PREPARATORY SURVEY
ON
THE PROJECT FOR REINFORCEMENT OF POWER SUPPLY
TO ACCRA CENTRAL
IN
THE REPUBLIC OF GHANA

FIELD REPORT

11th FEBUARY 2014

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Contents

1. Outline of the Project

1.1 Background of the Project

In response to the request from the Government of the Republic of Ghana (Ghana), the Japan International Cooperation Agency (JICA), in consultation with the Government of Japan, decided to conduct a Preparatory Survey (the Survey) on the Project for Reinforcement of Power Supply to Accra Central (the Project).

JICA sent to Ghana the Preparatory Survey Team (the Team) headed by Mr. Fuyuki Sagara, Advisor, Energy and Mining Division 1, Industrial Development and Public Policy Department, JICA, to conduct the first field survey and the Team is scheduled to stay in the country from 12th January to 17th February, 2014.

The Team continued discussions with the concerned officials of Ghana and the field survey in Ghana in consideration of mutual understandings made on the minuets of discussions signed between the Ministry of Energy and Petroleum (MoEP), Ministry of Finance (MoF), Ghana Grid Company Limited (GRIDCo), Electricity Company of Ghana (ECG) on 23rd January, 2014.

GRIDCo, ECG and the Team had series of technical discussions to form mutual understandings about the contents, scope, preconditions for the Outline Design, basic specifications, general layouts, and so on of the Project in the first field survey. GRIDCo, ECG and the Team agreed to record the following issues described on this Field Report as a conclusion of the discussions.

Components of the Project will be further examined and may be modified through the consultation with the Japanese Ministry of Foreign Affairs and JICA headquarters. It is important for the Ghana side to understand that the Preparatory Survey is not a commitment for the future implementation of the Project.

Particularly, in consideration of the schedule and procedures of Japan's Grant Aid projects, the Team explained that the outline design, planning of the implementation schedule, the cost estimation and so on of the Project will be carried out in accordance with the mutual understandings made on this field report immediately after the first field survey. GRIDCo and ECG expressed understanding about the schedule and procedures of Japan's Grant Aid projects. GRIDCo and ECG agreed for the Team to progress the further study, the outline design, planning of the implementation schedule, the cost estimation and so on of the Project in accordance with the mutual understandings made on this field report immediately after the first field survey.

1.2 Framework for the Project

The framework for the Project is shown as follows.

(1) The responsible ministry is the Ministry of Energy and Petroleum (MoEP).
(2) The implementing agency is Ghana Grid Company Limited (GRIDCo).
(3) The relevant organization is Electricity Company of Ghana Limited (ECG).

1.3 The Scope of the Japanese side on Minutes of Discussions on 23rd January, 2014

The Scope of the Japanese side on Minutes of Discussions on 23rd January, 2014 is shown in Table 1.3-1 and Figure 1.3-1.

Three (3) sets of 161/34.5 kV transformers (125 MVA, Outdoor type) shall be installed as the scope of the Japanese side. The fourth units of a transformer and the GISs for the transformer will be procured and installed by the Ghana side in the future.

Table 1.3-1 Outline of the Final Components

Components		Capacity
Procurement and Installation Work		
1. Accra Central BSP		
(1) 161 / 34.5 kV Transformers (ODAF, Outdoor, Metal Enclosure Type)		125 MVA × 3units
(2) 161 kV Gas Insulated Switchgears (GIS)		
1) Incoming Feeders	(Outdoor Type)	2 sets
2) Transformers Feeders	(Outdoor Type)	3 sets
3) Bus Coupler	(Outdoor Type)	1 set
4) Bus System (Double Bus Type)	(Outdoor Type)	1 set
5) Voltage Transformers	(Outdoor Type)	2 set
(3) 33 kV GISs (Double Bus Type)		
1) 125 MVA Transformer bays	(Indoor Type)	3 sets
2) 33/11 kV Transformer bays	(Indoor Type)	3 sets
3) 33 kV Feeder bays	(Indoor Type)	14 sets
4) Bus Coupler bay	(Indoor Type)	2 sets
5) Bus Section bays	(Indoor Type)	1 set
6) Station Transformer bays	(Indoor Type)	3 sets
7) Earthing Transformer bays	(Indoor Type)	2 sets
(4) SCADA Interface Panel		1 set
2. 161kV Transmission Line from the Avenor Branch Point to Accra Central BSP (1 Circuit for Achimota Line and 1 circuit for Mallam Line)		
(1) 161 kV Overhead Line (ACSR, TERN, twin bundle or equivalent)		Approx. 3 km
(2) 161 kV Underground Cable (XLPE Cable, Copper, 1,600 mm^2)		Approx. 0.4 km
Procurement Work		
3. Underground cable for 33 kV Sub transmission Line between Station D and Station E for the decommissioning part (XLPE, Al, 630 mm^2, 3 cores or equivalent)		Approx. 6 km × 2 Circuits
4. Maintenance Tools for the Equipment of the Project		1 lot
5. Spare Parts for the Equipment of the Project		1 lot
Construction Work		
6. Foundation for the Equipment of the Project (Gas Insulated Switchgears, Transformers, Towers for 161 kV Transmission Line)		1 lot
7. Building for a control room of Accra Central BSP		1 building

[Remark] Quantities shall be examined in the outline design.

Figure 1.3-1 Location of the Requested Components

1.4 Obligations/Undertakings of the Ghana side for the Project

(1) Preconditions

- GRIDCo shall obtain an Environmental Permit (EP) from the Environmental Protection Agency (EPA) by July, 2014 after implementation of Environmental and Social Impact Assessment (ESIA) and submitting Environmental Impact Statement (EIS) in timely manner.
- GRIDCo (ECG) shall secure the land for the Project on entire 161 kV transmission line route, and show the evidences, especially for the 15 meters ROW that ECG owns on the existing 33 kV line between Avenor branch point and Graphic Road Primary Substation.
- GRIDCo (ECG) shall secure the land for the installation of 33 kV sub-transmission underground cables procured by the Japanese side between Avenor Primary Substation and Graphic Road Primary Substation with using utility space which can minimize any adverse impacts on the occupants and structures on the route, and show the evidences.

(2) Necessary Inputs by the Ghana side

1) Prior to the Commencement of the Construction Work

- GRIDCo (ECG) shall decommission and remove the existing equipment, facilities, materials and so on (cable culvert, Ring Main Unit, capacitor banks, 33 kV terminal poles, and so on) at Graphic Road Primary Substation which obstruct the installation of the

equipment and materials of the Project before commencement of installation work by the Japanese side.

- GRIDCo (ECG) shall decommission and remove the existing towers of 33 kV sub-transmission line between Avenor Primary Substation and Graphic Road Primary Substaion, including their foundations, along the route for 161 kV transmission line of the Project before commencement of the installation work covered by the Japanese side.
- GRIDCo (ECG) shall obtain permission from related authorities for 161 kV transmission lines and 33 kV sub-transmission lines to go across the roads and a railway before commencement of installation work by the Japanese side.
- GRIDCo (ECG) shall procure and supply to the Japanese side total 6 units (3 units for GRIDCo and 3 units for ECG) of energy meters for transaction.
- GRIDCo (ECG) shall resettle occupants in accordance with the resettlement plan prepared at the stage of the survey in smooth manner, if necessary.

2) During the Construction Work

- GRIDCo shall complete upgrading work of 161 kV transmission lines between Achimota BSP and Mallam BSP, which have enough capacity to supply power to Accra Central BSP of the Project, before commencement of installation work of 161 kV transmission lines of the Project by the Japanese side. In addition, GRIDCO shall procure and install a termination pole (Pole Number "N0") for connection with the 161 kV transmission lines provided by the Japanese side. (See DWG No.-T01)
- GRIDCo (ECG) shall schedule power outages required for installation work of the Project and carry out them in timely manner. GRIDCo (ECG) shall also manage any issue concerning the power outages, including related procedures, and compensation to and grievances from customers.
- After arrangement of temporary work by himself, GRIDCo (ECG) shall implement the scheduled power outages and, decommission and remove 6 units in total 14 units of the existing 33 kV switchgears from the western side prior to installation of 15 units in total 28 units of 33 kV switchgears of the Project by the Japanese side at Graphic Road Primary Substation. (See Figure 2.1.1-2)

  GRIDCo (ECG) shall keep the above mentioned temporary conditions until completion of installation of these 33 kV switchgears of the Project by the Japanese side.

  In the same manner, GRIDCo (ECG) shall implement the scheduled power outage and shall decommission and remove remaining 8 units of the existing 33 kV switchgears prior to installation of remaining 13 units of 33 kV switchgears of the Project by the Japanese side.

GRIDCo (ECG) shall also prepare new floor openings for the new 33 kV switchgears. The more detail arrangement shall be discussed between the related parties at the implementation stage.

- GRIDCo (ECG) shall secure a temporary storage yard (Approx. 5,000 m2) for the Project within the lot of ECG Project Office. The Ghana side shall also prepare an access point at ECG Project Office, where construction vehicles go through to the route of 161 kV transmission line of the Project along the railway for their installation.
- GRIDCo (ECG) shall obtain permit for the Japanese side to enter the business establishments where the 161 kV towers of the Project will be located and to carry out installation work of the Project.
- GRIDCo (ECG) shall install 33 kV underground cables to be procured by the Japanese side for the section between Avenor Primary Station and Graphic Road Primary Substation, immediately after the cables are delivered to the Project site.
- GRIDCo (ECG) shall monitor impact to the neighboring people around construction sites of the Project and improve the construction activities, if necessary.

3) After the Commencement of Operation

- With applying the materials for the final connection work procured by the Japanese side, GRIDCo shall carry out the final connection work between the termination pole (Pole Number "N0") procured and installed by GRIDCo in the upgrading work of 161 kV transmission lines between Achimota BSP and Mallam BSP, and the termination pole done by the Japanese side. (See DWG No. T-01)
- GRIDCo (ECG) shall carry out the final connection work between the SCADA interface panel procured and installed by the Japanese side and the existing SCADA network at Accra Central BSP with providing equipment and material by himself. (See Figure 2.1.1-3) Japanese engineers shall be present at the time of commissioning of the SCADA system.
- GRIDCo shall carry out the final connection work of optical fiber cables at the terminal box procured and installed by the Japanese side beside the termination pole (Pole Number "N1") procured and installed by the Japanese with providing equipment and material by himself. (See DWG No. T-01)
- GRIDCo (ECG) shall recover or modify the existing fences and gates at Graphic Road Primary Substation in accordance with the layout and arrangement of the equipment and facilities of the Project.
- GRIDCo (ECG) shall provide the setting list of the protection relays to the Japanese side.

2. Technical requirements confirmed in the first field survey

2.1.1 Technical requirements for the equipment of the substation of the Project

(1) Applicable Codes and Standards

The equipment of Accra Central BSP and Graphic Road Primary Substation shall be designed in accordance with IEC, JEC standards and/or equivalent.

(2) Basic Concept for the Substations

The following basic concept is applied for Accra Central BSP Substation.

1) Noise

The Ghana side explains to the Team that Area around Graphic Road Primary Substation is classified as "Light industrial area" and its noise emission shall be in consistency with the following table.

Table 2.1.1.-1 Noise limitation of light industrial area;

Time	Noise Level
Daytime (06:00 – 22:00)	Less than 65 dB
Nighttime (22:00 – 06:00)	Less than 60 dB

[Note] According to NEMA guideline for reference, the standard noise of this capacity size of transformer is around 85 dB

In order to maintain the severe noise limitation around the substation, the Team proposed introduction of "Steel Enclosure Type" of transformers. GRIDCo agreed to introduce the type to be in consistency with the above mentioned criteria. This steal enclosure equips with a function of firewalls. The Steel Enclosure Rough Dimension is shown as Figure 2.1.1-1.

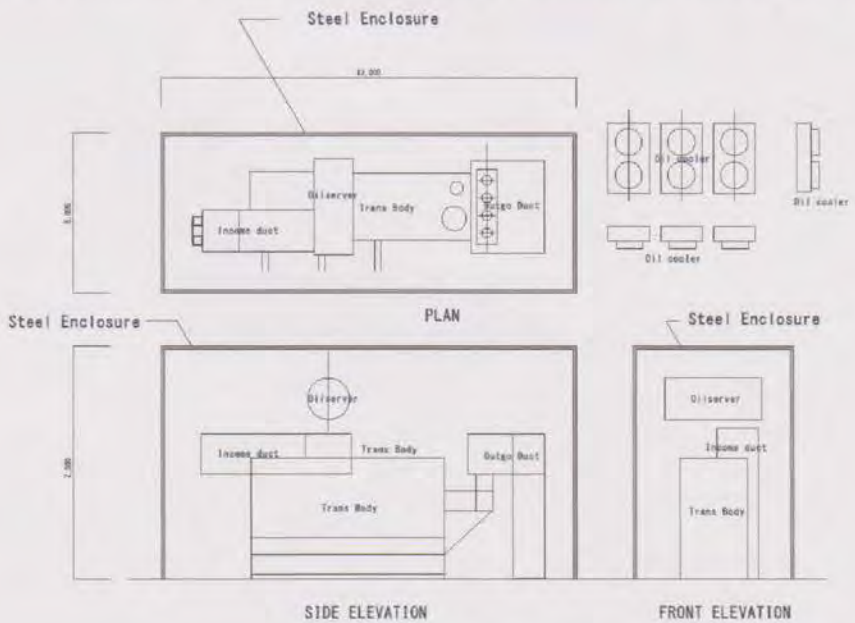


Figure 2.1.1-1: Steel Enclosure Rough Dimension

Due to the "Steel Enclosure", air insulated bushing connections cannot be applied. The connection of the transformers shall be made by "Elephant" type connection (cable box type connection).

2) Replacement work for 33 kV switchgears at Graphic Road Primary Substations

33 kV GISs shall be installed at existing 33 kV Switchgear room of Graphic Road Primary Substations. The replacement of the switchgear should be carried out in consideration of minimizing duration of scheduled power outage. Detailed procedure of the replacement of the 33 kV switchgears is shown in the following figure.

The steel structures under the new switchgears might be installed to raise the switchgear to the level of approx. 1.0 m from the floor level and to secure space for smooth cable connection without cutting the existing beams of the building. The detail design shall be carried out at the implementation stage.

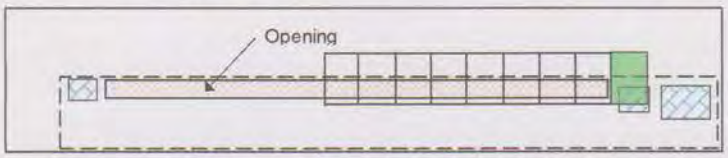
In addition, GRIDCo (ECG) and the Team agreed that the cable to Earthing transformers should be through one of the windows near the Earthing transformer of the existing building. See DWG. No. E-02.

Stage 0

ECG installs "Additional panel (called No.16)" for temporary power supply, before commencement of JICA Project.
ECG requires the three (3) month prior notice before the commencement of JICA Project.

Stage 1

Panel No. 2 to 7 should be removed by ECG. Continuous power supply for removed panels should be done by ECG, using temporary power supply panel, and/or temporary bypass circuit by the other substations.
Additional floor openings are made by ECG, in accordance with information by Japanese side.

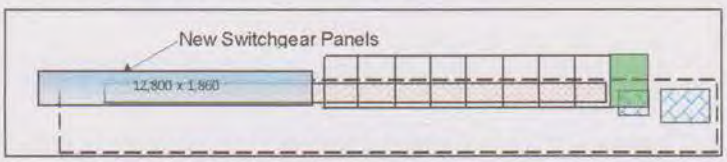


Existing Panel Name

No.	NAME
2	OKASHIE-2
3	OKASHIE-1
4	AVENOR-II
5	(Not in use)
6	(None)
7	Measuring
8	Bus Coupler
9	TR. T31
10	ADABRAKA
11	CATHADRAL
12	TR. T32
13	KOTOBABI
14	AVENOR-II
15	LARTEBIOKOSHIE

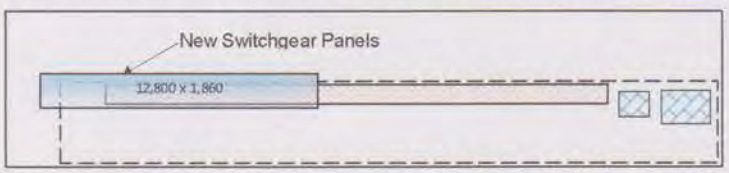
Stage 2

15 panels of New 33 kV Switchgear should be installed by Japanese side, and energized after the installation.
The channel base of the new switchgear might be raised from the floor level, due to the location of the existing floor openings.



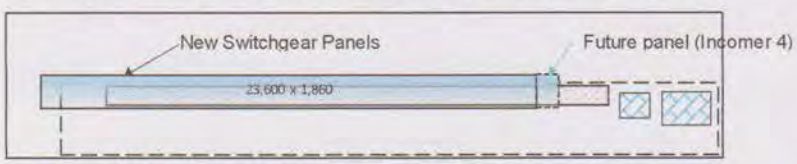
Stage 3

Remaining existing Panel No. 8 to 16 should be removed by ECG. Temporary power supply for removed panels are conducted by ECG, as same as Stage 1 above.
Additional floor openings are made by ECG, in accordance with information by Japanese side.



Stage 4

Remaining new switchgears should be installed by Japanese side, then completed.



Note;
1) Since the above work may continue for several months, ECG is required to supply power to his customers during the works.
2) The size of the new 33 kV Switchgear panels may change depending on different manufacturers.
3) The detailed schedule such as duration of the works should be discussed at the stage of the implementation.

[Note] The panel arrangement of 33 kV Switchgear may change due to locations of the floor openings.

Figure 2.1.1-2 Replacement work for 33 kV switchgears

3) Interface of SCADA system

Interface panels (terminal boards) for SCADA system are installed in the new control building for the GRIDCo's system and in the existing control room for the ECG's system.

The connection works at the interface panels should be done by GRIDCo and ECG, respectively. Detailed work demarcation is shown in the following figure.

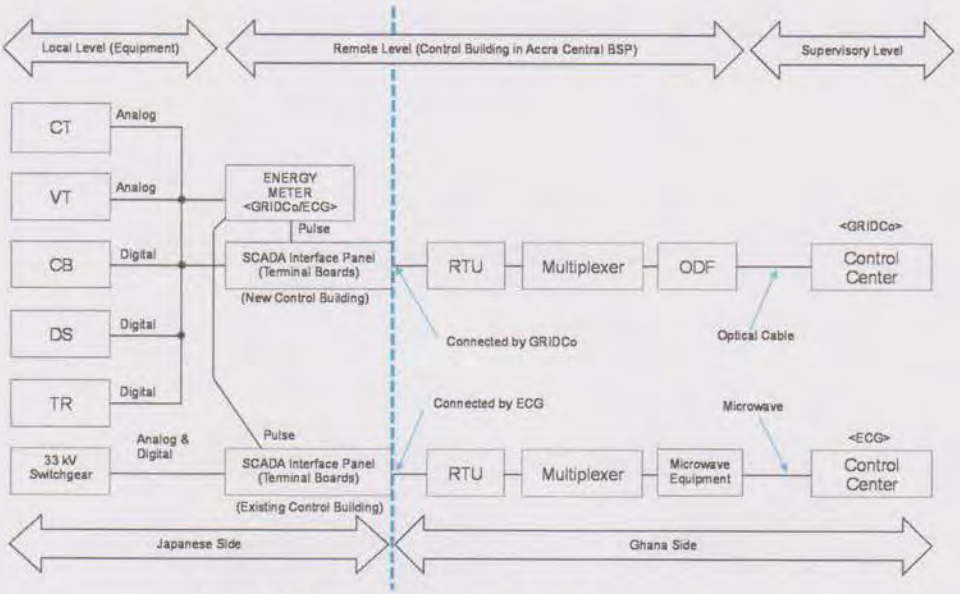


Fig. 2.1.1-3 Interface of SCADA system

(3) Requirements for the equipment of the substations

The specifications of the Equipment procured by the Japanese side are shown in Table 2.1.1-2 and Table 2.1.1-3. Single Line Diagram for the equipment is shown in DWG No. E-01.

Table 2.1.1-2 Equipment to be supplied for Accra Central BSP Substation by the Japanese side

No.	Description	Specifications	Q'ty
AC1	161/34.5 kV Transformer		3 sets
	➢ Capacity	125 MVA	
	➢ Primary voltage	161 kV	
	➢ Voltage regulating range	161 kV +/- 10%	
	➢ Steps (taps)	+/- 8 steps (17 taps)	
	➢ Secondary voltage	34.5 kV	
	➢ Cooling	ODAF	
	➢ Vector group	YNd11	
	➢ % impedance	13%	
	➢ Rated basic impulse withstand voltage	161 kV: 650 kV (Bushings: 750 kV) 34.5 kV: 170 kV	
	➢ Rated power frequency withstand voltage (1 min.)	161 kV: 325 kV 34.5 kV: 70 kV	
	➢ Bushing CT	161 kV line: 3 CTs 161 kV neutral: 1CT 34.5 kV line: 3 CTs	
	➢ Neutral earthing	161 kV : Solidly earthing system 34.5 kV: earthing transformers	
	➢ Connection	161 kV side: Cable connection (1 x 400 mm^2/phase) 34.5 kV side: Cable connection (2 x 800 mm^2/phase)	
	➢ Noise	Special consideration is made on the transformers in order to maintain the noise limitation around the substation.	
	➢ Others	- Fire walls between transformers are not necessary since the transformer is enclosed by "Steel	

No.	Description	Specifications	Q'ty
		Enclosure" and there is no exposed conductors on Transformers. - Future space for No.4 Transformer is considered.	
AC2	161 kV SF_6 Gas Insulated Switchgears		1 lot
	➢ Standards	IEC, JEC or equivalent	
	➢ Busbar configuration	Double Busbar system	
	➢ Quantity	Feeder bays : 2 bays Transformer bays : 3 bays Bus Coupler bay : 1 bay VT bay : 1 bay	
	➢ Rated voltage	170 kV	
	➢ Rated current	Busbar: more than 3,150 A Bus coupler: more than 3,150 A Feeder: more than 2,000 A Transformer: more than 800 A	
	➢ Rated interrupting current	31.5 kA	
	➢ Rated short-time withstand current (short time)	31.5 kA (3 sec.)	
	➢ Rated basic impulse withstand voltage	750 kV	
	➢ Rated power frequency withstand voltage (1 min.)	325 kV	
	➢ Circuit Breaker		
	- Auto-reclosing	Yes	
	- Operating sequence	O-0.3 sec.-CO-3 min.-CO (Three phase)	
	➢ Current Transformer		
	- Feeder bays	4 CTs	
	- Transformer bays	None	
	- Coupler bay	2 CTs	
	- Secondary current	1 A or 5 A, both can be accepted.	
	➢ Voltage Transformer	161/√3 kV/115/√3 V	
	➢ Others		
	-Future bays for 161 kV feeders	- Future space for 1 x spare feeder bay and 1 x spare transformer feeder bay is considered.	
	-Lightning Arresters (LA) for Transformer bays	- LAs are supplied for Transformer bays.	
AC3	161 kV XLPE Cable		*200 m
	➢ Circuit	Primary circuit of 125 MVA Transformer	
	➢ Type	XLPE	
	➢ No. of core	Single core	
	➢ Cross section	*400 mm^2 [*Note] Size and length is subject to change.	
AC4 -1	Control and Protection Control and Protection Panel		1 lot
	➢ Type of Control and Protection panel	Duplex type panel	
	➢ Panel arrangement	Front of panel: 161 kV Switchgear Control and 125 MVA Transformer voltage regulating control with mimic bus, control switches, meters, alarms and other control devices Rear of panel: 161 kV Protection relays	
	➢ Standard Protection system (recommended)		
	- 161 kV Transmission line protection	Main: Directional Phase Comparison Relay Back-up: Distance Relay (Over reach/Under reach) Intertripping scheme should be applied.	
	- 161/34.5 kV Transformer protection	Transformer Differential Relay/Overcurrent Relay	
	- 161 kV Busbar protection	Current Differential Relay	
	- Other 161 kV protection system	Breaker Failure Protection shall be applied.	

