDS feeder)	3 sets
	3) Bus bar current	800 A	
	4) Circuit breaker	36 kV, 800 A, 25 kA (one second)	
	5) Metering	Multimeter (V, A, W, VA, VAR, PF, Hz, WH)	
	6) Protection relays	Over-current relay, ground fault over-current relay, automatic reclosing relay	
	7) Power source for AC control	To be supplied from the existing low voltage panel (AC 3-phase 4-wire, 415/240 V)	
	8) Power source for DC control	To be supplied from the existing DC panel (DC 125 V)	
	9) Number of cable terminals	3 feeders ・ One for connection to the existing distribution board (new cable: 36 kV, XLPE insulation, copper conductor, single core, 240 mm^2, 2 cables per phase, ant-repellent PVC jacket) ・ One for connection to the Buipe/Yapei feeder (existing cable: 36 kV, XLPE insulation, aluminium conductor, single core, 185 mm^2, one cable per phase, aluminium strand armour, ant-repellent PVC jacket) ・ One for the UDS feeder (new cable: 36 kV, XLPE insulation, aluminium conductor, single core, 185 mm^2, one cable per phase, aluminium strand armour, ant-repellent PVC jacket)	
3	36 kV Cable		1 set
	1) Specifications	・ For connection to the existing distribution board (new cable: 36 kV, XLPE insulation, copper conductor, single core, 240 mm^2, 2 cables per phase, ant-repellent PVC jacket) ・ For the UDS feeder (new cable: 36 kV, XLPE insulation, aluminium conductor, single core, 185 mm^2, one cable per phase, aluminium strand armour, ant-repellent PVC jacket)	

Table 2-2-2.15 Outline Specifications of the Main Equipment for the 11.5 kV Distribution Lines (11.5 kV distribution lines from the UDS Primary Substation)

No.	Item	Specifications	Qty.
1	11.5 kV Distribution line 1) Electric pole types a) 1A (intermediate pole) b) 1B (light angle pole) c) 1C (medium angle pole) d) 1D (heavy angle pole) e) 1E (cross pole) f) 1F (section pole) g) 1H (terminal pole) h) 1K (disconnecting switch pole) 2) Conductor type	 0° ~ 5° 5° ~ 20° 20° ~ 60° 60° ~ 90° 90° AAAC 120 mm^2	1 set
2	12 kV Cable 1) Type 2) Conductor, insulation, armour, jacket 3) Number of cores, conductor size	 Armoured cable for direct underground laying Aluminium conductor, XLPE insulation, aluminium strand armour, ant-repellent PVC jacket ・ Single core, 185 mm^2 (from the new 11.5 kV disconnecting switch pole (for the Tolon feeder) to the existing dual-line terminal pole) ・ Single core, 185 mm^2 (from the new 11.5 kV disconnecting switch pole (for the Cheshegu feeder) to the existing pole)	1 set

(2) Improvement of the Distribution System at the Sunyani Site (Brong-Ahafo Region)

1) Basic Points and Plan Contents

① Construction of the Kotokrom Primary Substation

a) Construction Site for the New Substation

The VRA-NED will secure part of the land owned by the military and the new substation will be constructed on a site of some 40 m x 30 m.

b) Installation of Transforming Equipment

One main transformer (34.5/11.5 kV, 7.5 MVA, oil-filled, self-cooling, with on-load tap changer), one station transformer (11.5/0.433 – 0.25 kV, 100 kV, oil-filled, self-cooling), one terminal pole for the 34.5 kV sub-transmission line (steel pole with a disconnecting switch and lightning arrester) and three terminal poles for the 11.5 kV distribution lines (steel poles with a disconnecting switch and lightning arrester) will be installed outdoors.

Two 34.5 kV distribution boards, five 11.5 kV distribution boards and a station power supply system (low voltage board and DC power supply unit) will be installed inside the substation building (approximately 260 m^2).

c) Main Transforming Equipment

Based on the estimated power demand in 2018, the main transformer to be installed at the new substation will be one transformer with a capacity of 7.5 MVA and an on-load tap changer (voltage adjustment range of 34.5 kV ± 10%) will be provided. The winding for this transformer will use the delta connection for the 34.5 kV side which is used as the standard connection by the VRA for primary substations and the star connection for the 11.5 kV side (vector symbol: Dyn11). The neutral point will be directly grounded. The impedance will be roughly 6% which is the standard value for transformers of this class.

Both the 34.5 kV and 11.5 kV distribution boards will use air insulation as in the case of the existing transformers. The circuit breakers will be operated from a distribution board and instruments and protection relays will be installed on the distribution board. The circuit breakers will be vacuum circuit breakers and will have a mechanism to allow their drawing out. The short-time withstand current value for the circuit breakers of the 34.5 kV distribution boards and 34.5 kV distribution equipment will be 25 kA (one second) which is the standard value adopted by Japanese manufacturers based on the relevant JIS and JEC standards. This decision is aided by the fact that the short-circuiting current value will be approximately 4.2 kA when the current main transformer (161/34.5/11.5 kV, 20/12.5/12.5 MVA, %Z: 10% (161/34.5 kV)) at the Sunyani BSP Substation replaced by a new transformer (161/34.5/11.5 kV, 33/25/25 MVA, %Z: 10% (161/34.5 kV)) in 2012. The short-time withstand current value for the circuit breakers of the 11.5 kV distribution boards and 11.5 kV distribution equipment will be 12.5 kA (one second) which is the standard value adopted by Japanese manufacturers based on the relevant JIS and JEC standards. This is based on a three phase short-circuiting value of approximately 6.3 kA for the main transformer (34.5/11.5 kV, 7.5 MVA, %Z: 6%) at the Kotokrom Primary Substation. An automatic reclosing relay will be installed for each distribution feeder from a 11.5 kV distribution board so that a circuit breaker will be automatically restored at the time of a minor grounding incident to improve the power supply reliability. The VRA standards will be used as the specifications for the instrument transformers for the 34.5 kV distribution boards and 11.5 kV distribution boards and instrument current transformers (secondary side current value: 5A) and instrument voltage transformers (secondary side voltage: 115/53 V) will be installed.

The station transformer will be an oil-filled type and will be installed outdoors. The capacity of this single transformer will be 100 kVA to operate the transforming equipment and to supply the station power. The primary/secondary voltages of the transformer will use the VRA standard of 11.5 kV/433 – 250 V (zero voltage switching). The neutral point on the secondary side will be directly grounded.

An alkali battery or lead battery may be used as the DC power source. As the cadmium contained in an alkali battery poses a problem for its disposal, a lead battery will be used. The capacity of this battery will be sufficient to cover a power outage lasting 12 hours. The voltage of the DC power source will be 125 V which is the standard voltage adopted by the VRA.

d) Auxiliary Electrical Installations

The 36 kV and 12 kV cables to be used at the new substation sites will be aluminium conductor, XLPE insulation, aluminium strand, armoured sheathed power cables in accordance with the VRA standards and will be buried approximately 1.2 m below the ground surface. The low voltage and control cables will be copper conductor cables and will be laid in conduits.

The design grounding resistance at the new substations will be 1 ohm or less based on the relevant VRA standard. As the planned substation site has firm ground, it will be necessary to use grounding mesh and grounding electrodes (grounding poles, a grounding plate and grounding resistance reducer). The grounding wire to be used for the grounding mesh will be stranded bare copper wire. The lightning rod of the substation building will be linked to the grounding mesh of the said substation.

e) Substation Building and Auxiliary Facilities

A building (260 m^2) and auxiliary facilities will be constructed at the Kotokrom Primary Substation Site to house the 34.5 kV distribution board, 11.5 kV distribution board and station power supply system. The earmarked land for the Kotokrom Primary Substation is some 70 m wide (east – west) and 60 m long (north – south) and is large enough to accommodate the planned new substation. The location of the substation building will be determined in view of the planned installation of one terminal pole for the 34.5 kV sub-transmission line and three terminal poles for the 11.5 kV distribution lines. This building is outlined below.

- Building : one single story building
- Structure : RC rigid structure and concrete block walls
- Area : building area of 260 m^2 and floor area of 260 m^2

The main features of the building and building services and other relevant aspects of its construction plan are described next.

f) Principal Rooms and Building Services

Table 2-2-2.16 List of the Main Rooms and Building Services for the Substation Building

Room, etc.	Area (m^2)	Systems/Specifications
Distribution Board Room	195	Lighting, air-condition and ventilation
Battery Room	15	Lighting and ventilation
Staff Office	23.5	Lighting, air-conditioning and ventilation
Spare Parts Storage	17.5	Lighting and ventilation
Toilet	9	Lighting, flush toilet, wash basin and ventilation
Exterior	-	Gravelled premises, concrete parking area and stormwater drainage ditches
Plumbing	-	Water supply tank, flush toilet, wash basin, septic tank and infiltration basin
Electrical Installations	-	Distribution boards, indoor lighting, outdoor lighting, lightning rod and grounding
Auxiliary Facility	-	Oil separator for the transformer
Total	260	

g) Specifications of the Principal Structural Bodies

Table 2-2-2.17 Specifications of the Principal Structural Bodies

Structural Body	Specifications
Foundations	RC, spread foundations
Floor and plumbing/cabling pits	RC
Pillars and beams	RC
Walls	Concrete block masonry

h) Exterior Finishes

Table 2-2-2.18 Exterior Finishes

Section	Type of Finish
Foundations	Exposed concrete
External walls	Mortar with a trowel finish and EP finish
Roof	Aluminium zinc alloy plated steel sheeting with a paint finish

i) Interior Finishes

Table 2-2-2.19 Interior Finishes

Area	Section	Type of Finish
Distribution Board Room	Floor	Mortar with trowel finish and non-slip paint finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joists and veneer gypsum board
Battery Room	Floor	Mortar with trowel finish and acid-resistant paint finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joists and veneer gypsum board
Staff Room	Floor	Mortar with trowel finish and P tile finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joists and veneer gypsum board
Spare Parts Storage	Floor	Mortar with trowel finish and non-slip paint finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joints and veneer gypsum board
Toilet	Floor	Ceramic tile finish
	Wainscoting	Earthenware tile finish
	Walls	Mortar with trowel finish and EP finish
	Ceiling	LGS joints and veneer gypsum board

The structural plan for the substation is outlined next.

j) Principal Building Structure

The principal structure of the new substation building will be a RC rigid structure with concrete block masonry employed for the walls. As this type of structure is commonly used in Ghana, all of the necessary materials can be easily procured. Its advantages include the existence of many engineers and technicians who are familiar with this type of structure and the building maintenance is easy.

k) Foundations

The geological survey results for the Project sites indicate that there is a 0 ~ 0.2 m thick sand gravel layer at the surface of which the allowable bearing capacity is 180 kN/m^2. Below this is a consolidated laterite layer to a depth of 1.8 m with an allowable bearing capacity of 350 kN/m^2. As the bearing capacity of the ground is sufficient, spread foundations will be employed.

The plan for the building services is outlined next.

l) Lighting and Power Outlet System

The relevant JIS standard will be used to determine the illuminance for indoor lighting and such lighting will, in principle, be provided by fluorescent lamps. Mercury lamps will be used for outdoor lighting.

m) Air-Conditioning System

An air-conditioning system will be installed in the distribution board room and staff room.

n) Ventilation System

The installation of a ventilation fan in every room will be considered.

o) Fire Extinguishing System

A fire extinguisher (10 kg) will be provided in the distribution board room and battery room for initial fire extinguishing activities.

p) Equipment Foundations

Separate foundations will be constructed to support heavy transforming equipment, etc.

② Construction of 34.5 kV Sub-Transmission Line (from the Sunyani BSP Substation to the Kotokrom Primary Substation)

a) Construction of 34.5 kV Sub-Transmission Line

To determine the route for the new 34.5 kV sub-transmission line, a route map was firstly prepared using a satellite image map of the area. This was followed by field reconnaissance by a Study Team member accompanied by a VRA-NED engineer to check any obstacles, special natural conditions and other relevant matters. The routes for the underground cable section and overhead cable section were then finalised.

This sub-transmission line will run underground (for approximately 0.5 km) from the 34.5 kV distribution board room of the Sunyani BSP Substation to a new 34.5 kV disconnecting switch pole which will be located 12.5 m away from the central point of the No. 157 pylon for the 161 kV Techiman transmission line situated outside the Sunyani BSP Substation. The overhead line will then run on the wayleave (15 m wide zone on both sides of the line linking the central points of the pylons for the 161 kV Techiman transmission line) up to near the No. 144 pylon, keeping a distance of some 12.5 m from the said line linking the central points of the pylons. It will then turn northwards along the perimeter of the land owned by the military to the new Kotokrom Primary Substation. Dual-line terminal poles instead of intermediate poles will be used at places with many undulations to avoid disengagement of the overhead cables from the insulators. The construction work for the overhead line for the some 400 m long section from the 34.5 kV disconnecting switch pole outside the Sunyani BSP Substation must avoid Wednesdays when a local market is held.

In view of preventing damage due to open burning and preserving the urban landscape, steel electric poles will be used for this sub-transmission line. The

height of these poles will be 15 m above ground and the new sub-transmission line will run above the existing 34.5 kV sub-transmission and 11.5 kV distribution lines. The standard span will be 90 m in consideration of the planned cable size, tensile load of the cable and pole strength. The overhead cable will be the VRA standard AAAC 120 mm. The creepage distance for the insulators will be 25 mm/kV in view of the likelihood of pollution due to the harmattan. The arms for insulator insulation will be made of zinc-plated steel.

The underground cables used for this sub-transmission line will be the VRA standard AAAC XLPE insulation single core 185 mm^2 sheathed cable with aluminium wire armour for underground application. This cable will be laid some 1.2 m below the ground surface.

b) Insulation of 34.5 kV Distribution Board (at the Sunyani BSP Substation)

One 34.5 kV feeder will be required at the Sunyani BSP Substation to feed the new 34.5 kV sub-transmission line heading for the Kotokrom Primary Substation. Because of the absence of a drawing showing the bus structure for the existing some 20 year old 34.5 kV distribution board as in the case of the Tamale BSP Substation, it will be impossible to conduct the work to connect the bus of the existing 34.5 kV distribution board and the bus of the new 34.5 kV distribution boards. Because the existing 34.5 kV distribution board installed in the power room of the Tamale BSP Substation does not have an unused reserve feeder, a new 34.5 kV distribution board will be installed next to the existing board. Due to the difficulty to connect the buses of these two distribution boards, a cable link will be established between the existing 34.5 kV distribution board (Berekum feeder) and the bus of the new 34.5 kV distribution board. This new 34.5 kV distribution board will be equipped with a Kotokrom Primary Substation feeder and a Berekum feeder. The connection of the bus between the two distribution boards will use cable of which the bus current is equivalent to 800 A (36 kV, copper conductor, XLPE insulation single core 240 mm^2 with PVS jacket; two conductors per phase).

Each distribution feeder of the new 34.5 kV distribution board will be equipped with an automatic reclosing relay so that a circuit breaker is automatically restored at the time of a minor grounding incident to improve the power supply reliability. This new 34.5 kV distribution board will be the compact gas insulation type as the existing power room of the Sunyani BSP substation does not have sufficient space for the additional installation of a conventional type distribution board. The power to operate the new 34.5 kV distribution board will be provided from the existing power board (AC 3-phase 4-wire 415/240 V, DC 125 V).

③ Construction of 11.5 kV Distribution Lines (between the connecting points to the existing 11.5 kV distribution lines and the Kotokrom Primary Substation)

a) Construction of 11.5 kV Distribution Lines

New 11.5 kV distribution lines will be constructed for the following three sections from the Kotokrom Primary Substation to each of the existing three 11.5 kV feeders.

- Kotokrom Primary Substation to the Hospital feeder:
  overhead line of some 4,300 m long; underground line of some 30 m long
- Kotokrom Primary Substation to the New Dormaa feeder:
  overhead line of some 600 m long; underground line of some 400 m long
- Kotokrom Primary Substation to the Chiraa feeder:
  overhead line of some 700 m long; underground line of some 30 m long

In view of preventing damage due to open burning and preserving the urban landscape, steel electric poles will be used for these distribution lines. The height of these poles will be 15 m above ground as the new distribution line will run above the existing 11.5 kV distribution line. The standard span will be 90 m. For overhead sections, a VRA standard AAAC 120 mm^2 cable will be used. Meanwhile, a VRA standard sheathed cable with aluminium conductor XLPE insulation 185 mm^2 single core aluminium strand armoured will be used for underground sections. The underground cable will be buried some 1.2 m below the ground surface.

b) Installation of New Distribution Board (Ring Main Unit)

A new outdoor distribution board (ring main unit) will be installed on the Sunyani Regional Hospital premises to branch out distribution to (i) the existing 11.5 kV distribution line (Feeder No. 27F8B) from the Sunyani BSP Substation to the Sunyani Regional Hospital, (ii) an 11.5 kV distribution line (Feeder No. KTF1B) from the Kotokrom Primary Substation and (iii) the existing RMU in the power room on the said hospital premises. Power supply to the Sunyani Regional Hospital will normally be provided from the Kotokrom Primary Substation. The Sunyani BSP Substation will act as a standby substation and these two substations will not be simultaneously operated as far as power supply to the hospital is concerned.

2) Outline Specifications of the Main Equipment

Table 2-2-2.20 Outline Specifications of the Main Equipment
for the Kotokrom Primary Substation

No.	Item	Specifications	Qty.
1	34.5/11.5 Transformer		1 set
	1) Type	Outdoor oil-immersed type with on-load tap changer	
	2) Rated voltage of primary side	34.5 kV	
	3) Rated voltage of secondary side	11.5 kV	
	4) Rated capacity	7.5 MVA	
	5) Cooling method	ONAN	
	6) Number of phases	3	
	7) Frequency	50 Hz	
	8) Tap voltage	34.5 kV ± 10%	
	9) Number of taps	17 taps	
	10) Step voltage	1.25%	
	11) Windings connection and vector symbol	Primary side: delta Secondary side: star (neutral lead out) Dyn11	
	12) % Impedance	approx. 6%	
	13) Cable cover	Elephant type cable duct with base plate	
2	34.5 kV Switchgear Cubicle		
	1) Type	Indoor distribution cubicle	
	2) Component of Switchgear Cubicles		
	2.1) Incoming feeder switchgear cubicle		
	a) Number of cubicle		1 set
	b) Circuit breaker (CB)		
	- Type	VCB, drawer type	
	- Rated voltage	36 kV	
	- Rated current	630 A	
	- Rated short-time withstand current	25 kA (one second)	
	c) Earthing switch (ES)		
	- Type	Mechanical or electrical interlock with CB	
	2.2) Transformer metering cubicle		
	a) Number of cubicle		1 set
	b) Current transformer for metering		
	- Current ratio	Primary side: 150 – 75 A/ Secondary side: 5 A	
	- Accuracy class	CL: 0.2	
	- Burden	15 VA	
	c) Current transformer for protection relays		
	- Current ratio	Primary side: 150 – 75 A / Secondary side: 5 A	
	- Accuracy class	CL: 5P20	
	- Burden	15 VA	
	d) Potential Transformer		
	- Voltage ratio	Primary side: 34.5/√3kV / Secondary side: 115/√3V	
	- Accuracy class	CL: 0.2	
	- Burden	25 VA	
	e) Metering	Multimeter (V, A, W, VA, VAR, PF, Hz, WH)	
	f) Protection relays	Under-voltage relay, over-current relay, ground fault over-current relay, percentage differential relay	

No.	Item	Specifications	Qty.
3	11.5 kV Switchgear Cubicles		
	1) Type	Indoor distribution cubicle	
	2) Component of Switchgear Cubicles		
	2.1) Transformer feeder switchgear cubicle		
	a) Number of cubicle		1 set
	b) Bus bar current	800 A	
	c) Circuit breaker (CB)		
	- Type	VCB, drawer type	
	- Rated voltage	12 kV	
	- Rated current	630 A	
	- Rated short-time withstand current	12.5 kA (one second)	
	d) Earthing switch (ES)		
	- Type	Mechanical or electrical interlock with CB	
	e) Current transformer for metering		
	- Current ratio	Primary side: 200 – 100 A /Secondary side: 5 A	
	- Accuracy class	CL: 0.2	
	- Burden	15 VA	
	f) Current transformer for protection relays		
	- Current ratio	Primary side: 200 – 100 A / Secondary side: 5 A	
	- Accuracy class	CL: 5P20	
	- Burden	15 VA	
	g) Potential transformer		
	- Voltage ratio	Primary side:11.5/√3kV / Secondary side: 11.5/√3V	
	- Accuracy class	CL: 0.2	
	- Burden	50 VA	
	h) Metering	Multimeter (V, A, W, VA, VAR, PF, Hz, WH)	
	i) Protection relays	Under-voltage relay, over-voltage relay, ground fault over-current relay, automatic voltage regulating relays	
	2.2) 11.5 kV Distribution feeder cubicle		
	a) Number of cubicle		
	b) Circuit breaker (CB)		3 sets
	- Type	VCB, drawer type	
	- Rated voltage	12 kV	
	- Rated current	630 A	
	- Rated Short-time withstand current	12.5 kA (one second)	
	c) Earthing Switch		
	- Type	Mechanical or electrical interlock with CB	
	d) Current transformer for metering		
	- Current ratio	Primary side: 200 – 100 A / Secondary side: 5 A	
	- Accuracy class	CL: 0.2	
	- Burden	15 VA	
	e) Current transformer for protection relays		
	- Current ratio	Primary side: 200 – 100 A / Secondary side: 5A	
	- Accuracy class	CL: 5P20	
	- Burden	15 VA	
	f) Potential transformer		
	- Voltage ratio	Primary side:11.5/√3kV / Secondary side: 11.5/√3V	
	- Accuracy Class	CL: 0.2	
	- Burden	50 VA	
	g) Metering	Multimeter (V, A, W, VA, VAR, PF, Hz, WH)	
	h) Protection relays	Over-current relay, ground fault over-current	

No.	Item	Specifications	Qty.
		relay, automatic reclosing relay	
	2.3) Station transformer feeder switchgear cubicle		
	a) Number of boards		1 set
	b) Circuit breaker (CB)		
	- Type	VCB, drawer type	
	- Rated voltage	12 kV	
	- Rated current	630 A	
	- Rated Short-time withstand current	12.5 kA (one second)	
	c) Earthing switch (ES)		
	- Type	Mechanical or electrical interlock with CB	
	d) Current transformer for metering		
	- Current ratio		
	- Accuracy class	Primary side: 10 A / Secondary side: 5 A	
	- Burden	CL: 1.0	
	e) Current transformer for protection relays	15 VA	
	- Current ratio		
	- Accuracy class	Primary side: 10 A / Secondary side: 5 A	
	- Burden	CL: 5P10	
	f) Instruments	15 VA	
	g) Protection relays	Multimeter (V, A, W, VA, VAR, PF, Hz, WH)	
		Over-current relay, ground fault over-current relay	
4	Station transformer (STR)		1 set
	1) Type	Outdoor oil-immersed	
	2) Rated voltage of primary side and tap	11.5 kV ± 2.5%, ±5% taps (non-voltage tap change)	
	3) Rated voltage of secondary side	433 – 250 V	
	4) Rated capacity	100 kVA	
	5) Number of phases	3	
	6) Frequency	50 Hz	
	7) Winding connection and vector symbol	Primary side: delta Secondary side: star (drawn from the neutral point) Dyn11	
	8) % Impedance	approx. 5%	
	9) Current transformer for protection relays		
	- Current ratio	Primary side: 100 – 50 A / Secondary side: 5 A	
	- Accuracy class	CL: 10P10	
	- Burden	25 VA	
	10) Cable cover	Elephant type cable duct with baseplate	
5	LV Service panel		
	1) Number of panel		1 set
	2) Type	Indoor self-contained	
	3) Rated voltage (number of phases and wires)	AC 415/240 V (3-phase 4-wire)	
	4) Circuit breaker type	Earth leakage circuit breaker (ELCB), 4 poles, 225 AF/150 AT	
	5) Current transformer for metering		
	- Current ratio	Primary side: 200 A / Secondary side: 5 A	
	- Class	CL: 1.0	
	- Burden	25 VA	
	6) Metering	Ammeter (with changing-over switch)	
	7) Protection relay	Ground fault over-current relay	
6	DC service panel and battery charger		
	1) Number of panel		1 set
	2) Type	Indoor self-contained	