No.	Description	Specifications	Q'ty
-2	Energy Meter Panel	A panel with three (3) sets of Energy meters (one (1) set for future space) is provided at Control Room (2) in the new Control building. See DWG. No. E-01.	1 panel
-3	Interface Panel for SCADA System of GRIDCo	Interface terminals for Digital I/O, Analogue I/O and Pulse signals are provided for RTU of SCADA system in the Control building.	1 panel
AC5	Others		
-1	DC Power Supply System		1 lot
	➢ DC Voltage	125 V DC	
	➢ Battery Capacity	To be advised later.	
-2	AC Power Supply System		1 lot
	➢ AC Voltage	415/240 V AC (Three phases and four wires)	
	➢ Station Service Transformer	Capacity: 200 kVA (Tentative) (2 sets) Final capacity will be informed later. AC distribution panel (1 panel) is included.	
-3	Substation Earthing	Earthing conductors, terminals, lightning rods and other necessary materials are provided.	1 lot

Table 2.1.1-3 Equipment to be supplied for Graphic Road Primary Substation by the Japanese side

No.	Description	Specifications	Q'ty
GR1	34.5 kV Switchgears		28 panels
	➢ Standards	IEC	
	➢ Quantity	Following bays are provided. Control, metering and protection relays are mounted on the respective Switchgear. - 3 x 125 MVA Transformer bays - 3 x 33/11 kV Transformer bays - 14 x 33 kV Feeder bays - 2 x Bus Coupler bay - 1 x Bus Section bays - 3 x Station Transformer bays - 2 x Earthing Transformer bays Future space for 1 x 125 MVA Transformer bay is considered.	
	➢ Rated voltage	36 kV	
	➢ Rated current	Busbar: 2,500 A Bus coupler: 2,500 A Bus Section: 2,500 A Feeder: 1,250 A 161/34.5 kV Transformer: 2,500 A 33/11 kV Transformer: 630 A	
	➢ Rated interrupting current	40 kA	
	➢ Rated short-time withstand current (short time)	40 kA (3 sec.)	
	➢ Rated basic impulse withstand voltage	170 kV	
	➢ Rated power frequency withstand voltage (1 min.)	70 kV	
	➢ Circuit Breaker		
	- Auto-reclosing	Yes	
	- Operating sequence	O-0.3 sec.-CO-3 min.-CO (Three phase)	
	➢ Current Transformer		
	- Secondary current	5 A	
	➢ Voltage Transformer	33/√3 kV/110/√3 V	
	➢ Protection relays	Numerical relays should be applied.	
	➢ Standard Protection system (scheme)		
	- 33 kV Incomer (161/34.5 kV Transformer) protection	67/50/51, 67/50/51N	

No.	Description	Specifications	Q'ty
	- 33 kV Feeder Protection - 33 kV Bus Coupler Protection - 33 kV Bus Section Protection - 33/11 kV Transformer Protection	67/50/51, 67/50/51N, 21, 27DC, 79 50/51, 50/51N, 86, 95 50/51, 50/51N 50/51, 50/51N, 87	
GR2	33 kV XLPE Cable		
-1	Secondary circuits of 125 MVA Trans- former		*600 m
	➢ Type	XLPE	
	➢ No. of core	Single core	
	➢ Cross section	*800 mm^2, copper	
	➢ No. per phase	3 cables per phase	
-2	Station Service Transformer		*400 m
	➢ Type	XLPE	
	➢ No. of core	Three core	
	➢ Cross section	*240 mm^2 copper	
-3	Earthing Transformer		*300 m
	➢ Type	XLPE	
	➢ No. of core	Single core	
	➢ Cross section	500 mm^2 copper	
	➢ No. per phase	1 cable per phase	
		[Note] - *Size and length is subject to change. - ECG agreed that the cable route of Earthing transformers is through one of the windows near the Earthing transformer of the existing building. See DWG. No. E-02.	
GR3	Control		
-1	Energy Meter Panel	A panel with three (3) sets of Energy meters (one (1) set for future space) is provided in existing building. See DWG. No. E-01 and E-02.	1 panel
-2	Interface Panel for SCADA System of ECG	Interface panel is provided for SCADA system at the next to existing SCADA panels in existing building.	1 panel
GR4	Others		
-1	DC Supply System	110 V DC Batteries and charger is provided at existing Battery room.	1 lot
	➢ DC Voltage	110 V DC	
	➢ Battery Capacity	500 Ah (Tentative)	
-2	Earthing Transformer		2 sets
	➢ Voltage	33 kV	
	➢ Capacity	19.4 Ω 1060 A per phase	

2.1.2 Technical requirements for the facilities of the substation of the Project

(1) Design Conditions for the Substation Facilities

The design conditions for the substation Facilities are shown in the following Table 2.1.2-1.

Table 2.1.2-1 Basic Conditions for the Facility Design of the Project

Items		Values
Altitude		Less than 10 m
Ambient Temperature	Maximum	40 Degrees Centigrade
	Minimum	17 Degrees Centigrade
	Mean	31 Degrees Centigrade
Maximum Wind Velocity		34 m/s
Annual Rain Fall		806.8 mm/year
Seismic Force		Horizontal 0.1G
Soil Bearing Capacity		5 t/m^2

(2) Requirements for the Substation Facilities

1) Outline of Control Building

The Outline of Control Building is shown in Table 2.1.2-2.

Table 2.1.2-2 Outline of the Control Building

Items	Contents	Details
Structure	Reinforced Concrete Frame Structure	-
Height of story	4 stories	BF: Cable Maintenance Pit GF: Control Room (1), Control Office (1), Entrance, Toilet 1F: Control Room (2), Battery Room, Shower 2F: Control Room (3), Control Office (2), Toilet RF: 2 units of 200 kVA transformer, Air-conditioning Units with Sound Proofing Wall
Total Floor Area	Approx. 440 m^2	-
Building Area	Approx. 100 m^2	-
Exterior	Wall Finishing	Concrete with Urethane Paint
	Roof Finishing	Concrete Plate t=100 wire-mesh @200 Urethane joint @2000 each Insulation t=100 Asphalt Membrane 3 Layer Water Proofing
Interior	Wall Finishing	Paint on Mortar iron trowel
	Floor Finishing	Free Access Floor h=300mm Ceramic Tile 450*450, 300*300
	Ceiling	System Ceiling with Gypsum Board t=12mm Paint Finishing

2) Foundations of 161/34.5 kV transformers

The Outline of the Foundations of 161/34.5 kV transformers is shown in Table 2.1.2-3.

Table 2.1.2-3 Outline of the Foundations of 161/34.5 kV transformers

Items	Contents	Details
Structure	Reinforced Concrete Wall Structure	-
Height of story	1 story	BF: Cable Culvert (2), (3), Mechanical Pit, Oil Pit 1F: 3 units of 125 MVA transformer (Steel Enclosure) and one Future Space, Oil Cooler Rack for them and future expansion [Note] For the equipment to avoid submerging to water on heavy rainy days, the floor level of the foundations shall be 1.5 m- raised from the ground level.
Total Floor Area	Approx. 370 m^2	-
Building Area	Approx. 430 m^2	-

3) Foundations of GISs

The Outline of the Foundations of GISs is shown in Table 2.1.2-4.

Table 2.1.2-4 Outline of the Foundations of GISs

Items	Contents	Details
Structure	Reinforced Concrete Wall Structure	-
Height of story	1 story	BF: Cable Pit for 161 kV cable (6) and Future Space for (3) cable 1F: GIS and Future Space [Note] For the equipment to avoid submerging to water on heavy rainy days, the floor level of the foundations shall be 1.5 m- raised from the ground level.
Total Floor Area	Approx. 140 m^2	-
Building Area	Approx. 180 m^2	-

4) Cable Culvert

The Outline of the Cable Culvert is shown in Table 2.1.2-5.

Table 2.1.2-5 Outline of the Foundations of GISs

Items	Contents
Cable Culvert (1) from GISs to 125 MVA transformers	Reinforced Concrete Box Culvert Approx. 30 m^2 (W=2.2 m, H=1.4 m with Cable Rack)
Cable Culvert (4): from 125 MVA transformers to Existing ECG Building	Reinforced Concrete Box Culvert Approx. 70 m^2 (W=1.7 m, H=3.0 m with Cable Rack)
Cable Culvert (5): from Gate A to Existing ECG Building	Reinforced Concrete Box Culvert Approx. 35 m^2 (W=1.7 m, H=3.0 m with Cable Rack)

The size of each Cable Culvert is as follows. Cable Culvert (2) is for smooth cable installation to each transformer. Cable Culvert (3) is for smooth cabling from each transformer.

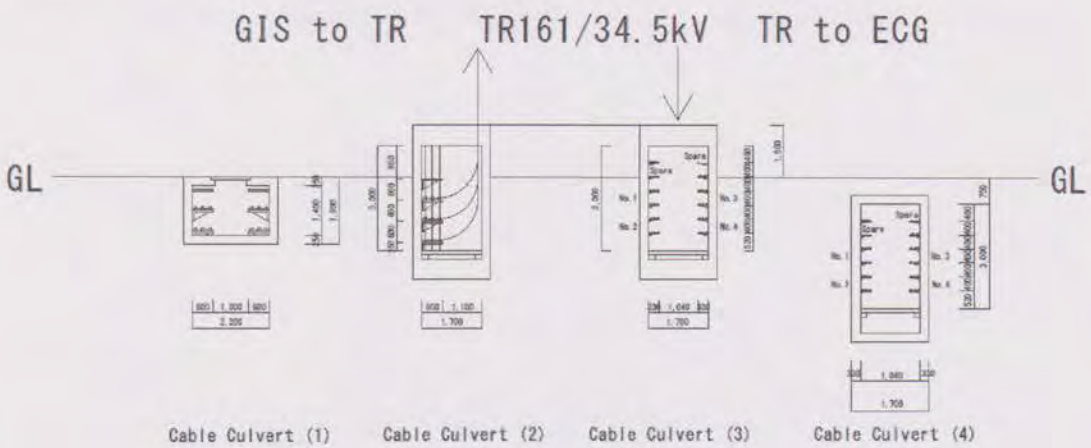


Figure 2.1.1-4 Cable Culvert required Dimension

2.2 Basic Concept for 161 kV Transmission Line and 33 kV Sub-Transmission Line

161 kV transmission line between Avenor Branch Point and Accra Central BSP shall be installed as shown in DWG. No. T-01. Requirements for the transmission lines shall be as follows.

The underground cables for 161 kV transmission lines shall be protected in conduit pipe at the parts across roads and a rail way. The laying depth shall be 1.3 m from the ground level.

(1) Design Conditions for 161 kV Transmission Line

Natural Conditions and Electrical Conditions are shown in Table 2.2-1 and Table 2.2-2, respectively.

Table 2.2-1 Natural Conditions

Items	Design Values
Altitude	Less than 50 m
Conductor temperature	-
Minimum temperature	10 degree C
Everyday temperature	28 degree C
Maximum temperature	80 degree C
Wind speed	31.1 m/s
Seismic force	Not considered
Soil bearing capacity	5 ton/m^2 (depend on boring survey)

Table 2.2-2 Electrical Conditions

Items	Design Values
Minimum clearance of conductor	-
Phase to ground	1,500 mm
Phase to phase	3,000 mm
Height of conductor (See Note 1)	-
General area (m)	7.5 m
Waterway (m)	7.5 m
Road crossing (m)	8.5 m
Shield angle (OPGW and conductor)	15 degree
Minimum creepage distance of insulator (See Note 2)	25 mm/kV
Equivalent salt deposit density	0.25 mg/cm^2

[Notes]

1. The minimum clearance of conductor shall be designed at conductor temperature of 65 degree C.
2. The minimum creepage distance shall be designed "Pollution Level III Heavy" in the following table.

(2) Requirements for 161 kV Transmission Line

Specifications for 161 kV Transmission Line are shown in Table 2.2-3.

Table 2.2-3 Specifications for 161 kV Transmission Line

No.	Items	Specifications		Q'ty
TL1	➢ Tower	Style of tower:	Steel lattice type	
		Configuration of tower:	Narrow base type See DWG. No. T-02	
		Type of tower:	Suspension type (Angle: 0-2 degree), Tension type (Angle: 0-20 degree), Termination tower (Angle: 0-20 degree)	7 towers 10 towers 1 tower

No.	Items	Specifications	Q'ty
		Safety factor: 1.1 for suspension towers 1.2 for tension towers Grounding resistance: less than 10 ohms. [Note] Broken wire condition shall be two ACSR conductors or one conductor and one shield wire.	
TL2	➢ Overhead Line (Conductor)	Type: ACSR Size TERN (Aluminum: 402.8 mm2, total: 430 mm2)	38.0 km
TL3	➢ Insulator	Standards: IEC60383-1 or equivalent Size: 254 mm suspension insulators Creepage distance: 320 mm Material: Porcelain Color: Brown Ball and socket coupling: 16mm Dry lightning impulse withstand voltage: one unit 110 kV Wet power-frequency withstand voltage: one unit 40 kV Electro-mechanical falling load: 120 kN Number of insulators shall be 17 units/phase	1 lot
TL4	➢ Shield Wire and Optical Cable	Type: OPGW Number of Core: 48 cores Type of optical fiber cable: Type G655 or equivalent The shielding angle: less than 15 degree.	6.8 km 1.4 km
TL5	➢ 161 kV Underground Cable	Type: XLPE Size: 1,600 mm^2 Conductor: Copper Number of core: Single Core Type of sheath: PVC with anti-termite protection Color of sheath: Black Armor: Aluminum armor for direct buried in the ground	3.8 km

(3) Basic Concept for 33 kV Sub-Transmission Line

Specifications for 33 kV transmission Line are shown in Table 2.2-4.

Table 2.2-4 Specifications for 33 kV Underground Cables

No.	Items	Specifications	Q'ty
DL1	➢ 33 kV Underground Cable	Type: XLPE Size: 630 mm^2 Conductor: Aluminum Number of core: Single Core Type of sheath: PVC with anti-termite protection Color of sheath: Blue Armor: Aluminum wire armor for direct buried in the ground	48 km (3.6 km x 3 phases x 2 cables / phase x 2 circuits × 110%)

2.3 Procurement Plan of Spare Parts and Maintenance Tools

Capability of sustainable operation and maintenance for the equipment of the Project by the

Recipient is one of conditions for the Japan's Grant Aid. The Ghana side shall keep operation and maintenance for the equipment of the Project properly by himself, including procurement of spare parts. On the other hand, the warranty period for the Project is 1 year after insurance of the completion certificate in case of the Japan's Grant Aid. To secure operation and maintenance for the equipment of the Project for the warranty period, the Spare parts required for the period shall be provided as the scope of the Japanese.

Possession of maintenance tools for proper operation and maintenance for the equipment of the Project by the Recipient is one of conditions for the Japan's Grant Aid. However, the special tools required for operation and maintenance of the equipment of the Project shall be provided as the scope of the Japanese.

Outline of the spare parts and maintenance tools of the Project is shown in Attachment-2. More detailed parts, tools, test equipment and the quantity will be explained with the Draft Final Report.

2.4 On-the-Job Training (OJT)

An On-the-job training (OJT) will be carried out during the construction period. Through the OJT, maintenance and operation for the equipment of the Project will be carried out by Japanese skilled engineer of the manufacturers of the equipment of the Project at the project site.

3. Tentative Implementation Schedule of the Project

The tentative implementation schedule is shown as Attachment-3. In case that the Project is adapted by the Japanese Government, the Project will proceed as follows in the earliest scenario. The installation work of the Project will start in June, 2015. It is important for both sides to understand that the Preparatory Survey is not a commitment for the future implementation of the Project.

- The Exchange of Notes between the Ghana and Japanese Government will be signed in August, 2014.
- The Tender Opening will be held in February 2015.
- Installation work of the Project will start in June, 2015.
- Commissioning of the Project will be in April, 2017.

4. Drawings

Part 1 Substation

E-01: SINGLE LINE DIAGRAM FOR ACCRA CENTRAL BSP SUBSTATION (PRELIMINARY)

E-02: LAYOUT OF PANELS OF THE PROJECT IN THE EXISTING BUILDING AT GRPHIC ROAD PRIMARY SUBSTATION

Part 2 Transmission Lines

T-01: 161 kV T/L Route Map

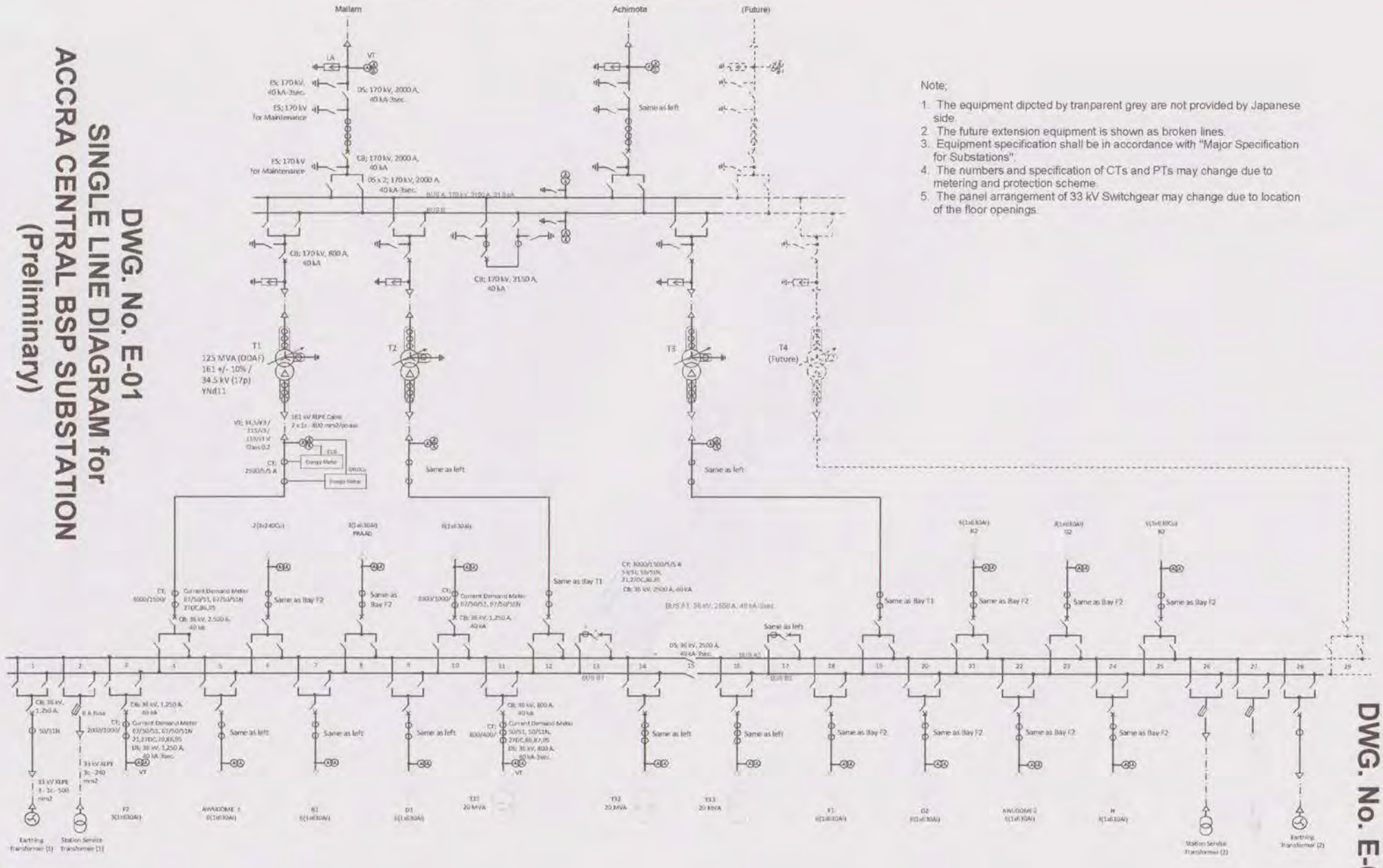
T-02: Outline of Towers (1)-(2)

T-03: 33 kV Underground Cable Route

Part 3 Architectural

A-01: SITE LAYOUT of ACCRA CENTRAL BSP

SINGLE LINE DIAGRAM for ACCRA CENTRAL BSP SUBSTATION (Preliminary)



Note;

1. The equipment dipcted by tranparent grey are not provided by Japanese side.
2. The future extension equipment is shown as broken lines.
3. Equipment specification shall be in accordance with "Major Specification for Substations".
4. The numbers and specification of CTs and PTs may change due to metering and protection scheme.
5. The panel arrangement of 33 kV Switchgear may change due to location of the floor openings.

DWG. No. E-01

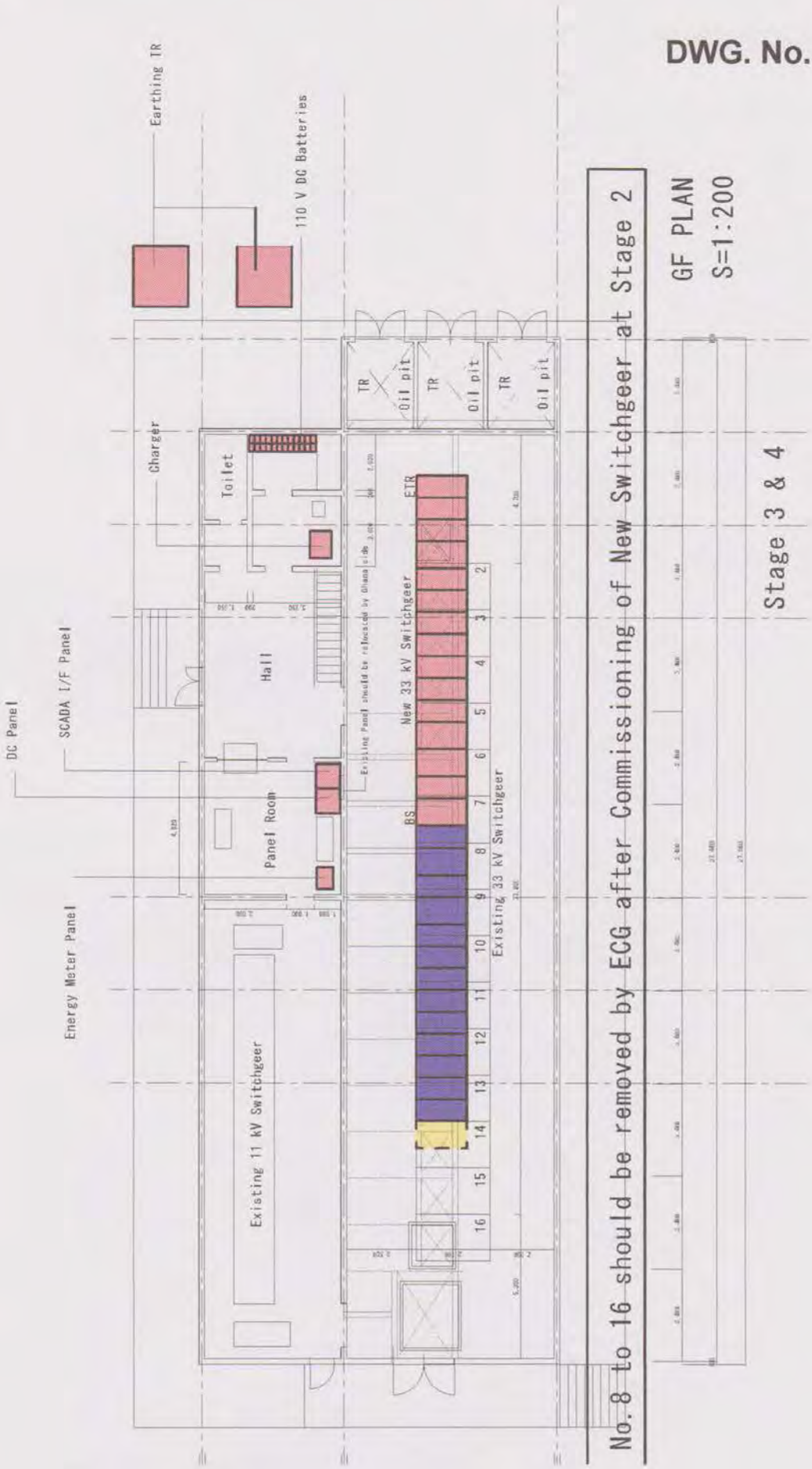
SINGLE LINE DIAGRAM for

ACCRA CENTRAL BSP SUBSTATION

(Preliminary)