No.	Item	Specifications	Qty.
	3) Rated voltage 4) Circuit breaker type 5) Battery charger	DC 125 V Mold case circuit breaker (MCCB) With float charging functions	
7	Battery 1) Type 2) Rated voltage (voltage per cell) 3) Number of battery cells 4) Discharge duration (duration of commercial power outage) 5) Battery capacity	 Lead acid sealed type 125 V (2 V/cell) 63 cells 12 hours 150 Ah/10 hrs (the battery capacity shall be secured of an outage duration of 12 hours into consideration)	1 set
8	34.5 kV Disconnecting switch pole 1) Quantity 2) Type 3) Pole mounting equipment - Arrester - Circuit breaker	 Steel pole (x 2), arrester, circuit breaker 36 kV, 10 kA, zinc oxide gapless type 36 kV, 630 A, 25 kA (one second)	1 set
9	11.5 kV Disconnecting switch pole 1) Quantity 2) Type 3) Pole mounting equipment - Arrester - Circuit breaker	 Steel pipe (x 2), arrester, circuit breaker 12 kV, 10 kA, zinc oxide gapless type 12 kV, 630 A, 12.5 kA (one second)	3 sets
10	36 kV Cable 1) Type 2) Conductor, insulation, armour, jacket 3) Number of cores, conductor size	 Armoured cable for direct underground laying Aluminium conductor, XLPE insulation, aluminium strand-armoured power cable with ant-repellent PVC jacket Single core, 185 mm^2, single cable per phase (from the 34.5 kV disconnecting switch pole to the 34.5 kV distribution board; from the 34.5 kV circuit board to the 34.5 kV side of the transformer)	1 set
11	12 V Cable 1) Type 2) Conductor, insulation, armour, jacket 3) Number of cores, conductor size	 Armoured cable for direct underground laying Aluminium conductor, XLPE insulation, aluminium strand-armoured power cable with ant-repellent PVC jacket ・ Single core, 185 mm^2, 3 cables per phase (from the 11.5 kV side of the transformer to the 11.5 kV distribution board) ・ Single core, 185 mm^2, single cable per phase (from the 11.5 kV distribution board to the 11.5 kV disconnecting switch pole) ・ Single core, 185 mm^2, single cable per phase (from the 11.5 kV distribution board to the 11.5 kV side of the station transformer)	1 set

Table 2-2-2.21 Outline Specifications of the Main Equipment for the 34.5 kV Sub-Transmission Line (from the Sunyani BSP Substation to the Kotokrom Primary Substation)

No.	Item	Specifications	Qty.
1	34.5 kV Sub-transmission line		1 set
	1) Electric pole types		
	a) 3A (intermediate pole)	0°~ 5°	
	b) 3B (light angle pole)	5° ~ 20°	
	c) 3C (medium angle pole)	20° ~ 60°	
	d) 3D (heavy angle pole)	60° ~ 90°	
	e) 3E (cross pole)	90°	
	f) 3F (section pole)		
	g) 3K (disconnecting switch pole)		
	2) Conductor type	AAAC120 mm^2	
2	34.5 kV Switchgear Cubicles in Sunyani BSP Substation		1 set
	1) Type	Indoor SF6 gas-insulation	
	2) Number of boards	・ One for connection with the existing distribution board (Berekum feeder) ・ One for the distribution feeder (Berekum feeder) ・ One for the distribution feeder (Kotokrom feeder)	3 sets
	3) Bus bar current	800 A	
	4) Circuit breaker	36 kV, 800 A, 25 kA (one second)	
	5) Instruments	Multimeter (V, A, W, VA, VAR, PF, Hz, WH)	
	6) Protection relays	Over-current relay, ground fault over-current relay, automatic reclosing relay	
	7) Power source for AC control	To be supplied from the existing low voltage panel (AC 3-phase 4-wire, 415/240 V)	
	8) Power source for DC control	To be supplied from the existing DC panel (DC 125 V)	
	9) Number of cable terminals	3 feeders ・ One for connection to the existing distribution board (new cable: 36 kV, XLPE insulation, copper conductor, single core, 240 mm^2, 2 cables per phase, ant-repellent PVC jacket) ・ One for connection to the Berekum feeder (existing cable: 34.5 kV, XLPE insulation, aluminium conductor, single core, 185 mm^2, one cable per phase, aluminium strand armour, PVC jacket) ・ One for the Kotokrom feeder (new cable: 34.5 kV, XLPE insulation, aluminium conductor, single core, 185 mm^2, one cable per phase, aluminium strand armour, PVC jacket)	
3	36 kV Cable		1 set
	1) Specifications	・ For connection to the existing distribution board (new cable: 36 kV, XLPE insulation, copper conductor, single core, 240 mm^2, 2 cables per phase, ant-repellent PVC jacket) ・ For the UDS feeder (new cable: 36 kV, XLPE insulation, aluminium conductor, single core, 185 mm^2, one cable per phase, aluminium strand armour, ant-repellent PVC jacket)	

Table 2-2-2.22 Outline Specifications of the Main Equipment for the 11.5 kV Distribution Lines
(11.5 kV distribution lines from the Kotokrom Primary Substation)

No.	Item	Specifications	Qty.
1	11.5 kV Distribution line 1) Electric pole types a) 1A (intermediate pole) b) 1B (light angle pole) c) 1C (medium angle pole) d) 1D (heavy angle pole) e) 1E (cross pole) f) 1F (section pole) g) 1K (disconnecting switch pole) 2) Conductor type	 0°~ 5° 5° ~ 20° 20° ~ 60° 60° ~ 90° 90° AAAC 120 mm^2	1 set
2	11.5kV (Ring Main Unit) 1) Type 2) Number of feeders 3) Rated voltage 4) Rated current 5) Short-time withstand current 6) Number of cable terminals	 Outdoor SF6 gas-insulation Power receiving: 2 feeders (with a grounding device) Power distribution: 1 feeder (with a grounding device) 12 kV 630 A 12.5 kA (one second) 3 feeders (12 kV, XLPE insulation, aluminium conductor, 3 cores, 185 mm^2, aluminium strand armour, PVC jacket)	1 set
3	12 kV Cable 1) Type 2) Conductor, insulation, armour, jacket 3) Number of cores, conductor size	 Armoured cable for direct underground laying Aluminium conductor, XLPE insulation, aluminium strand armour, ant-repellent PVC jacket ・ 3 cores, 185 mm^2 (from the new 11.5 kV disconnecting switch pole (Hospital feeder) to the RMU) ・ Single core, 185 mm^2 (from the new 11.5 kV disconnecting switch pole (for the Chiraa feeder) to the existing dual-line terminal pole) ・ Single core, 185 mm^2 (from the new 11.5 kV disconnecting switch pole (for the New Dormaa feeder) to the existing dual-line terminal pole)	1 set

2-2-3 Outline Design Drawings

The following outline design drawings have been prepared for the Project.

(1) Improvement of Tamale Distribution System in Northern Region

Drawing No.	Drawing Title
Fig. 2-2-3.1	Tamale 34.5/11.5 kV Network Diagram
Fig. 2-2-3.2	Single Line Diagram of UDS Primary Substation
Fig. 2-2-3.3	Single Line Diagram of Tamale BSP Substation
Fig. 2-2-3.4	Layout of UDS Primary Substation
Fig. 2-2-3.5	Elevational Plan of UDS Primary Substation
Fig. 2-2-3.6	Sectional Plan of UDS Primary Substation
Fig. 2-2-3.7	Layout of Tamale BSP Control Room
Fig. 2-2-3.8	Cable Route of Tamale BSP
Fig. 2-2-3.9	Route Map of Tamale Distribution System

(2) Improvement of Sunyani Distribution System in Brong-Ahafo Region

Drawing No.	Drawing Title
Fig. 2-2-3.10	Sunyani 34.5/11.5 kV Network Diagram
Fig. 2-2-3.11	Single Line Diagram of Kotokrom Primary Substation
Fig. 2-2-3.12	Single Line Diagram of Sunyani BSP Substation
Fig. 2-2-3.13	Layout of Kotokrom Primary Substation
Fig. 2-2-3.14	Elevational Plan of Kotokrom Primary Substation
Fig. 2-2-3.15	Sectional Plan of Kotokrom Primary Substation
Fig. 2-2-3.16	Layout of Sunyani BSP Control Room
Fig. 2-2-3.17	Cable Route of Sunyani BSP
Fig. 2-2-3.18	Layout of Ring Main Unit
Fig. 2-2-3.19	Route Map of Sunyani Distribution System

(3) Pole Assembling Drawings for Distribution Line

Drawing No.	Drawing Title
Fig. 2-2-3.20	34.5/11.5 kV Intermediate Pole (0 – 5 deg.)
Fig. 2-2-3.21	34.5/11.5 kV Light Angle Pole (5 – 20 deg.)
Fig. 2-2-3.22	34.5/11.5 kV Medium Angle Pole (20 – 60 deg.)
Fig. 2-2-3.23	34.5/11.5 kV Heavy Angle Pole (60 – 90 deg.)
Fig. 2-2-3.24	34.5/11.5 kV Cross Pole (90 deg.)
Fig. 2-2-3.25	34.5/11.5 kV Section Pole
Fig. 2-2-3.26	34.5/11.5 kV T-off Pole
Fig. 2-2-3.27	34.5/11.5 kV Terminal Pole
Fig. 2-2-3.28	34.5/11.5 kV Disconnecting Switch Pole (Horizontal Type)
Fig. 2-2-3.29	34.5/11.5 kV Disconnecting Switch Pole (Vertical Dead End Type)
Fig. 2-2-3.30	34.5/11.5 kV Disconnecting Switch Pole (Vertical Section Type)

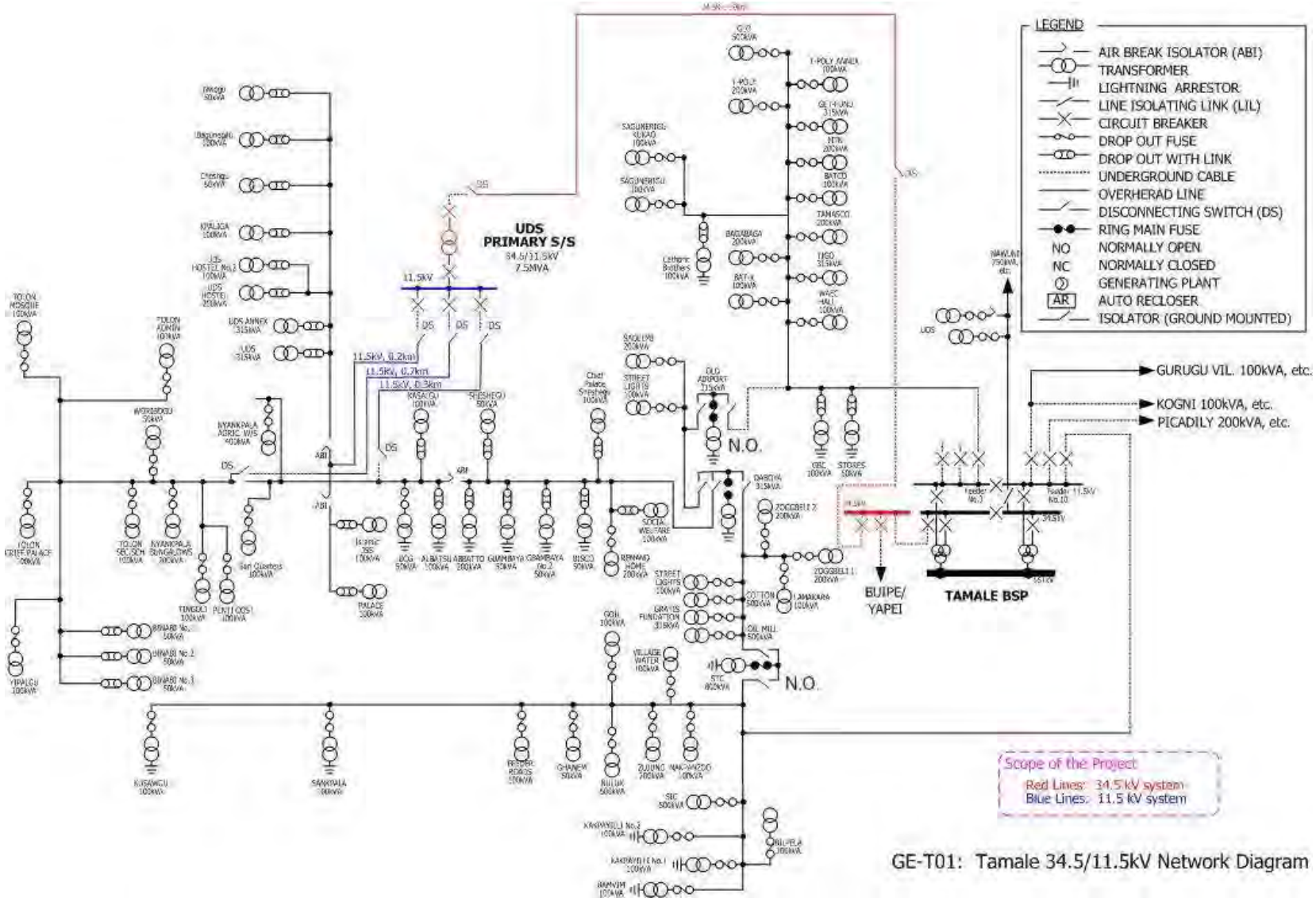


Fig. 2-2-3.1 Tamale 34.5/11.5 kV Network Diagram

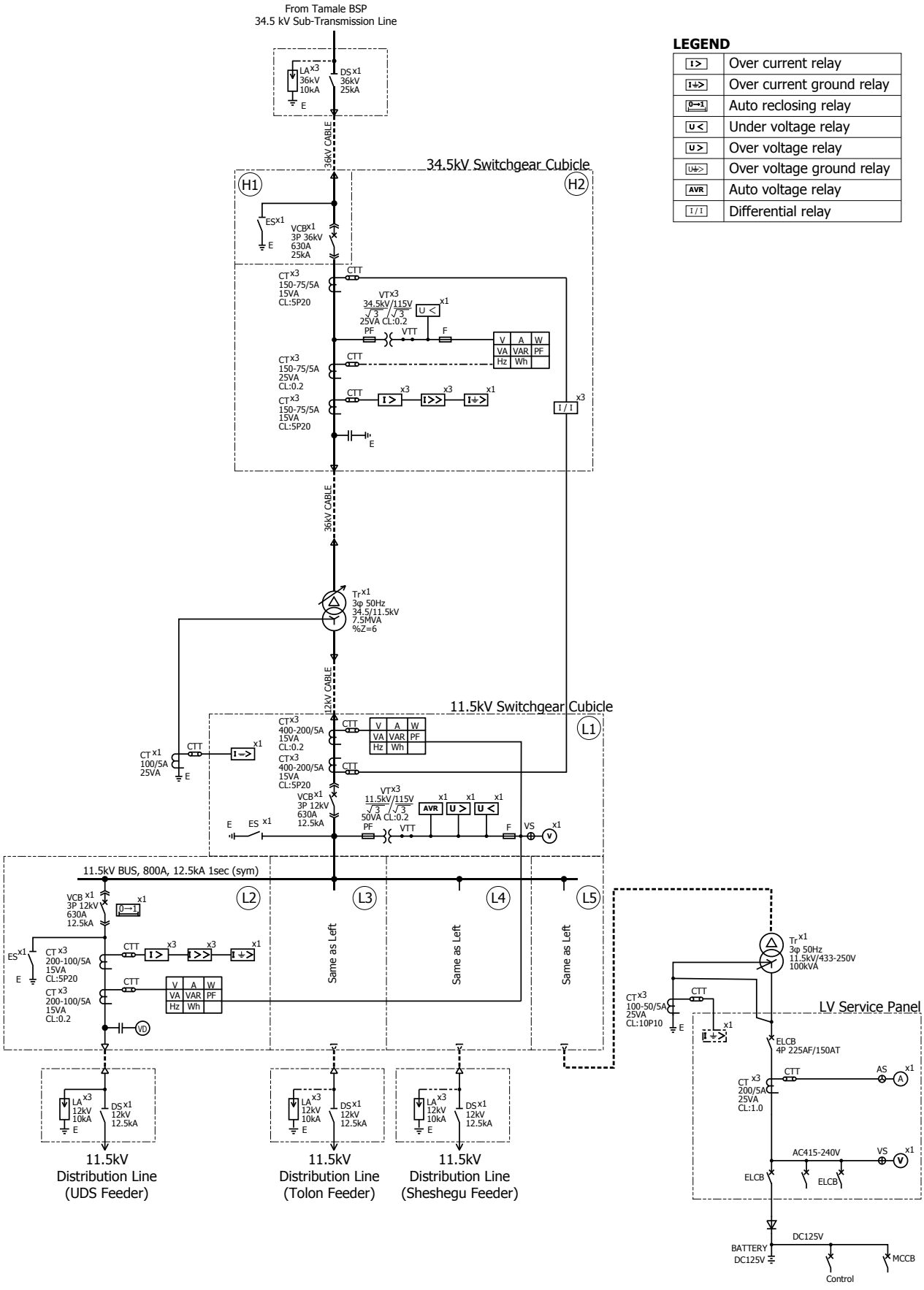


Fig. 2-2-3.2 Single Line Diagram of UDS Primary Substation

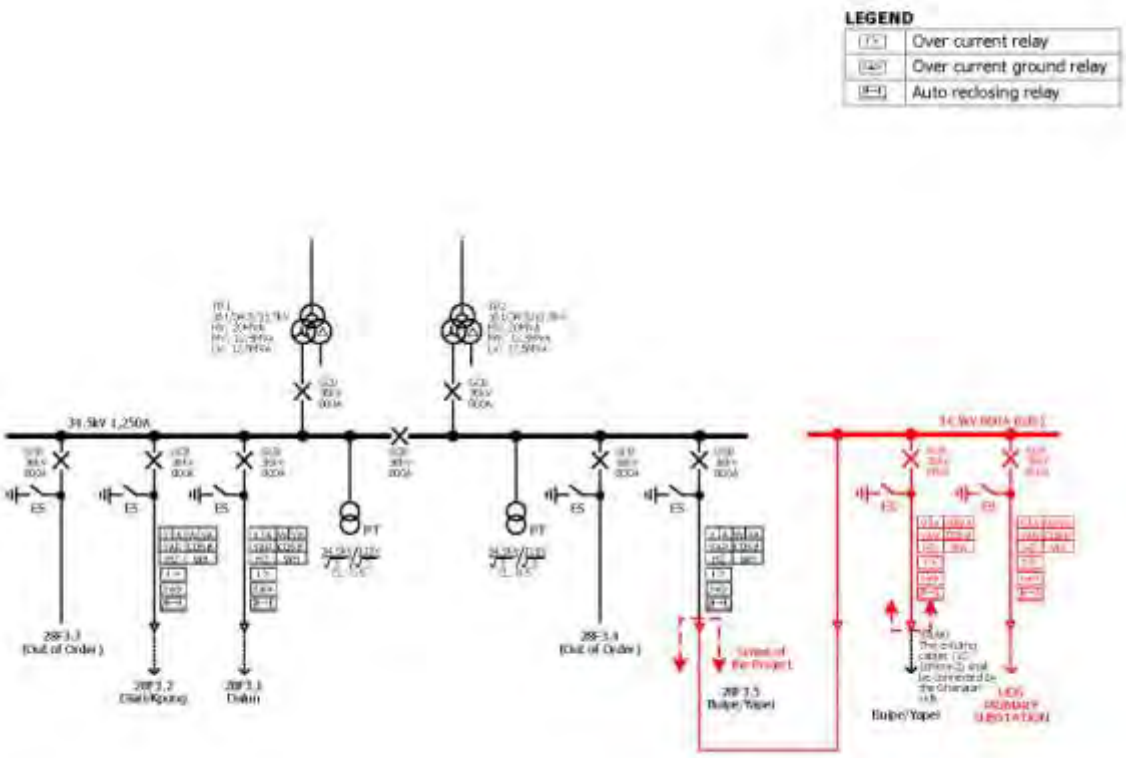


Fig. 2-2-3.3 Single Line Diagram of Tamale BSP Substation

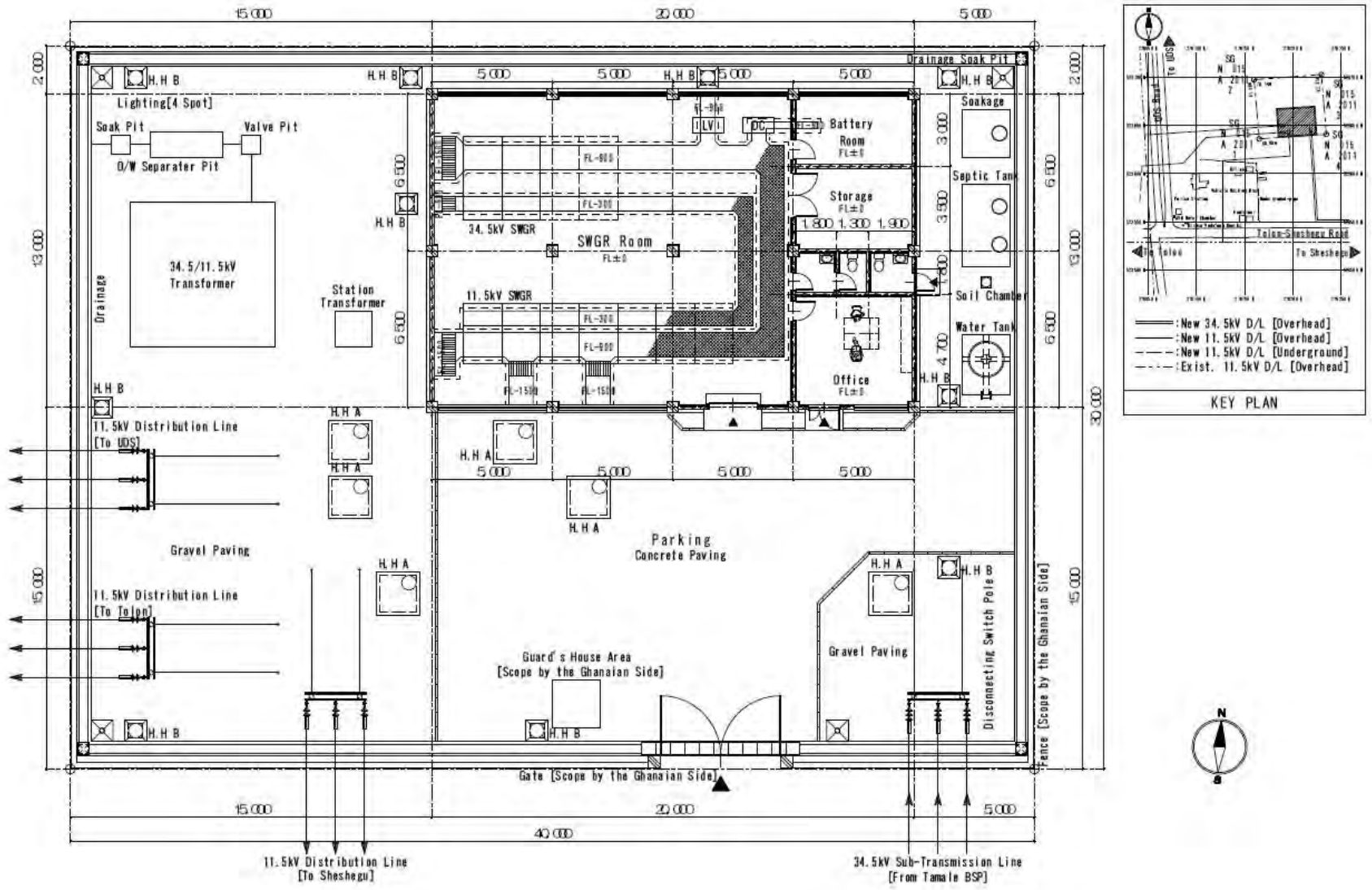


Fig. 2-2-3.4 Layout of UDS Primary Substation

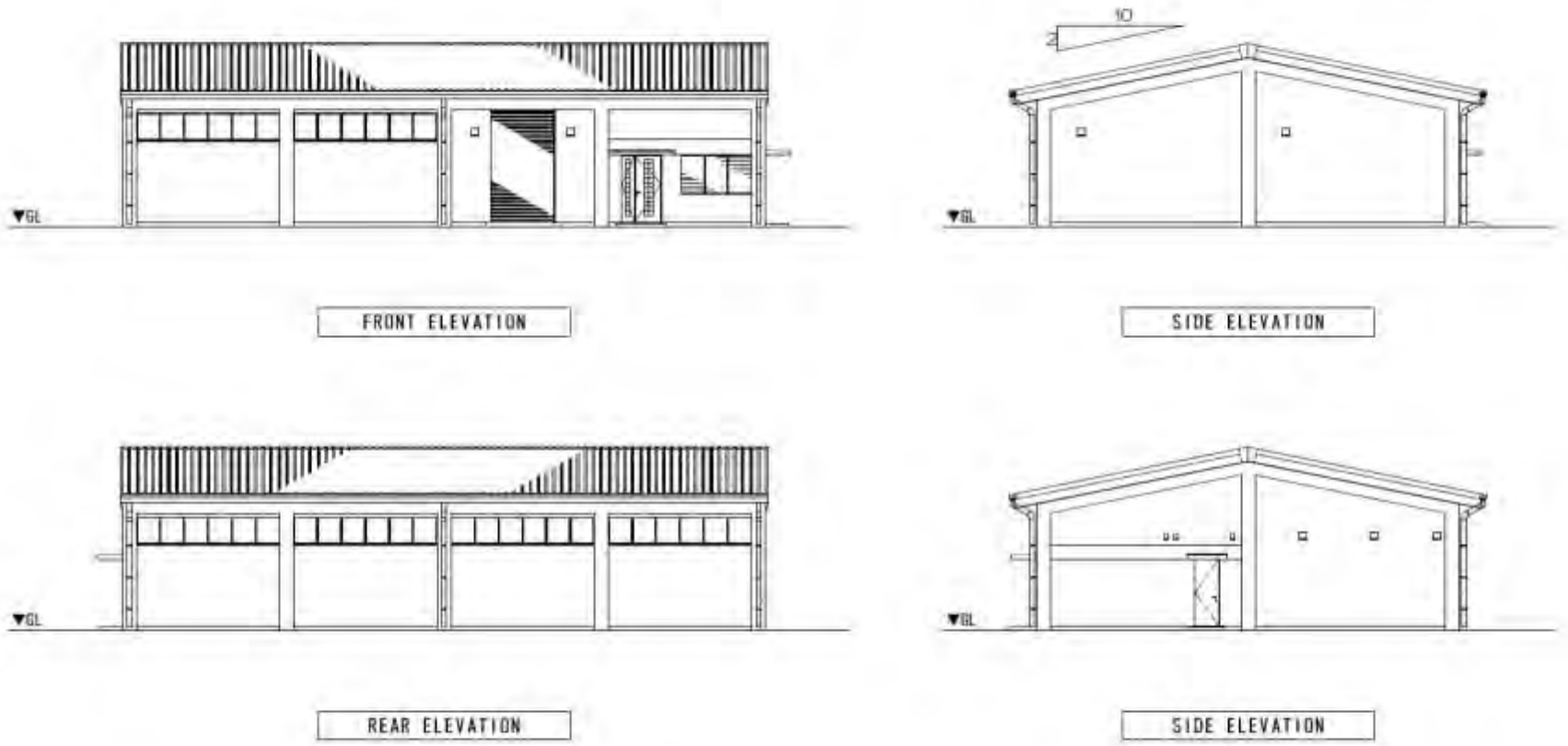


Fig. 2-2-3.5 Elevational Plan of UDS Primary Substation

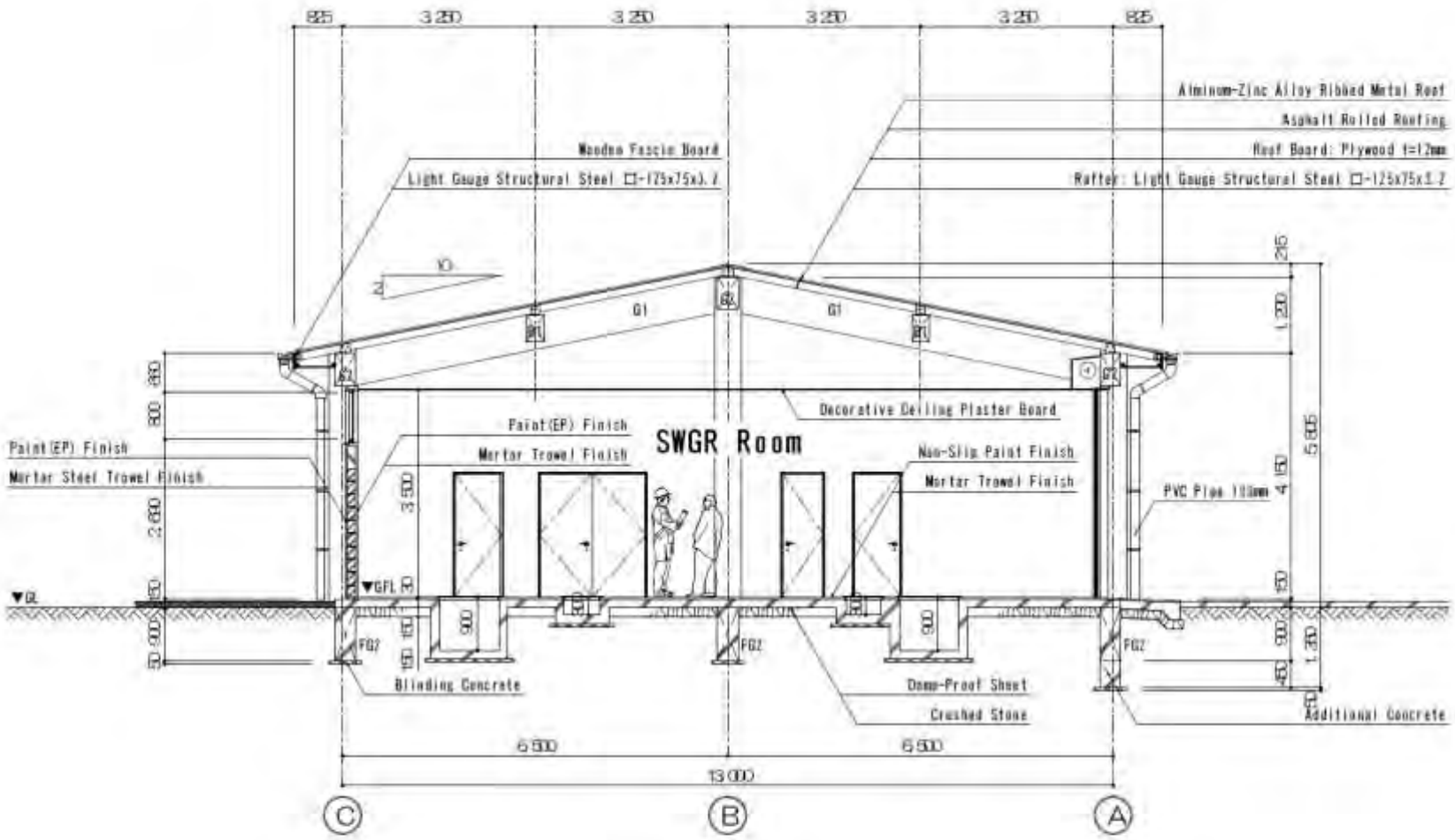


Fig. 2-2-3.6 Sectional Plan of UDS Primary Substation

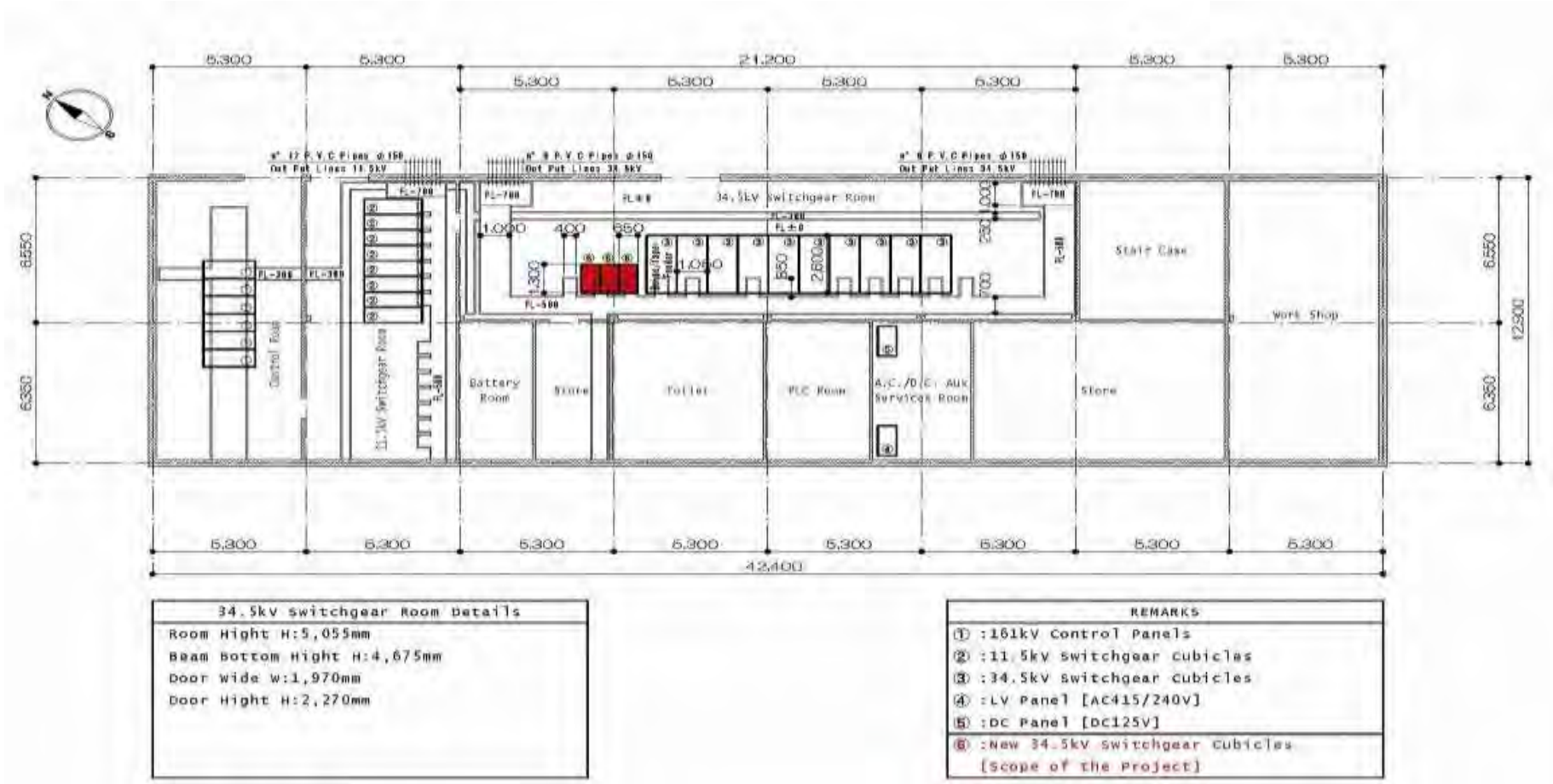


Fig. 2-2-3.7 Layout of Tamale BSP Control Room

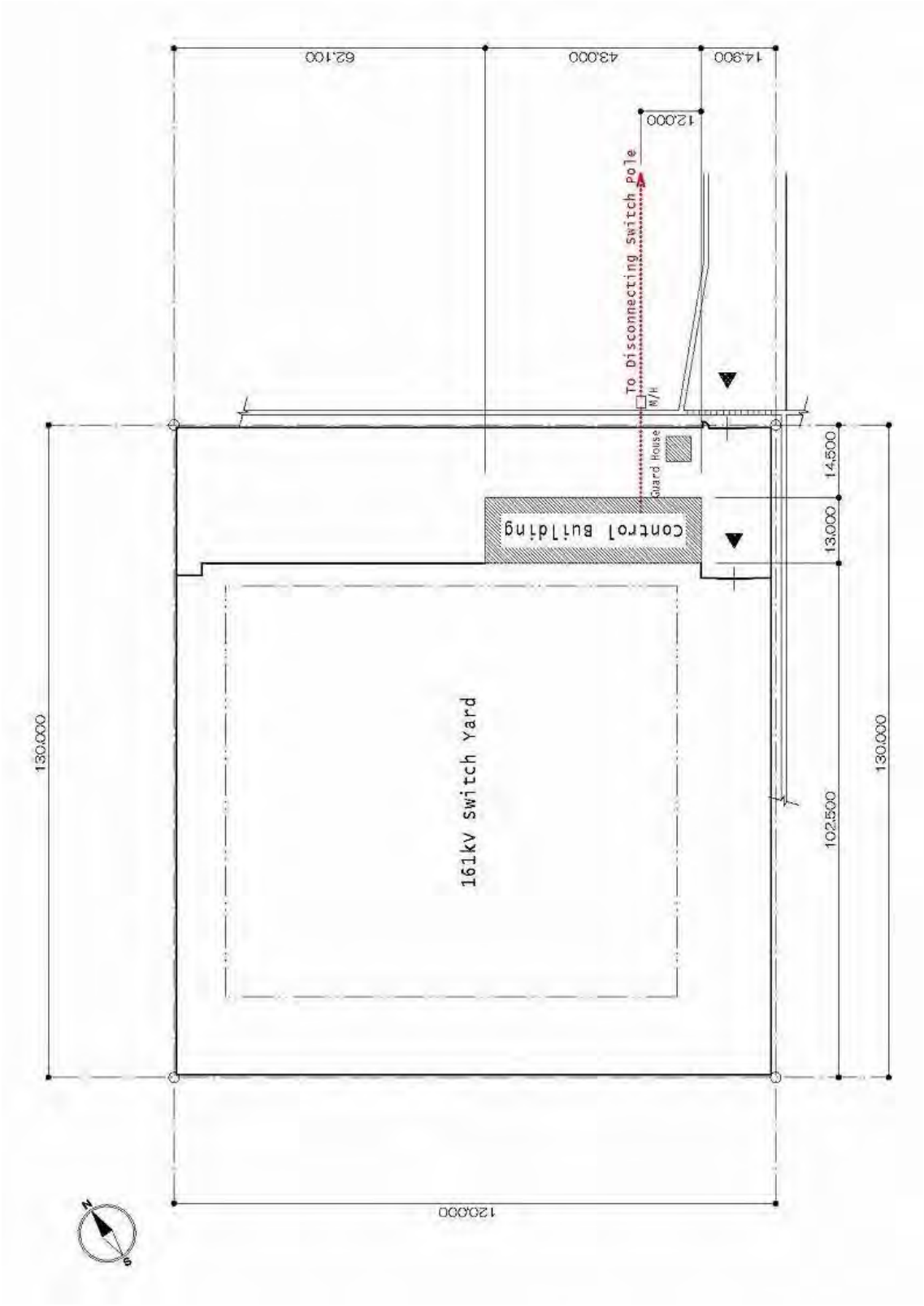


Fig. 2-2-3.8 Cable Route of Tamale BSP

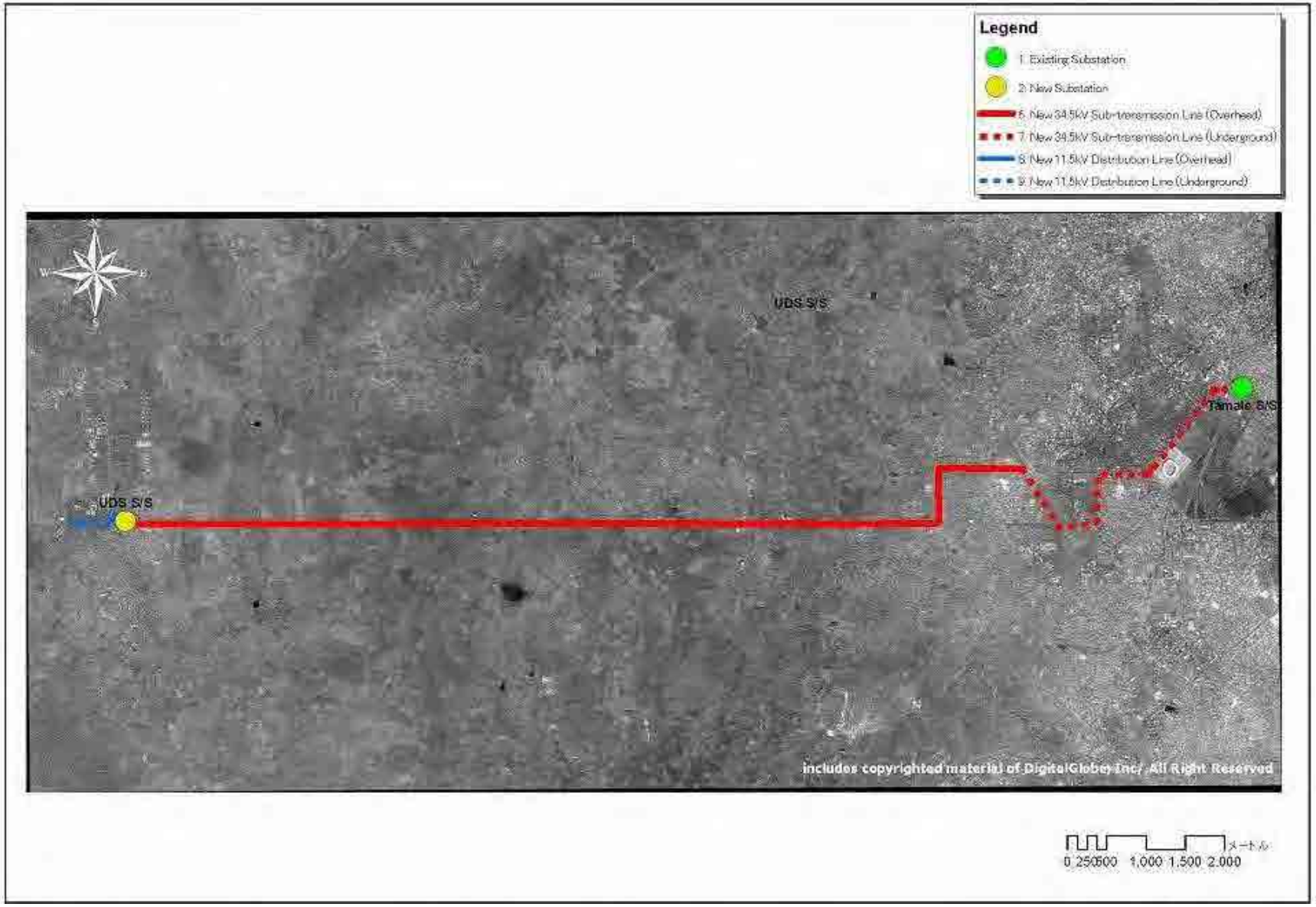


Fig. 2-2-3.9 Route Map of Tamale Distribution System

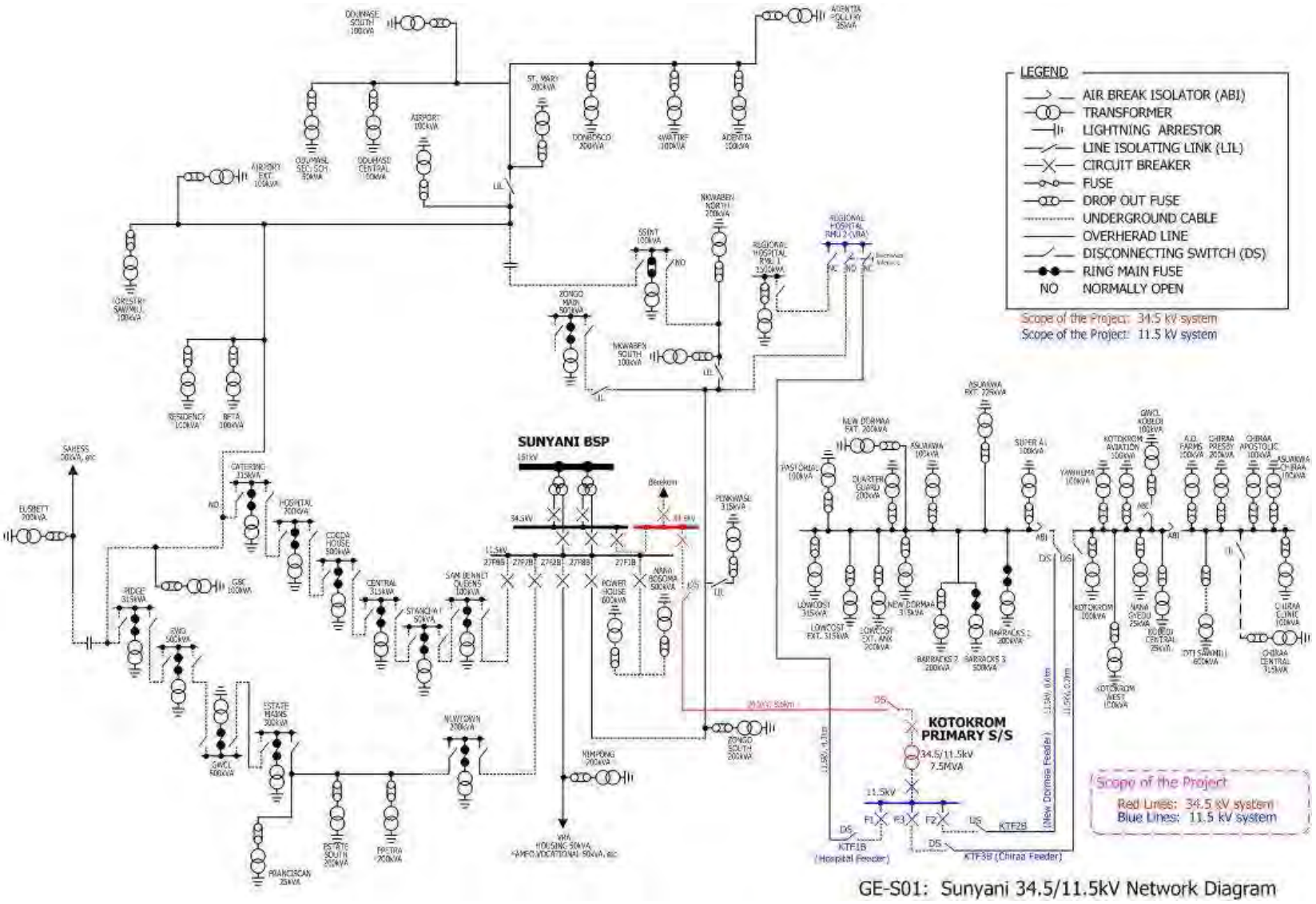


Fig. 2-2-3.10 Sunyani 34.5/11.5 kV Network Diagram

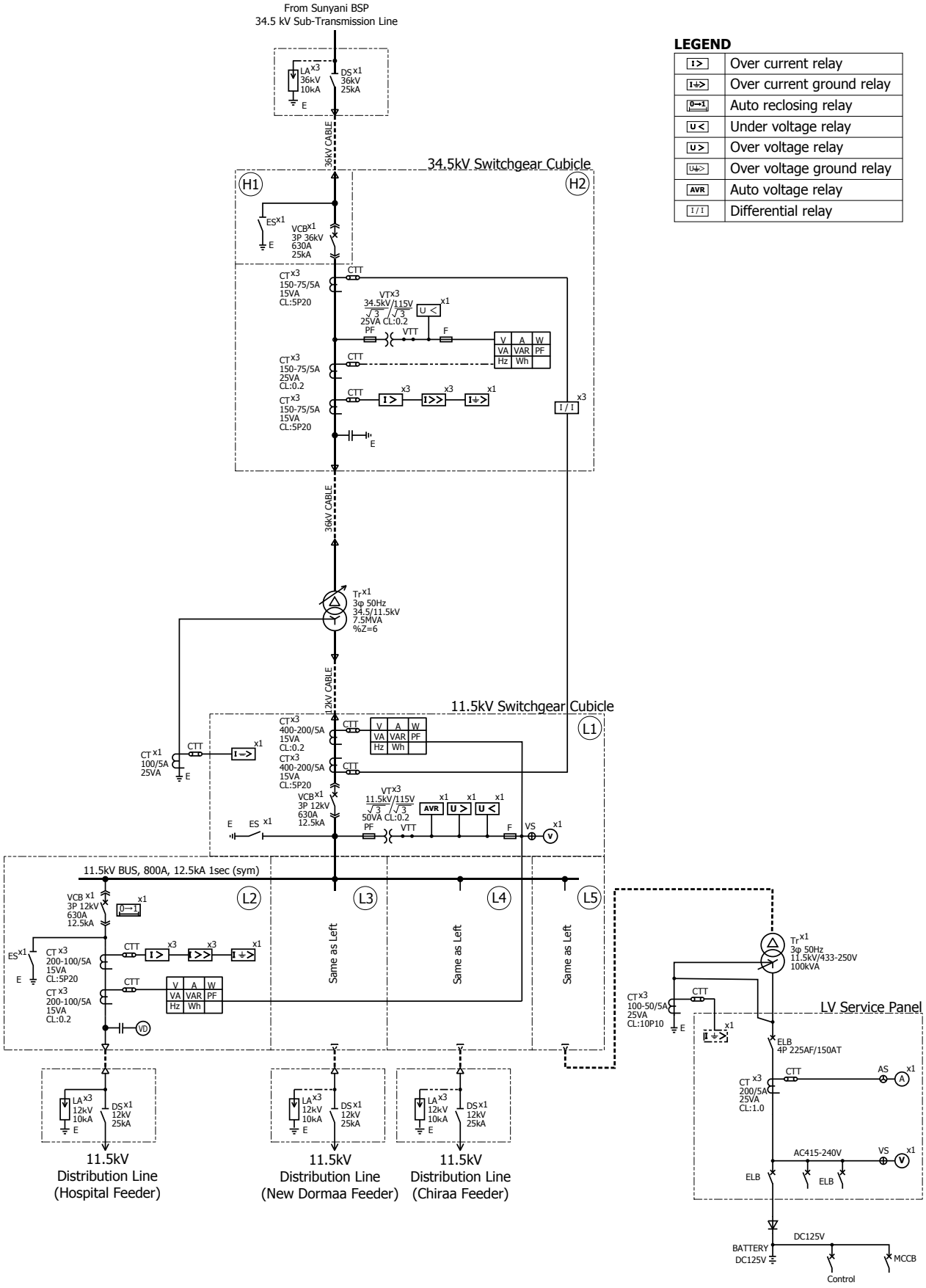


Fig. 2-2-3.11 Single Line Diagram of Kotokrom Primary Substation

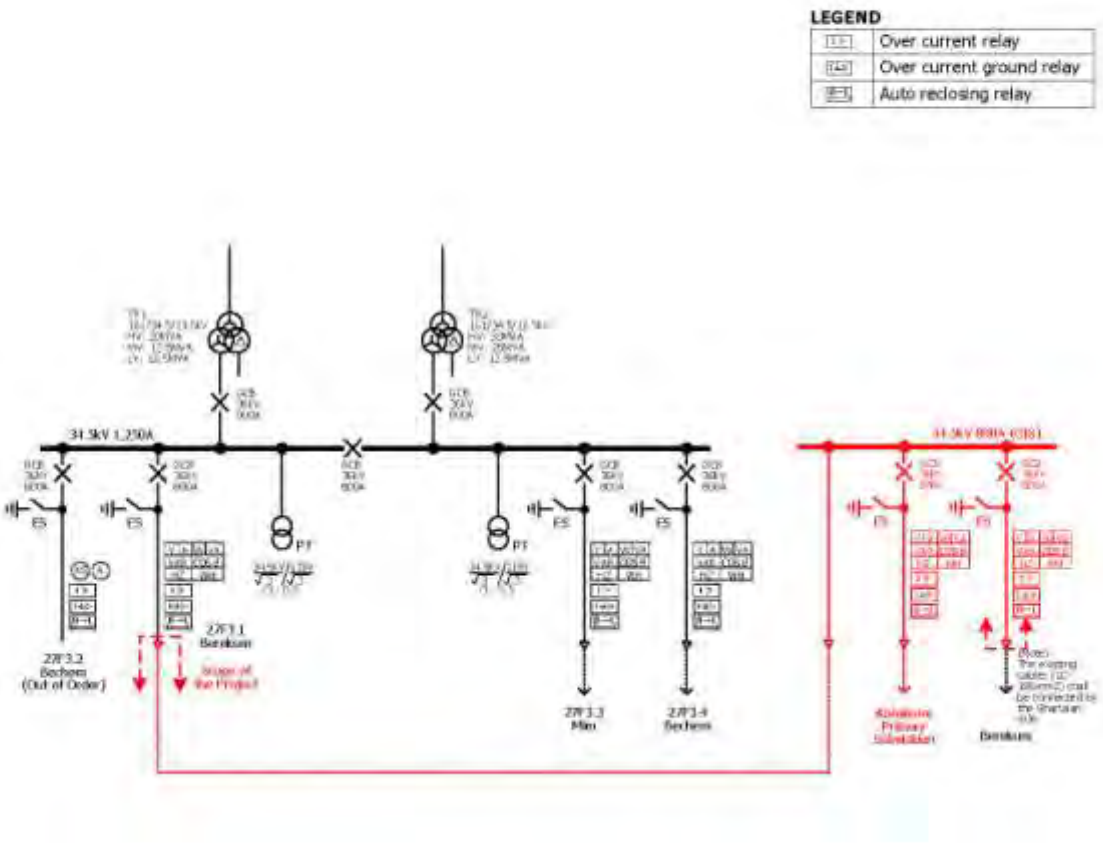


Fig. 2-2-3.12 Single Line Diagram of Sunyani BSP Substation

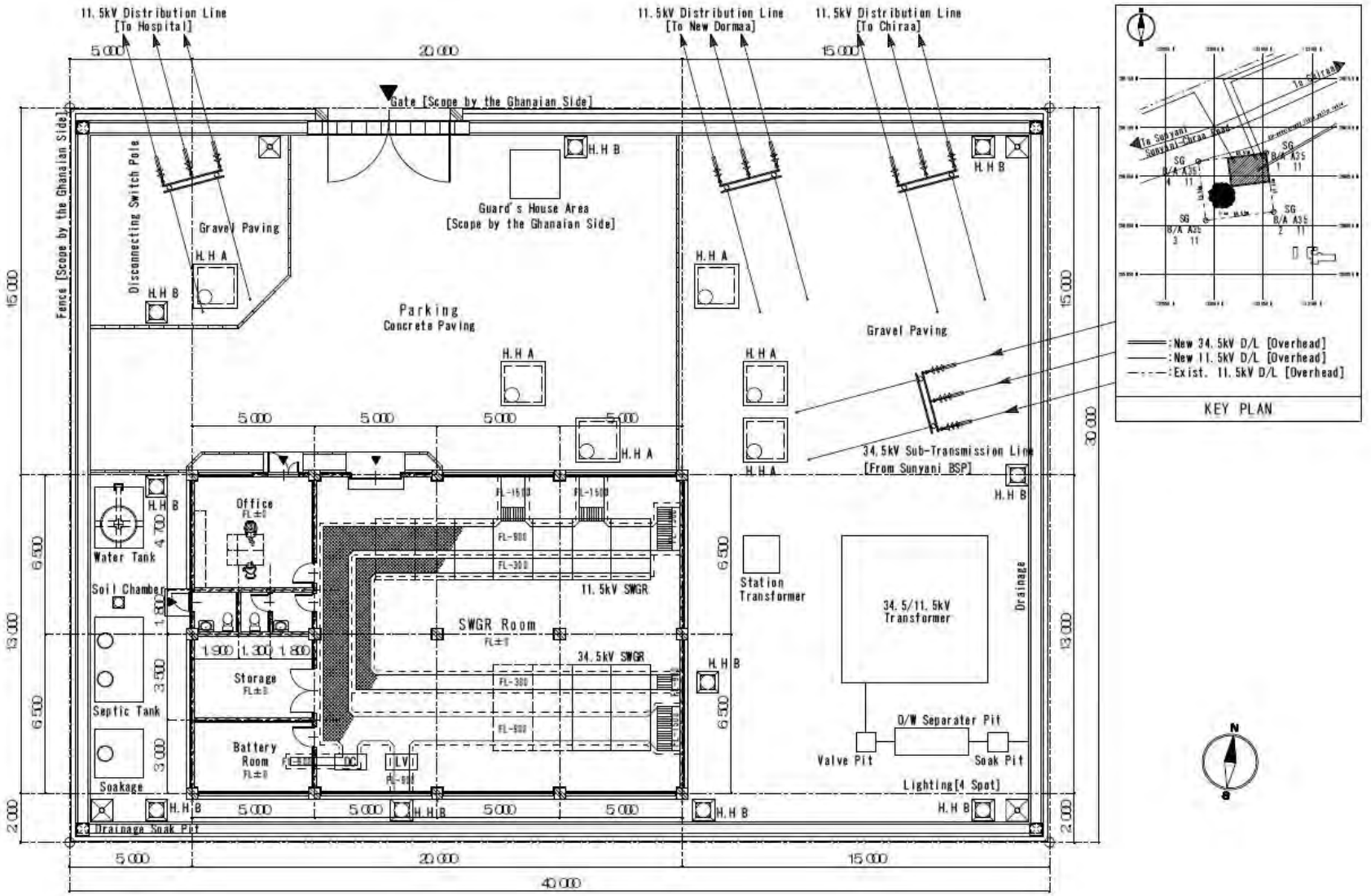


Fig. 2-2-3.13 Layout of Kotokrom Primary Substation

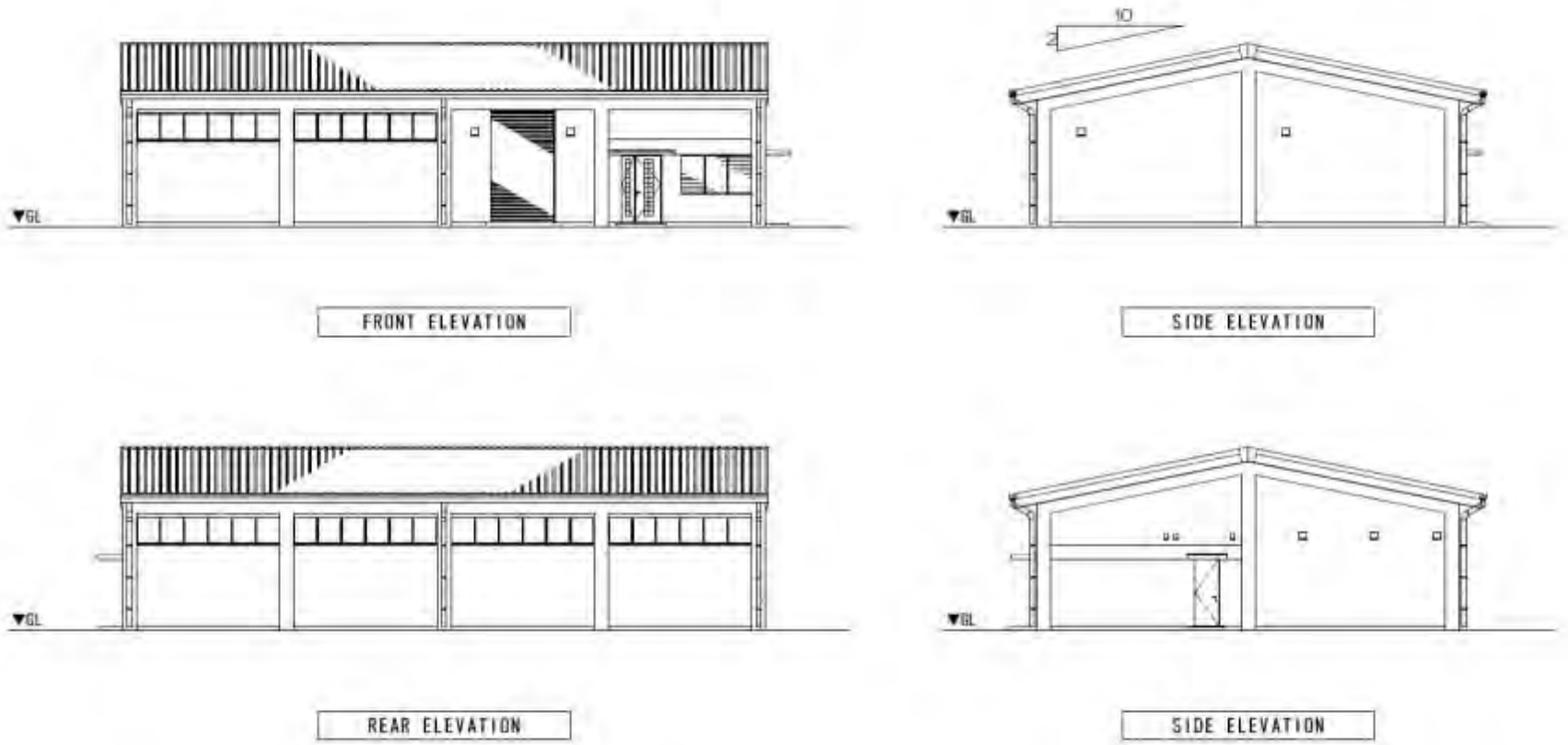


Fig. 2-2-3.14 Elevational Plan of Kotokrom Primary Substation

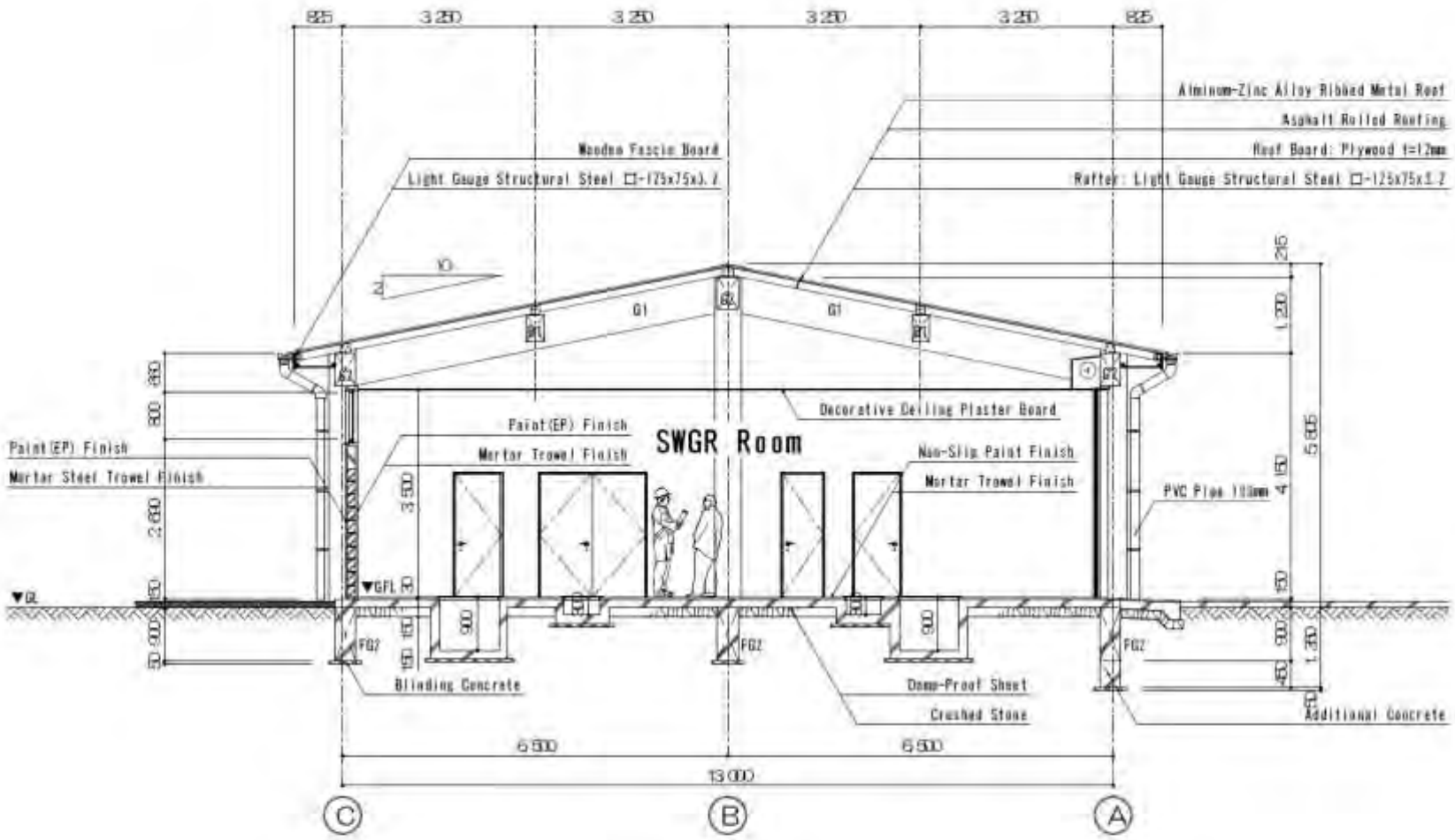


Fig. 2-2-3.15 Sectional Plan of Kotokrom Primary Substation

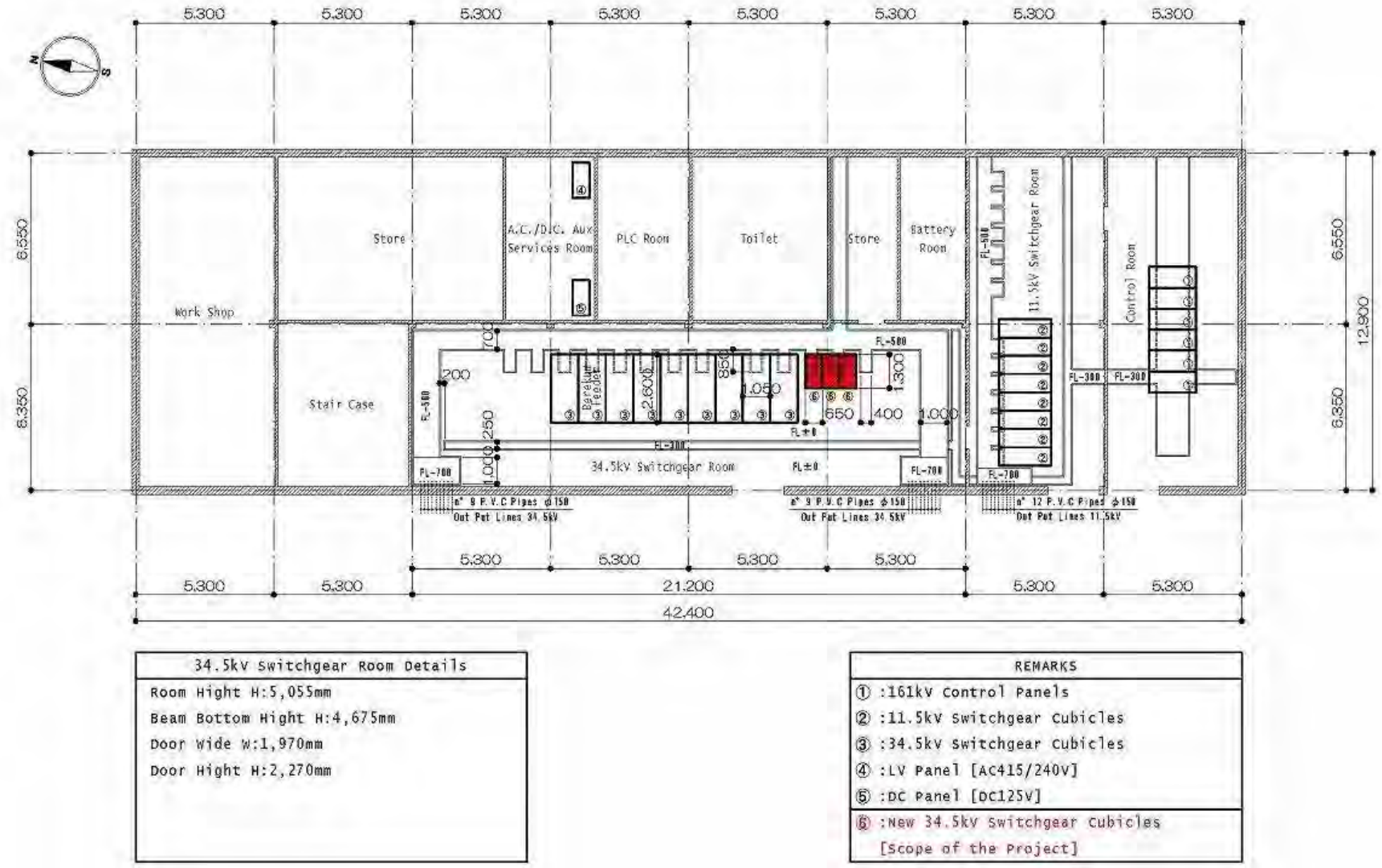


Fig. 2-2-3.16 Layout of Sunyani BSP Control Room

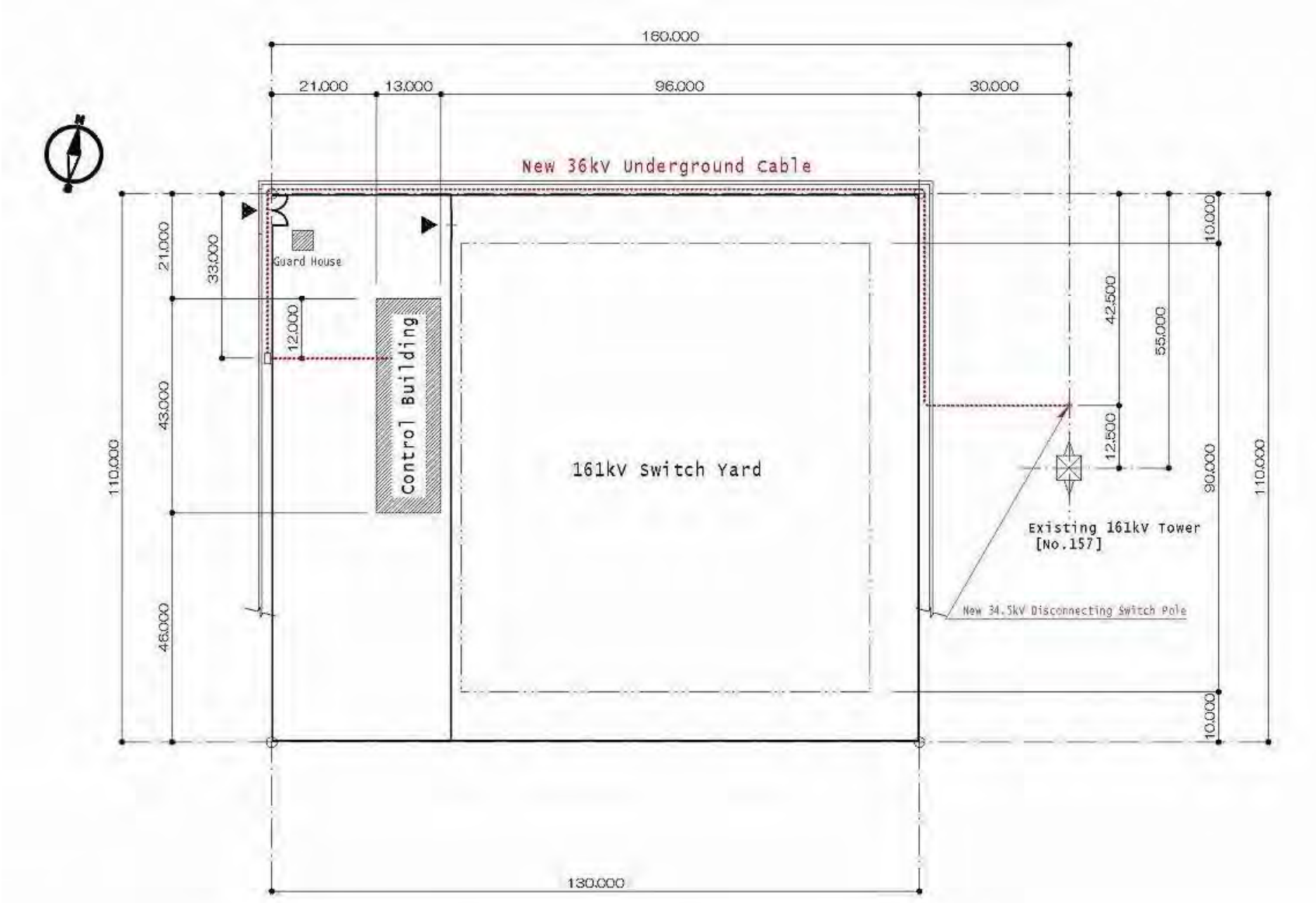


Fig. 2-2-3.17 Cable Route of Sunyani BSP

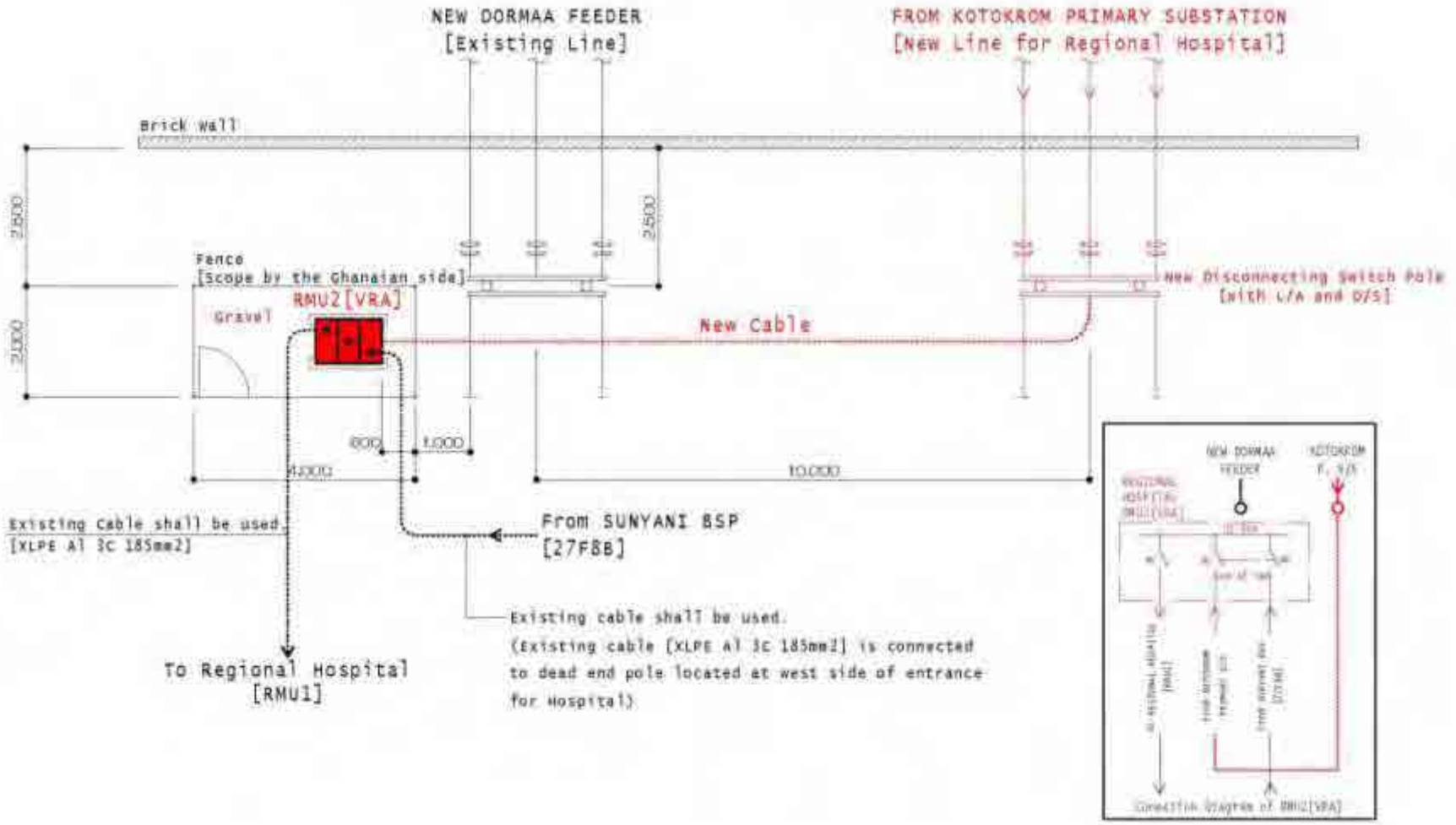


Fig. 2-2-3.18 Layout of Ring Main Unit

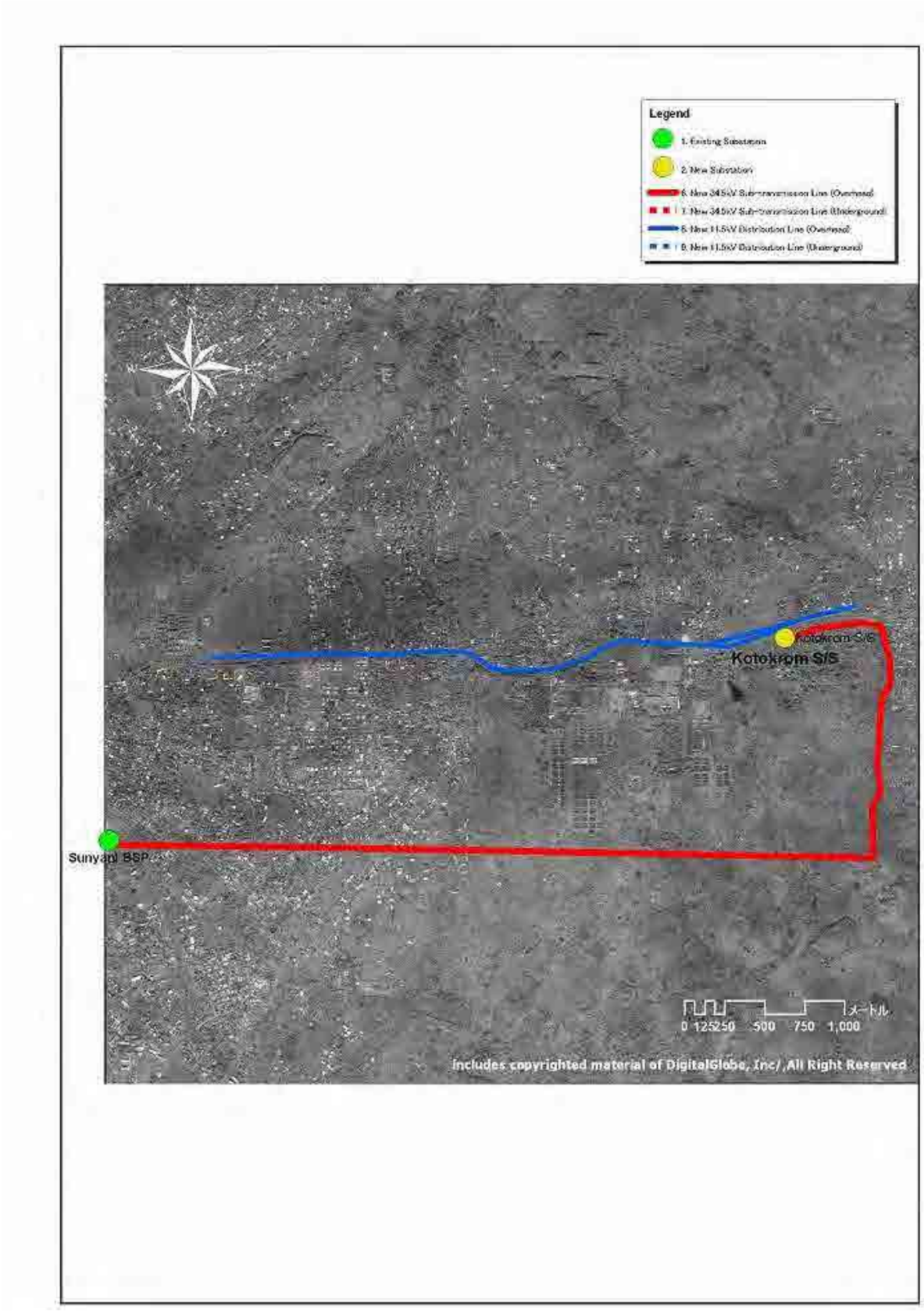
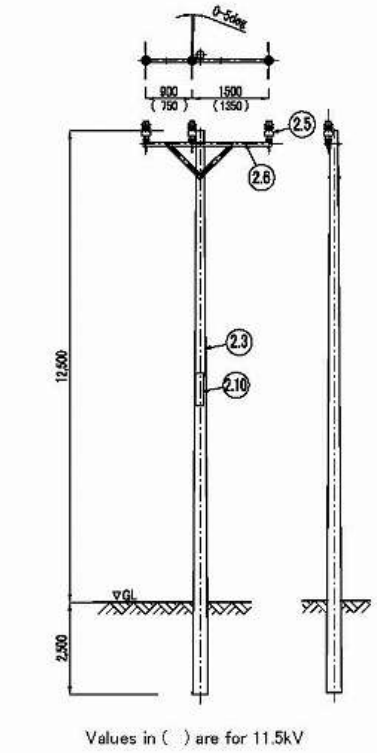


Fig. 2-2-3.19 Route Map of Sunyani Distribution System

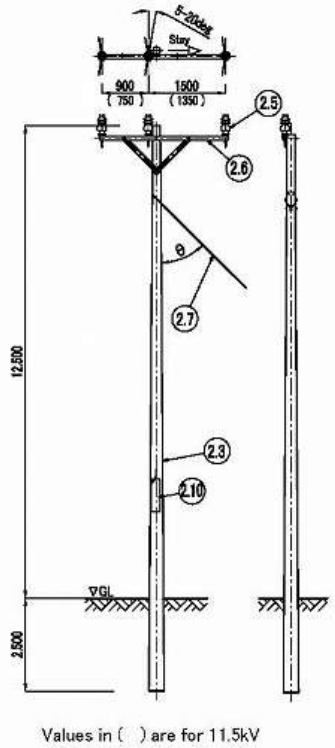


Values in ( ) are for 11.5kV

P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Load Isolator	負荷開閉器	0
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	0
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	0
2.2	Connector	コネクター	0
2.3	Steel Pole (15m)	鋼管柱 (15m)	1
2.4	Strain Insulator Set	耐張碍子セット	0
2.5	Pin Insulator set	ピン碍子セット	3
2.6	Crossarm set	腕金セット	1
2.7	Stay Wire Set	支線セット	0
2.8	Earth Wire Set	接地線セット	0
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

Remarks : Pole Type "1A" is for 11.5kV and then type 3A is for 34.5kV.

Fig. 2-2-3.20 34.5/11.5 kV Intermediate Pole (0 – 5 deg.)

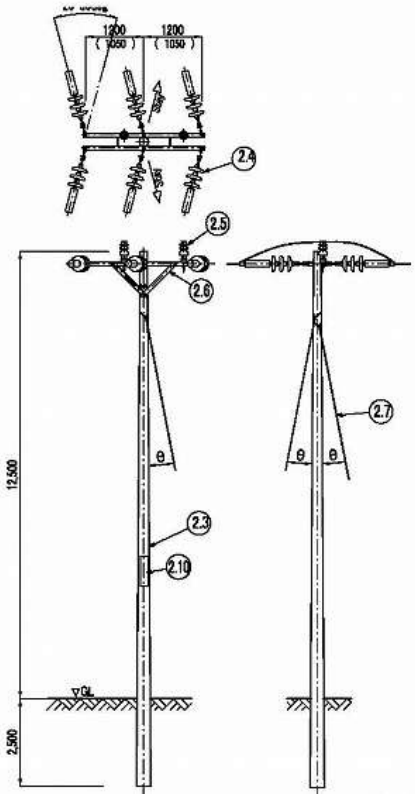


Values in ( ) are for 11.5kV

P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Load Isolator	負荷開閉器	0
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	0
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	0
2.2	Connector	コネクター	0
2.3	Steel Pole (15m)	鋼管柱 (15m)	1
2.4	Strain Insulator Set	耐張碍子セット	0
2.5	Pin Insulator set	ピン碍子セット	3
2.6	Crossarm set	腕金セット	1
2.7	Stay Wire Set	支線セット	1