DWG. No. E-01

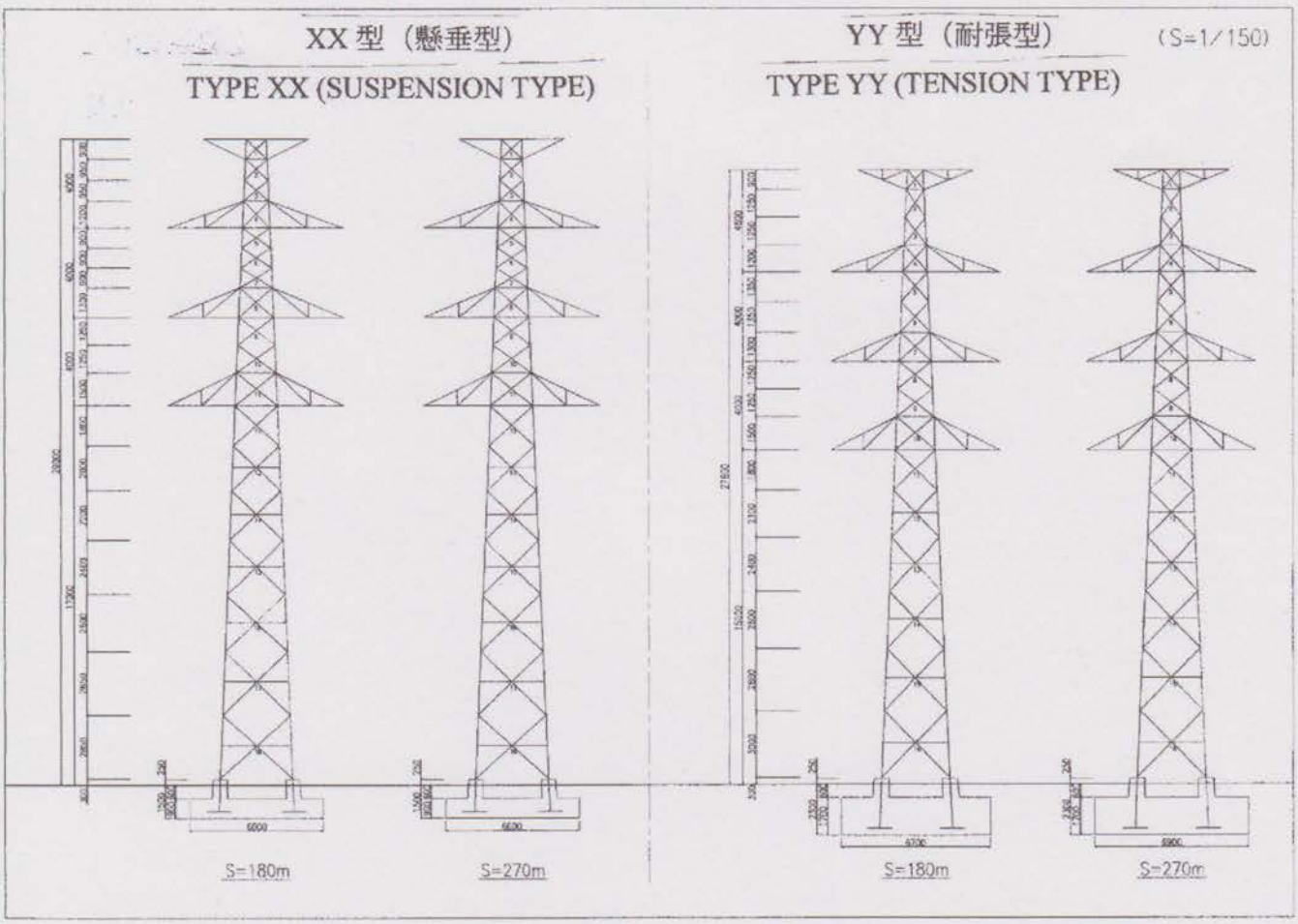
A6-21



DWG. No. E-02

LAYOUT OF PANELS OF THE PROJECT IN THE EXISTING BUILDING AT GRPHIC ROAD PRIMARY SUBSTATION

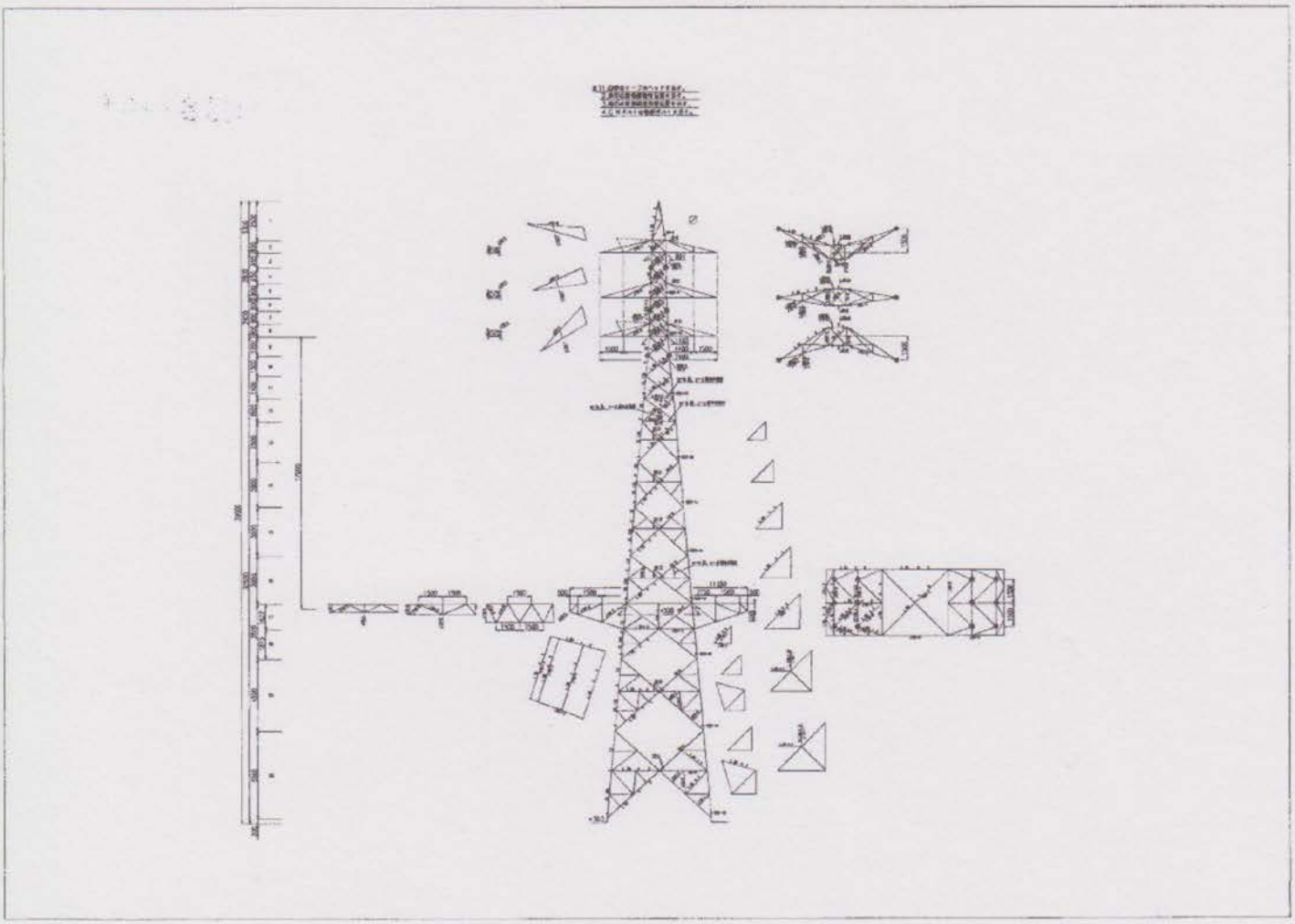
T-01 161 kV T/L ROUTE MAP(1)



T-02 OUTLINE OF TOWER (1)

ZZ 型（ケーブル引留型）

TYPE ZZ (CABLE TERMINATION TYPE)

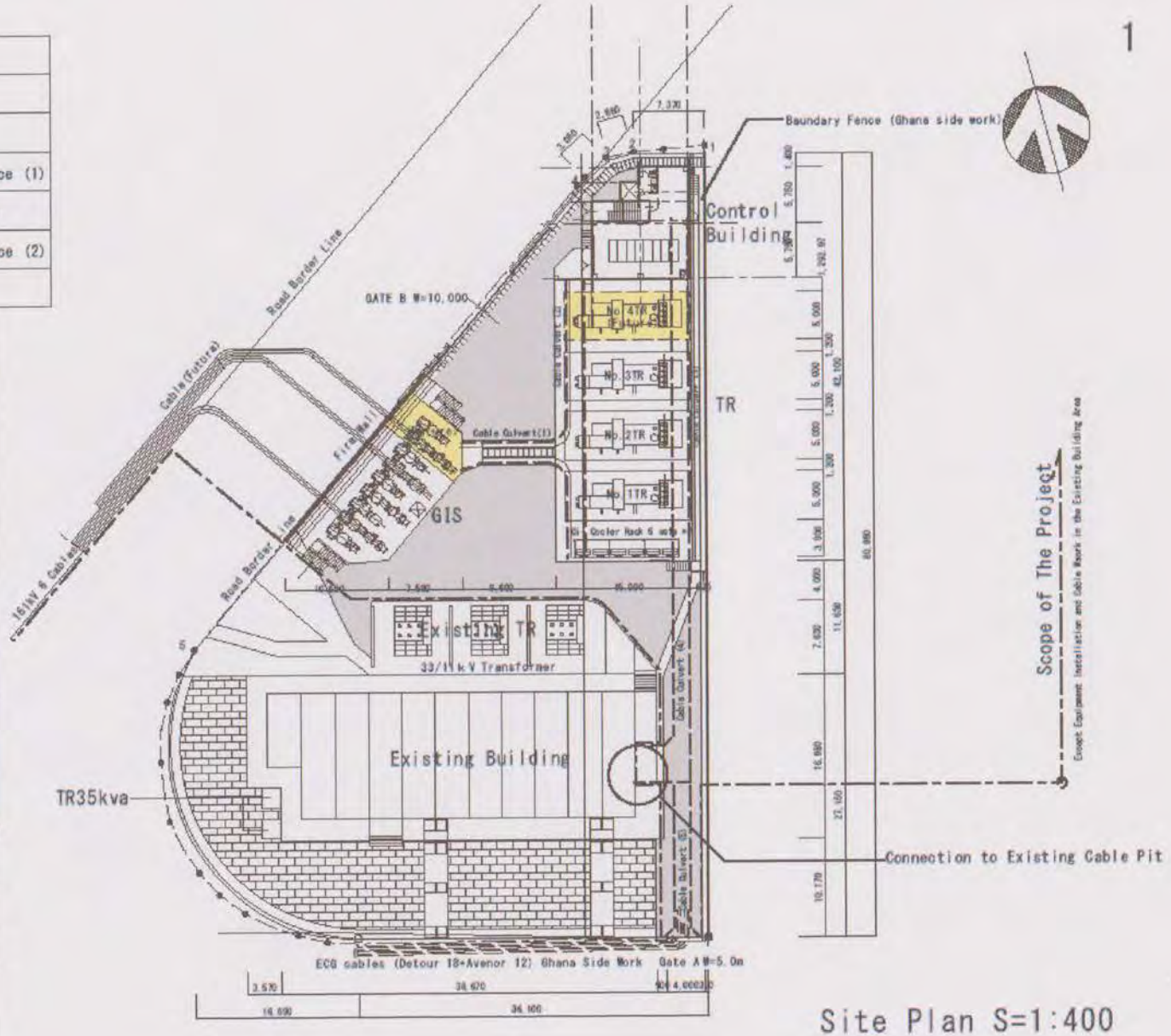


T-02 OUTLINE OF TOWER (2)

T-03 33kV UNDERGROUND CABLE ROUTE MAP

A-01 SITE LAYOUT of ACCRA CENTRAL BSP

	Facility List
1.	Control Building
	BF Cable Pit, Water Tank, Pump
	GF Control Room (1), Control Office (1)
	1F Control Room (2), Battery Room
	2F Control Room (3), Control Office (2)
	RF Trans, Air-con unit
2.	GIS
	BF Cable Pit
	GF GIS 3sets, space for future
3.	Trans
	BF Mechanical Pit,
	BF Cable Culvert (2), (3)
	GF Trans No.1, 2, 3& Space No.4
	Oil cooler Rack (12sets)
4.	Cable Culvert
	Cable Culvert (1) GIS-TR
	Cable Culvert (4) TR-Existing
	Cable Culvert (5) Existing 33kV
5.	Fire Wall
	Fire wall for GIS
6.	Gate B
	W=10m full open gate



A6-27

1. Member List of the Study Team

First Field Survey

Name	Assignment	Organization
Fuyuki SAGARA	Team Leader	Japan International Corporation Agency
Kazunari NOGAMI	Chief Consultant/ Power Supply Planning 1	Yachiyo Engineering Co., Ltd.
Masatsugu KOMIYA	Deputy Chief Consultant/ Power Supply Planning 2	Yachiyo Engineering Co., Ltd.
Kenji SAKEMURA	Substation Planning	West Japan Engineering Consultants, Inc.
Masayuki TAMAI	Transmission Planning	Yachiyo Engineering Co., Ltd.
Tatsunari HAYASHI	Power Flow Analysis	West Japan Engineering Consultants, Inc.
Yasuo HORIGOME	Facility Planning	Yachiyo Engineering Co., Ltd
Kyohei KUROHANE	Procurement Planning/ Cost Estimation	Yachiyo Engineering Co., Ltd.
Takeshi OMURA	Social and Environmental Considerations	Yachiyo Engineering Co., Ltd.

Spare Parts List for GRIDCo

No.	Name of Spare Parts	Q'ty
1.	132 kV Gas Insulated Switchgear	
(1)	Closing coil for CB	1
(2)	Trip coil for CB	1
(3)	Closing contactor for DS & ES	1
(4)	Opening contactor for DS & ES	1
(5)	Interlock coil for DS & ES	1
(6)	Space heater element	6
(7)	SF6 gas and storage cylinder	3
2.	161/34.5 kV, 125 MVA Transformer	
(1)	161 kV Bushing	1
(2)	34.5 kV Bushing	1
(3)	Buchholz relay	1
(4)	Oil thermometer	1
(5)	Oil level gauge	1
(6)	MCCB (each type)	1
(7)	Auxiliary relay (each type)	1
(8)	Fuse (each type)	100%
(9)	Lamp (each type)	100%
(10)	LED lamp (each type, with socket)	1
3.	Control and Protection	
(1)	Meter (each type)	1
(2)	Switch (each type)	1
(3)	Lamp (each type)	100%
	LED lamp (each type, with socket)	10%
(4)	MCCB (each type)	1
(5)	Auxiliary relay (each type)	3
(6)	Magnetic contactor (each type)	1
4.	Transformer voltage regulation control	
(1)	Transformer voltage regulator	1
(2)	MCCB (each type)	1
(3)	Meter (each type)	1
(4)	Lamp (each type)	100%
	LED lamp (each type, with socket)	10%
(5)	Fuse (each type)	1
5.	161/34.5 kV Transformer protection	
(1)	Protection relay (each type)	1
(2)	MCCB (each type)	1
(3)	Lamp (each type)	100%
	LED lamp (each type, with socket)	10%
(4)	Fuse (each type)	1
6.	161 kV Transmission line protection	

No.	Name of Spare Parts	Q'ty
(1)	Protection relay (each type)	1
(2)	MCCB (each type)	1
(3)	Lamp (each type)	100%
	LED lamp (each type, with socket)	10%
(4)	Fuse (each type)	1
7.	161 kV Bus protection	
(1)	Protection relay (each type)	1
(2)	MCCB (each type)	1
(3)	Lamp (each type)	100%
	LED lamp (each type, with socket)	10%
(4)	Fuse (each type)	1
8.	DC Power supply	
(1)	MCCB (each type)	1
(2)	Meter (each type)	1
(3)	Lamp (each type)	100%
	LED lamp (each type, with socket)	10%
(4)	Fuse (each type)	1
9.	AC Distribution panel	
(1)	MCCB (each type)	1
(2)	Meter (each type)	1
(3)	Lamp (each type)	100%
	LED lamp (each type, with socket)	10%
(4)	Fuse (each type)	1
10.	161 kV XLPE Cable	
(1)	Cable termination kit for 161 kV XLPE cable (each type, 3 phases)	1

Spare Parts List for ECG

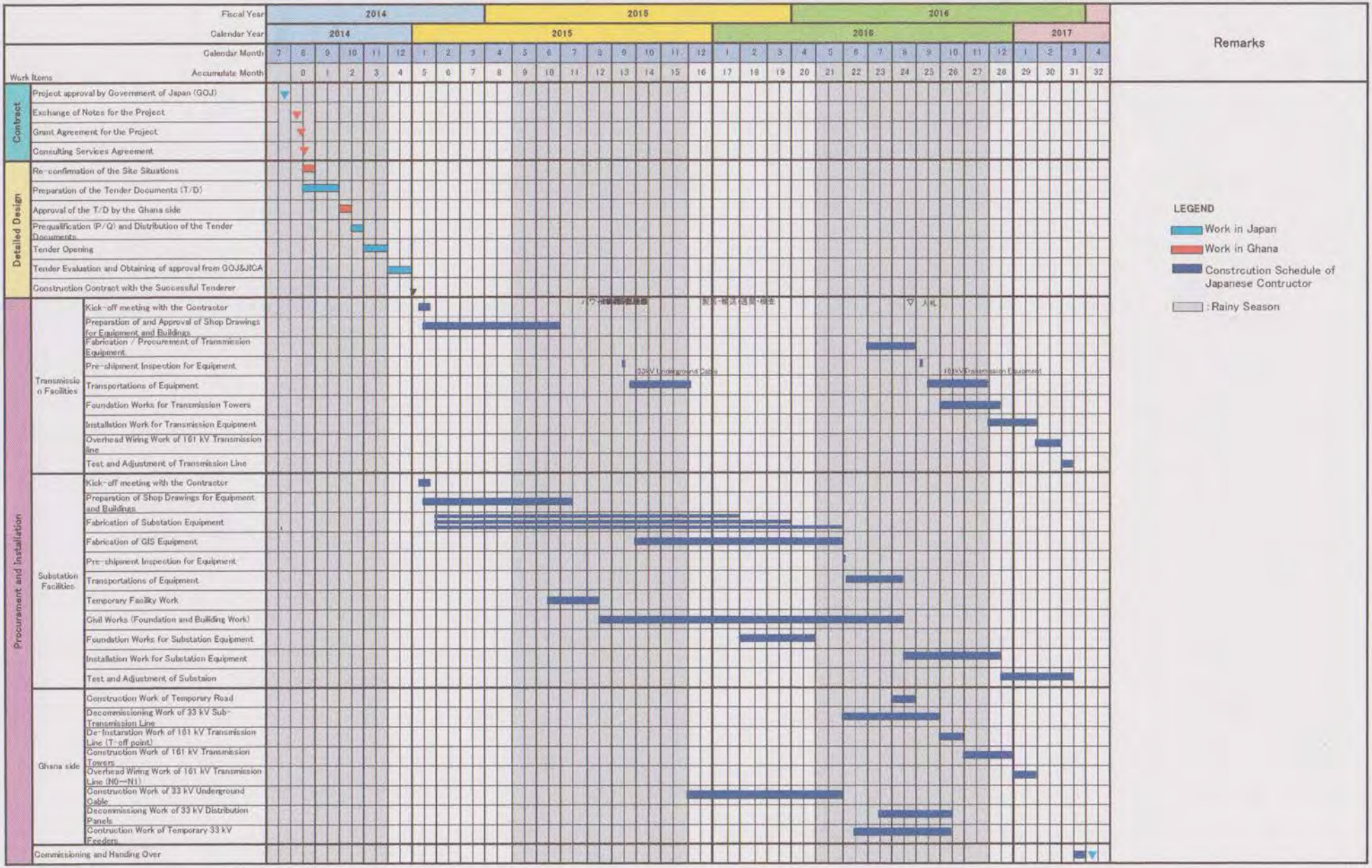
No.	Name of Spare Parts
1.	33 kV Switchgear
(1)	Lamp (each type)
	LED lamp (each type, with socket)
(2)	MCCB (each type)
(3)	Protection relay (each type)
(4)	Auxiliary relay (each type)
(5)	Magnetic contactor (each type)
(6)	Trip coil (each type)
(7)	Closing coil (each type)
(8)	Space heater element
(9)	Meter (each type)
(10)	Switch (each type)
2.	DC Power supply
(1)	MCCB (each type)
(2)	Meter (each type)
(3)	Lamp (each type)
	LED lamp (each type, with socket)
(4)	Fuse (each type)
3.	33 kV XLPE Cable
(1)	Cable termination kit for 161 kV XLPE cable (each type, 3 phases)

Testing Equipment and Maintenance Tools

No.	Equipment	Unit	Q'ty
MT-1	Oil purifier with tank	set	1
MT-2	Transformer oil withstand voltage tester	set	1
MT-3	Phase rotation meter	set	2
MT-4	Voltage detector (200 kV AC)	set	2
MT-5	Voltage detector (3 to 34.5 kV AC)	set	2
MT-6	Voltage detector (600 V AC)	set	2
MT-7	Megger (500 V DC)	set	2
MT-8	Megger (1,000 V DC)	set	2
MT-9	Digital multifunctional tester	set	2
MT-10	Analog multifunctional tester	set	2
MT-11	Portable type earthing resistor tester	set	2
MT-12	Clamp meter	set	2
MT-13	Maintenance tools (for electrical works)	set	2
MT-14	Gas handling unit for GIS	set	2

Attachment-3

Tentative Implementation Schedule of the Project



A6-31

1. Present Situation and Power Demand Forecast in the Project Site

1.1 Demand Forecast in Accra Area

(1) Upper level plan for the Project

GRIDCo had prepared the following master plan studies and is developing the power system in Ghana. In addition, these studies have been reviewed under the assistance of United States Trade and Development Agency (USTDA) in December 2012. The Japan's Grant Aid Project shall keep in consistency with the existing upper level plan of the Recipient as follows.

Table 2.1-1 Existing Master Plan Studies

Studies	Study Period
Transmission System Master Plan for Ghana (November 2011)	2010 – 2021
Generation Master Plan Study for Ghana (February 2012)	2011 - 2026
Technical Assessment Report by USTDA (Feasibility Study for the Eastern Transmission Line)	2012 - 2026

The demand forecasts (base case) estimated in the above mentioned studies are applied in the Outline Design of the Project. They have, however, been estimated with targeting the whole system in Ghana. Therefore, The Team reviewed the demand forecast with targeting Accra Area in considering of historical data of demand on each BSP provided from GRIDCo to the Team and in consistency with the philosophy on the demand forecasts estimated in the above mentioned studies.

The following descriptions are conditions and results of demand forecast for the Outline Design of the Project.

(2) Target year of the Project

The commissioning year of the Project is assumed to be in 2017 in case of adaption of the Project by the Japanese Government and the earliest progress (However, it is paid attention that no commitment is made for realization of the Project by the Japanese side at the stage of the Preparatory Survey of the Project).

In consideration of urgency of the Japan's Grant Aid for the Project, effectiveness of the Project shall be evaluated at least within a few years. On the other hand, the target year for design of the Project shall be set not to go over the capacity of the Project within a few years.

In consideration of the above conditions and experience of similar projects under the Japan's Grant Aid, the target year for evaluation of effectiveness and design of the Project set as follows.

Table 2.1-2 Target year of the Project

Items	Target year
Target year for evaluation of effectiveness of the Project	3 years after commissioning (2017)
Target year for design of the Project	10 years after commissioning (2027)

(3) Conditions for demand forecast in Accra Area

In economic analysis in Technical Assessment Report by USTDA, it has been revealed that real GDP has strong correlation with power consumption in Ghana but then population has not. As the result of the economic analysis, the following function is obtained for approximation of the demand forecast in Ghana (***a1***, ***a2*** and ***a3*** are invariables). The same function is applied for the demand forecast in Accra Area of the Project. Invariables such as ***a1***, ***a2*** and ***a3*** in the function shall, however, be estimated in accordance with approximation with using the historical data of macro-economic parameters and demand on each BSP provided from GRIDCo to the Team.

$$\boldsymbol{Ln}\,(\text{Power Consumption}_{\,i}) = \boldsymbol{a1} + \boldsymbol{a2} \times \boldsymbol{Ln}\,(\text{Real GDP}_{\,i}) + \boldsymbol{a3} \times \boldsymbol{Ln}\,(\text{Power Consumption}_{\,i-1})$$

1) Macro-economic Parameters and their annual growth (Base case)

The following table shows the historical data for Ghana's population and real GDP (Constant 2005 US$) from 1992 to 2011 shown in Technical Assessment Report by USTDA. It is described that in the report the data has been obtained from two different, reliable sources: the U.S. Bureau of Census, in the case of the population, and the World Bank, in the case of the GDP. Real GDP shown in the table is applied for approximation to show correlation between power consumption and real GDP.

Table 2.1-3 Ghana's Population and Real GDP from 1992 to 2011

Year	Population	GDP (constant 2005 US$)
1992	15,655,847	6,018,522,257
1993	16,141,178	6,310,420,587
1994	16,610,887	6,518,664,466
1995	16,992,937	6,786,739,258
1996	17,354,886	7,099,096,283
1997	17,722,810	7,396,999,769
1998	18,116,256	7,744,687,665
1999	18,520,249	8,085,453,654
2000	18,935,103	8,384,615,439
2001	19,357,355	8,720,000,057
2002	19,798,703	9,112,400,059
2003	20,250,113	9,586,244,863
2004	20,689,541	10,123,074,575
2005	21,126,090	10,720,336,364
2006	21,563,400	11,406,437,892
2007	21,996,825	12,143,084,616
2008	22,427,962	13,166,950,385
2009	22,858,579	13,780,416,117
2010	23,286,035	14,692,687,226
2011	23,714,498	16,690,892,880

[Source] Technical Assessment Report by USTDA, 2012

2) Load factor

The following table shows the historical data and average of load factor shown in Technical Assessment Report by USTDA. The average of load factor shown in the table is applied for transformation from power consumption to peak demand in the demand forecast of the Project.

Table 2.1-3 Ghana's Population and Real GDP from 1992 to 2011

Year	Average demand (MW)	Peak demand (MW)	Load Factor
2000	564	822	69%
2001	589	860	69%
2002	611	869	70%
2003	640	1,007	64%
2004	685	1,064	64%
2005	732	1,169	63%
2006	769	1,277	60%
2007	732	1,299	56%
2008	845	1,345	63%
2009	914	1,432	64%
2010	1,005	1,615	62%
2011	1,076	1,668	65%
Average	**764**	**1,202**	**64%**

[Source] Technical Assessment Report by USTDA, 2012

3) Historical data of demand on each BSP provided from GRIDCo to the Team

The following table shows the historical data of demand on each BSP provided from GRIDCo to the Team shown in Technical Assessment Report by USTDA. The historical data shown in the table is applied for approximation to show correlation between power consumption and real GDP.

In addition to demand shown below power supply from Winneba BSP to Accra Area in 33 kV also consider as demand of Accra Area.

Table 2.1-4 Historical data of demand on each BSP in Accra Area

Unit: GWh

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Achimota BSP	1524	1398	1265	1423	1508	1607	1564	1572	1748	1787	1975	2117	2025	1850
Mallam BSP		208	415	339	371	410	502	449	612	667	774	844	1044	1184
A3 BSP													0.21	396

[Source] Technical Assessment Report by USTDA, 2012

(4) Result of demand forecast in Accra Area

As the result of econometric analysis under the above mentioned conditions, the following function is obtained for approximation of the demand forecast in Accra Area. R-square is calculated to 0.974 and the goodness of fit is observed.

$$\boldsymbol{Ln}\,(\text{Power Consumption}_{i}) =$$
$$\boldsymbol{-13.082} + \boldsymbol{0.86707} \times \boldsymbol{Ln}\,(\text{Real GDP}_{i}) + \boldsymbol{0.84191} \times \boldsymbol{Ln}\,(\text{Power Consumption}_{i-1})$$

In accordance with the above obtained function, the following figure is obtained as the demand forecast in Accra Area. In the demand forecast by the Team, demand in each year is assumed relatively higher than one in the master plan studies but their averages of annual growth rate are the almost same and in range of 6% to 6.5%. The demand in 2017, the target year for evaluation of effectiveness of the Project is 757 MW and the target year for design of the Project is 1,374 MW in the demand forecast by the Team.

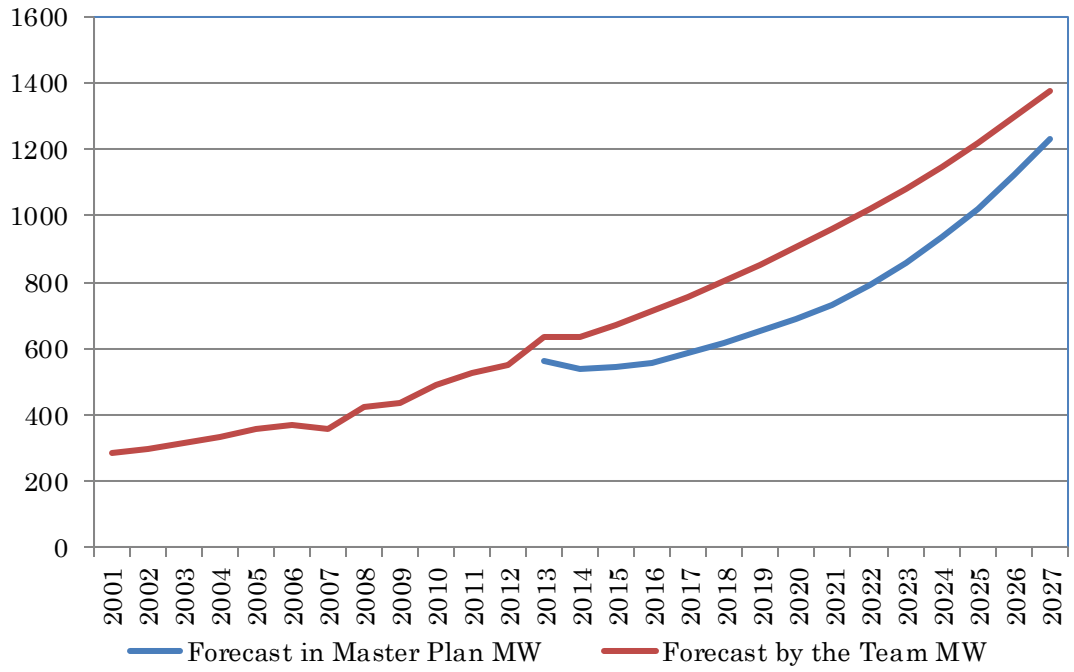


Figure 2.1-1 Demand Forecast for design of the Project

(5) Power Demand on each BSP in Accra Area

In accordance with the above mentioned demand forecast, power demand on each BSP in Accra Area will be estimated as the example of load distribution to confirm the appropriateness and effectiveness of the project as a Japan's Grant Aid project.

1.2 Power flow analysis

(1) Objectives of Load Flow Analysis for the Project

The load flow analysis of the Project aims to confirm appropriateness and effectiveness of the Project as a Japan's Grant Aid project. The load flow analysis will be carried out at the time of target year for evaluation of effectiveness of the Project (2017) and the target year for design of the Project (2027).

From the view of the study objective, the Team will conduct load flow analysis for the area focused on the Project instead of the whole transmission system in Ghana. Basic Concept of Power Flow Analysis is shown in Table 3-1.

Table 3-1 Basic Plan for Load Flow Analysis

Area	- Transmission system between Akosombo and Aboadze (see Fig. 3-1)
Voltage level	- 161kV or more of the transmission system in the area - Primary substation and 33kV distribution liens in Accra area
Demand	- Demand forecast is aforementioned section 2.1. - Power factor is 87% (see Table 3-3).

Section for analysis	- Commission year (2017) - Target year for evaluation of effectiveness of the Project (2020) - Target year for design of the Project (2027)
Evaluation	- Power flow is within each capacities of the equipment like transformers, transmission line conductors, etc. - Voltage limit is "within ±5% of the nominal voltage at all times under Normal State" regulated at Art 12.10 in "NATINAL ELECTRICITY GRID CODE (October 2009)". - Rated short-time current is within the interrupting capability of Circuit Breakers.

(2) Model

For the purpose of the analysis, transmission system between Akosombo power station and Aboadze power station, which supply power to Accra area, was modeled based on the data (see Annex-2) of generators, transmission lines and transformers provided by GRIDCo.

Fig. 3.1 shows a load flow chart simulated by the model based on the actual peak demand and generating power. From the verification between the load flow result and actual load flow/bus voltage, the Team confirmed the model is available for the analysis.

(3) Basic Data for the Load Flow Analysis

The load flow analysis of the Project will be carried out in accordance with the data provided by GRIDCo and ECG during the first field survey, shown in Annex-2.

The following table shows the average of power factor at each BSP shown in Transmission System Master Plan for Ghana by GRIDCo. The averages of power factor for Achimota BSP and Mallam BSP shown in the table are applied to the load flow analysis of the Project.

Table 3-3 Power Factor at Substations

BSP	Power Factor
Achimota	0.87
Mallam	0.87
New Tema	0.87
Kenyase	0.92
Kumasi	0.87
Techiman	0.92
Tamale	0.92
Sawla	0.92
Others	0.90

[Source] Transmission System Master Plan for Ghana, 2011

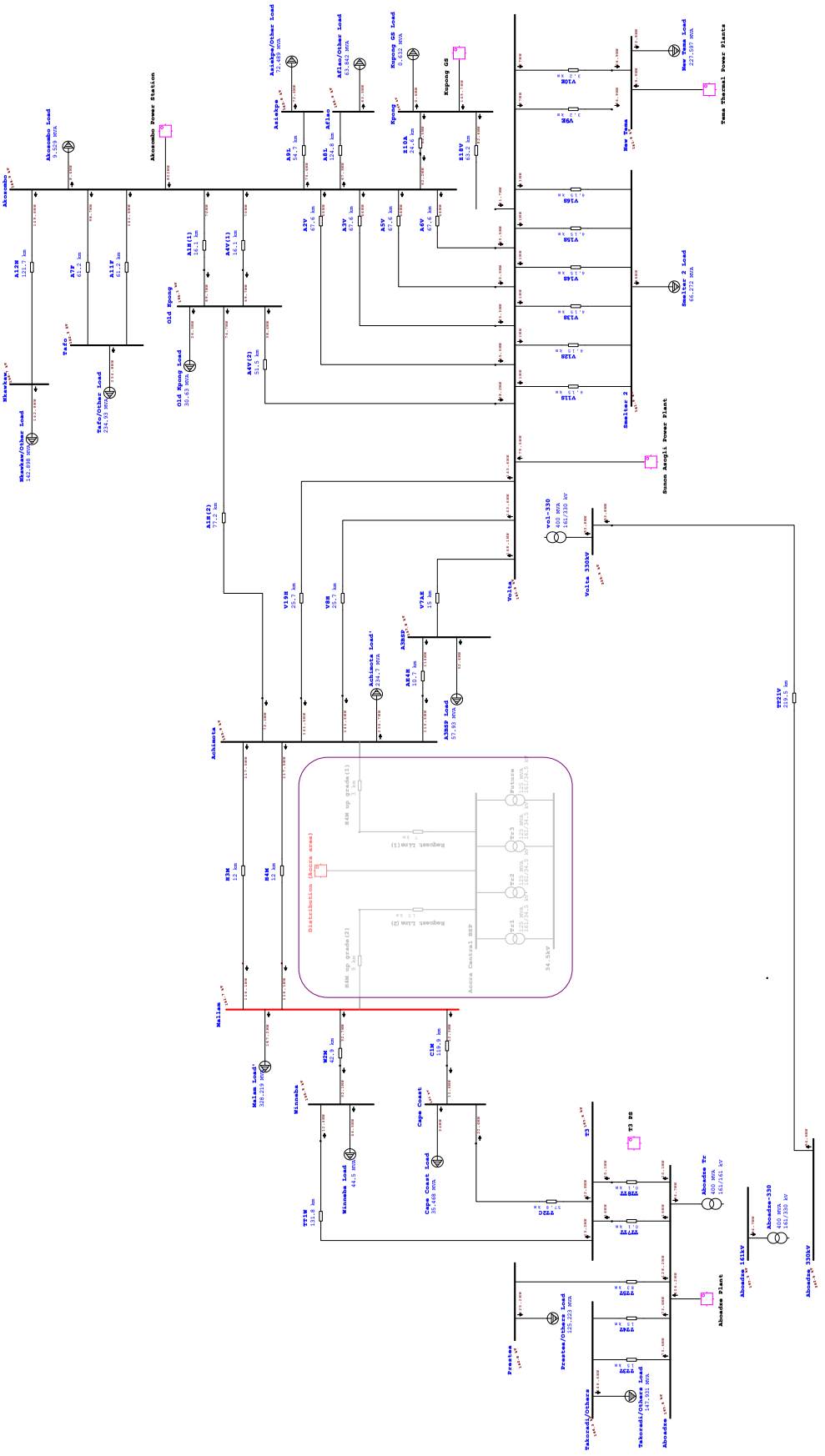


Fig.3-1 Model and the Result of Load Flow (May 7, 2013)

(1) Main Characteristics Generator

Location	Unit	Type	Rated				Impedance Rated capacity MVA Base
			(MW)	(KV)	(MVA)	PF (%)	Xd" (p.u.)
Akosombo	Akosombo G1	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G2	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G3	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G4	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G5	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G6	Hydro	170.5	14.4	179.50	95	0.210
Aboadze T1	TAPCo GT1	Gas Turbine	120.4	13.8	141.70	85	0.214
	TAPCo GT2	Gas Turbine	120.4	13.8	141.70	85	0.214
	TAPCo HRSG	Steam Turbine	123.5	13.8	145.30	85	0.220
Aboadze T2	TICo GT1	Gas Turbine	120.4	13.8	141.70	85	0.214
	TICo GT2	Gas Turbine	120.4	13.8	141.70	85	0.214
Aboaze T3	T1-G1	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G2	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G3	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G4	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G5 (HRSG)	Steam Turbine	31.0	13.8	38.75	80	0.217
Kpong	Kpong G1	Hydro	45.9	13.8	51.00	90	0.270
	Kpong G2	Hydro	45.9	13.8	51.00	90	0.270
	Kpong G3	Hydro	45.9	13.8	51.00	90	0.270
	Kpong G4	Hydro	45.9	13.8	51.00	90	0.270
Sunon Asogli	Asogri(1) GT1	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(1) GT2	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(1) HRSG	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(2) GT1	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(2) GT2	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(2) HRSG	Steam Turbine	29.0	11.0	36.29	80	0.148
Tema TT1PP	TT1PP GT1	Gas Turbine	113.4	14.4	141.70	80	0.179
	CENIT GT	Gas Turbine	113.4	14.4	141.70	80	0.179
Tema MRP	MRP GT1	Gas Turbine	47.3	11.5	52.50	90	0.171
	MRP GT2	Gas Turbine	20.0	11.5	22.25	90	0.171
	MRP HRSG	Steam Turbine	15.0	11.5	16.70	90	0.171
TT2PP	TT2PP GT1	Gas Turbine	7.8	11.0	9.75	80	0.171
	TT2PP GT2	Gas Turbine	7.8	11.0	9.75	80	0.171
	TT2PP GT3	Gas Turbine	7.8	11.0	9.75	80	0.171
	TT2PP GT5	Gas Turbine	12.9	11.0	13.10	80	0.244
	TT2PP HRSG	Steam Turbine	12.9	11.0	13.10	80	0.244
Bui	Bui1	Hydro	133.0	13.8	147.80	90	0.270
	Bui2	Hydro	133.0	13.8	147.80	90	0.270
	Bui3	Hydro	133.0	13.8	147.80	90	0.270

(2) Main Characteristics Transmission Lines

Location		Line No.	Voltage	Length	Conductor			Impedance(pu)			Thermal rating	
From	To		(kV)	(km)	Type	Code	Size (mm^2)	R	X	Y	(A)	(MVA)
Akosombo	Old Kpong	A1H(1)	161	16.1	AAC	LILAC	403	0.00510	0.02450	0.01220	764	213
		A4V(1)	161	16.1	AAC	LILAC	403	0.00510	0.02450	0.01220	764	213
	Volta	A2V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
		A3V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
		A5V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
		A6V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
	Kpong	Z10A	161	24.6	AAC	LILAC	403	0.00770	0.03810	0.01830	764	213
	Tafo	A7F	161	61.2	AAC	MISTLETOE	282	2.70000	9.70000	2.20000	610	170
		A11F	161	61.2	ACSR	TOUCAN	182 x 2	1.60000	6.80000	3.10000	653 x 2bundle	182 x 2bundle
	Asiekpe	A9L	161	54.7	AAC	DAFFODIL	177	0.03940	0.08890	0.03870	459	128
	Aflao	A8L	161	124.8	AAC	DAFFODIL	177	0.08837	0.20254	0.08827	459	128
Old Kpong	Volta	A4V(2)	161	51.5	AAC	LILAC	403	0.01620	0.07840	0.03905	764	213
	Achimota	A1H(2)	161	77.2	AAC	LILAC	403	0.02434	0.11751	0.05856	764	213
Achimota	Mallam	H3M	161	12.0	AAC	MISTLETOE	282	0.70000	2.40000	0.60000	610	170
		H4M	161	12.0	AAC	MISTLETOE	282	0.70000	2.40000	0.60000	610	170
Mallam	Cape Coast	C1M	161	119.9	AAC	MISTLETOE	282	0.05336	0.18728	0.08801	610	170
	Winneba	W2M	161	42.9	AAC	MISTLETOE	282	0.02045	0.07182	0.03377	610	170
T3	Winneba	TT1W	161	131.8	AAC	MISTLETOE	282	0.04217	0.16248	0.07654	610	170
	Cape Coast	TT2C	161	57.8	AAC	MISTLETOE	282	0.02356	0.09065	0.04263	610	170

Location		Line No.	Voltage	Length	Conductor			Impedance(pu)			Thermal rating	
From	To		(kV)	(km)	Type	Code	Size (mm^2)	R	X	Y	(A)	(MVA)
Volta	Kpong	Z18V	161	63.2	AAC	HAWTHORN	604	0.01140	0.08430	0.03890	979	273
	New Tema	V9E	161	3.2	AAC	TOUCAN	265 x2	0.00085	0.00358	0.00324	653 x 2bundle	182 x 2bundle
		V10E	161	3.2	AAC	TOUCAN	265 x2	0.00085	0.00358	0.00324	653 x 2bundle	182 x 2bundle
	Smelter Two	V11S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V12S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V13S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V14S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V15S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V16S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
	A3BSP (Accra East)	V7AE	161	15.0	AAC	LILAC	403	0.00470	0.02290	0.01137	764	213
	Achimota	V8H	161	25.7	AAC	LILAC	403	0.00810	0.03980	0.01950	764	213
		V19H	161	25.7	AAC	LILAC	403	0.00810	0.03980	0.01950	764	213
	Aboadze	TT21V	330	219.5	ACSR	TERN	430 x2	0.90000	5.67000	46.35000	500 x 2bundle	875 x 2bundle
A3BSP (Accra East)	Achimota	AE4H	161	10.7	AAC	LILAC	403	0.00340	0.01630	0.00811	764	213
Aboadze Plant	T3	TT6TT	161	0.1	ACSR	uncoded	400 x2	0.00003	0.00015	0.00007	875 x 2bundle	244 x 2bundle
		TT7TT	161	0.1	ACSR	uncoded	400 x2	0.00003	0.00015	0.00007	875 x 2bundle	244 x 2bundle
	Takoradi	TT3T	161	15.0	AAC	MISTLETOE	282	0.00610	0.02350	0.01100	610	170
		TT4T	161	15.0	AAC	MISTLETOE	282	0.00610	0.02350	0.01100	610	170
	Prestea	TT5T	161	83.0	ACSR	TOUCAN	265 x2	0.01953	0.08532	0.07726	653 x 2bundle	182 x 2bundle

(3) Main Characteristics Transformers

Location			Rating			Impedance (%) Rating Power MVA Base	Vector Grope	Load Tap Changer
			Voltage (%)		Power (MVA)			
	From	To	Prim.	Sec.				
Achimota	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.71	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.30	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.30	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.38	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.30	YNd11	On-Load
Mallam	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.38	YNd11	On-Load
	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.34	YNd11	On-Load
	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.06	YNd11	On-Load
	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.06	YNd11	On-Load
A3BSP	A3BSP 161kV	A3BSP 34.5kV	161	34.5	66	11.51	YNd11	On-Load
	A3BSP 161kV	A3BSP 34.5kV	161	34.5	66	10.19	YNd11	On-Load
Akosombo	Akosombo G1	Akosombo 161kV	14.4	161	200	13.39	YNd1	Off-Load
	Akosombo G2	Akosombo 161kV	14.4	161	200	13.29	YNd1	Off-Load
	Akosombo G3	Akosombo 161kV	14.4	161	180	13.00	YNd1	Off-Load
	Akosombo G4	Akosombo 161kV	14.4	161	200	13.35	YNd1	Off-Load
	Akosombo G5	Akosombo 161kV	14.4	161	200	13.35	YNd1	Off-Load
	Akosombo G6	Akosombo 161kV	14.4	161	180	13.30	YNd1	Off-Load
Aboadze T1	TAPCo GT1	Aboadze 161kV	13.8	169	155	12.60	YNd1	Off-Load
	TAPCo GT2	Aboadze 161kV	13.8	169	155	12.60	YNd1	Off-Load
	TAPCo HRSG	Aboadze 161kV	13.8	169	155	12.60	YNd1	Off-Load
Aboadze T2	TICo GT1	Aboadze 161kV	13.8	161	141	11.45	YNd1	Off-Load
	TICo GT2	Aboadze 161kV	13.8	161	141	11.45	YNd1	Off-Load
Aboadze T3	T1-G12	T3 161kV	13.8	161	62.5	0.10	YNd1	Off-Load
	T1-G34	T3 161kV	13.8	161	62.5	0.10	YNd1	Off-Load
	T1-G5 (HRSG)	T3 161kV	13.8	161	62.5	0.10	YNd1	Off-Load
Kpong G.S.	Kpong G1	Kpong G.S. 161kV	13.8	169	51	10.60	YNd1	Off-Load
	Kpong G2	Kpong G.S. 161kV	13.8	169	51	10.50	YNd1	Off-Load
	Kpong G3	Kpong G.S. 161kV	13.8	169	51	10.40	YNd1	Off-Load
	Kpong G4	Kpong G.S. 161kV	13.8	169	51	10.60	YNd1	Off-Load
Sunon Asogli	G1 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G2 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G3 (HRSG)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G4 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G5 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G6 (HRSG)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load

Location			Rating			Impedance (%) Rating Power MVA Base	Vector Grope	Load Tap Changer
			Voltage (%)		Power (MVA)			
	From	To	Prim.	Sec.				
Tema TT1PP	TT1PP GT1	TT1PP 161kV	14.4	161	145	14.85	YNd1	Off-Load
	CENIT GT	TT1PP 161kV	14.4	161	145	14.85	YNd1	Off-Load
Tema MRP	MRP Generator	Tema MRP 161kV	11.5	161	165	13.10	YNd1	Off-Load
Tema TT2PP	TT2PP Generator	Tema TT2PP 161kV	11.0	161	75	9.08	YNd1	Off-Load
Bui	Bui G1	Bui 161kV	14.4	161	160	13.13	YNd1	Off-Load
	Bui G2	Bui 161kV	14.4	161	160	13.00	YNd1	Off-Load
	Bui G3	Bui 161kV	14.4	161	160	13.08	YNd1	Off-Load
Aboadze	Aboaze 330kV	Aboadze 161kV	330	161	200 x2	10.00	YNd11	-
Volta	Volta 330kV	Volta 161kV	330	161	200 x2	10.00	YNd11	-

(4) Main Characteristic Capacitor

Location	Voltage (kV)	Bank No.	Rating/bank (Mvar)	Total rating (Mvar)
Achimota	34.5	5	21.8	109.0
New Tema	34.5	2	10.8	21.6
Winneba	34.5	2	21.6	43.2
Cape Coast	34.5	2	10.8	21.2
Accra East	34.5	2	21.6	43.2
Mallam	34.5	2	21.6	43.2