2.8	Earth Wire Set	接地線セット	0
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

Preferable Stay Angle : $30° \leqq \theta \leqq 45°$

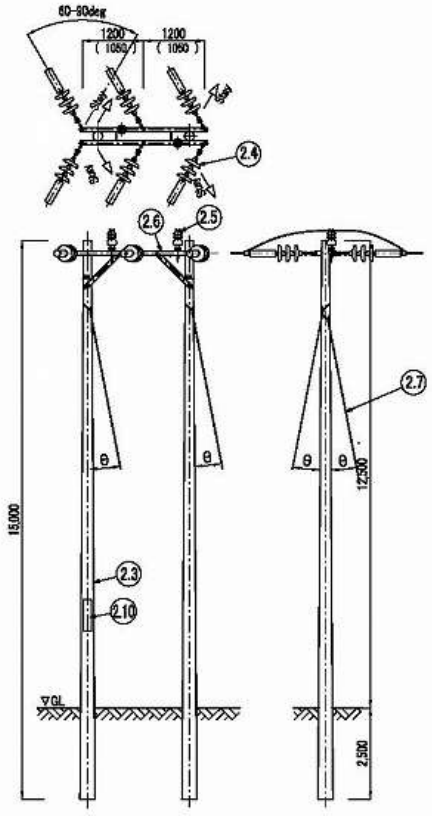
Fig. 2-2-3.21 34.5/11.5 kV Light Angle Pole (5 – 20 deg.)



P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Load Isolator	負荷開閉器	0
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	0
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	0
2.2	Connector	コネクター	0
2.3	Steel Pole (15m)	鎖管柱 (15m)	1
2.4	Strain Insulator Set	耐張碍子セット	6
2.5	Pin Insulator set	ピン碍子セット	2
2.6	Crossarm set	腕金セット	2
2.7	Stay Wire Set	支線セット	2
2.8	Earth Wire Set	接地線セット	0
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

Preferable Stay Angle : 30° ≦ θ ≦ 45°

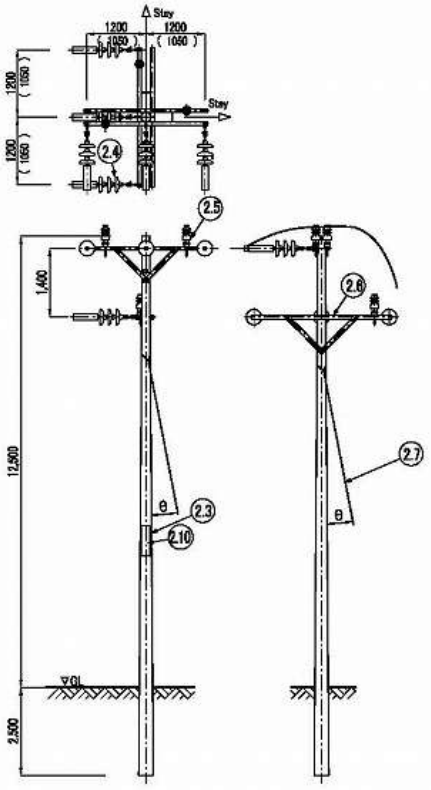
Fig. 2-2-3.22 34.5/11.5 kV Medium Angle Pole (20 – 60 deg.)



P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Load Isolator	負荷開閉器	0
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	0
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	0
2.2	Connector	コネクター	0
2.3	Steel Pole (15m)	鎖管柱 (15m)	2
2.4	Strain Insulator Set	耐張碍子セット	6
2.5	Pin Insulator set	ピン碍子セット	2
2.6	Crossarm set	腕金セット	2
2.7	Stay Wire Set	支線セット	4
2.8	Earth Wire Set	接地線セット	0
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

Preferable Stay Angle : 30° ≦ θ ≦ 45°

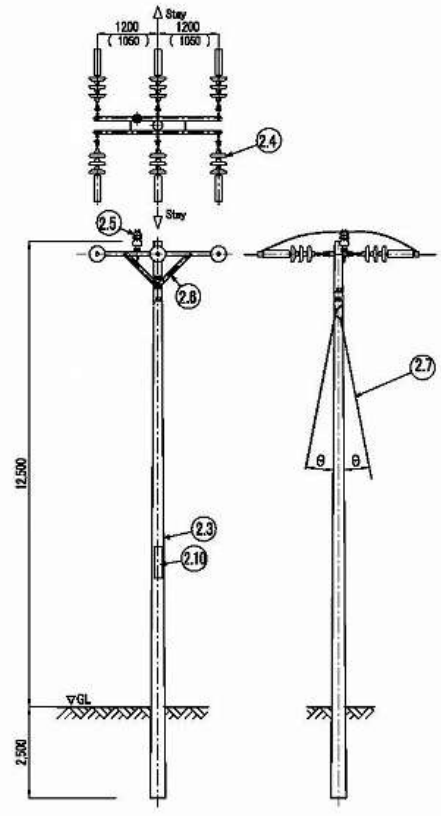
Fig. 2-2-3.23 34.5/11.5 kV Heavy Angle Pole (60 – 90 deg.)



P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Load Isolator	負荷開閉器	0
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	0
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	0
2.2	Connector	コネクター	0
2.3	Steel Pole (15m)	鎖管柱 (15m)	1
2.4	Strain Insulator Set	耐張碍子セット	6
2.5	Pin Insulator set	ピン碍子セット	3
2.6	Crossarm set	腕金セット	4
2.7	Stay Wire Set	支線セット	2
2.8	Earth Wire Set	接地線セット	0
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

Preferable Stay Angle : 30° ≦ θ ≦ 45°

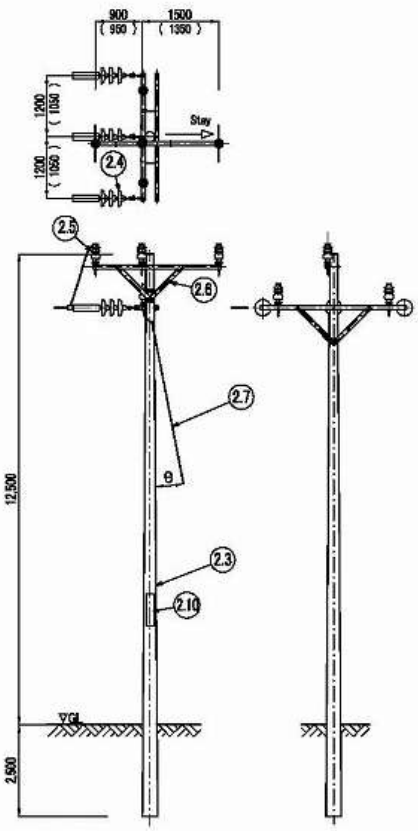
Fig. 2-2-3.24 34.5/11.5 kV Cross Pole (90 deg.)



P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Load Isolator	負荷開閉器	0
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	0
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	0
2.2	Connector	コネクター	0
2.3	Steel Pole (15m)	鎖管柱 (15m)	1
2.4	Strain Insulator Set	耐張碍子セット	6
2.5	Pin Insulator set	ピン碍子セット	1
2.6	Crossarm set	腕金セット	2
2.7	Stay Wire Set	支線セット	2
2.8	Earth Wire Set	接地線セット	0
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

Preferable Stay Angle : 30° ≦ θ ≦ 45°

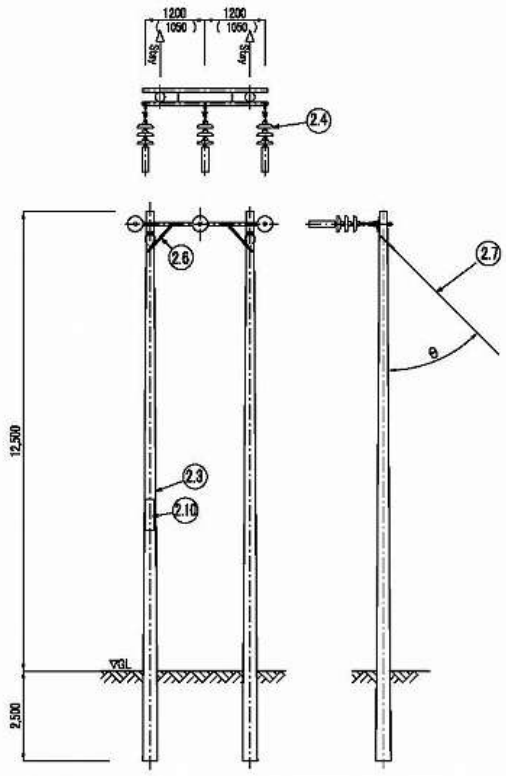
Fig. 2-2-3.25 34.5/11.5 kV Section Pole



P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Load Isolator	負荷開閉器	0
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	0
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	0
2.2	Connector	コネクター	0
2.3	Steel Pole (15m)	鎖管柱 (15m)	1
2.4	Strain Insulator Set	耐張碍子セット	3
2.5	Pin Insulator set	ピン碍子セット	5
2.6	Crossarm set	腕金セット	3
2.7	Stay Wire Set	支線セット	1
2.8	Earth Wire Set	接地線セット	0