(5) Existing and Planned Generation

Power Station	Generator	Type	Commission Year	Capacity
Akosombo	Akosombo G1	Hydro	existing (1965)	170.525 MW
	Akosombo G2	Hydro	existing (1965)	170.525 MW
	Akosombo G3	Hydro	existing (1965)	170.525 MW
	Akosombo G4	Hydro	existing (1965)	170.525 MW
	Akosombo G5	Hydro	existing (1972)	170.525 MW
	Akosombo G6	Hydro	existing (1972)	170.525 MW
Aboadze T1	TAPCo GT1	Gas Turbine	existing (1998)	120.4 MW
	TAPCo GT2	Gas Turbine	existing (1998)	120.4 MW
	TAPCo HRSG	Steam Turbine	existing (1998)	123.5 MW
Aboadze T2	TICo GT1	Gas Turbine	existing (2001)	120.4 MW
	TICo GT2	Gas Turbine	existing (2001)	120.4 MW
	TICo HRSG	Steam Turbine	2015	123.5 MW
Aboadze T3	T1-G1	Gas Turbine	existing (2013)	31 MW
	T1-G2	Gas Turbine	existing (2013)	31 MW
	T1-G3	Gas Turbine	existing (2013)	31 MW
	T1-G4	Gas Turbine	existing (2013)	31 MW
	T1-G5 (HRSG)	Steam Turbine	existing (2013)	31 MW
Aboadze T3 expansion	T2-G	Gas Turbine	2015	120 MW
	T2-HRSG	Steam Turbine	2015	60 MW
Aboadze T4	T4-G1	Gas Turbine	2018	133.3 MW
	T4-G2	Gas Turbine	2018	133.3 MW
	T4-HRSG	Steam Turbine	2018	133.3 MW
Kpong GS	Kpong G1	Hydro	existing (1982)	45.9 MW
	Kpong G2	Hydro	existing (1982)	45.9 MW
	Kpong G3	Hydro	existing (1982)	45.9 MW
	Kpong G4	Hydro	existing (1982)	45.9 MW
Kpone	Kpone GT1	Gas Turbine	2014	120.5 MW
	Kpone GT2	Gas Turbine	2014	120.5 MW
	Kpone HRSG	Steam Turbine	2016	123.5 MW
Asogli	Asogri(1) GT1	Gas Turbine	existing (2010)	29.0 MW
	Asogri(1) GT2	Gas Turbine	existing (2010)	29.0 MW
	Asogri(1) HRSG	Gas Turbine	existing (2010)	29.0 MW
	Asogri(2) GT1	Gas Turbine	existing (2010)	29.0 MW
	Asogri(2) GT2	Gas Turbine	existing (2010)	29.0 MW
	Asogri(2) HRSG	Steam Turbine	existing (2010)	29.0 MW
	Asogri(3) GT1	Gas Turbine	2016	60 MW
	Asogri(3) GT2	Gas Turbine	2016	60 MW
	Asogri(3) HRSG	Steam Turbine	2016	60 MW
	Asogri(4) GT1	Gas Turbine	2016	60 MW
	Asogri(4) GT2	Gas Turbine	2016	60 MW
	Asogri(4) HRSG	Steam Turbine	2016	60 MW

Power Station	Generator	Type	Commission Year	Capacity
Tema TT1PP	TT1PP GT1	Gas Turbine	existing (2009)	113.4 MW
	CENIT GT	Gas Turbine	existing (2012)	113.4 MW
	TT1PP HRSG	Steam Turbine	2017	113.4 MW
Tema MRP	MRP GT1	Gas Turbine	existing (2007)	47.3 MW
	MRP GT2	Gas Turbine	existing (2007)	20 MW
	MRP HRSG	Steam Turbine	existing (2007)	15 MW
Tema TT2PP	TT2PP GT1	Gas Turbine	existing (2010)	7.8 MW
	TT2PP GT2	Gas Turbine	existing (2010)	7.8 MW
	TT2PP GT3	Gas Turbine	existing (2010)	7.8 MW
	TT2PP GT5	Gas Turbine	existing (2010)	13.1 MW
	TT2PP HRSG	Steam Turbine	existing (2010)	13.1 MW
Bonyere 1	GT1	Gas Turbine	2016	150 MW
	GT2	Gas Turbine	2016	150 MW
	HRSG	Steam Turbine	2016	150 MW
Bonyere 2	GT1	Gas Turbine	2017	150 MW
	GT2	Gas Turbine	2017	150 MW
	HRSG	Steam Turbine	2017	150 MW
Bui	Bui1	Hydro	existing (2013)	133 MW
	Bui2	Hydro	existing (2013)	133 MW
	Bui3	Hydro	existing (2013)	133 MW
Pwalugu	Pwalugu 1	Hydro	2026	24 MW
	Pwalugu 2	Hydro	2026	24 MW
Hemang	Heman 1	Hydro	2020	46.5 MW
	Heman 2	hydro	2020	46.5 MW
Juale	Juale 1	Hydro	2020	41.5 MW
	Juale 2	Hydro	2020	41.5 MW

3. Environmental and Social Considerations

3.1 Environmental Permit (EP)

3.1.1 Schedule of Environmental and Social Impact Assessment (ESIA)

GRIDCo started the process to obtain an Environmental Permit (EP) for the Project as they submitted an Environmental Assessment (EA) application of the Project on Environmental Protection Agency (EPA) in October 2013. EPA requested GRIDCo to conduct ESIA for the Project in the end of December 2013 after the screening process.

GRIDCo will procure a local consultant to conduct the ESIA and prepare an Environmental Impact Statement (EIS). The draft EIS will be submitted to EPA for review and comments will be given if necessary. GRIDCo will revise the draft EIS and submit it to EPA and EPA will issue the EP if they approve it. Table 3-1 explains an expected time schedule of ESIA that GRIDCo has planned to obtain the EP for the Project by July 2014 with six-month implementation period of ESIA.

The EP is issued with specific conditions including the mitigation measures over the entire construction activities of the Project.

Table 3-1 Expected Time Schedule of ESIA Conducted by GRIDCo

No.	ESIA Procedures	Scheduled Month	Year
1	Submission of EA Application (Registration Form)	October	2013
2	Project Screening	December	
3	Scoping (Terms of Reference) including Public Hearing	February	2014
4	EIA Study	February – April	
5	Draft EIS Submission	April	
6	Draft EIS Review (50 Working Days) including Public Hearing	April - June	
7	Draft EIS Submission after Review	July	
8	EP Issued (15 Working Days)	July	

Source: GRIDCo, JICA Study Team

3.1.2 Land Issues for the ROW of Project

The necessary lands for the Project should be secured prior to the EP so that the Project is evaluated how feasible on the scheduled Japan Grand Aid procedure. In this context, public lands can be used for the Project because no land acquisition procedures are required although resettlement can occur.

For the Project, GRIDCo is going to use the existing 15 meters ROW of 33 kV sub-transmission line after the 33 kV sub-transmission line is decommissioned and removed. Therefore, GRIDCo should secure the following land matters by 15th February, 2014 in advance to accommodate the Japan Grand Aid procedure although GRIDCo will fulfill these obligations in the ESIA.

For 161 kV Transmission Line:

- Evidence showing the ROW of 161 kV transmission line for the Project between Avenor branch point and Graphic Road Primary Substation, which belongs to ECG with legal basis. (ECG says that they have 15 meters ROW on the existing 33 kV line.)
- Consent with Accra City Municipal Government to use land in the playground for constructing a 161 kV tower and for the 161 kV overhead line over passing two roads and the playground (GRIDCo may prepare an agreement by exchange of documents signed by both parties.)
- Consent with the owners of bus parking space and a vacant building for the 161 kV overhead line over passing the parking space (GRIDCo may prepare an agreement by exchange of documents signed by both parties.)
- Consent with Accra City Municipal Government or any other authorities to use utility space for the underground cable installation along Graphic Road (GRIDCo may prepare an agreement by exchange of documents signed by both parties.)

For 33 kV Sub-transmission Line:

- Appropriate route where GRIDCo (ECG) installs the underground cable of 33 kV sub-transmission line with using the cables procured by the Japanese side between Avenor Primary Substation and Graphic Road Primary Substation in order to avoid any adverse impacts on residents and structures on the route.
- Relating the above, an evidence showing the ROW of route. (GRIDCo (ECG) should use the public space between the rail track and the buildings to avoid impacts on the informal settlers through coordination with the railway company. GRIDCo (ECG) may prepare an agreement by exchange of documents signed by both parties.)
- Measures to avoid resettlement if GRIDCo (ECG) needs to demolish or remove the structures on the route. (GRIDCo (ECG) should demolish or remove the structures and recover those after they installed the underground cable.)

3.2 Anticipated Impacts on Environmental and Social Considerations

3.2.1 Focal Points of Adverse Impacts on Environment and Social Conditions

The results of 1st field survey shows that most lands on the Project route composes of two sections, the north and south sections straddled Ring Road West. The Project Site has totally flat in topography and the requested route passes over residence of informal settlers, grass field and factory sites. Most part of the north section is dominated by the residence of informal settlers. The grass fields and factories are located in the south section.

Through the 1st field survey, the Team found the following focal points which should be considered most in the Project Site.

- Structures around the towers can be affected on the Project route
- Socio-economic activities can be affected on the Project route

- Ambient Noise from the 161/34.5 kV Transformers at Accra Central BSP in the existing Graphic Road Sub-station

3.2.2 Land Acquisition and Involuntary Resettlement

The existing 15 meters ROW of 33 kV sub-transmission line can be used for the 161 kV transmission line in the Project. The land requirements and construction works are limited at the ground level around the existing 33 kV sub-transmission towers. Moreover, the Team is designing the structures of 161 kV transmission towers to reduce their sizes on the ground and of the foundation as much as possible. The sizes will be less than double of the existing towers except special towers. Consequently, the Project can minimize the adverse impact on the structures and socio-economic activities of informal settlers around the towers.

However, more space should be secured for construction works, accesses and security reasons during the construction period. The Team estimates this construction space including the tower foundations at 15 meter square for each. People and structures in this area should be removed for the Project.

The Existing Conditions:

Table 3-2 summarizes the existing conditions on the Project Route. Three critical sites for resettlement were identified at tower number N6, N9 and N14 on the Project Route. Those towers are surrounded by small scale buildings with simple structure of the informal settlers. These structures and the resident socio-economic activities will be affected by the constructions of 161 kV transmission towers. Total 151 population in 22 households were identified by the social survey.

Table 3-2 Affected Population in 15m Square Area

Tower No.	Household	Population	Tower No.	Household	Population
N1	0	0	N10	0	0
N2	1	4	N11	0	0
N3	0	0	N12	0	0
N4	1	4	N13	0	0
N5	0	0	N14	6	28
N6	5	38	N15	1	6
N7	0	0	N16	0	0
N8	0	0	N17	0	0
N9	8	71	N18	0	0
Total				22	151

Source: JICA Study Team

Besides, the end point of overhead line at number N18 is located in a private sector, a car service workshop. The tower should be designed with special feature and structure for the end point of overhead line. The tower may require more land of the existing 33 kV tower.

Meanwhile, an existing 33 kV sub-transmission tower is located in very little space in a plastic

factory, LETAP Packaging Factory. (See Number E0 in Table 3-3.) The site has no enough space which can be secured for the construction works without affecting the factory buildings. Nor the access can be secured easily in the factory. Therefore, the Team has concluded to exclude this site to construct 161 kV transmission tower from the Project Route. Physical conditions are also summarized in section 3.4.

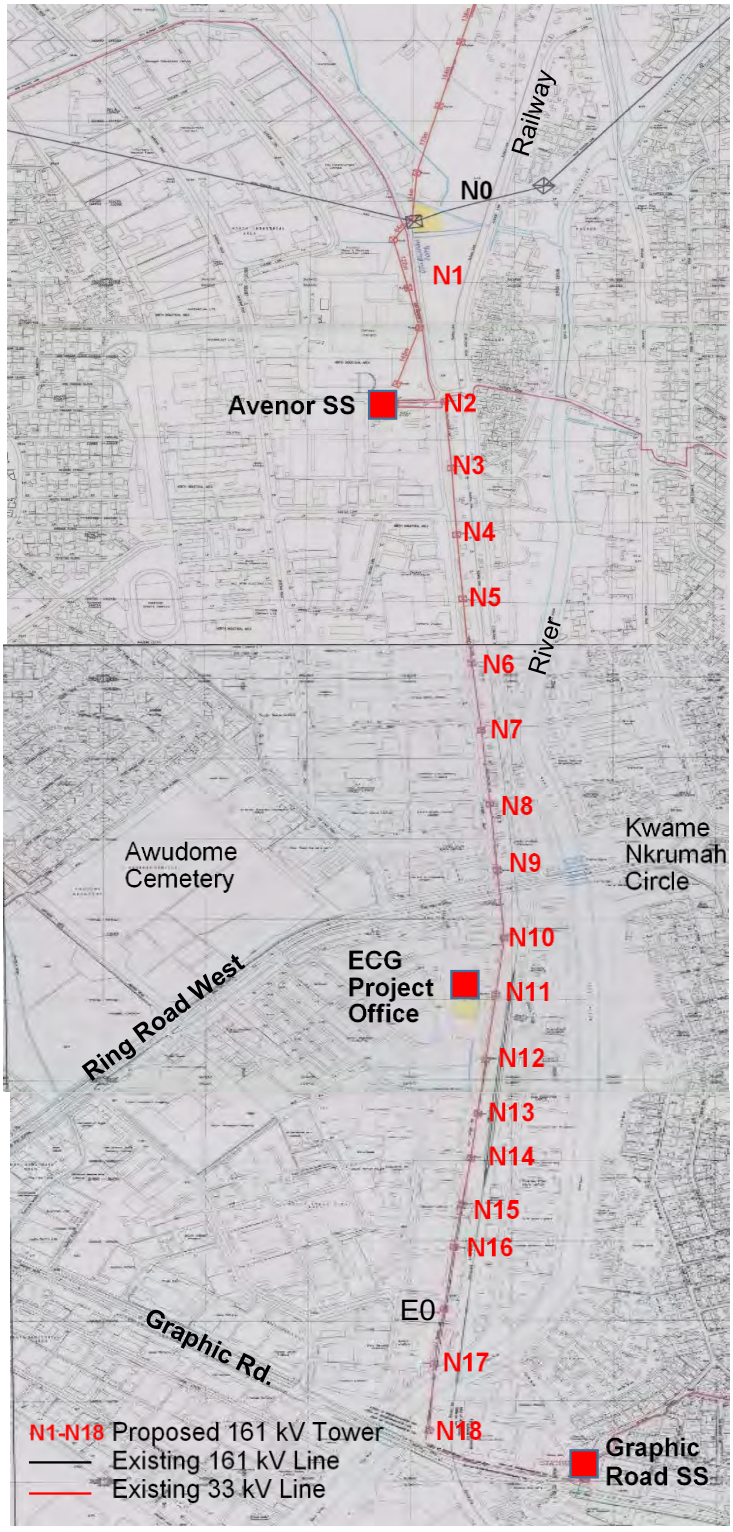


Figure 3-1 Proposed 161 kV Tower Locations

Table 3-3 Existing Conditions on Proposed 161 kV Transmission Line Route

No.	Type	Location Code	Distance (m)	Local Conditions	Note	Photo
N0	by GRIDCo	N: 5.584262 E:-0.219947		- Along a road - Parking space for trucks and cars	No resettlement	
N1	（YY）	N: 5.582600 E:-0.220268	190.0	- Open space owned by Accra City	No resettlement	
N2	（YY）	N: 5.579820 E:-0.220282	310.0	- Along Otublohum Rd. - At the T intersection corner - Small scale shops with simple structure are adjoining	Some resettlement Commercial: 4 population, 1 household	
N3	YY）	N: 5.578316 E:-0.220180	160.5	Along Otublohum Rd. Parking space for large buses, small scale buildings with simple structure are adjoining	No resettlement	
N4	（XX）	N: 5.576812 E:-0.220021	160.5	- Along Otublohum Rd. - Small scale buildings with simple structure and goat market are adjoining	Some resettlement Commercial: 4 population, 1 household	

No.	Type	Location Code	Distance (m)	Local Conditions	Note	Photo
N5	(XX)	N: 5.575289 E:-0.219864	155.4	- Along Otublohum Rd. - Parking space for large buses, small scale buildings with simple structure are adjoining	No resettlement	
N6	(XX)	N: 5.573832 E:-0.219733	181.3	- Along Otublohum Rd. - Surrounded by small scale buildings with simple structure	**Critical site of resettlement** Dwelling: 34 population, 4 households Commercial: 4 population, 1 household	
N7	(XX)	N: 5.572297 E:-0.219612	150.2	- Along Otublohum Rd. - Parking space for large buses and machinery, small scale buildings with simple structure are adjoining	No resettlement	
N8	(YY)	N: 5.570694 E:-0.219432	165.7	- Along Otublohum Rd. - Parking space for large buses, a simple structure building are adjoining	No resettlement	
N9	(YY)	N: 5.569124 E:-0.219311	150.2	- Along Otublohum Rd. - Surrounded by small scale buildings with simple structure	**Critical site of resettlement** Dwelling: 42 population, 4 households Commercial: 29 population, 4 household	
N10	(YY)	N: 5.567666 E:-0.219160	150.2	- Along railway - Wall of bus terminal is close - Grass field	No resettlement	

No.	Type	Location Code	Distance (m)	Local Conditions	Note	Photo
N11	(XX)	N: 5.566368 E:-0.219313	129.5	- Along railway - Wall of ECG Project Office is close - Grass field	No resettlement	
N12	(XX)	N: 5.564893 E:-0.219509	150.2	- Along railway - Wall of ECG Project Office is close - Grass field	No resettlement	
N13	(XX)	N: 5.563630 E:-0.219680	119.1	- Along railway - Cultivation	No resettlement	
N14	(YY)	N: 5.562670 E:-0.219829	98.4	- Along railway - Surrounded by small scale buildings with simple structure	**Critical site of resettlement** Dwelling: 13 population, 3 households Commercial: 15 population, 3 household	
N15	(YY)	N: 5.561550 E:-0.219956	103.6	- Along railway - Wall of ESKAY Therapeutics LTD is close - Small scale buildings with simple structure (recycle shop) are adjoining - Public toilet is close	Some resettlement Dwelling: 6 population, 1 households	
N16	(YY)	N: 5.560646 E:-0.220109	145.0	- In the parking space of TOYOTA Ghana Workshop Limited	In factory	

No.	Type	Location Code	Distance (m)	Local Conditions	Note	Photo
E0	-	-	-	− In LETAP Packaging Factory − Factory buildings are very close to the existing 33 kV tower	**Narrow Space,** Excluded from 161 kV transmission route	
N17	（YY）	N: 5.557966 E:-0.220427	258.9	− In the parking space of NAMCO Netherland African Manufacturing Co. − A wall and small scale structure are close	In factory	
N18	NEW Type	N: 5.556549 E:-0.220630	145.0	− Along Grahic Road − Car Service Workshop is adjoining	In business establishment	

Source: JICA Study Team

Mitigation Measures:

GRIDCo will prepare a Resettlement Action Plan (RAP) through the ESIA study. GRIDCo has own environmental management system stated in the "Framework for Environmental and Social Management of Bulk Transmission Line Projects in Ghana, January 2009" which also includes the land acquisition and resettlement policy framework applying the World Bank Operational Policies OP 4.12 Involuntary Resettlement (December 2001).

In addition, GRIDCo is preparing the "Land Acquisition and Resettlement Policy Framework" separated by the environmental and social management framework, which is waiting for review of GRIDCo Committee. GRIDCo complies these policy frameworks with the legislations of Ghana on environmental and social considerations in the ESIA and the RAP preparations. All environmental and social impacts including resettlement matters are studied to be mitigated in the ESIA and the RAP.

3.2.3 Noise

The Existing Conditions:

Ambient noise is generated from the 161/34.5 kV transformer operations and the noise level is anticipated at 85 dB(A). According to Town and Country Planning Department of Accra City, the Accra Central BSP (in the Graphic Road Primary Substation) is located in "Light Industry Areas" where permissible noise levels are 65 dB(A) in daytime and 60 dB(A) in nighttime, which are

stipulated in Environmental Quality Guidelines for Ambient Noise (EPA) shown in Table 3-4.

Table 3-4 Environmental Quality Guidelines for Ambient Noise (EPA)

Zone	Description of Area of Noise Reception	Permissible Noise Level in dB(A)	
		DAY (6:00-22:00)	NIGHT (22:00-6:00)
A	Residential areas with low or infrequent transportation	55	48
B1	Educational (school) and health (hospital, clinic) facilities	55	50
B2	Areas with some commercial or light industry	60	55
C1	Areas with some light industry, places of entertainment or public assembly, and places of worship located in this zone	65	60
C2	Predominantly commercial areas	75	65
D	Light industrial areas	70	60
E	Predominantly heavy industrial areas	70	70

Source: EPA

Mitigation Measures:

The Team will propose the design of 161/34.5 kV transformers and the control building to meet the guidelines for ambient noise as the details are described in Chapter 4. Each transformer is covered by iron box with insulation so that the noise levels will decrease under 60 dB(A) from the transformers.

3.2.4 Other Prospected Impacts and Mitigation Measures

Other prospected adverse impacts are listed as follows and most of them are caused during the construction period. GRIDCo's "Framework for Environmental and Social Management of Bulk Transmission Line Projects in Ghana, January 2009" stipulates how GRIDCo mitigates these adverse impacts. The Environmental Management Plan (EMP) is prepared in the ESIA and contractor(s) are also required to prepare own EMP, so-called HSES (Health, Safety, Environmental and Social) Management Plan, according to the ESIA/EMP. The contractor shall spell out how the contractors will achieve environmental targets and objectives specified in the ESIA/EMP. Most of adverse impacts during the construction period will be mitigated by executing the HSES Management Plan.

- Obstruction of the existing social infrastructures and services: Traffic can be disturbed by construction vehicle nearby the construction sites during the construction period. Telecommunication lines and water supply pipe settled underground can be affected by the installation works of 161 kV transmission underground cable along Graphic Road.
- Obstruction of cultural property: There are no cultural heritages nearby the Project Route. However, some small houses of worships can be seen nearby the existing towers. They may be affected by the construction works.
- HIV/AIDS: As the Project does not have large-scale construction works and the local employment can be expected, no considerable influx of workers is expected. Therefore, there is low risk of infectious diseases due to the mass inflow of laborers from other areas. However, the

external workers could induce/illicit for sexual relationships with the local peoples and it would enlarge risks on both of them without sensitizations.

- Groundwater contamination: The boring survey identified water table levels are high at about 1.6 meters from the ground level. Leakage and/or spillage of insulation oil of transformers can temporally contaminate groundwater during the construction period at Accra Central BSP.
- Accident: Although a contractor will use few heavy machinery, the manual nature of the work means that there is a possibility of accidents involving workers. The works to construct towers and install wires also can induce the accidents both on the workers and local people.

3.3 Resettlement Action Plan

3.3.1 Resettlement Policy for the Project

The following key policies are extracted from the policy frameworks mentioned above for the Project. These policies mostly covers JICA's Guidelines for Environmental and Social Considerations and WB Operational Policies OP 4.12.

- Except where unavoidable, all necessary steps should be taken to avoid built up areas or sites of environmental and social cultural significance;
- Alternative sites where the impact will be minimized or avoided should be preferred;
- Acquisition of ROW are carried out in such a way as to minimize as much as possible the impact on people;
- GRIDCo is committed to ensuring the restoration of the livelihood of all people adversely affected by its operations;
- Compensation Payment should be fair and adequate and the affected persons should not be made worse off as a result of the implementation of any of GRIDCo Projects;
- GRIDCo must ensure that the livelihood and living standards of the affected people prior to the displacement should not be made worse off but rather improved;
- Resettlement or compensation payments are made on the basis of open market value or Replacement Cost of the property;
- Prior to the commencement of constructional activities, the PAPs should have been paid their compensation to enable them relocate;
- The affected people should be engaged and fully involved in the planning, implementation and monitoring of the resettlement process;
- Grievance redress system is established with grievance redress committee;
- Census and Inventory are conducted in
- Lack of formal title to land should not be a bar to compensation or resettlement/rehabilitation. All affected person are eligible regardless of legal or ownership titles;
- Cash compensation for the loss of income during the transition period;

- Vulnerable groups such as households headed by women or children, the aged, and the physically disabled etc. are cared to be provided to improve their socio-economic conditions rather than simply restoring then to their pre-project levels of vulnerability.