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

Preferable Stay Angle : 30° ≦ θ ≦ 45°

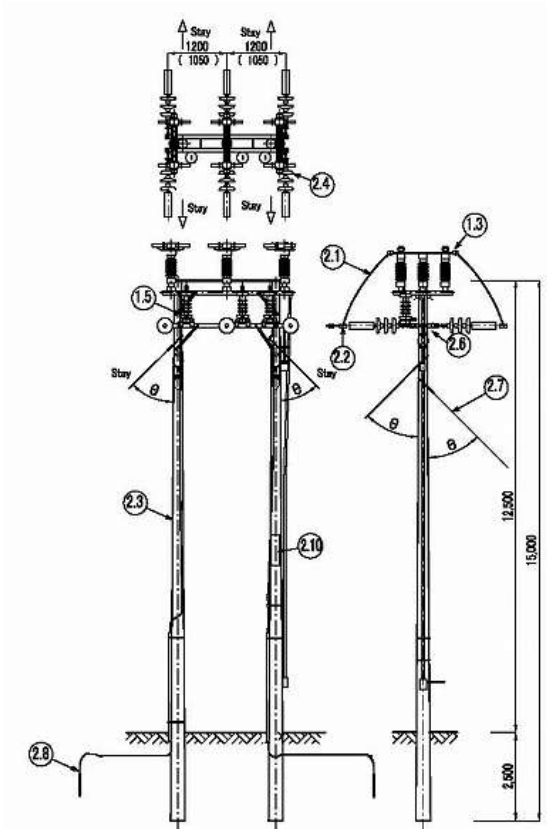
Fig. 2-2-3.26 34.5/11.5 kV T-off Pole



P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Load Isolator	負荷開閉器	0
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	0
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	0
2.2	Connector	コネクター	0
2.3	Steel Pole (15m)	鎖管柱 (15m)	2
2.4	Strain Insulator Set	耐張碍子セット	3
2.5	Pin Insulator set	ピン碍子セット	0
2.6	Crossarm set	腕金セット	2
2.7	Stay Wire Set	支線セット	2
2.8	Earth Wire Set	接地線セット	0
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

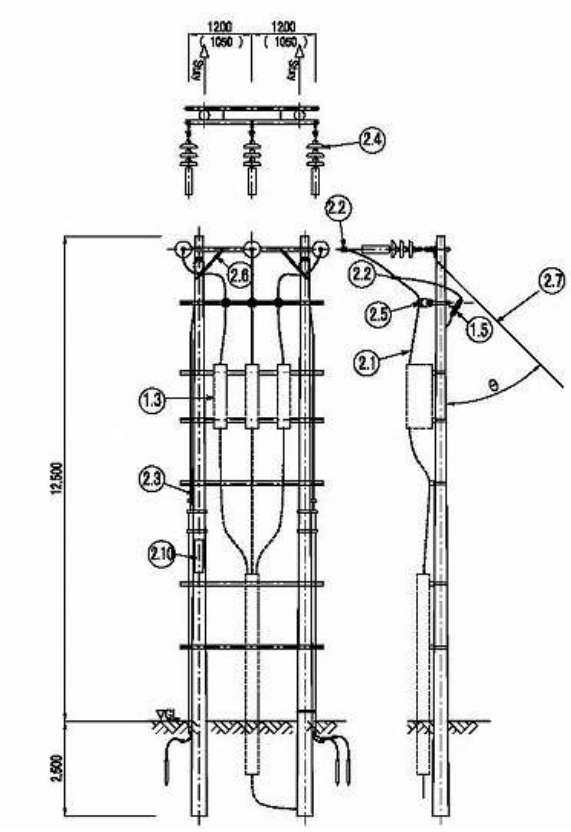
Preferable Stay Angle : 30° ≦ θ ≦ 45°

Fig. 2-2-3.27 34.5/11.5 kV Terminal Pole



P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Disconnecintg Switch with Operating Device	断路器（操作装置付）	1
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	1
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	30
2.2	Connector	コネクター	3
2.3	Steel Pole (15m)	鋼管柱 (15m)	2
2.4	Strain Insulator Set	耐張碍子セット	6
2.5	Pin Insulator set	ピン碍子セット	0
2.6	Crossarm set	腕金セット	2
2.7	Stay Wire Set	支線セット	4
2.8	Earth Wire Set	接地線セット	3
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

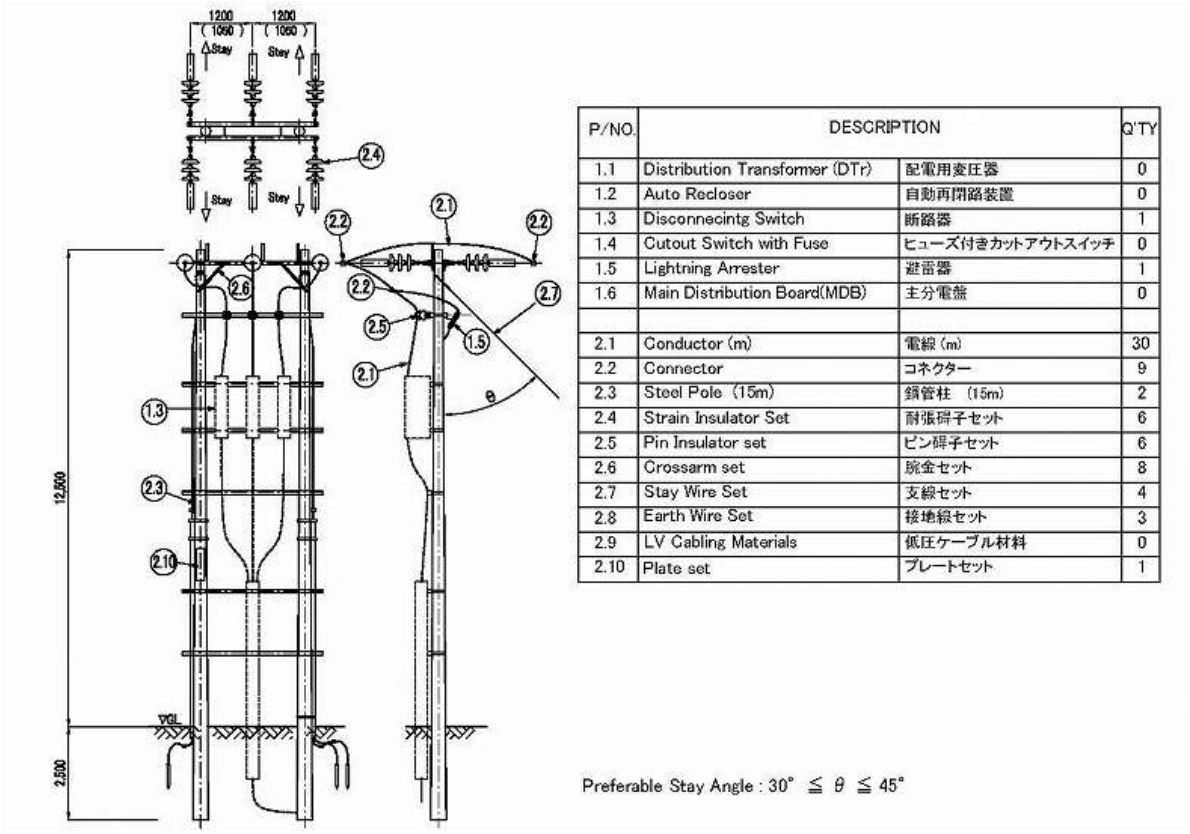
Fig. 2-2-3.28　34.5/11.5 kV Disconnecting Switch Pole (Horizontal Type)



P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Disconnecintg Switch	断路器	1
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	1
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	30
2.2	Connector	コネクター	6
2.3	Steel Pole (15m)	鋼管柱 (15m)	2
2.4	Strain Insulator Set	耐張碍子セット	3
2.5	Pin Insulator set	ピン碍子セット	3
2.6	Crossarm set	腕金セット	8
2.7	Stay Wire Set	支線セット	2
2.8	Earth Wire Set	接地線セット	3
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

Preferable Stay Angle : 30° ≦ θ ≦ 45°

Fig. 2-2-3.29　34.5/11.5 kV Disconnecting Switch Pole (Vertical Dead End Type)



P/NO.	DESCRIPTION		Q'TY
1.1	Distribution Transformer (DTr)	配電用変圧器	0
1.2	Auto Recloser	自動再閉路装置	0
1.3	Disconnecintg Switch	断路器	1
1.4	Cutout Switch with Fuse	ヒューズ付きカットアウトスイッチ	0
1.5	Lightning Arrester	避雷器	1
1.6	Main Distribution Board(MDB)	主分電盤	0
2.1	Conductor (m)	電線 (m)	30
2.2	Connector	コネクター	9
2.3	Steel Pole (15m)	鋼管柱 (15m)	2
2.4	Strain Insulator Set	耐張碍子セット	6
2.5	Pin Insulator set	ピン碍子セット	6
2.6	Crossarm set	腕金セット	8
2.7	Stay Wire Set	支線セット	4
2.8	Earth Wire Set	接地線セット	3
2.9	LV Cabling Materials	低圧ケーブル材料	0
2.10	Plate set	プレートセット	1

Fig. 2-2-3.30　34.5/11.5 kV Disconnecting Switch Pole (Vertical Section Type)

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The Project will be implemented within the framework of the grant aid scheme of the Government of Japan. Accordingly, the Project will only be implemented after its approval by the Government of Japan and the formal Exchange of Notes between the Government of Japan and the Government of Ghana. The basic issues and special points for consideration for the implementation of the Project are described below.