3.3.2 Procedure of Land Acquisition and Resettlement Works

According to the land acquisition and resettlement policies, GRIDCo may take the following steps for resettlement as described in Table 3-5. The RAP will be studied and prepared in the ESIA. Public consultations will also be conducted in the ESIA. The PAPs are initially consulted in this stage. The ESIA will be scheduled until July. GRIDCo may start Census and Inventory works immediately after E/N.

Lands Management Section of Engineering Department of GRIDCo is responsible to the land acquisition and resettlement works. Another important institution is Land Valuation Division (LVD) of Lands Commission. The LVD determines all matters of compensations for land compulsorily acquisition, especially undertakes valuation of immovable properties.

Table 3-5 Expected Resettlement Procedures

No.	Resettlement Steps	Responsible Organization
A.	Pre-Resettlement Implementation Stage	
(1)	RAP Preparation	− GRIDCo Lands Management: Environmental Unit, Lands Acquisition Unit − Local Consultant
(2)	Institutional Arrangements	− GRIDCo Engineering Department
B.	Resettlement Implementation Stage	
(3)	Census and Inventory	− GRIDCo Lands Management: Surveying Unit, Lands Acquisition Unit − Lands Commission: Land Valuation Division − PAPs or PAP's representatives
(4)	Valuation of Lost Assets and Incomes	− GRIDCo Lands Management: Lands Acquisition Unit − Lands Commission: Land Valuation Division − Independent Valuers (Private Valuation Consultants)
(5)	Compensation Entitlement	− GRIDCo Lands Management: Lands Acquisition Unit − Lands Commission: Land Valuation Division − Independent Valuers
(6)	Negotiation and Consent	− GRIDCo Lands Management: Lands Acquisition Unit − Lands Commission: Land Valuation Division
(7)	Budget Disbursement	− GRIDCo
(8)	Payment and Relocation	− GRIDCo Lands Management: Lands Acquisition Unit − Lands Commission: Land Valuation Division − Opinion leaders, an elder or chief
C.	Cross-Culling Issues	
(9)	Public Consultation Meeting	− GRIDCo Lands Management: Environmental Unit, Lands Acquisition Unit
(10)	Grievance Redress Mechanism (GRM)	− GRIDCo Lands Management: Environmental Unit, Lands Acquisition Unit − Grievance Redress Committee − Commission on Human Rights and Administrative Justice (CHRAJ) − Courts
(11)	Monitoring and Evaluation	− GRIDCo Lands Management Environmental Unit, Lands Acquisition Unit

Source: Framework for Environmental and Social Management of Bulk Transmission Line Projects in Ghana January 2009, Land Acquisition and Resettlement Policy Framework, JICA Study Team

3.4 Physical Conditions around the Existing Towers

N2

A white wall building

Small shop

Parking space

N3

A small building

Bus parking space

Parking space

15m Square

N4

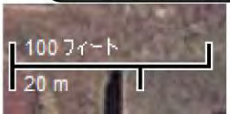
Small buildings around

Goat market

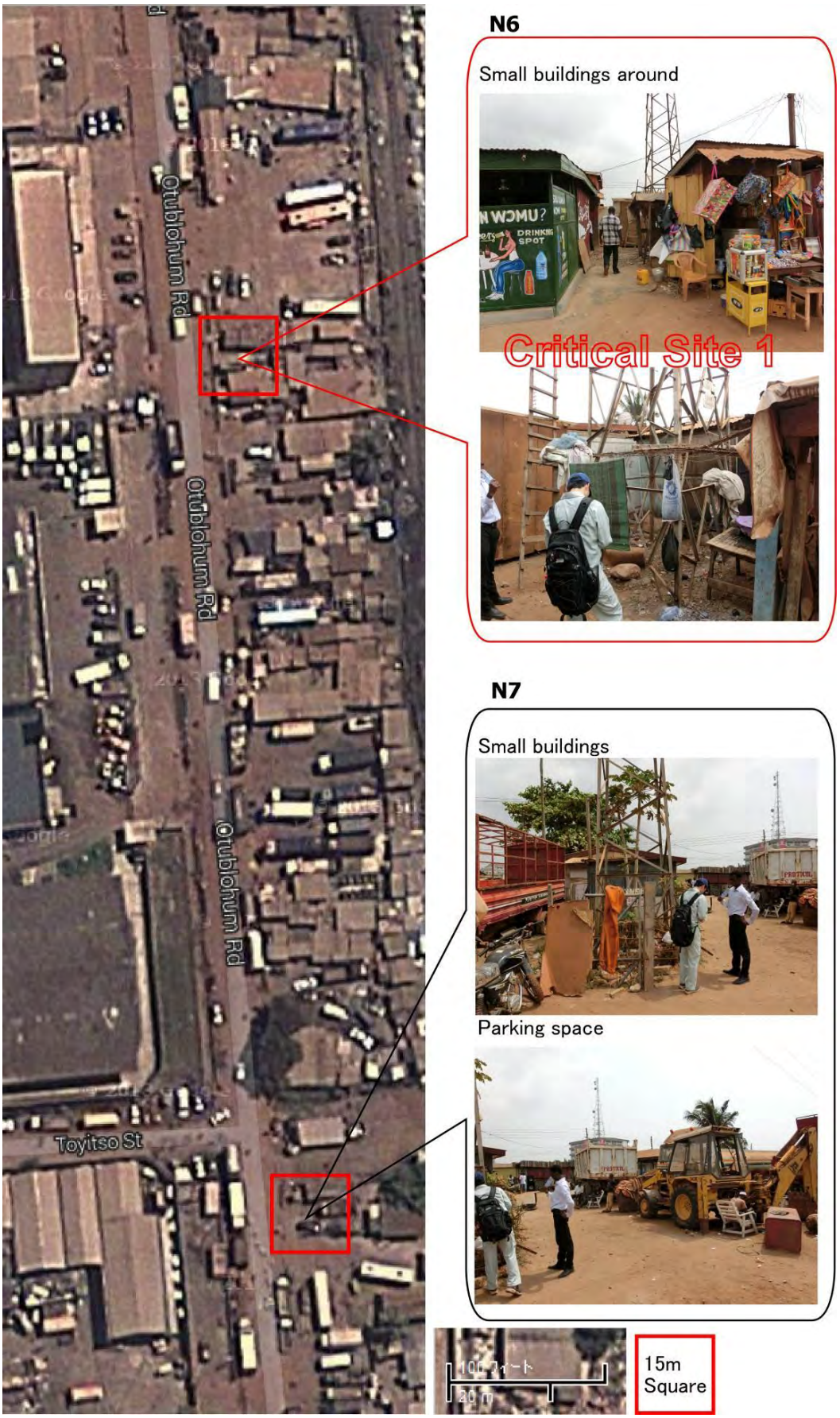
N5

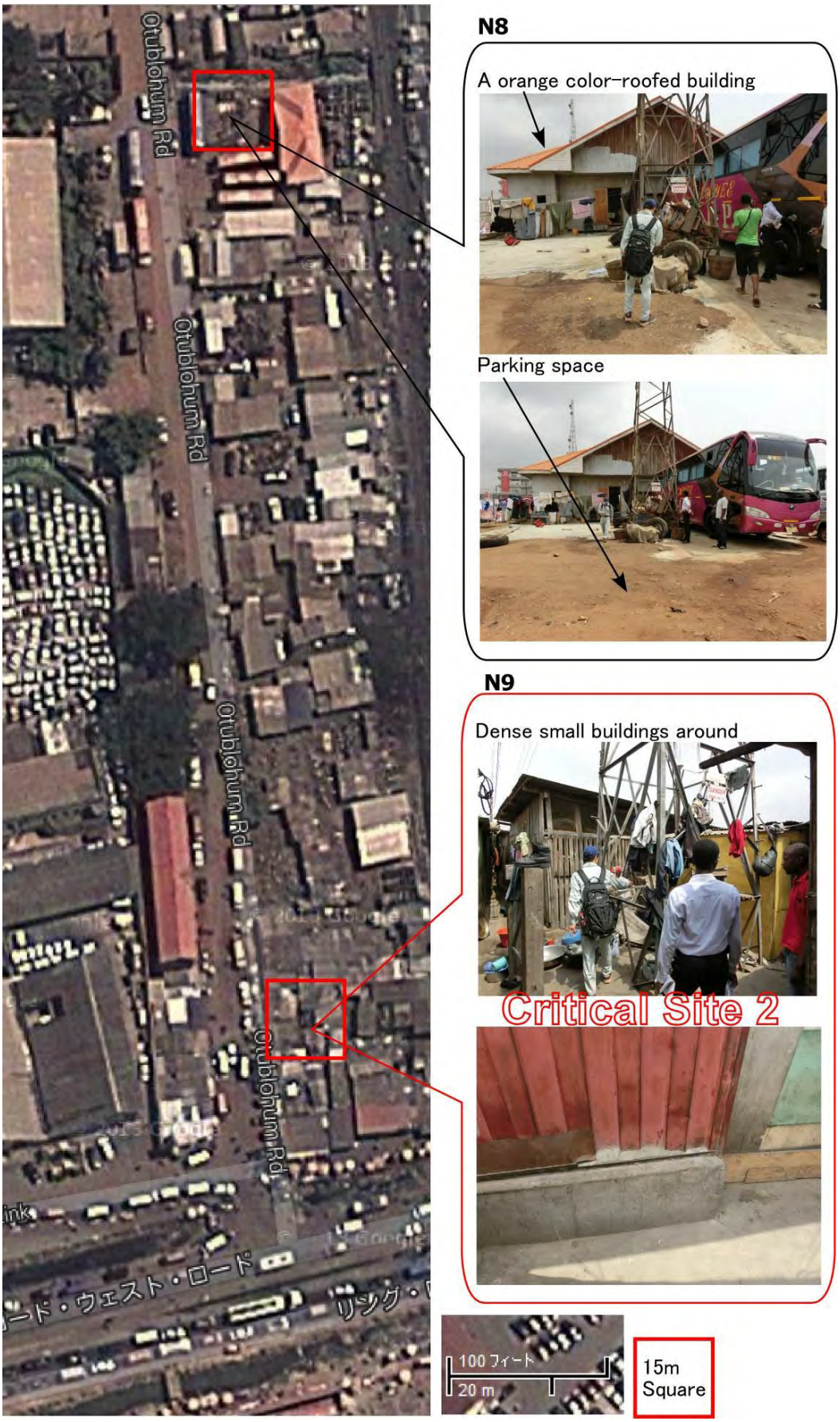
Small buildings

Parking space

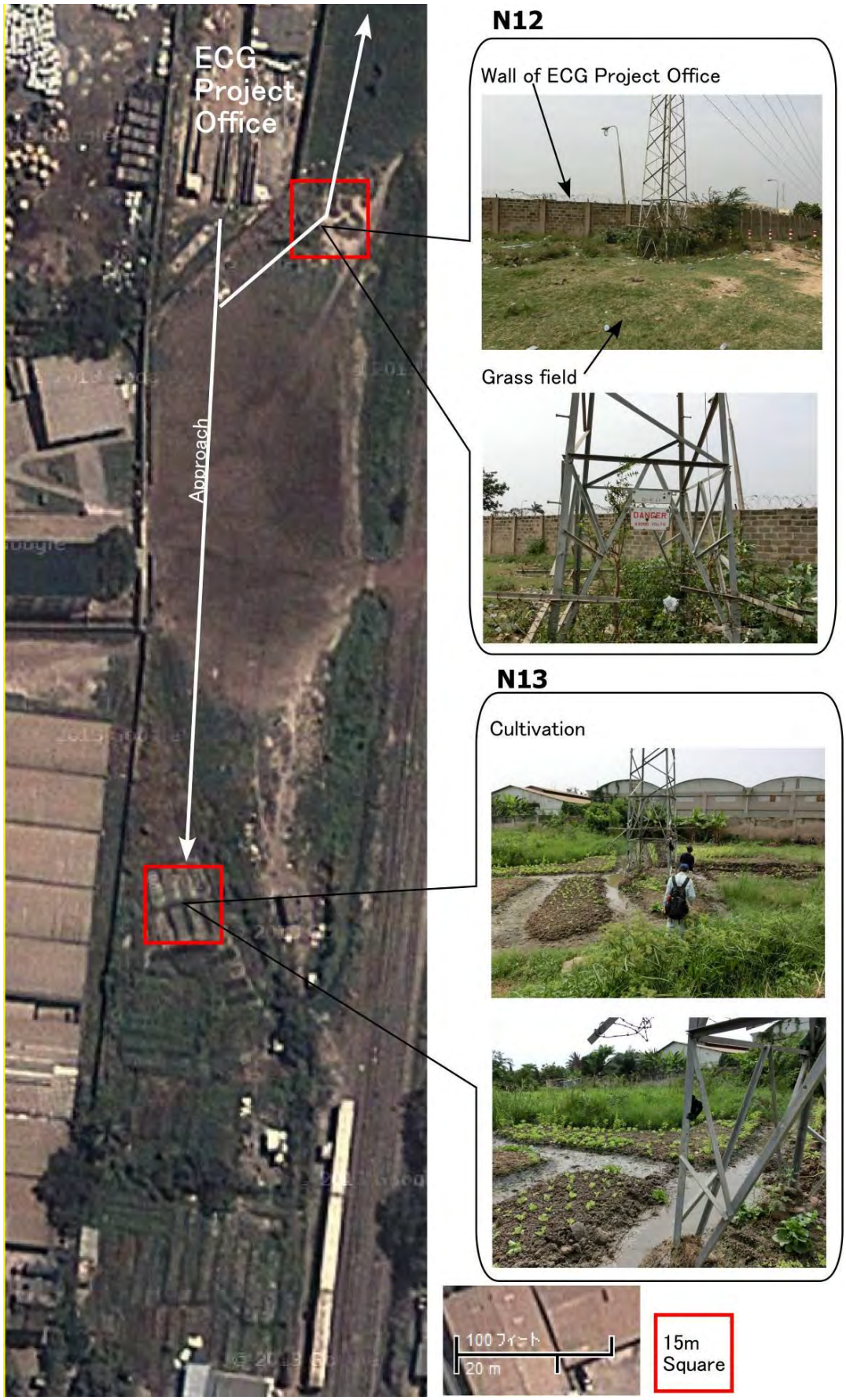


15m
Square


Otublohum Rd
Otublohum Rd
Otublohum Rd
Toyitso St
N6
Small buildings around
Critical Site 1
N7
Small buildings
Parking space
15m
Square


Otublohum Rd
Otublohum Rd
Otublohum Rd
Otublohum Rd
N8
A orange color-roofed building
Parking space
N9
Dense small buildings around
Critical Site 2
100 フィート
20 m
15m
Square


Bus Terminal
Approach
ECG Project Office
N10
Grass field
N11
Wall of ECG Project Office
Grass field
100 フィート
20 m
15m Square


ECG
Project
Office
Approach
N12
Wall of ECG Project Office
Grass field
DANGER
N13
Cultivation
100 フィート
20 m
15m
Square

N14

Dense small buildings around

Critical Site 3

From the railway side

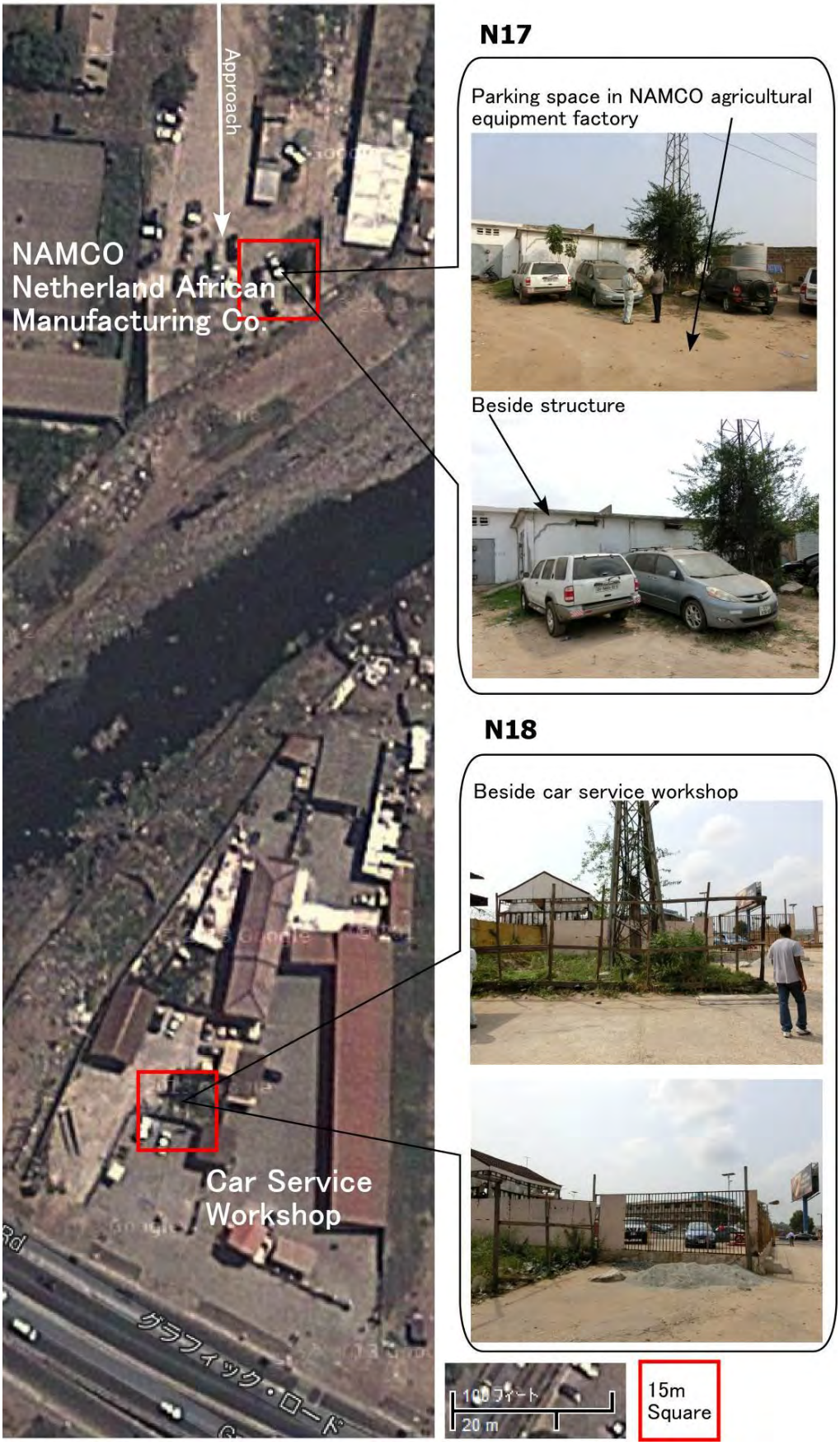
N15

In a recycle service

Critical Site 4

15m
Square


N16
TOYOTA
Ghana Workshop
Limited
Approach
Approach
LETAP
Packaging
Parking space
Parking gate
Narrow space in plastics factory
Critical Site 5
100フィート
20 m
15m
Square


Approach
NAMCO
Netherland African
Manufacturing Co.
Car Service
Workshop
グラフィック・ロード
N17
Parking space in NAMCO agricultural equipment factory
Beside structure
N18
Beside car service workshop
100フィート
20 m
15m
Square

1. Natural conditions for the equipment and facilities design are described as follows.

Table 2.1.2-1 Climatic Conditions

	Mean Temperature (degrees centigrade)		Mean Total Rainfall (mm)	Mean Number of Rain Days
	Daily Minimum	Daily Maximum		
Jan.	23.4	32.1	10.9	1
Feb.	24.1	32.7	21.8	2
Mar.	24.1	32.5	57.1	5
Apr.	24.2	32.2	96.8	6
May.	23.9	31.2	131.2	10
Jun.	23.1	29.3	221.0	15
Jul.	22.5	28.5	66.0	9
Aug.	22.2	28.0	28.0	7
Sep.	22.4	29.0	67.8	8
Oct.	23.9	30.5	62.4	7
Nov.	23.5	31.6	27.7	3
Dec.	23.4	31.7	16.1	2

[Source] Accra Meteorological Observatory 2014.01 (Average of 30 years from 1961-1990)

2. Comparison of required area for the Bulk supply Points

Accra Central BSP is extremely narrow compared to the other BSP, like Achimoto BSP and Mallam BSP as you can see in Table 4-1 Site Area Comparison Table.