(1) Project Implementing Body

The organization responsible for the supervision of the project implementation process on the Ghanaian side will be the Ministry of Energy (MOE). The responsibility for the operation and maintenance of the new equipment and systems after the commencement of their operation will fall on the VRA which is the implementing body of the Project. The MOE and VRA must appoint a person to be responsible for the Project so that the Project smoothly progresses through close liaisoning and consultation with the Japanese Consultant and Contractor. The selected person will be required to explain the contents of the Project to staff of the MOE and VRA involved in the Project as well as residents at the Project sites with a view to facilitating their understanding of and cooperation for the Project.

(2) Consultant

In order to procure and install the necessary equipment for the Project, the Japanese Consultant will conclude a consultancy agreement with the VRA and will conduct the detailed design and supervision of the site work for the Project. The Consultant will also prepare the tender documents and will execute the prequalification and tender on behalf of the VRA, i.e. the project implementing body.

(3) Contractor

The Contractor, which will be a Japanese corporation selected by the Ghanaian side by means of open tender in accordance with Japan's grant aid scheme, will conduct the procurement and installation of the new equipment, etc. As it is deemed necessary for the Contractor to provide after-care in terms of the supply of spare parts and the repair of breakdowns in regard to the new equipment, the Contractor must give proper consideration to the establishment of a post-project liaison system.

(4) Necessity to Dispatch Japanese Engineers

Under the Project, the work to construct a substation at two sites will involve civil engineering work, building construction work and transforming system installation work. At the same time, other work will be conducted to construct some 34.4 km long sub-transmission and distribution lines (some 27.5 km in the Tamale area and some 6.9 km in the Sunyani area). As the new substations, sub-transmission lines and distribution lines must be connected to the existing transforming and distribution systems, it will be essential for all of the planned work to be well

coordinated. Given the fact that various types of work will be simultaneously conducted, it will be essential for the Contractor to dispatch site managers who thoroughly understand the requirements of Japan's grant aid scheme and who are capable of providing consistent management of and guidance on schedule control, quality control, work progress control and safety control.

2-2-4-2 Implementation Conditions

(1) Conditions of the Construction Industry in Ghana

As described earlier in 2-2-1-4, there is more than one general construction company and electrical contractor in such large cities as Accra and Kumasi. It is, therefore, possible to procure ordinary workers, transport vehicles and construction machinery in Ghana and to employ a local company for the civil engineering work for the planned sub-transmission and distribution lines under the Project. Nevertheless, the dispatch of Japanese engineers to Ghana will be essential to ensure the scheduled completion date of the Project, quality control and safety control. The bulk volume of overhead cables, underground cables, electric poles and other items to be procured for the Project will also necessitate the presence of Japanese engineers to control their procurement and installation.

(2) Use of Local Materials

It is possible to procure such materials for the foundations as aggregates, cement and reinforcing bars in Ghana even though their quality control and delivery control are required. Many aid projects have, therefore, used locally procured materials. Locally procurable materials will be used as much as possible for the Project, partly for the fostering of local industries. However, the transforming and distribution equipment to be installed under the Project are not manufactured in Ghana and this must be imported from Japan or a third country.

(3) Safety and Security Measures

There are relatively few security problems in Ghana. As each Project site is located in the urban area of a local city, the site access is fairly good, making monitoring easy. One caution relating to the work is that the construction/installation work should not be conducted after sunset. Sufficient measures must also be taken to prevent the theft of equipment and materials and to ensure the safety of the workers at each work site.

(4) Tax Exemption Measures

To obtain the exemption of the equipment and materials to be procured under the Project from taxes (including VAT) in Ghana, the Contractor will, via the VRA, request that the MOE take the necessary measures. The MOE will then request that the Ministry of Finance issue a tax exemption certificate. In response to this request, the Ministry of Finance will issue the said certificate to its Customs Excise and Preventive Service (CEPS). (At the same time, a copy of this certificate will be issued to the MOE and the Contractor.) When the equipment, etc. procured for the Project arrives at a port or airport in Ghana, the contractor will attach a copy of the certificate to the shipping documents for submission to the CEPS. It is important to ensure that

this tax exemption measures is in place in time for the Project to avoid any delay of the implementation of the Project.

2-2-4-3 Scope of Works

For the implementation of the Project, the Japanese side will be responsible for the procurement, installation, testing, adjustment and necessary civil engineering work relating to the new 34.5 kV distribution boards at the existing BSP substations, new 34.5/11.5 kV substations, new 34.5 kV sub-transmission lines and new 11.5 kV distribution lines. The Ghanaian side will be responsible for the ground preparation for the new substations, weeding, etc. along the routes of the new sub-transmission and distribution lines and connection of the new lines with the existing distribution lines. Further details of the division of work between the two sides are given in Table 2-2-4.1.

Table 2-2-4.1 Division of Works (Provisional)

No.	Item	Responsible Side		Remarks
		Japan	Ghana	
1*	(1) Securing of the necessary land (for the new substations, 34.5 kV sub-transmission lines and 11.5 kV distribution lines)		○	Including the land to install a new RMU on the provincial hospital premises
	(2) Levelling, preparation, weeding and removal of obstacles at the construction sites		○	Including the temporary removal /relocation of market stalls along the new power line routes
2*	Erection of perimeter fences and gate at the new substations			
	(1) Temporary fencing and gate during the construction work	○		
	(2) Permanent fencing, gate and guardhouse		○	
3*	Road work			
	(1) Roads at the project sites	○		
	(2) Access roads to the project sites		○	
4*	Auxiliary work for the new substations			
	(1) Electrical work			
	a) Incoming line		○	Including the installation of a circuit breaker and WH meter (only during construct stage)
	b) Indoor wiring	○		
	(2) Water supply work			
	a) Service extension		○	
	b) Indoor plumbing and installation of the water tank	○		
	(3) Drainage work			
	a) Outside the Project sites		○	
	b) At the Project sites	○		
	(4) Telephone work		○	As required
	(5) Furniture		○	
5*	Transportation, customs clearance and taxation regarding equipment, etc.			
	(1) Transportation to the port of landing in Ghana	○		
	(2) Tax exemption and customs clearance at the port of landing		○	
	(3) Transportation from the port of landing to the Project sites	○		Delivery destinations: equipment yards near the Tamale and Sunyani BSP Substations
	(4) Exemption or payment of VAT on		○	

No.	Item	Responsible Side		Remarks
		Japan	Ghana	
	locally procured materials			
6*	Necessary measures to obtain the following permits - Permit for the installation work - Permit for any entry to restricted areas		○	These permits must be obtained prior to the implementation of the Project.
7*	Proper operation and maintenance of the new facilities and equipment		○	Including weeding and the removal of obstacles along the new power line routes
8*	Payment of expenses not included in the grant aid		○	
9*	Payment of the following commissions based on the banking agreement			
	(1) A/P-related commission		○	approx. ¥10,000 -
	(2) Payment-related commission		○	Some 0.1% of the total project cost
10*	Appropriation and execution of the budget for environmental and social considerations which are essential for project implementation		○	
11	Securing of the land for temporary yards, fencing and gates		○	Use of equipment yards near the Tamale and Sunyani BSP Substations
12	Securing of parking sites during the construction work		○	
13	Site office	○		For the Japanese Contractor
14	Proper storage and safety control at the temporary equipment yards	○		
15	Securing of the necessary work space and traffic control along the routes of the distribution lines		○	
16	Relocation of the existing overhead lines and underground cables or pipes and obtaining of the necessary permits (power, telephone, water supply and sewer lines)		○	As required
17	Obtaining of a permit for the work to lay underground cables across an existing road		○	As required
18	Securing of places for the disposal of surplus soil and waste water from the construction work		○	
19	Manufacture and procurement of equipment	○		
20	Installation, testing and adjustment of equipment	○		The Ghanaian side will loan the measuring instruments and maintenance tools provided under the Project to the Japanese Contractor.
21	Work for temporary power outages during the construction period		○	
22	Reconnecting of the existing cabling as part of the work to install an additional 34.5 kV distribution board at the Tamale and Sunyani BSP Substations		○	The terminal treatment materials will be provided by the Japanese side
23	Remodelling work of the cross arms and reconnection work of the jumper lines at the dual-line terminal pole at the connection point to the 11.5 kV Tolon feeder in Tamale		○	Including the materials required for this work
24	Cabling work at the existing pole at the connection point to the 11.5 kV Cheshegu feeder in Tamale		○	The cables and terminal treatment materials will be provided by the Japanese side.
25	Final connection to the existing 11.5 kV distribution lines		○	
26	Procurement of the materials required for the	○		

No.	Item	Responsible Side		Remarks
		Japan	Ghana	
	above final connection work			
27	Guidance on the operation and maintenance of the procured equipment	○		
28	Improvement of the low voltage distribution system along the target 11.5 kV distribution lines of the Project		○	
29	Safety and security arrangements for Project-related personnel at the Project sites		○	
30	Handling of and compensation for consumers in regard to power outages necessitated by the work		○	
31	Notification of the outage schedule and safety measures to consumers during the construction period		○	

Note: O denotes the responsible side for the work in question. Numbered items marked with an asterisk (*) are included in the M/D.

2-2-4-4 Consultant Supervision

The Consultant will organize a project team to be responsible for the detailed design and work supervision in a consistent manner in accordance with Japan's grant aid scheme and the concept and policies of the outline design in order to smoothly proceed with the implementation of the Project. Given the geographical distance of the two Project sites and many connections between the new substations, sub-transmission lines and distribution lines and the existing transforming facilities, it will be essential for the work supervision to be strictly coordinated with the operation of the VRA. For this reason, the Consultant will appoint at least one full-time on-site engineer to supervise the schedule control, quality control, work progress control and safety control at the work supervision stage. The Consultant will also dispatch expert engineers in accordance with the progress of the installation, test running and adjustment and handover testing to supervise the work assigned to the Contractor. Furthermore, the Consultant will arrange for Japanese experts to attend the inspection of the equipment manufactured in Japan or a third country at the manufacturing and pre-shipment stages to prevent any equipment problems after the delivery of the equipment to Ghana.

(1) Supervision Principles

The Consultant will supervise the work progress to ensure punctual completion within the planned period and will supervise and guide the Contractor in order to fulfil the work quality, amount of work and delivery time indicated in the contract without accidents or other problems at the site. The main points to be noted for the supervisory work are described below.

1) Schedule Control

The Consultant will make weekly or monthly comparisons between the actual work progress and the contract schedule submitted by the Contractor at the time of signing the contract for the following items. If the Consultant foresees any delay of the work, he will issue a warning to the Contractor, requesting that the latter submit a remedial plan to ensure the completion of the construction work and equipment delivery within the planned work period. These comparisons will mainly be conducted for the following matters.

① Quantity of the work conducted (including the volume of manufactured equipment by the manufacturers and the civil engineering and building work completed at the Project sites)

② Quantity of the equipment and materials delivered (for the transforming and distribution equipment and civil engineering and building work materials)

③ Confirmation of the preparations for the temporary work and construction machinery

④ Work efficiency and actual number of engineers, technicians and workers at work

2) Safety Control

The Consultant will discuss and cooperate with the representative of the Contractor with a view to supervising the on-site construction and installation work to prevent any accidents to workers and third parties during the construction period with due attention paid to the following safety control principles.

① Establishment of safety control rules and appointment of a person responsible for work safety

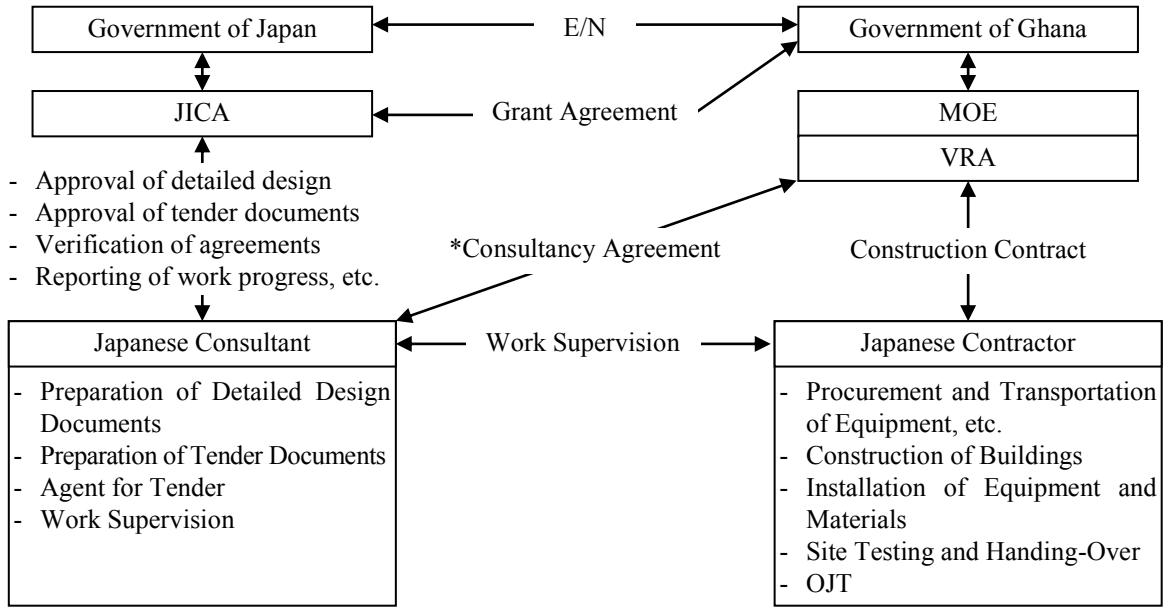
② Prevention of accidents to workers by means of the periodic inspection of the construction machinery

③ Introduction of travelling routes for work vehicles and construction machinery, etc. and the thorough enforcement of slow driving on the site

④ Enforcement of welfare measures and days-off for workers

(2) Project Implementation Regime

The project implementation regime, i.e. relationship between the parties involved in the implementation of the Project, including at the work supervision stage, is shown in Fig. 2-2-4.1.



* The consultancy agreement and construction agreement must be verified by the JICA.

Fig. 2-2-4.1 Project Implementation Regime

(3) Work Supervisors

In addition to the procurement and delivery of equipment and materials for the work to expand the existing BSP substations and to construct new substations, 34.5 kV sub-transmission lines and 11.5 kV distribution lines, the Contractor will undertake the associated building and civil engineering work using local construction companies as subcontractors. As the Contractor must make these subcontractors fully aware of and implement the schedule, quality and safety of the work as specified in the agreement, the Contractor will dispatch site supervisors with previous experience of similar work to advise the subcontractors.

In view of the scale and contents of the planned work involving transforming facilities and power lines, it is desirable that the Contractor assign those engineers listed in Table 2-2-4.2 as the minimum full-time on-site supervisors.

Table 2-2-4.2 Engineers to be Dispatched by the Contractor

Description	No.	Work Details	Dispatch Period
Site Manager (Local Procurement Manager)	1	General management of the on-site work, consultation and coordination with stakeholders, obtaining of the necessary authorisation, etc., OJT, equipment procurement and control, customs clearance, labour management and book-keeping	Entire construction period
Inspector No. 1	1	Checking and verification of the shop drawings for the distribution equipment and witnessing of the equipment inspection	Drawing checking and approval period; equipment testing period
Inspector No. 2	1	Checking and verification of the shop drawings for the transforming equipment and witnessing of the equipment inspection	Drawing checking and approval period; equipment testing period
Inspector No. 3	1	Checking and verification of the building drawings	Drawing checking and approval period
Assistant Local Procurement Manager (Building Work)	1	Assistant site manager (building work) (substation building in general) and coordination with local subcontractors	Building construction period
Assistant for Site Manager (Local Employee)	2	Assistance for the site manager	During the stay of the on-site site manager
Assistant for Local Procurement Manager (Local Employee)	2	Assistance for the local procurement manager (building work) at the UDS and Kotokrom Primary Substation sites	Building construction period
Office Boy (Local Employee)	2	Miscellaneous work	Entire construction period

2-2-4-5 Quality Control Plan

The Consultant will supervise the Contractor in regard to the following items so as to adhere to the quality and progress of the work for the facilities and equipment indicated in the contract documents (technical specifications and detailed design drawings, etc.) If the Consultant believes that the quality or work progress does not meet the requirements, he will demand that the Contractor correct, change or modify the situation.

① Checking of the shop drawings and specifications for the equipment

② Checking of the factory inspection results for the equipment or attendance at the shop inspection

③ Checking of the packaging, transportation and temporary on-site storage methods

④ Checking of the working drawings for the equipment and installation manuals

⑤ Checking of the test running, adjustment and inspection manuals

⑥ Supervision of the site installation of the equipment and attendance at the test running and inspection

⑦ Comparison between the equipment installation and building work drawings and the completed work

2-2-4-6 Equipment Procurement Plan

None of the planned transforming equipment to be procured and installed under the Project is manufactured in Ghana and it will, therefore, be necessary for this equipment to be procured in Japan and/or such European countries as the UK, France, Italy, Denmark or Germany. Although the VRA has recently procured equipment made in India or China, it still places much trust in Japanese and European products. While some European transforming equipment manufacturers have an agent in Ghana, few manufacturers provide an after-service, including a quick response to accident or repair needs and the swift supply of spare parts, for high voltage transforming equipment. This situation must be taken into consideration when deciding the procurement source(s) for the transforming equipment for the Project. The said decision must also take the ease of operation and maintenance of the selected equipment by engineers of the VRA into consideration. One critical point to be considered is that the VRA, which will be responsible for the operation and maintenance of the new facilities and equipment, is familiar with the operation and maintenance of Japanese equipment as the transformers and distribution equipment procured for past Japanese grant aid projects are still soundly operating today. Moreover, the VRA has expressed its trust in the excellent performance of the principal transforming equipment manufactured in Japan and the good after-service provided by Japanese manufacturers. For this reason, the VRA hopes that Japanese equipment will be procured for the Project. No special problems regarding the transportation and installation of heavy equipment are anticipated as a 30 ton class crane and trailer can be leased locally.

Based on the above considerations, the following procurement sources are judged to be appropriate for the equipment and materials to be used under the Project.

(1) Equipment and Materials for Local Procurement

Construction equipment and materials: cement, sand, aggregates for concrete, concrete blocks, bricks, reinforcing bars, timber, petrol, diesel oil, work vehicles, crane, trailer and equipment and materials for temporary structures

(2) Equipment for Procurement in Japan

1) Transforming Equipment

34.5/11.5 kV transformers, 34.5/11.5 kV distribution boards and others

2) Distribution Materials

Materials for the 34.5/11.5 kV sub-transmission and 11.5 kV distribution lines (steel poles, insulators, cross arms, grounding system and others)

(3) Materials for Third Country Procurement (DAC and/or ASEAN Countries)

Power cables, underground cables, RMU and other transmission/distribution-related products

2-2-4-7 Operational Guidance Plan

The basic principle for guidance on the initial operation and maintenance method of the equipment procured under the Project is that instructors dispatched by the equipment manufacturer(s) will provide OJT using the operation and maintenance manuals for the equipment in question. It will be necessary for the VRA to discuss the matter with the Consultant and the Contractor and to select participating engineers for OJT for the smooth implementation of the said guidance. It will be necessary for these selected engineers to spread their newly acquired knowledge and skills through OJT to other technical staff in order to improve the maintenance capability of the VRA. As the testing and adjustment of the transforming and distribution equipment during and after installation will require knowledgeable engineers of the manufacturer(s), it will be impossible to rely on local companies to provide such engineers. The dispatch of Japanese engineers will, therefore, be essential to conduct quality control and schedule control and to provide technical guidance on the new equipment.

2-2-4-8 Soft Component Plan

For the operation and maintenance of the distribution equipment to be procured and installed by the Japanese side under the Project, the VRA possesses the basic technical skills and necessary manpower and no special difficulties are anticipated for the VRA to conduct the maintenance work in question. In the case of the substation equipment, the operation and maintenance techniques can be transferred to the VRA (Project implementing body) through OJT which will include the test operation and adjustment of the equipment and systems during the construction period. Because of this, it is judged that the inclusion of a soft component in the Project is unnecessary.

2-2-4-9 Implementation Schedule

The project implementation schedule shown in Fig. 2-2-4.2 is adopted to comply with the grant aid scheme of the Government of Japan.

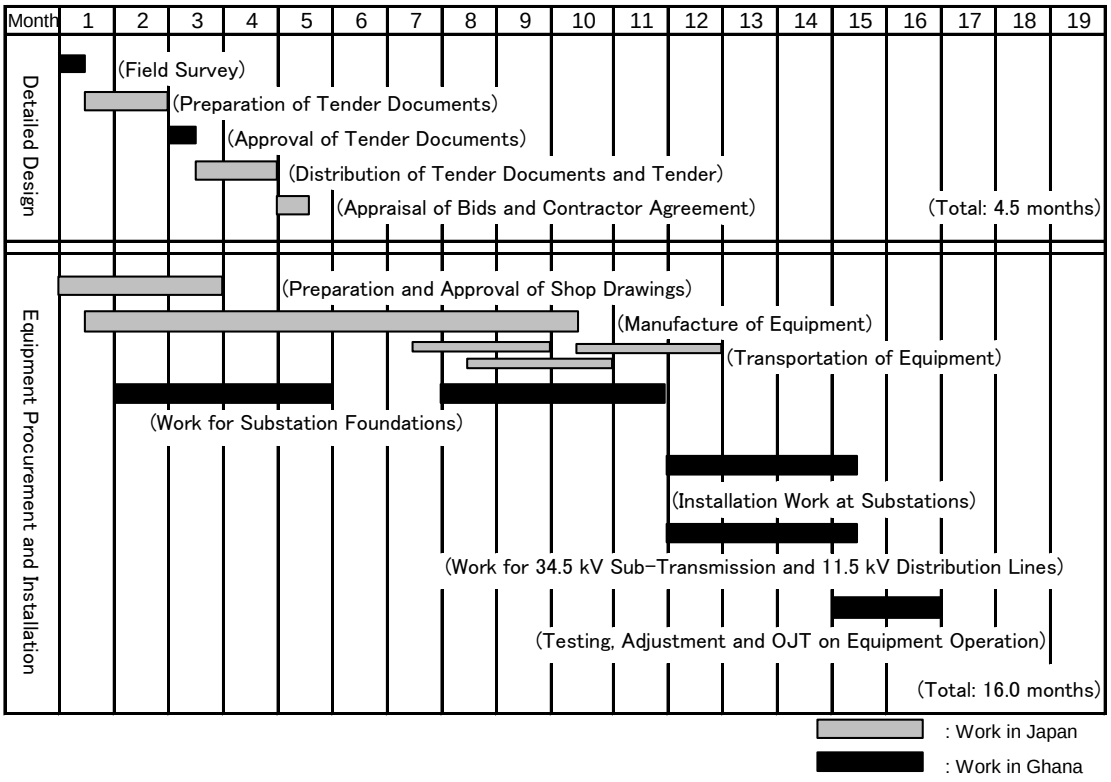


Fig. 2-2-4.2 Project Implementation Schedule

2-3 Obligations of the Recipient Country

In addition to the undertakings described in 2-2-4-3 – Scope of Works, the Ghanaian side will be responsible for the matters listed below.

(1) Provision of the necessary data and information for the Project

(2) Appointment of local engineers to receive training on operation and maintenance skills regarding the equipment to be installed under the Project and witnessing of the progress of the construction work and quality inspection of the equipment, etc.

2-4 Project Operation Plan

2-4-1 Basic Policy

The appropriate operation and maintenance of the transforming, transmission and distribution equipment and facilities as well as the preservation of their working environment are essential to improve the reliability of power supply to existing and new customers in the areas affected by the new equipment and facilities installed under the Project. The adoption of adequate preventive maintenance for the newly procured and installed equipment and newly constructed facilities aimed at improving their reliability, safety and efficiency is desirable to reduce the number of possible breakdowns. The basic concept of this preventive maintenance for the transforming, transmission and distribution facilities is shown in Fig. 2.4.1-1.