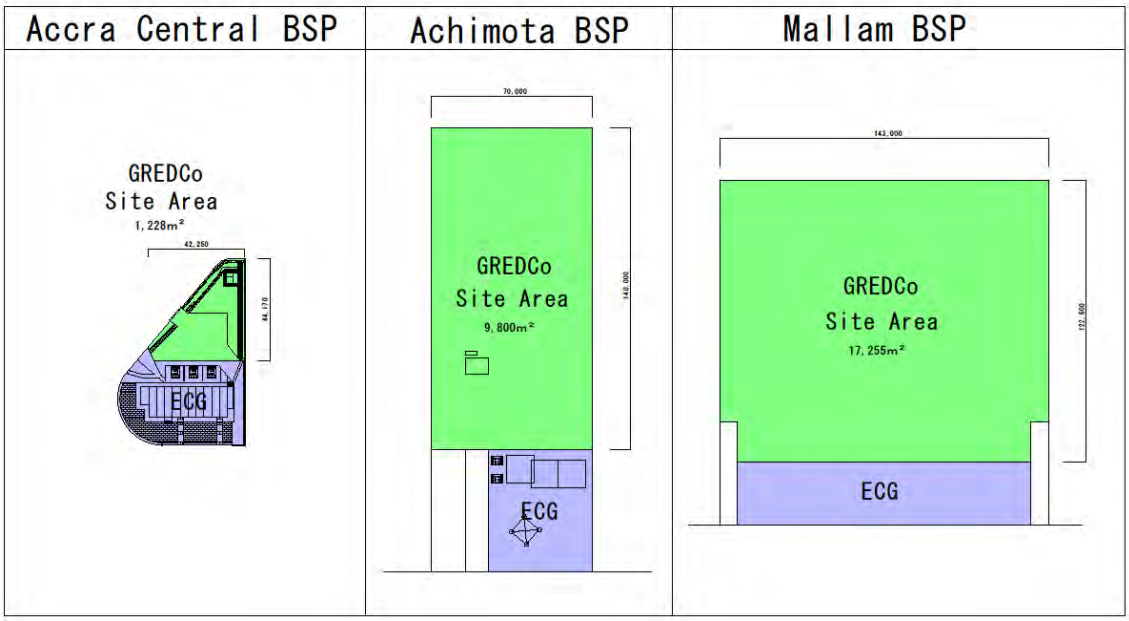
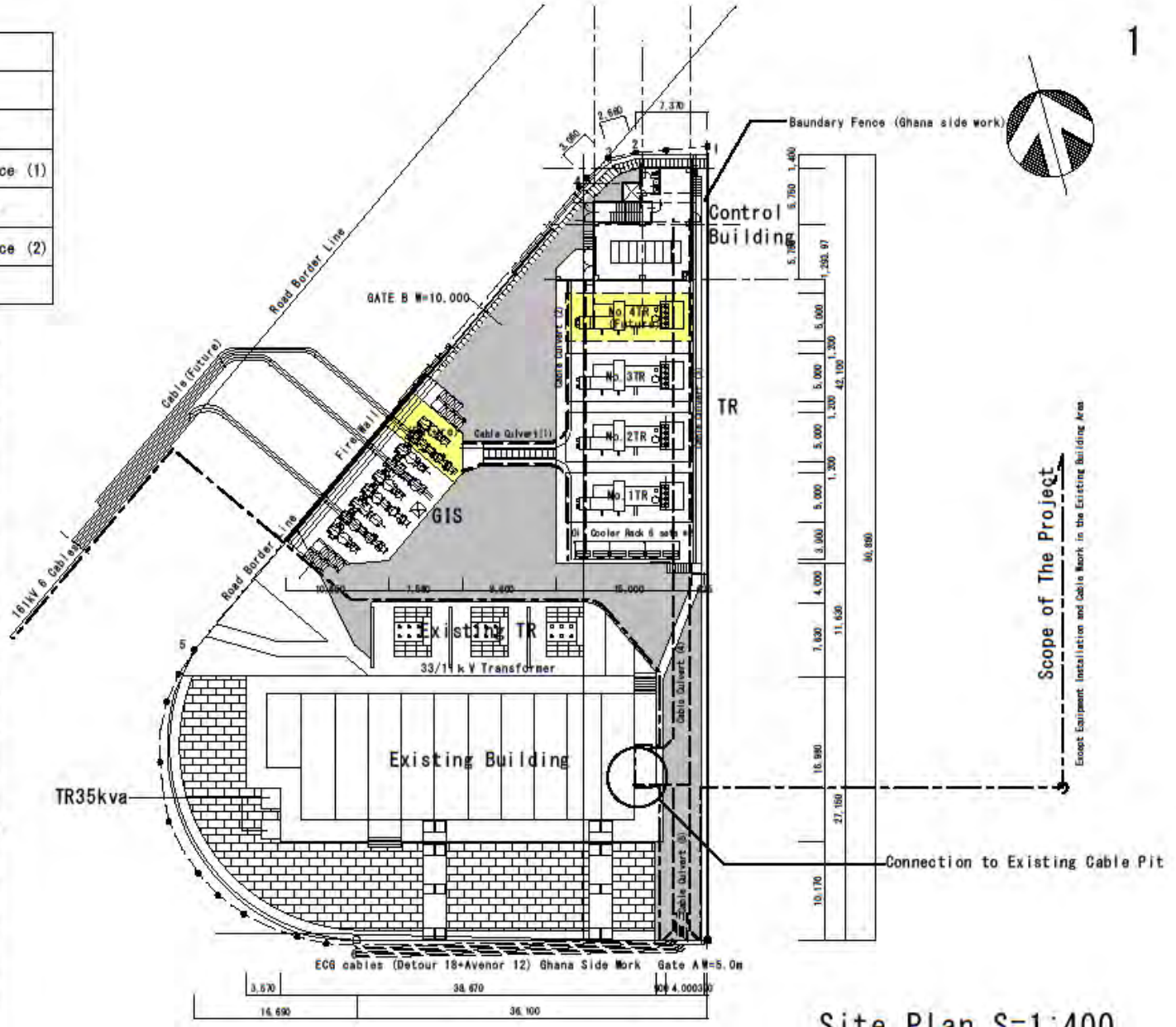
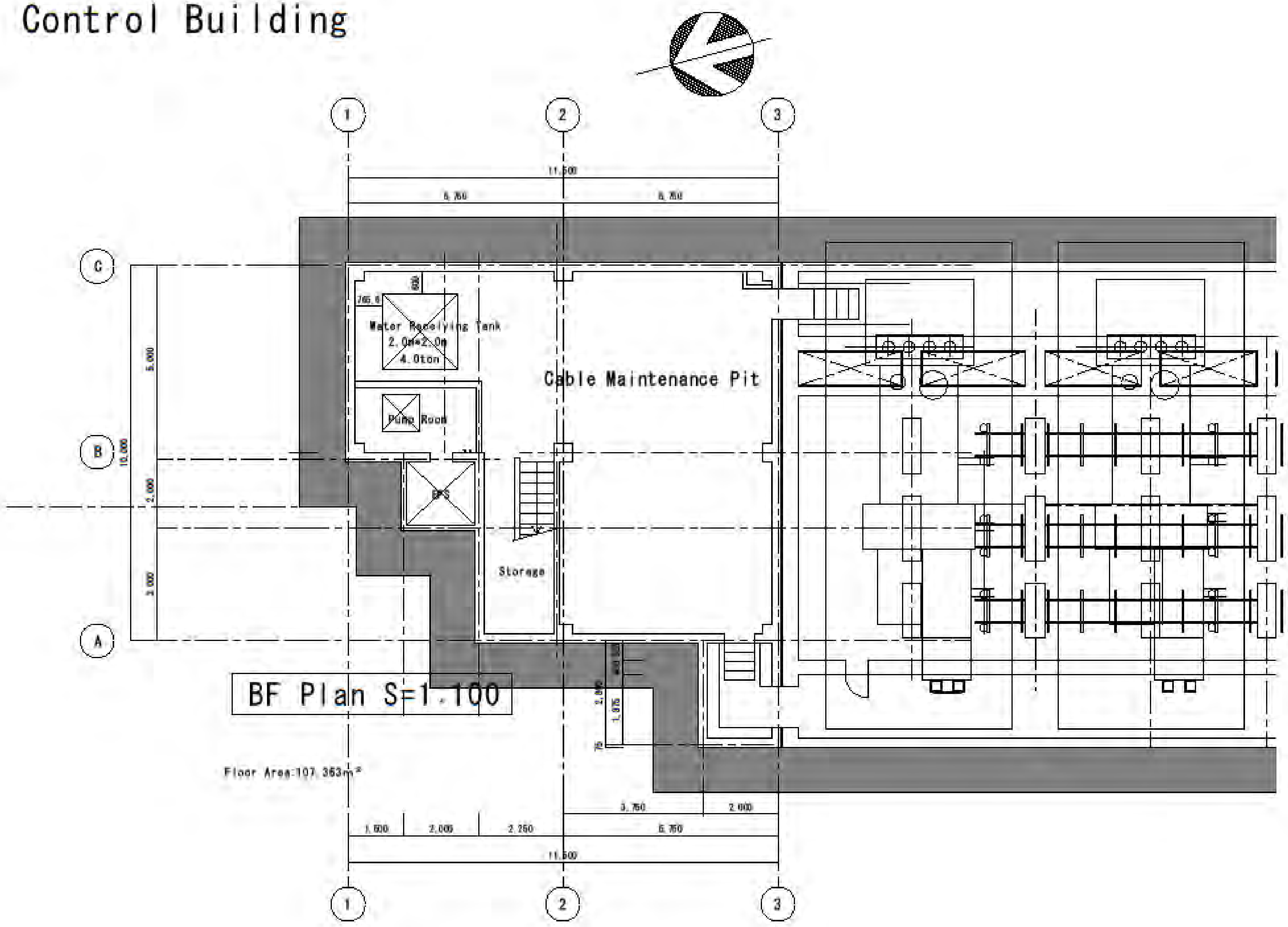


Table4-1: Site Area Comparison

Facility List	
1.	Control Building
	BF Cable Pit, Water Tank, Pump
	GF Control Room(1), Control Office (1)
	1F Control Room(2), Battery Room
	2F Control Room(3), Control Office (2)
	RF Trans, Air-con unit
2.	GIS
	BF Cable Pit
	GF GIS 3sets, space for future
3.	Trans
	BF Mechanical Pit,
	BF Cable Culvert (2), (3)
	GF Trans No.1, 2.3& Space No.4
	Oil cooler Rack (12sets)
4.	Cable Culvert
	Cable Culvert (1) GIS-TR
	Cable Culvert (4) TR-Existing
	Cable Culvert (5) Existing 33kV
5.	Fire Wall
	Fire wall for GIS
6.	Gate B
	W=10m full open gate

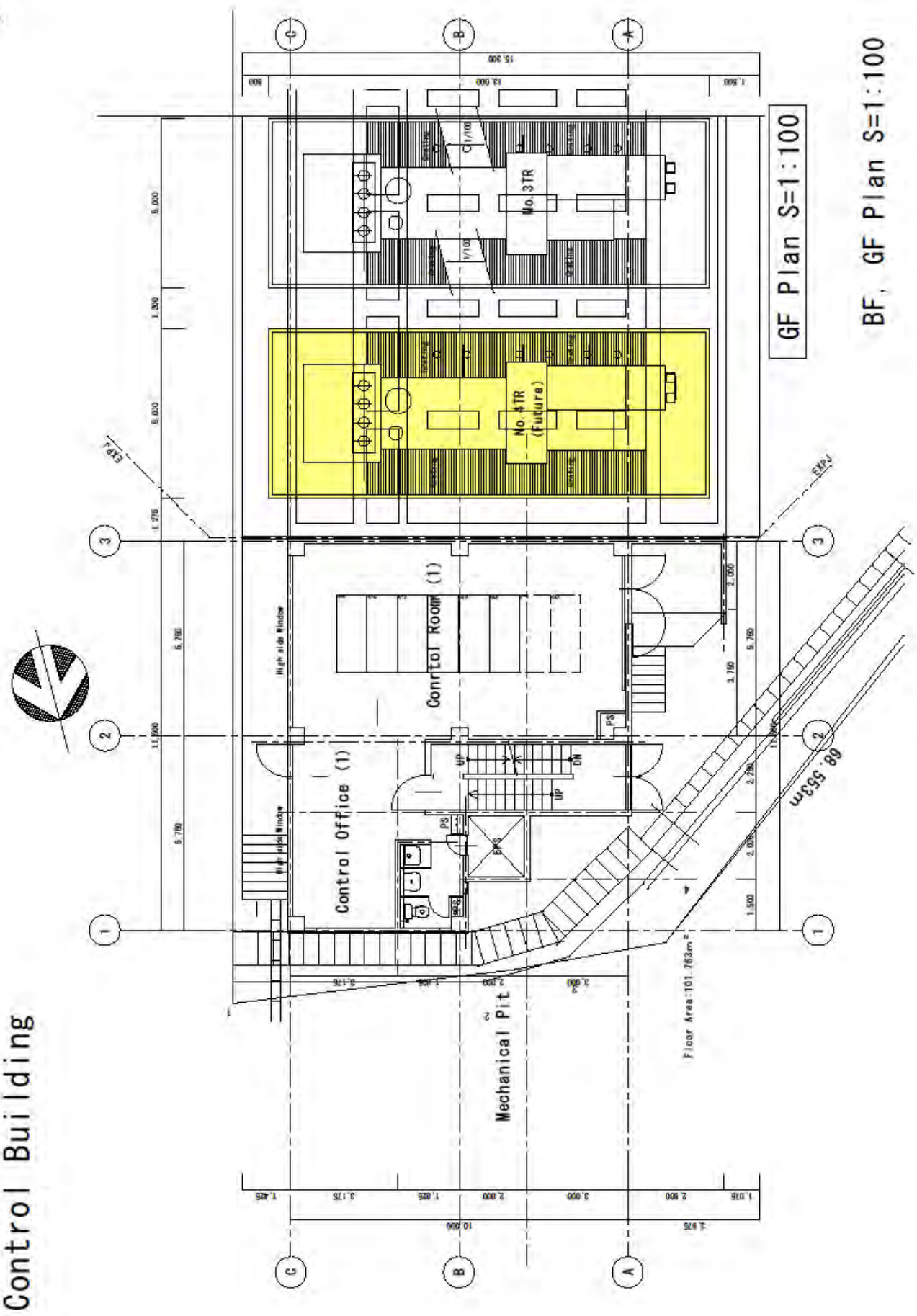


Control Building



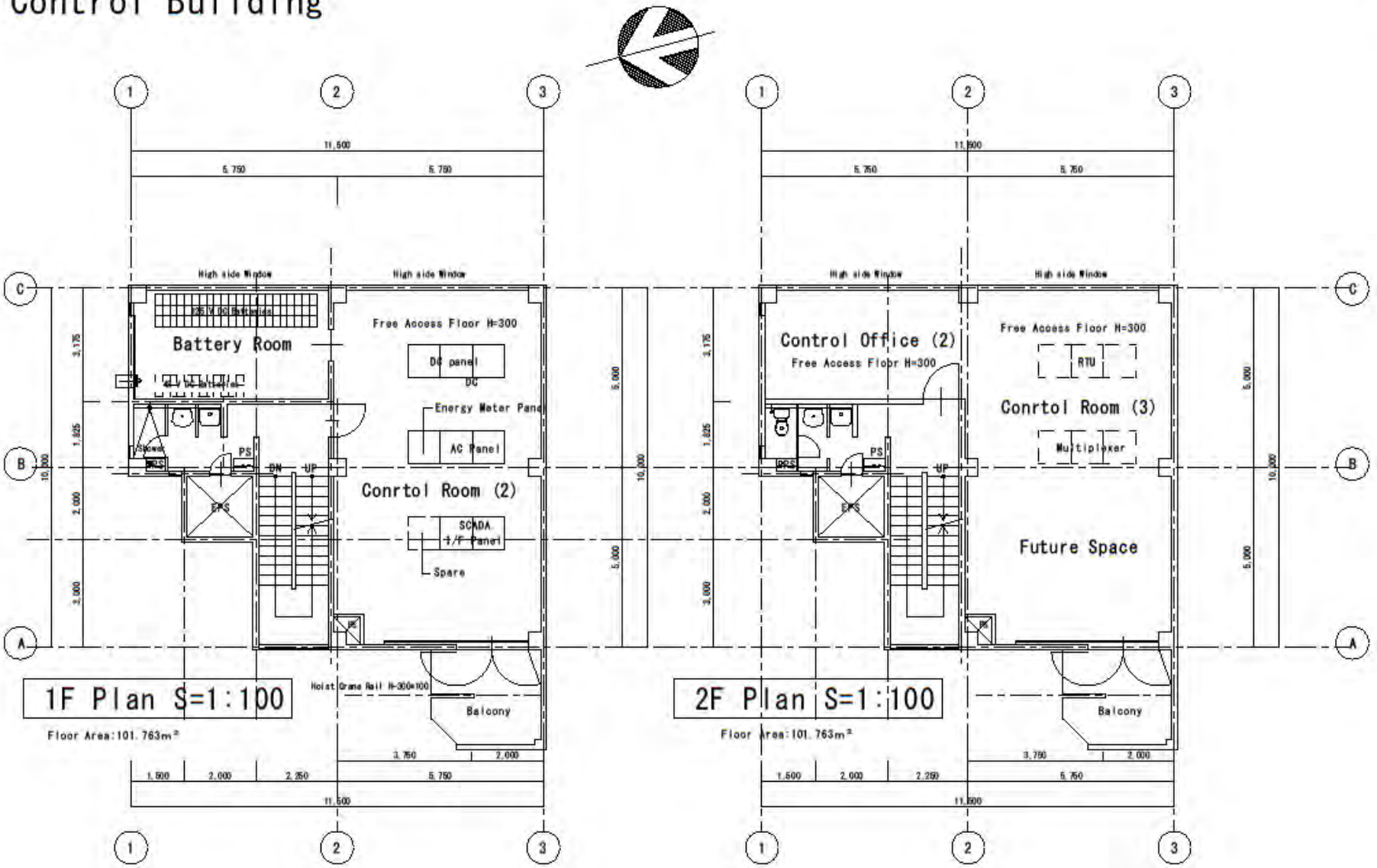
BF Plan S=1:100

A-02 CONTOL BUILDING BF PLAN of ACCRA CENTRAL BSP



A-03 CONTOL BUILDING GF PLAN of ACCRA CENTRAL BSP

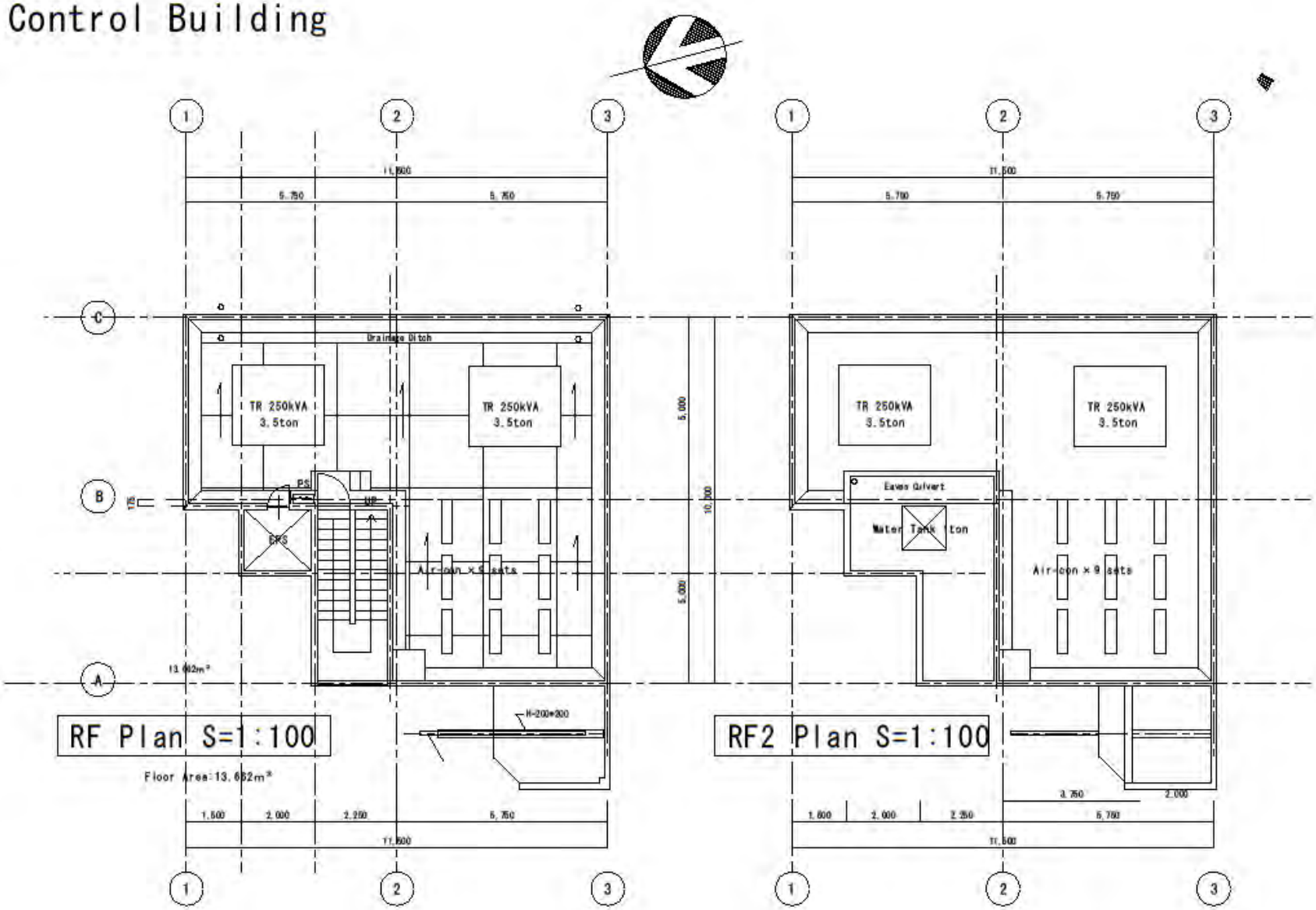
Control Building



1F, 2F Plan S=1:100

A-04 CONTOL BUILDING 1F, 2F PLAN of ACCRA CENTRAL BSP

Control Building



RF, Roof Plan S=1:100

A-05 CONTOL BUILDING RF, Roof PLAN of ACCRA CENTRAL BSP

Control Building

North-South Section S=1:100

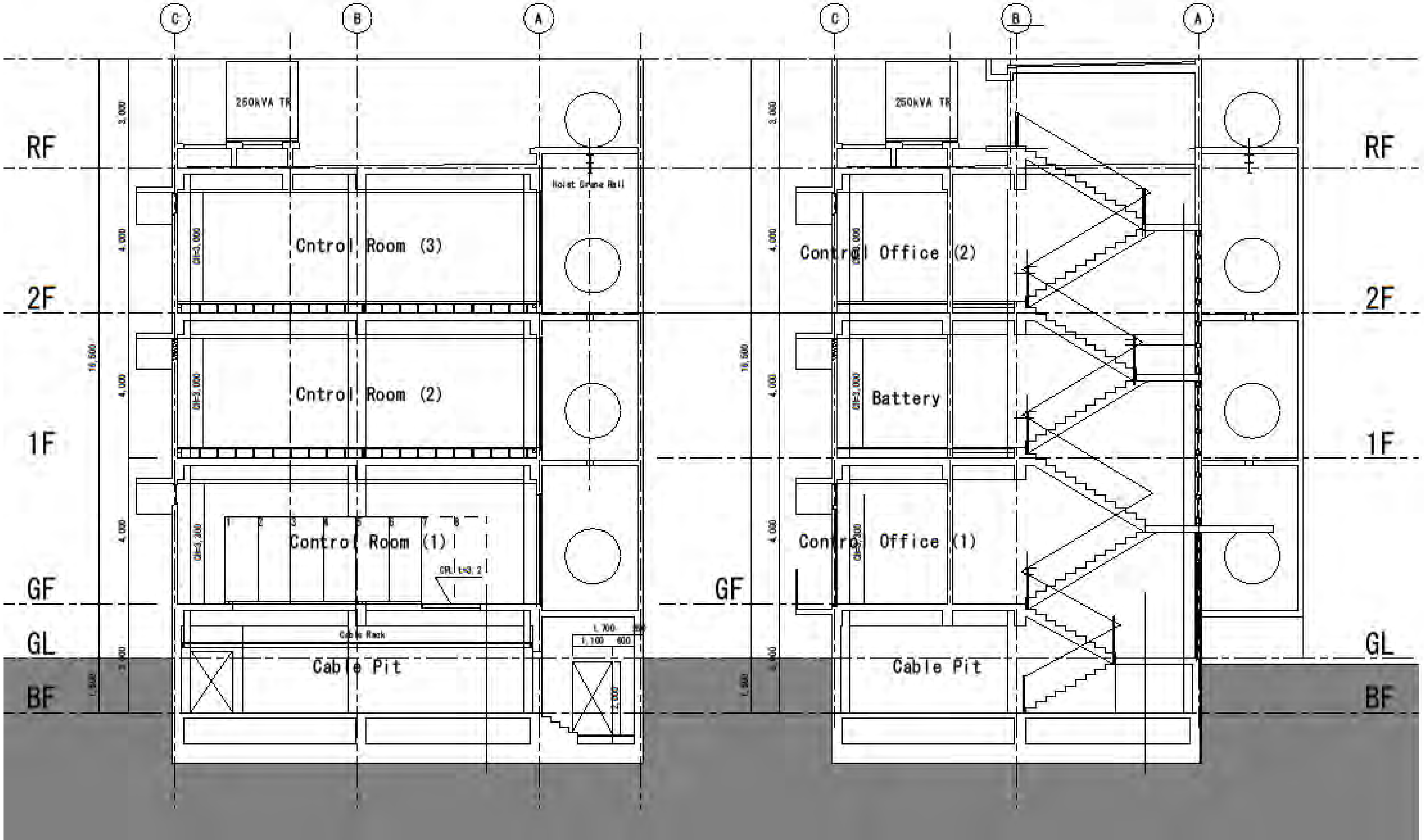
A-06 CONTOL BUILDING SECTION (1) of ACCRA CENTRAL BSP