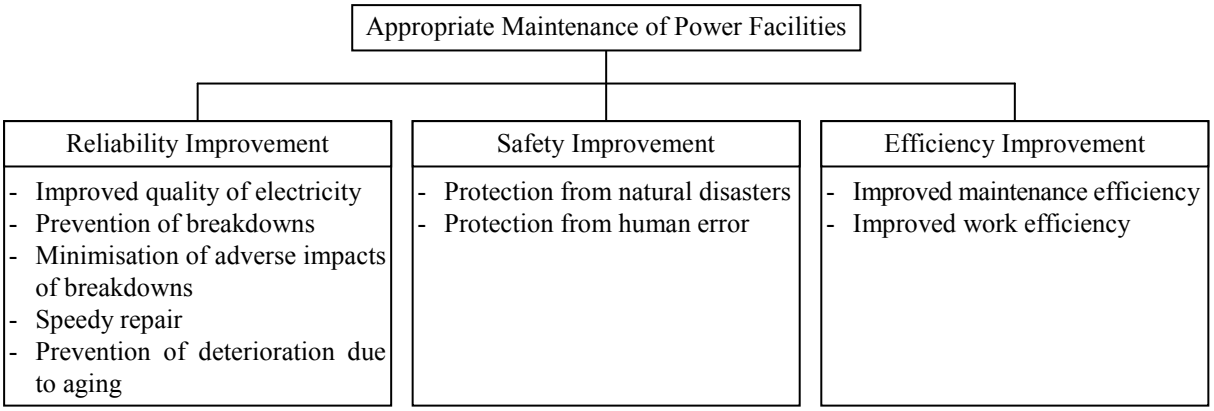


Fig. 2-4-1-1 Basic Concept of the Maintenance of the Transforming, Transmission and Distribution Facilities

The dispatch of engineers by the Japanese Contractor is planned as part of the Project to conduct OJT during the installation and test operation periods on the operation and maintenance of the new transforming, sub-transmission and distribution equipment and systems. With the provision of the necessary spare parts, testing instruments, maintenance tools and O & M manuals by the Japanese side along with proposals for the post-Project operation and maintenance system, the anticipated effects of OJT will be fully realised.

The operation and maintenance of the new equipment and systems (facilities) will be conducted as shown in Table 2.4.1-1 by local offices of the VRA which is based in Tamale. As additional workers will be recruited to match the construction of the new substations of the Project, the organization and manpower of the VRA are expected to be adequate for the management of its power supply business.

Table 2-4-1.1 Post-Project Operation and Maintenance System

VRA Section	Scope of Responsibility	Current Strength of Maintenance Staff	Planned Recruitment of Additional Staff
VRA-NED Head Office	Overall control of the distribution system in the four northern regions, including the Tamale and Sunyani areas	None	None
VRA-NED Tamale Office	・ Tamale BSP Substation ・ New UDS Primary Substation ・ 34.5 kV sub-transmission and 11.5 kV distribution lines	12	6 (3 operators, 2 guardsmen and 1 cleaner for the new substation)
VRA-NED Sunyani Office	・ Sunyani BSP Substation ・ New Kotokrom Primary Substation ・ 34.5 kV sub-transmission and 11.5 kV distribution lines	11	6 (as above)

2-4-2 Regular Check Items

(1) Regular Checking of Transforming Equipment

The standard regular check items for the transforming equipment to be procured and installed under the Project are shown in Table 2-4-2.1. As the table shows, the checking of transforming equipment is classified as (i) "patrolling checking" which is conducted daily using the human senses to check for any abnormal heating, sound or other of the equipment, (ii) "standard checking" to check located sections beyond the daily patrolling checking, including the fastening conditions of bolts, etc. of the equipment and the cleanliness of or damage to the surface of insulated items, etc. and (iii) "detailed checking" to check the proper functioning of the interlocking mechanism between equipment and the accuracy of instruments, etc.

Standard checking is conducted every one or two years while detailed checking is conducted approximately every four years.

The regular replacement of certain parts at the time of either standard checking or detailed checking is desirable based on confirmation of the characteristics as well as frequency of use of such parts. These include the fuses, measuring instruments and relays, etc. installed inside the distribution panels and others which are liable to performance deterioration, including the insulation performance, abrasion of the contact points and changes of the characteristics.

Table 2-4-2.1 Regular Check Items for Power Equipment

Subject	Check Item (Method)	Patrolling Checking	Standard Checking	Detailed Checking
Equipment Outlook	Switchgear indicator and indication light	○	○	
	Abnormal sound or odour	○	○	
	Thermal discolouration of terminals	○	○	
	Cracks, damage or staining of bushing and insulator	○	○	
	Rust on casings and frames	○	○	
	Abnormal temperature (thermometer)	○	○	
	Fastening of bushing terminals (mechanical check)	○	○	
Operating Apparatus and Control Panels	Correct indication by various instruments	○	○	○
	Counter indication		○	○
	Condensation, rust and damage inside consoles and panels		○	○
	State of oil supply and cleaning		○	○
	Fastening of cable terminals	○	○	○
	State of switchgear indication		○	○
	Air leakage and oil leakage		○	○
	Pressure before and after operation (air pressure, etc.)		○	○
	Working of instruments		○	○
	Rust, deformation and/or damage to springs	○	○	○
	Abnormality of fastening pins		○	○
	Auxiliary switchgear and relays		○	○
	DC control power source	○		
Measurement/ Testing	Measurement of insulation resistance		○	○
	Measurement of control resistance			○
	Breaker of heater cable		○	○
	Testing of relay function		○	○

(2) Regular Checking of Sub-Transmission and Distribution Lines

One of the most important services for consumers is the maintenance of sub-transmission and distribution lines by means of the detection of breakdowns and damage through regular patrols and immediate repair. When there is a risk of a grounding incident due to the possible contact of a sub-transmission or distribution line with a tree, the preventive measure of cutting such tree or branch must be taken. The major check items for patrolling checking are listed below.

① Cutting of power cables

② Damage to insulators

③ Contact between power cables and trees

④ Damage to electric poles

⑤ Tilting of electric poles

⑥ State of installation and operation, including undesirable oil leakage, of distribution transformer

⑦ Conditions of various switches

2-4-3 Spare Parts Procurement Plan

(1) Classification of Spare Parts

The spare parts to be procured under the Project are classified in the following two categories.

① Standard spare parts : spare parts which are required when parts of the equipment are aged or damaged

② Emergency spare equipment : equipment of which the urgent replacement is required at the time of an emergency to prevent the stoppage of the transmission or distribution system due to an equipment breakdown

(2) Subject Equipment and Systems for the Supply of Spare Parts

The standard spare parts and emergency spare equipment to be procured and provided under the Project will serve the following equipment and systems.

① 34.5/11.5 kV substation equipment
② 34.5 kV sub-transmission system
③ 11.5 kV distribution system

(3) Selection Criteria by Category

1) Standard Spare Parts

These are parts of which the replacement is regularly required due to their deterioration through routine usage and their quantities will be determined based on the perceived near-term need.

2) Emergency Spare Equipment

This category represents equipment of which damage due to an unforeseeable cause can cripple stable power supply operation as quick on-site repair is quite difficult. The reason for the selection of such equipment in the Project is described below.

① The vacuum circuit breaker protects the power system from abnormal current or voltage associated with lightning impulse, short-circuiting, grounding and switching impulse. Once it breaks down, it must be immediately replaced. The Project sites experience thunderstorms on some 40 ~ 50 days a year (according to Weatherbase, a website run by Canty and Associates LLC), indicating a relatively high occurrence of thunderstorms. When system operation continues during the thunderstorm season without the replacement of broken down protective equipment, a lightning strike could damage the transformers on the system, risking the occurrence of a fire which causes an outage over a wide area. The prevailing condition in Ghana is that the quick repair of broken down equipment on-site is difficult because of the non-existence of a stock of replacement equipment. This situation makes it essential for the Japanese side to procure spare vacuum circuit breakers so that the VRA-NED can quickly replace them to restore the normal power supply.

② There are two ways to replace broken down vacuum circuit breakers: (a) replacement of the entire equipment using the emergency spare equipment option and (b) replacement of all affected components, including coils and packings, using the standard spare parts option. As option (b) demands overhauling and testing skills, option (a) should be appropriate for the Project in view of the current technical capability of the VRA-NED.

(4) Budgetary Appropriation for Spare Parts

The current plan is to procure the minimum range and quantity of spare parts and spare equipment to cover one year's operation of the new equipment and systems. As such, the VRA-NED will be required to appropriate the necessary budget for the purchase of the required spare parts in the second year of operation onwards by the end of the first year of operation.

(5) Testing Instruments and Maintenance Tools

The testing instruments, maintenance tools, spare parts and emergency spare equipment listed in Table 2-4-3.1 will be procured under the Project to ensure the adequate operation and maintenance of the newly installed transformation and distribution equipment and systems. In view of the fact that the operation and maintenance of the new equipment/systems will be conducted by two local VRA-NED offices which are located at a distance of five hours driving, it will be practically impossible for these two offices to share the listed instruments, maintenance tools and other items. Accordingly, the necessary quantity of each item will be procured for each office.

Table 2-4-3.1 Spare Parts, Testing Instruments and Maintenance Tools to be Procured under the Project

No.	Item	Unit	Quantity	
			Tamale	Sunyani
1	Testing Instruments			
(1)	Oil insulation tester	Set*	1	1
(2)	Cable fault detector ( )	Set*	1	1
(3)	Single phase protection relay tester	Set*	1	1
(4)	Instrument calibration tester	Set*	1	1
(5)	Analogue tester	Set*	1	1
(6)	Phase indicator	Set*	1	1
(7)	Electroscope (AC3 ~ 35 kV)	Set*	1	1
(8)	Electroscope (AC 600 V)	Set*	1	1
(9)	Megohm meter (500 V)	Set*	1	1
(10)	Megohm meter (1,000 V)	Set*	1	1
(11)	DC withstand voltage tester (0 ~ 100 kV)	Set*	1	1
(12)	AC withstand voltage tester (0 ~ 50 kV)	Set*	1	1
(13)	Simple grounding resistance tester	Set*	1	1
(14)	Digital multimeter	Set*	1	1
(15)	Clamp-type tester	Set*	1	1
2.	Maintenance Tools			
(1)	Compressor (with dies)	Set*	1	1
(2)	Crimp tools (10 ~ 250 mm^2)	Set*	1	1
(3)	Cable cutter	Set*	1	1
(4)	Electrical work tools	Set*	1	1
(5)	Lifting for the drawing out of 36 kV and 12 kV circuit breakers	Set*	1	1
(6)	Torch for terminal cable treatment	Set*	1	1
(7)	Truck with aerial bucket ( )	Unit	1	1
3.	Standard Spare Parts			
3.1	For 34.5/11.5 kV transformer			
(1)	Gasket	Set*	1	1
(2)	Buchholz relay	Set*	1	1
(3)	Oil temperature gauge	Set*	1	1
(4)	Oil level gauge	Set*	1	1
(5)	34.5 kV bushing	Set*	1	1
(6)	11.5 kV bushing	Set*	1	1
3.2	For 34.5 kV distribution board			
(1)	Various lamps (100%)	Set	1	1
(2)	Various fuses	Set	1	1
(3)	Various MCCBs	Set	1	1
(4)	Various protection relays	Set	1	1
(5)	Various auxiliary relays	Set	1	1
(6)	Space heater	Set*	1	1
(7)	Various meters	Set	1	1
(8)	Various current transformers for instruments	Set	1	1
(9)	Various voltage transformers for instruments	Set	1	1
(10)	Various switches	Set	1	1
3.3	For 11.5 kV distribution board			
(1)	Various lamps (100%)	Set	1	1
(2)	Various fuses	Set	1	1
(3)	Various MCCBs	Set	1	1
(4)	Various protection relays	Set	1	1
(5)	Various auxiliary relays	Set	1	1
(6)	Space heater	Set*	1	1

No.	Item	Unit	Quantity	
			Tamale	Sunyani
(7)	Various meters	Set	1	1
(8)	Various current transformers for instruments	Set	1	1
(9)	Various voltage transformers for instruments	Set	1	1
(10)	Various switches	Set	1	1
3.4	For low voltage board			
(1)	Various lamps (100%)	Set	1	1
(2)	Various fuses	Set	1	1
(3)	Various MCCBs	Set	1	1
(4)	Various meters	Set	1	1
(5)	Various protection relays	Set	1	1
3.5	For DC power system			
(1)	Various lamps (100%)	Set	1	1
(2)	Various fuses	Set	1	1
(3)	Various MCCBs	Set	1	1
(4)	Various meters	Set	1	1
(5)	Various control boards	Set	1	1
(6)	Thyristor	Set	1	1
(7)	Silicon dropper	Set	1	1
3.6	Terminal cable treatment materials			
(1)	For 36 kV outdoor cable	Set*	1	1
(2)	For 36 kV indoor cable	Set*	1	1
(3)	Indoor socket type for 36 kV GIS	Set*	1	1
(4)	For 12 kV outdoor cable	Set*	1	1
(5)	For 12 kV indoor cable	Set*	1	1
(6)	Indoor socket type for 12 kV RMU	Set*	1	1
4.	Emergency Spare Equipment			
(1)	36 kV circuit breaker	Set*	1	1
(2)	12 kV circuit breaker	Set*	1	1

Note: * means a set of parts, etc. to service three phases.

2-5 Project Cost Evaluation

2-5-1 Initial Cost Estimation

In the case of the actual implementation of the Project under the grant aid scheme of the Government of Japan, The Ghanaian side is expected to pay the costs of its undertakings as listed below.

Estimated overall cost for the Ghanaian side: 764,400 GHc (= ¥44.17 million)

① Ground levelling and preparation, weeding and removal of obstacles at the Project sites 254,000GHc (= ¥14.68 million)

- Tamale : 122,000GHc
- Sunyani : 132,000GHc

② Construction of permanent fencing and gate at the new substations 132,000GHc (= ¥7.63 million)

- Tamale : 65,000GHc
- Sunyani : 67,000GHc

③ Construction of an external access road 69,000GHc (= ¥3.99 million)

- Tamale : 51,000GHc
- Sunyani : 18,000GHc

④ Auxiliary work for new substation (water supply and drainage work) 171,000GHc (= ¥9.88 million)

- Tamale : 87,000GHc
- Sunyani : 84,000GHc

⑤ Operation and maintenance of new equipment and systems 103,200GHc (= ¥5.96 million)

- Operator (1,000 GHc x 12 months x 3 x 2 sites = 72,000 GHc)
- Guardsman (500 GHc x 12 months x 2 x 2 sites = 24,000 GHc)
- Cleaner (300 GHc x 12 months x 2 sites =7,200 GHc)

⑥ Payment of bank commission based on banking 35,200GHc (= ¥2.03 million)

- A/P commission (200GHc)
- Payment commission (35,000GHc)

<Estimation Conditions>

①	Date of estimation	:	February, 2011
②	Foreign exchange rates	:	US$ 1 = ¥84.46 (TTS average from Aug., 2010 to Jan., 2011) 1 GHc = ¥57.80 (TTS average from Aug., 2010 to Jan., 2011) E1 = ¥112.73 (TTS average from Aug., 2010 to Jan., 2011)
③	Procurement and construction periods	:	The detailed design, equipment procurement and installation periods are as shown in the project implementation schedule.
④	Other	:	The Project will be implemented in accordance with the grant aid scheme of the Government of Japan

2-5-2 Operation and Maintenance Cost

A total of six operators will be assigned to the two new substations (three per substation) to be constructed under the Project, incurring an annual personnel cost of some 72,000 GHc (103,200 GHc a year, including the wages of guardsmen and cleaners). Meanwhile, the new 34.5 kV sub-transmission lines and 11.5 kV distribution lines will be maintained by the existing maintenance staff of the VRA-NED. It will be necessary for the VRA to set aside some 5,000 GHc a year in its budget to maintain the stock of spare parts listed in 2-4-3.1 for the reliable operation of the new substations. As the maintenance and repair budget of the VRA-NED Head Office in 2010 was approximately 2,460,000 GHc, such a small additional expense for the maintenance of the new substations should not pose any financial problem for the VRA.

CHAPTER 3 PROJECT EVALUATION

3-1 Preconditions

The preconditions for implementation of the Project are describe in follows, such as land acquisition of new sub-transmission lines and substations, the environmental permit for the Project, and etc. There are no particular issues for satisfaction for the preconditions, because the Ghanaian side has experiences of implementation of the Japan's grant aid projects.

1) New 34.5/11.5kV substations will be constructed in public areas not in use. The Ghanaian side shall obtain permits for use of these public areas from concerned agencies

2) The Ghanaian side is required to obtain permits from the Urban Planning Bureau of the relevant municipal authorities and land owners for the use of the road reserve and boundary zone of the military land along the planned routes of the new 34.5 kV sub-transmission and 11.5 kV distribution lines.

3) The Ghanaian side is required to obtain a permit to use the wayleave for the existing 161 kV transmission line to accommodate the new 34.5 kV sub-transmission line from GRIDCo which owns the said 161 kV transmission line.

4) The Ghanaian side is required to register the Project with the Environmental Protection Agency (EPA) and to obtain an EP in accordance with the relevant procedure (including the submission of a preliminary environmental report (PER)).

3-2 Necessary Inputs by the Recipient Country

The Ghanaian side must fully meet the following requirements.

(1) Prior to the Commencement of the Construction Work

1) The Ghanaian side is required to appropriate the necessary budget to cover the Project cost for the Ghanaian side without delay so that the work to be completed by the Ghanaian side before the start of the Japanese work will be duly completed.

2) The Ghanaian side is required to complete the weeding and removal of obstacles along the planned routes of the new 34.5 kV sub-transmission and 11.5 kV distribution lines before the start of the Japanese work.

3) The Ghanaian side is required to consult and coordinate with the Japanese Contractor and local stakeholders whenever necessary to check any impacts on or interference to underground public utility systems (water supply pipes, sewers and broadcasting/telephone

lines) on and around the planned routes of the new 34.5 kV sub-transmission and 11.5 kV distribution lines before the start of the Japanese work.

4) The Ghanaian side is required to check any interference between the dual carriageway, which is being planned by the Urban Planning Bureau of the Sunyani Municipal Authority, and the locations of the new electric poles for the 11.5 kV distribution line as soon as the point where this distribution line crosses the said dual carriageway has been finalised. The Ghanaian side is also required to convey the check results to the Japanese side. (It has been confirmed that the planned span of 90 m for the 11.5 kV distribution lines to be newly constructed under the Project is sufficiently wide for the planned width of some 25 m for the dual carriageway in question.)

(2) During the Construction Work and After the Commencement of Operation

1) In line with the construction schedule for the primary substations, sub-transmission lines and distribution lines for which equipment is procured and installed by the Japanese side, the Ghanaian side is required to fulfil its obligations, including reconnection of the 34.5 kV feeders, connection of the 11.5 kV feeders at their terminals and the planning and execution of power outages. The Ghanaian side is also required to appoint an engineer in charge for each Project site and to facilitate the smooth implementation of the construction work through the preparation and execution of a schedule plan, personnel plan, equipment procurement plan and other relevant plans.

2) The distribution system in the service area of the VRA-NED consists of three modes of power supply: direct supply using a 34.5 kV sub-transmission line from a BSP, supply using an 11.5 kV distribution line and supply from a BSP via a primary substation. There is no uniformity of the power distribution method. One example is the use of different neutral grounding systems even for the same voltage class. Given the prospect of a massive increase of the power demand and the construction of many more primary substations in the coming years, there is a strong need for unification of the system protection methods for each voltage class.

3) The wire connection method used for the transformers at the existing BSPs is different from that used for the transformers of the new primary substations to be constructed under the Project, producing different phase cycles. In view of this, the Ghanaian side is required to completely separate the distribution systems fed by these two types of transformers to prevent their mixing up through strict system control.

4) The service area of the VRA-NED has seen a major increase of the power demand due to an increase of the power consumption per user and an increase of the number of consumers reflecting the economic growth in the area. Accordingly, the amount of electricity sold has been increasing. Nevertheless, the financial performance of the VRA-NED has been declining, recording a growing deficit, indicating that there is a problem in regard to the tariff. Since 2006, the electricity charge has been increased in several stages with the approval of the Public Utilities Regulatory Commission (PURC). Further revision of the

tariff will be required in the coming years to ensure the self-reliant and sustainable development of the power sector in Ghana.

5) A range of equipment, etc. to construct substations, sub-transmission lines and distribution lines will be procured under the Project to meet the assumed power demand up to five years from the commencement of their operation. Nevertheless, the Ghanaian side is required to review the estimated power demand from time to time to prepare a plan for the installation of additional distribution transformers and to expand the systems after the completion of the Project together with allocation of the necessary budget.

6) To reduce the number of accidents involving distribution cables to ensure a stable power supply, the Ghanaian side is required to conduct regular patrols with a view to preventing damage to the electric poles and cables due to cutting and open burning along the distribution routes by local residents.

7) The Ghanaian side is required to swiftly appoint engineers to participate in the OJT under the Project so that these engineers can spread their newly acquired knowledge and skills to other non-participating engineers.

8) The Ghanaian side shall undertake the procedures concerned for tax exemption for the materials and equipment for the Project and giving conveniences for persons concerned from Japan

3-3 Important Assumptions

The following assumptions are crucial to produce and sustain the expected outputs and effects of the Project.

(1) Regarding the Overall Goal

- The rural electrification policy of Ghana will not be changed.
- The politics and economy of Ghana will remain stable.

(2) Regarding the Project Targets

- The operation and maintenance of the new equipment and systems will be continually conducted in a proper manner.
- The collection of the service charge and financial support will continue.
- The security of the new facilities will be maintained.

(3) Regarding the Project Outputs

- The generating facilities will remain fully operational.
- The operation and maintenance plan will be properly implemented.

- The connection charge and service charge will be borne by consumers (and/or the government).

3-4 Project Evaluation

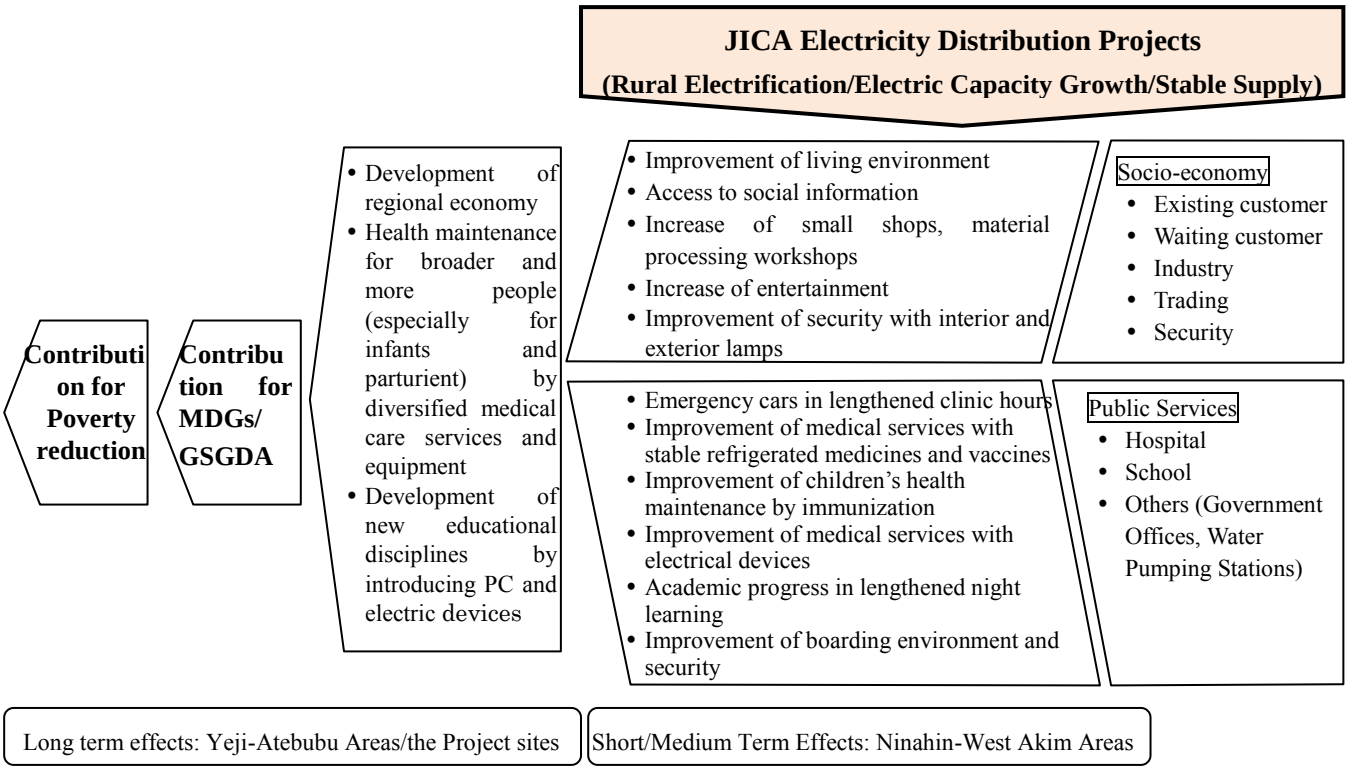
3-4-1 Relevance

The relevance of the Project to the spirit of Japan's grant aid scheme is judged to be strong as it not only contributes to the realisation of the development programme and energy policy of Ghana but also benefits the people of Ghana, including the poor.

(1) Benefits

1) Expected effects from the Past-JICA Projects

The project will supply stable and quality electricity for about 114 thousand people (direct beneficiaries) in the Project sites (Tamele and Sunyani). Other 675 thousand people also can be benefited by the Project which will contribute improving stable operations of medical and educational facilities. Moreover, hospitals and schools, the larger existing customers, are also beneficiaries from the Project as they have electricity shortage and instable electricity supply as a whole, and will have the stable and quality electricity supply by the Project. Figure 3-4-1.1 shows the flow of effects from the JICA Electricity Distribution Projects and those contributions for the national policies based on the results of the Study.



Source: JICA Study Team

Figure 3-4-1.1 Effects and Contribution from the JICA Electricity Distribution Projects

2) Beneficial Effects from the Project

① Synergetic Effect with the Other Projects

As mentioned in Chapter 1, the electricity networks have been actively built with the Self Help Electrification Project (SHEP) and Ghana Energy Development and Access Project (GEDAP). The SHEP is for electrification of rural areas and GEDAP is for improving electrified areas in order to increase operation efficiency and electrification rate. However, the existing electrical problems of core electricity networks are left unsolved. If the SHEP and GEDAP are stimulated without solving the existing problems, blackout, voltage fluctuation and voltage depression, those problems can be amplified. Therefore, improvement of the core electricity networks in the Project can contribute to enhance the effectives from the SHEP and GEDAP, and a synergetic effect can be expected to reinforce an integrated electricity networks. (See Figure 3-4-1.2)

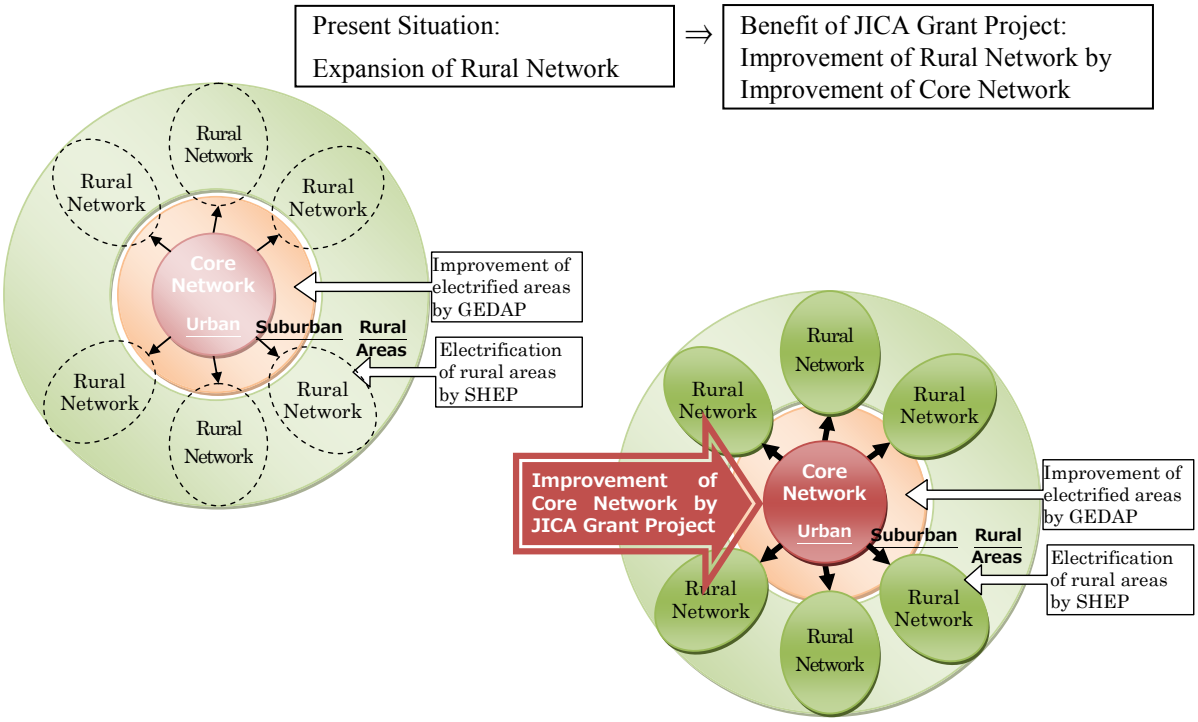


Figure 3-4-1.2 Project Effects from Enhancement of Electricity Networks

② Major Beneficial Effects by Improvement of Electricity Supply in Tamale and Sunyani

The existing problems, blackout, voltage fluctuation and voltage depression, are mainly caused by overload and too long length of feeder lines from substations. Consequently, those problems have increased risks on maintaining and developing socio-economic activities and public services, and of damages on electrical equipment. Those risks will also increase direct risks on household and industry for their living environment, livelihood, business and security. Even if the waiting customers are electrified without solving those existing problems, the same risks can be on them.

Similarly, the direct risks on hospitals and schools have been increased to patients, medical workers, medical equipment, healthcare environment (medical accidents), operation (finance/service expansion), students, teachers, boarding environment and security. Additionally, indirect risks on local communities which owe healthcare services and immunization to hospital's supports will also increase. Figure 3-4-1.3 shows a linkage of the risks by the existing problems of electricity supply.

In the linkage of the risks, the Project will build the primary substations and install the feeder lines to improve the blackout, voltage fluctuation and voltage depression. Then, the Project will decrease the risks on the beneficiaries, the existing customers, waiting customers, students/teachers in schools, patient/medical workers in hospitals and local communities to maintain and develop the socio-economic activities and public services.

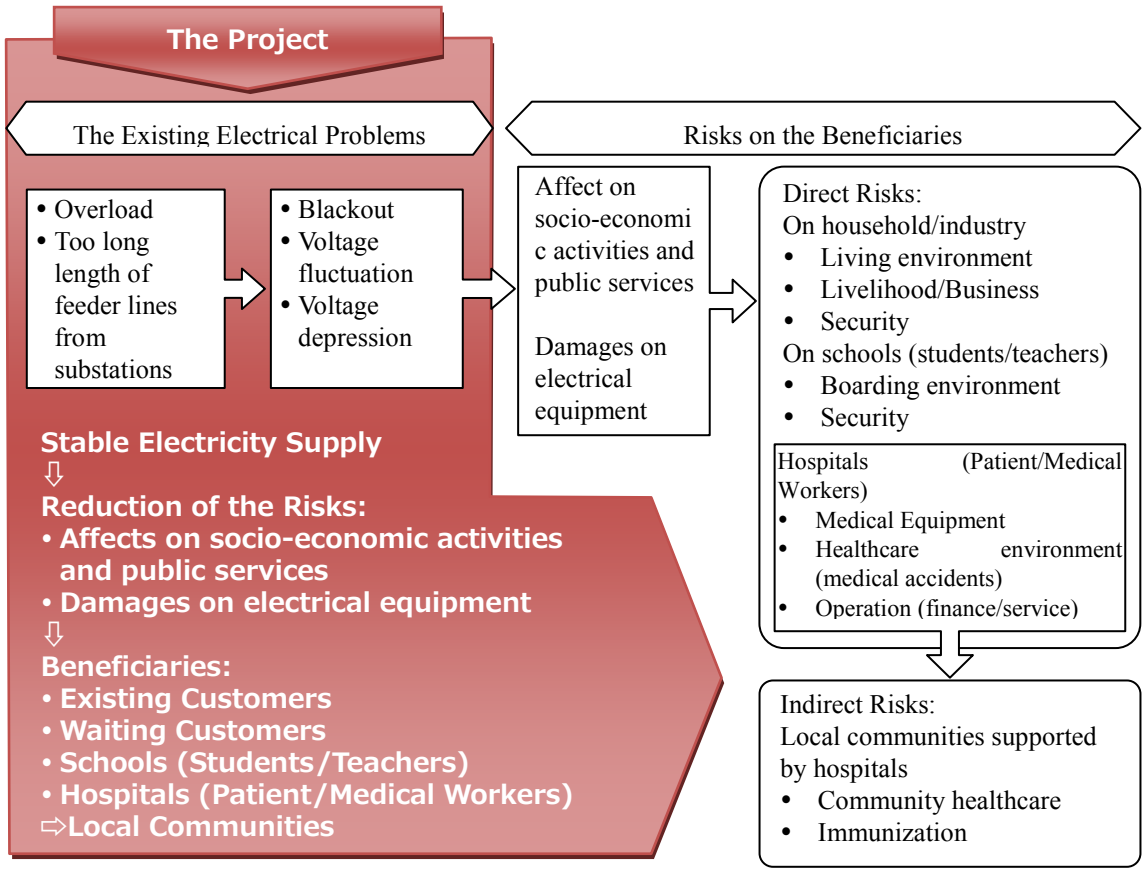


Figure 3-4-1.3 Linkage of the Existing Electrical Problems and Improvement of Risks on the Beneficiaries

(2) Urgency

Outages, voltage fluctuations and significant voltage drops are not unusual at the Project sites, adversely affecting the livelihoods as well as daily lives of local residents, industries, medical services and teaching at schools. At the Sunyani site in particular, there is the Sunyani Regional Hospital which the largest hospital in the north and which serves not only residents of the Brong-Ahafo Region (with a population of 2.26 million) but also those of nearby regions. The unstable power supply means that medical equipment can be rendered useless during operations, endangering the lives of patients. Meanwhile, there is an area at the Tamale site where small cotton factories, small agricultural equipment manufacturing factories and sawmills are concentrated to support agriculture which is the region's principal industry. The unstable power supply at this site too makes it impossible for these factories to maintain stable operation. In the light of these realities, the level of urgency of the Project is very high.

(3) Contribution to the Stable Operation of Public Welfare Facilities

The unstable power supply at the Project sites is badly affecting the operation of such public facilities as hospitals and schools. As described in (2) above, medical care at the Sunyani Regional Hospital, the largest hospital in the north, is frequently interrupted. Other problems caused by the unstable power supply include the stoppage of medical equipment during operations due to voltage drops and the frequent breakdowns of equipment using electricity,

contributing to the significant decline of the hospital's medical services. Local health centres also experience the malfunctioning of refrigerators in which medicines and vaccines are stored, sterilisers and other equipment.

There are a number of educational institutions, including universities, vocational training schools and senior high schools at the Project sites for the education of those who will become major players in Ghana's industries and economy in the coming years. However, the teaching efficiency at these institutions is adversely affected by outages and voltage fluctuations or drops which render computers and other electrical equipment useless at times. Outages at night also affect not only the work of students in dormitories but also the preparation of lessons by teachers.

As the Project will ensure a stable power supply at the Project sites, it will contribute to the operation of medical, educational and other public facilities.

(4) Operation and Maintenance Capability

Since 1989, a number of distribution work involving the voltage class planned under the Project has been conducted in Ghana under a series of five rural electrification projects with Japanese grant aid and also under the SHEP. As the specifications of the transforming and distribution equipment and systems to be procured under the Project are comparable with those of the equipment and systems procured under previous Japanese grant aid projects, the VRA-NED which will be responsible for operation and maintenance has the necessary capability to install, operate and maintain the equipment and systems in question. No special problems are, therefore, anticipated in regard to the implementation of the Project in terms of operation and maintenance.

(5) Contribution of the Project to Development Programmes in Ghana

The stable supply of higher quality power, which will be made possible by the Project, will reduce the risks posed by an unstable power supply to socioeconomic activities and public services for such beneficiaries of power supply as existing consumers, those awaiting connection, patients and staff of medical institutions, students, teachers and all other members of local communities, resulting in the beneficial effects listed below. Further expected contributions include those to the achievement of the MDGs in terms of poverty reduction, lowering of the infant mortality rate and improvement of the health of pregnant women and to "human resources development and improved productivity and employment" which are the priority targets of the GSGDA.

- Benefit for local industries and economy : improved business and operational environment for the self-employed, small factories and workplaces
- Benefit for the poor : improved learning environment for children, increased opportunities for new means of livelihood, improved living conditions and improved environment for medical services at all levels

- Benefit for infants and pregnant women : improved environment for medical services at all levels
- Benefit for students : improved learning environment at schools

As there is a master plan for the distribution sector in Ghana, addressing such issues as the renewal and expansion of the distribution system and its extension to rural areas, the Project will contribute to the improvement of the distribution system in line with this master plan which was produced by a relevant study (Power Distribution System Master Plan Study for Ghana) by the JICA.

(6) Consistency with Japanese Assistance Policy for Ghana

In the Japanese assistance policy for Ghana, "Economical Growth with reduction of poverty" was set as one of the most important goals, focused on in Ghana Poverty Reduction Strategy I/II (GPRS I/II). And, "Activation of Rural and Agricultural Area" and "Industrial Development" are set as most important subjects to achieve "Economical Growth with reduction of poverty". In addition, to achieve these subjects, such target as "Agricultural Development", Improvement of Living Level of people in poverty", "Development of Private Sector", and "Capacity Development of Industrial Sector" are described in the Japanese assistance policy for Ghana.

「Activation of Rural and Agricultural Area」	Strategic Program 1	「Agricultural Development」
	Strategic Program 2	「Improvement of Living Level of people in poverty」
「Industrial Development」	Strategic Program 3	「Development of Private Sector」
	Strategic Program 4	「Capacity Development of Industrial Sector」

3-4-2 Effectiveness

The following effects are expected as a result of the implementation of the Project.

(1) Quantitative Effects (Size of Population Directly Benefitting: 114,000)

Indicator	Reference Value (2010)	Target Value (2018)
Voltage Drop (%)	Tamale : -25% Sunyani : -37%	Tamale : -10% or less Sunyani : -10% or less
Annual Total of Outage Duration (hours/year)	Tamale : 125 Sunyani : 27	Tamale : 88 Sunyani : 19
Improvement of Electrification (households)	Tamale : - Sunyani : -	Tamale : ➢ Existing Customers: 5,084 households ➢ Waiting: 3,916 households ➢ Total: 9,000 households (Approx. 66,600 persons) Sunyani : ➢ Existing Customers: 4,577 households

		➢ Waiting: 4,380 households ➢ Total 8,957 households (Approx.47,500 persons)

(2) Qualitative Effects (Size of Population Indirectly Benefitting: 675,000)

Current Situation and Problems	Improvement Measures Under the Project	Project Effects and Degree of Improvement
< Large-Scale Medical Facility > 1. Sunyani is a main local city in which the Sunyani Regional Hospital is located for the treatment of seriously ill inpatients and outpatients from not only Brong-Ahafo Region but also from other nearby regions. There have been incidents where the emergency power generating system at the time of an outage has not properly functioned during an operation, threatening patient safety. The poor power quality (voltage drop or fluctuations) impede efficient medical treatment as precision medical equipment can be badly affected. ● Sunyani Regional Hospital This hospital is ranked fourth in the country after only the university hospitals in Accra, Kumasi and Tamale. It currently experiences outages some six times a month with a total duration of eight hours. There have been breakdowns of its medical equipment due to voltage fluctuations.	< Improvement of the Distribution System in Sunyani > Following the master plan for the distribution sector, equipment and materials for the Kotokrom Primary Substation (7.5 MVA), 34.5 kV sub-transmission lines (5 km) and 11.5 kV distribution lines (three feeders) will be procured and installed. Other items to be procured under the Project include such maintenance equipment as a cable failure point detector and aerial platform vehicle and spare parts for distribution equipment.	The implementation of the Project will improve the quality and supply reliability of power in Sunyani and the resulting avoidance of outages during operations will enable safe medical treatment. The overall medical care conditions for urgent patients and other outpatients from the local area and other regions will be greatly improved. The improved power supply will prevent failures of the X-ray and other important medical equipment and treatment based on accurate data will be consistently provided. Through such improvements, the Project will contribute to the achievement of the MDGs: "lowering of infant mortality" and "improvement of the health of pregnant women". ● Sunyani Regional Hospital <u>Patients: approx. 20,000/month</u> An exclusive feeder to the hospital will be installed under the Project and the availability of two supply sources will improve the power supply reliability. The normal use of an exclusive line will mean better power quality. <u>169 communities (with a population of some 600,000) in the service area will benefit.</u>
< Small Medical Facilities > 2. At health centres and other small medical facilities used by local residents, refrigerators to store medicines and vaccines, sterilisers and other electrical equipment play an important role in medical care. An outage means that such equipment cannot be used as well as a lack of lighting, hampering the medical care provided by these facilities.	< Improvement of the Distribution System in Tamale > Following the master plan for the distribution sector, equipment and materials for the UDS Primary Substation (7.5 MVA), 34.5 kV sub-transmission lines (19 km) and 11.5 kV distribution lines (three feeders) will be procured and installed. Other items to be procured under the Project include such maintenance equipment as a cable failure point detector and aerial platform vehicle and spare parts	The implementation of the Project will improve the power quality and supply reliability, ensuring the proper functioning of refrigerators to store medicines and vaccines, sterilisers and other medical equipment. These improvements will result in assured medical treatment at the facilities and the vaccination of children in communities. As the local patients include many infants and pregnant women, their health will be improved. The proper treatment of patients at night will also be

Current Situation and Problems	Improvement Measures Under the Project	Project Effects and Degree of Improvement
	for distribution equipment. < Improvement of the Distribution System in Sunyani > Following the master plan for the distribution sector, equipment and materials for the Kotokrom Primary Substation (7.5 MVA), 34.5 kV sub-transmission lines (5 km) and 11.5 kV distribution lines (three feeders) will be procured and installed. Other items to be procured under the Project include such maintenance equipment as a cable failure point detector and aerial platform vehicle and spare parts for distribution equipment.	possible. Through such improvements, the Project will contribute to the achievement of the MDGs: "lowering of infant mortality" and "improvement of the health of pregnant women". < Improvement of the Distribution System in Tamale > ● God Cares Community Hospital ● Tolon Health Center ● Nyamkpala Health Center Patients: 4,500/month The Project will benefit 79 communities (some 75,000 people) in the service areas of these medical facilities. < Improvement of the Distribution System in Sunyani > ● Chiraa Health Center Patients: 1,000/month
< Educational Facilities > 3. Universities, vocational schools and senior high schools for the education of those who will become major players in future industries and the economy experience poor teaching efficiency as the use of electrical equipment is often prevented by outages or voltage fluctuations or drops. Outages at night also affect not only the work of students in dormitories but also the preparation of lessons by teachers.	As above	The Project will enable the steady use of lighting systems, PCs, laboratory equipment and others, vitalising educational activities. The homework of students in the dormitories, etc. at night will not be disrupted by outages, improving their learning efficiency. With these improvements, the Project will contribute to the "achievement of universal primary education", a MDG, and educational activities at higher levels. < Improvement of the Distribution System in Tamale > ● UDS University ● Grich Computer and Secretarial School ● Tamale Technical Institute ● Bisco Senior High School ● Tolon Senior High School ● Other primary and junior high schools Students: approx. 23,000 < Improvement of the Distribution System in Sunyani > ● Sunyani Nurses' Training College ● Catholic Technical Institute ● Sunyani Business and Secretarial School ● Chiraa Senior High School ● Twene Amanfo Senior High

Current Situation and Problems	Improvement Measures Under the Project	Project Effects and Degree of Improvement
		School ● Other primary and junior high schools Students: approx. 27,000
< Local Industries > 4. Local industrial facilities at the Project sites, including sawmills, raw cotton factories, agricultural equipment manufacturing factories and corn mills, suffer from a low level of productivity due to the malfunctioning of processing equipment caused by voltage drops or equipment breakdowns due to voltage fluctuations.	As above	The Project will improve the power supply quality (fewer voltage drops or fluctuations) and the power supply reliability at the Project sites, improving the operating rate of processing equipment and thereby vitalising local industries.

(3) Calculation of the Reduction Amount of GHG Emission by the Project

1) Effect of Lower Distribution Loss on CO_2 Reduction

The reduction amount of GHG emission attributable to a lower distribution loss as a result of the Project is calculated in the following manner using the emission factors listed in Table 3-4-2.1.

① Calculation of the reduced amount of power loss (GWh/year)

② Reduction of power loss (GWh/year) x 3,600 (GJ/GWh) ÷thermal efficiency of power generating system (0.45) = reduction of calorific value (GJ/year)

③ Reduced calorific value (GJ/year) x emission constant x 44/12 = reduction amount of CO_2 emission

Table 3-4-2.1 Emission Factor by Type of Fuel

Type of Fuel	Unit Calorific Value	Emission Factor
Coal	28.9 GJ/t	0.0247 tC/GJ
Crude Oil	38.2 GJ/kl	0.0187 tC/GJ
Gas Oil	38.2 GJ/kl	0.0187 tC/GJ
Bunker A Oil	39.1 GJ/kl	0.0189 tC/GJ
Natural Gas	40.9 GJ/10^3Nm^3	0.0139 tC/GJ

Source: Ministry of the Environment and METI, "Manual for Calculation of GHG Emission Amount and Reporting", June, 2007

As of 2009, the maximum power demand and annual power consumption in Ghana is 1,423 MW and 10,116 GWh respectively. Consequently, the load factor for the power system is 81% (annual power consumption ÷ 365 days ÷ 24 hours = maximum power demand). Assuming a similar load factor, the annual power consumption at each Project site is as shown in Table 3-4-2.2.

Table 3-4-2.2 Annual Power Consumption at Each Project Site

	Maximum Power Demand (MW)	Annual Power Consumption (GWh/year)
Tamale	4.233	30.04
Sunyani	3.628	25.74

The distribution loss in the service area of the VRA-NED has been around 20% in recent years and the distribution loss at the Project sites has been a similar figure. Assuming improvement of the distribution loss by some 5% through the implementation of the Project, the CO_2 reduction calculation results based on the actual load in 2010 are as shown in Table 3-4-2.3. This calculation uses the process described earlier and also assumes a reduction of the consumption of natural gas which is a fossil fuel used for gas-combined power generation.

Table 3-4-2.3 CO_2 Reduction at the Project Sites

	Annual Power Consumption (GWh/year)	Improved Power Loss (GWh/year)	CO_2 Emission Reduction (tons)
Tamale	30.04	1.502	512.4
Sunyani	25.74	1.287	524.8
Total	55.78	2.789	1,137.2

2) CO_2 Reduction Effect of New Energy Source for Lighting

① Expenditure Reduction Effect of New Energy Source for Lighting

The monthly lighting expenditure is calculated below for the case where kerosene lamps for lighting are replaced by fluorescent lamps while assuming the continuity of the general living standard.

The interview survey conducted at the target site for improvement of the distribution system in Tamale found that unelectrified local households possess approximately two kerosene lamps and that their monthly fuel expenditure is approximately 4 ~ 8 GHc.

The Power Distribution System Master Plan Study for Ghana reported that fluorescent lamps and incandescent lamps are most popularly used by electrified households in Ghana for lighting with average use of nine hours/day. The replacement of kerosene lamps by fluorescent lamps (13 W) will result in a monthly power consumption as follows.

13 W x 2 x 9 hours/day x 30 days/month x 1/1,000 kW/W = 7.020 kWh/month

As the metered electricity charge of the VRA-NED is 0.17 GHc/kWh as of 2010, the consumption of the above amount of electric energy will result in a monthly charge of some 1.2 GHc which is approximately one-fifth of the cost of using two kerosene lamps.

7.02 kWh/month x 0.17 GHc/kWh = 1.193 GHc/month

② Effect of Change of Energy Source for Lighting on GHG Reduction

Here, the effect on GHG reduction is calculated assuming that households awaiting connection in Tamale and Sunyani are electrified under the Project and that their kerosene lamps are replaced by fluorescent lamps.

The number of households awaiting connection at the two Project sites is approximately 8,300. Assuming monthly power consumption of 7.020 kWh/month per household for lighting, the annual consumption is approximately 0.7 GWh.

7.02 kWh/month/household x 8,300 x 12 months/year = 699,192 kWh/year
= 0.6992 GWh/year

Assuming that this electric energy consumed comes from a gas combined power generation system, the annual emission volume of CO_2 is approximately 290 tons. In the following equation, the thermal efficiency of this generation system and emission factor for natural gas are assumed to be 45% and 0.0139 Ct/GJ respectively.

0.6992 GWh/year x 3,600 GJ/GWh ÷ 0.45 x 0.0139 Ct/GJ x 44/12 CO_2 t/Ct
= 285.1 CO_2 t/year

Given the monthly expenditure of 4 ~ 8 GHc per household using kerosene lamps to cover the fuel cost, an average monthly expenditure of 6 GHc for fuel is assumed. As of 2010, the unit cost of kerosene in Accra is some 1.5 GHc/litre. The total annual consumption of kerosene by those awaiting connection is approximately 400 kl.

6 GHc/month/household ÷ 1.5 GHc/l x 12 months/year x 8,300 households x 1/1,000 kl/l = 398.4 kl

The volume of CO_2 emission from the burning of this amount of fossil fuel is approximately 900 tons as calculated below, meaning that the use of electricity as the energy source for lighting reduces the CO_2 emission by some 700 tons a year. For this calculation, the unit calorific value and emission factor of kerosene are assumed to be 36.7 GJ/kl and 0.0139 Ct/GJ respectively.

398.4 kl x 36.7 GJ/kl x 0.0185 Ct/GJ x 44/12 CO_2 t/Ct = 991.8 CO_2 t/year