A6-75

A-07 CONTOL BUILDING SECTION (2) of ACCRA CENTRAL BSP

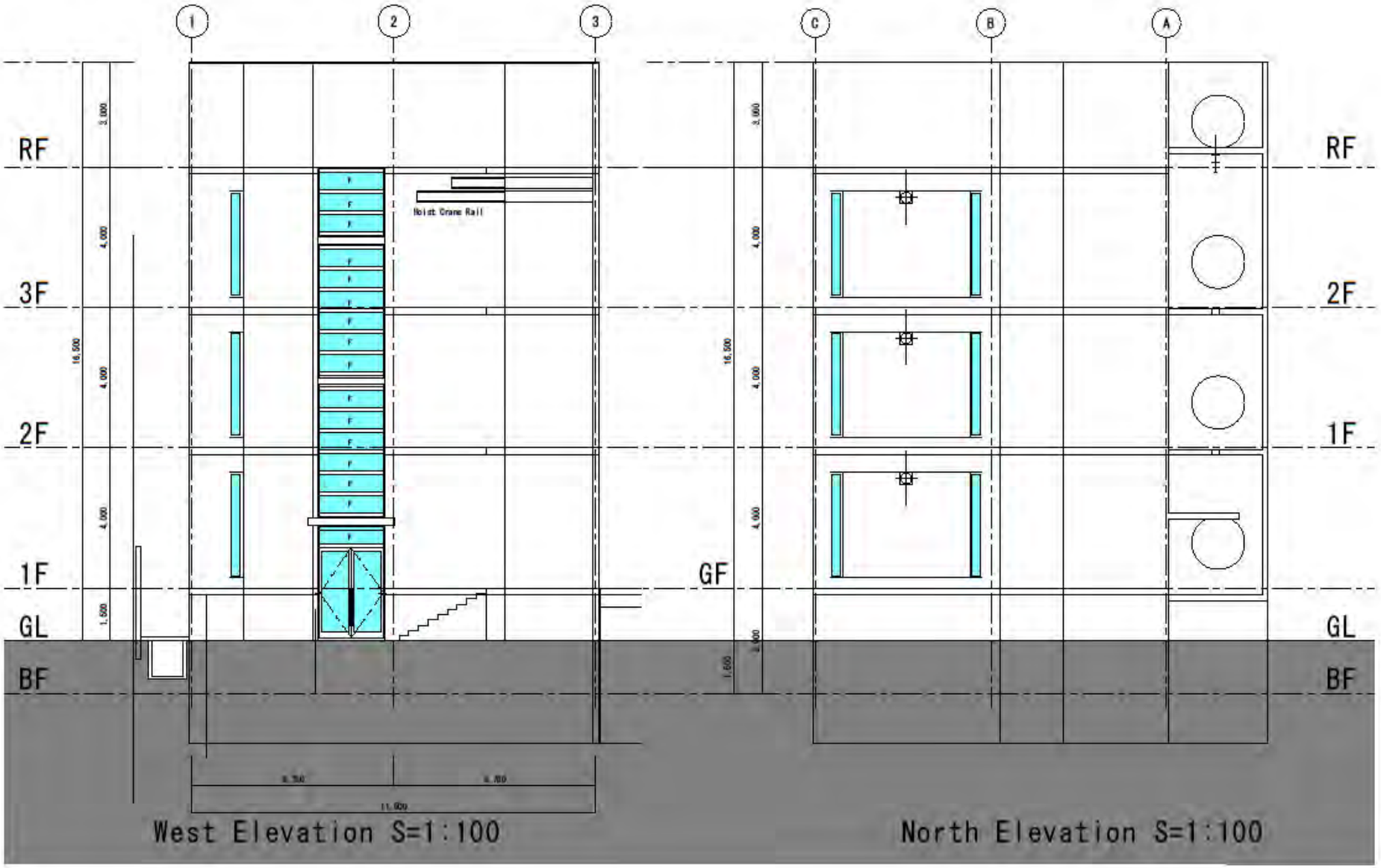
6a

Control Building

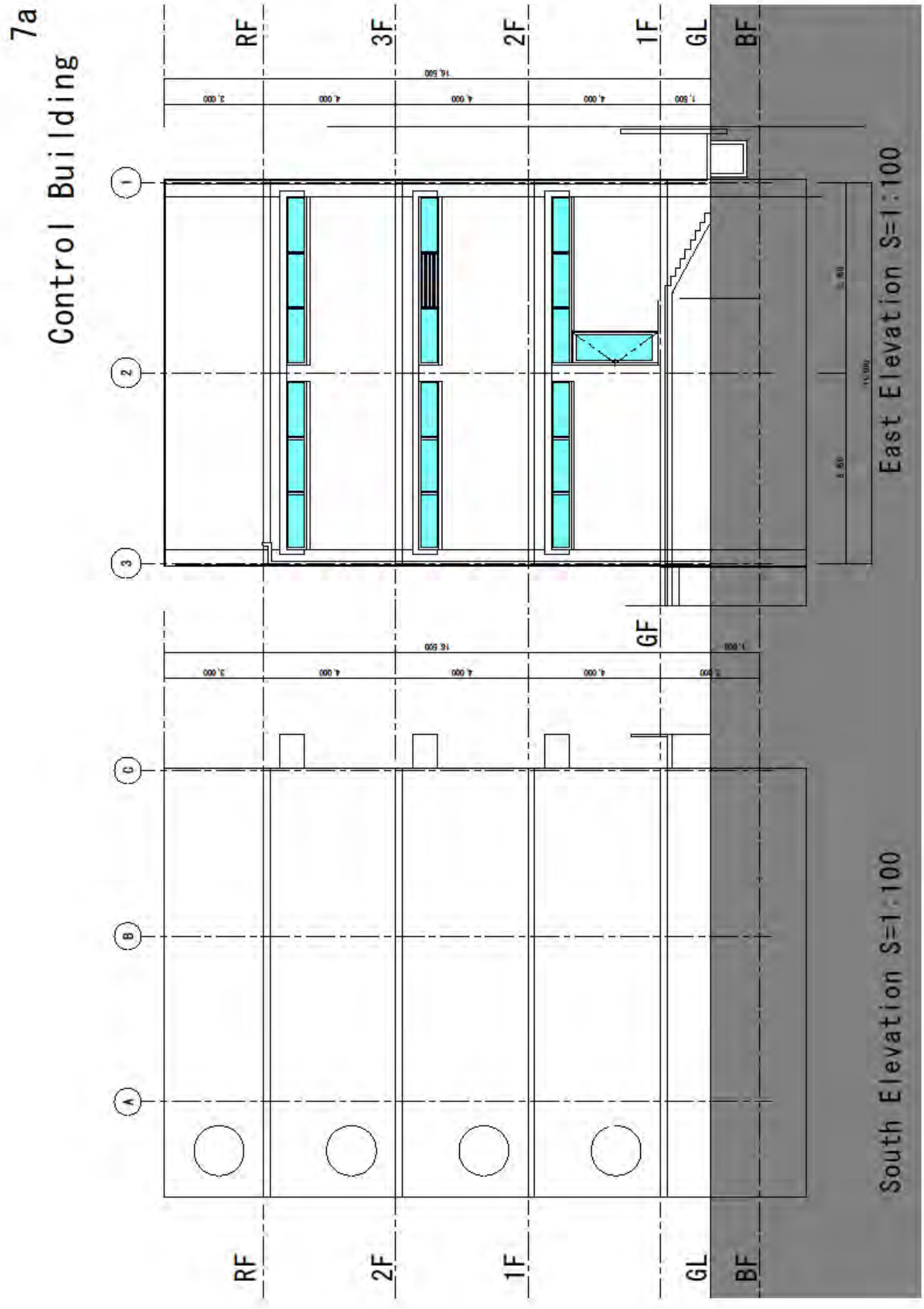


East-West Section S=1:100

Control Building

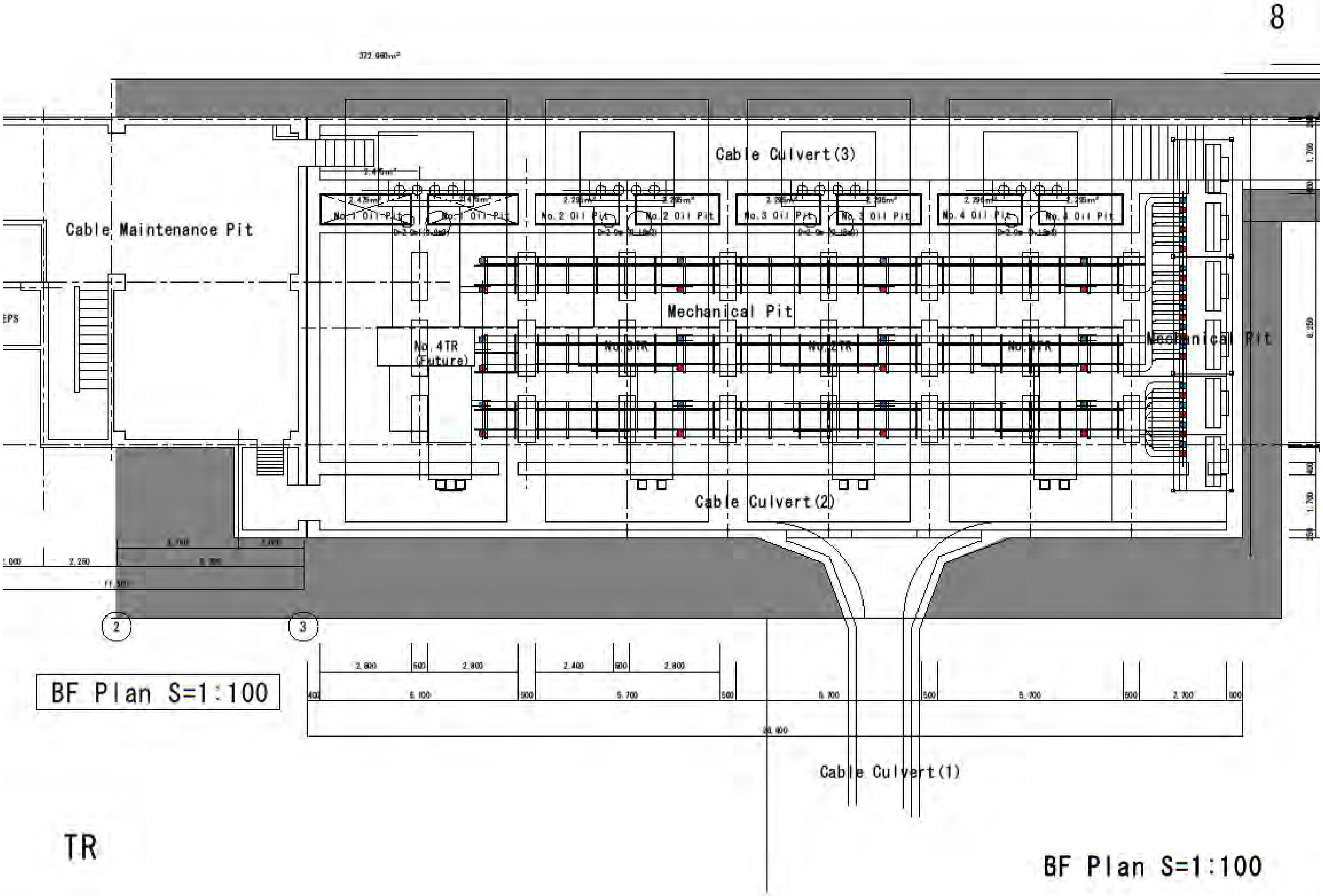


A-08 CONTOL BUILDING ELEVATION (1) of ACCRA CENTRAL BSP

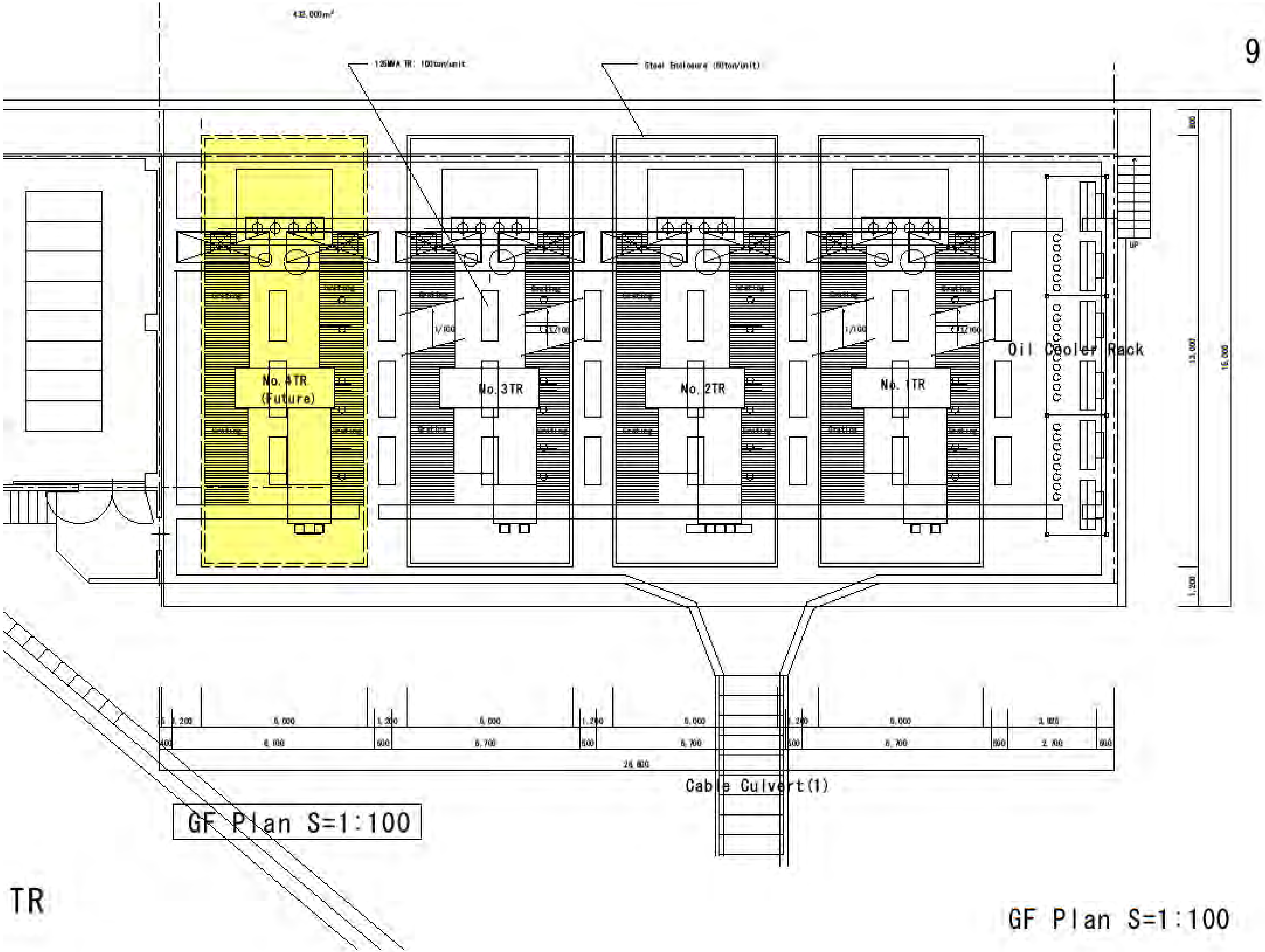


A-09 CONTOL BUILDING ELEVATION (2) of ACCRA CENTRAL BSP

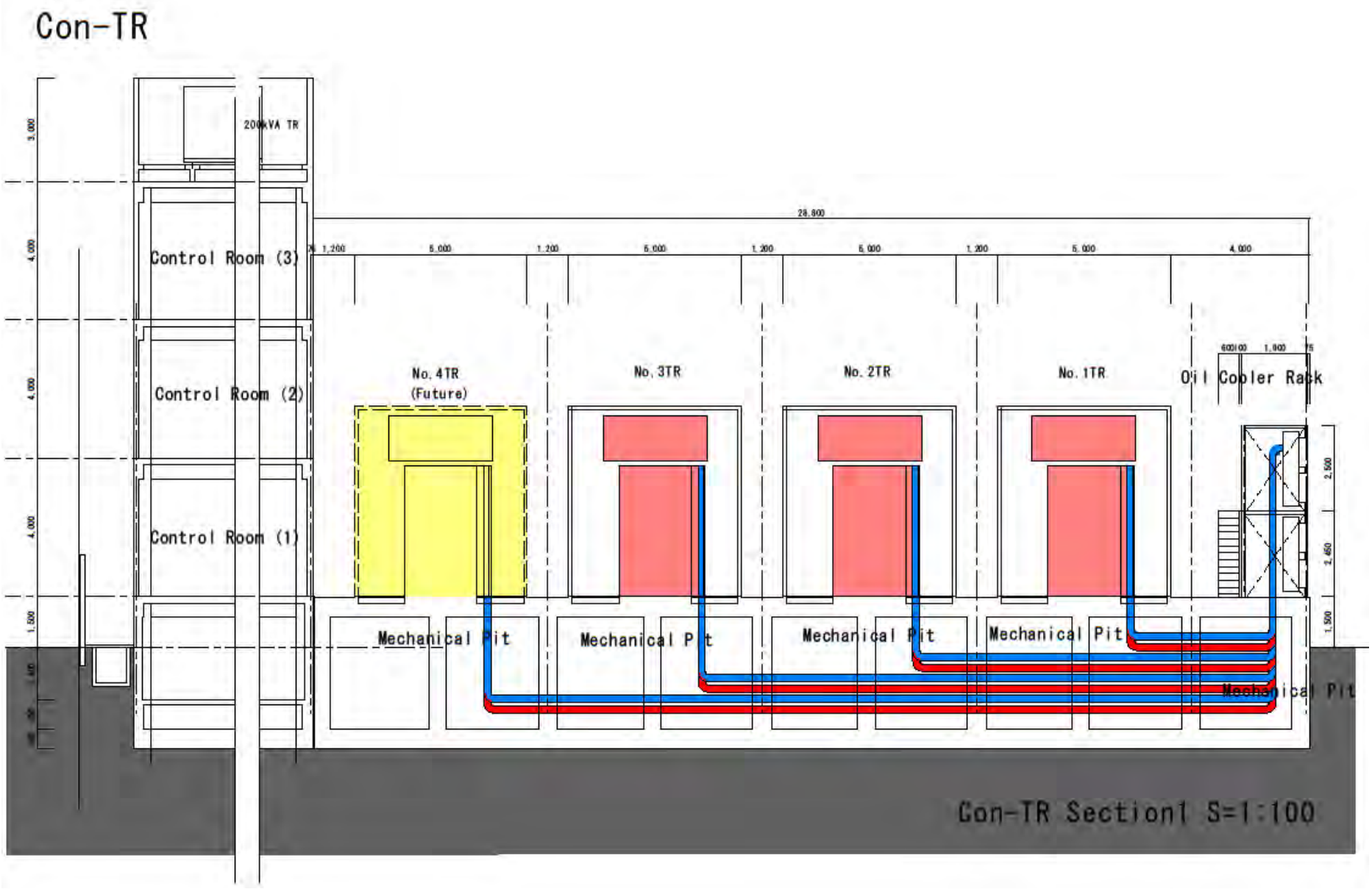
A-10 125MVA TRANSFORMER BF PLAN of ACCRA CENTRAL BSP

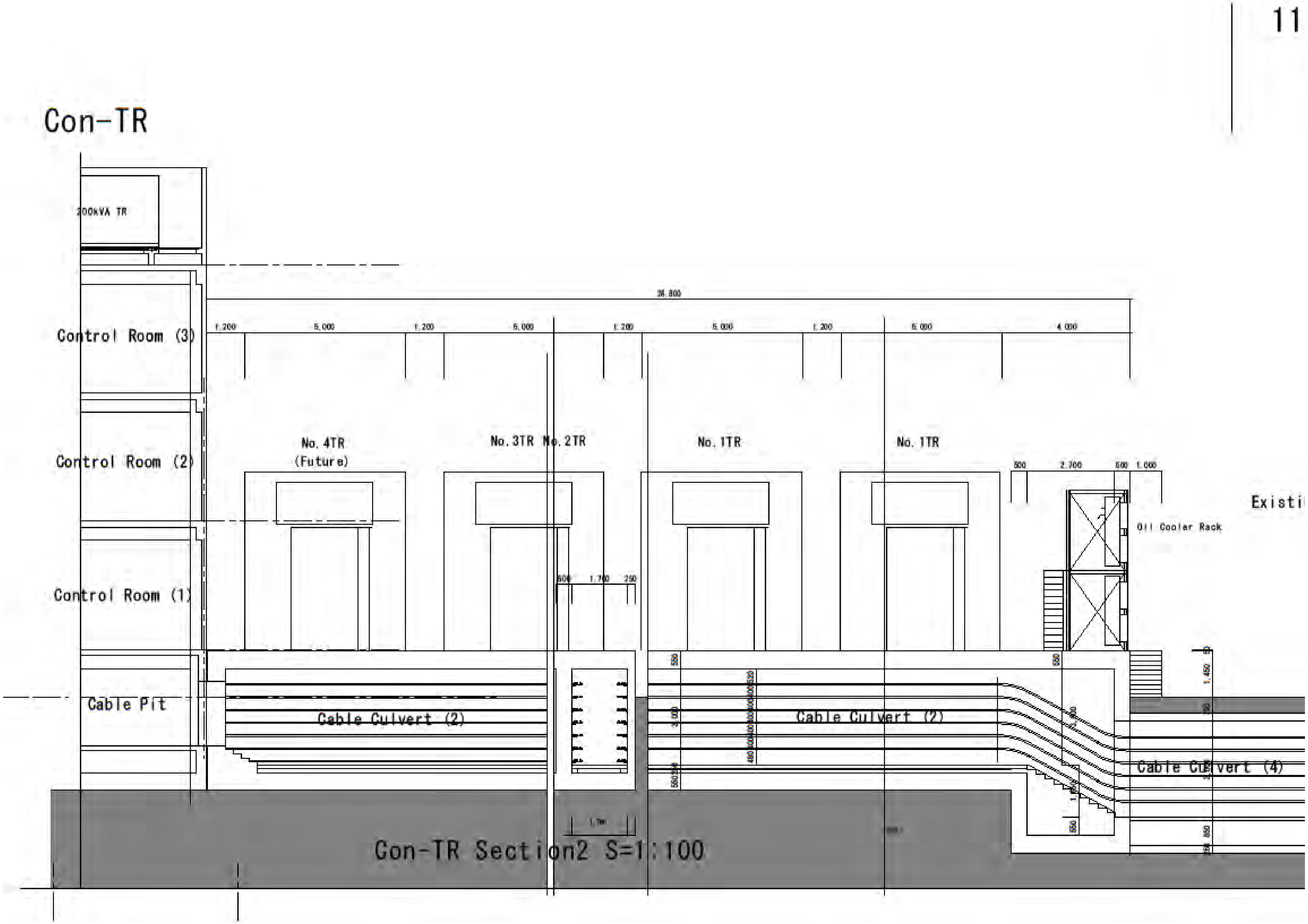


BF Plan S=1:100



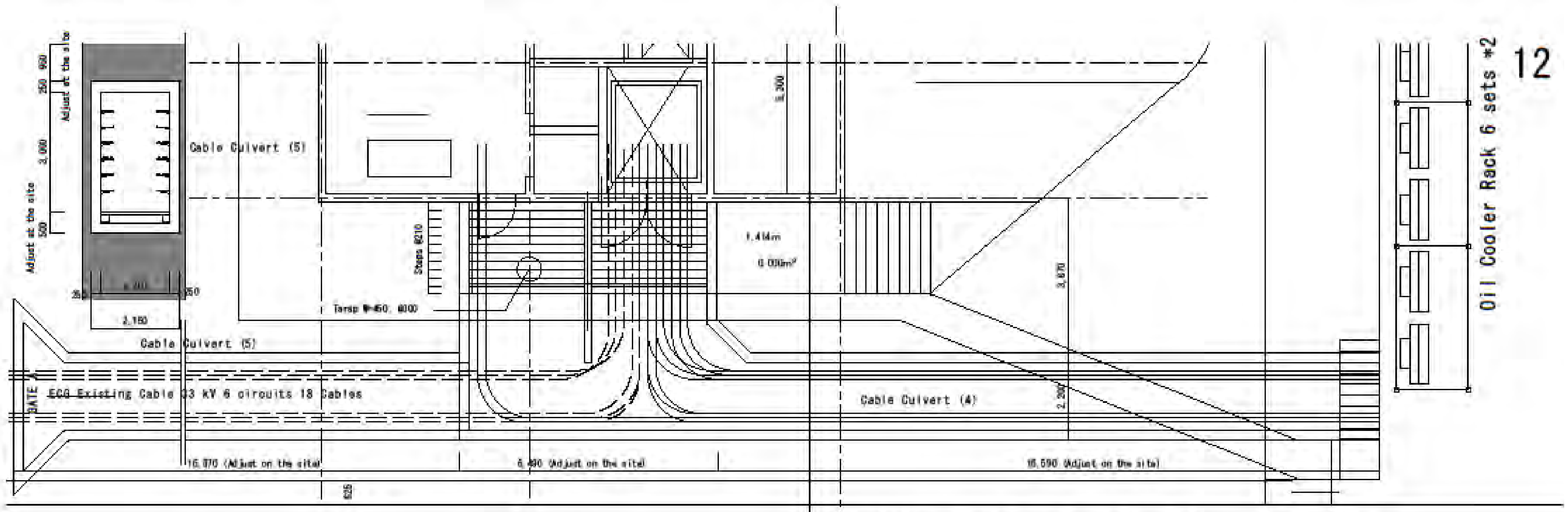
A-11 125MVA TRANSFORMER GF PLAN of ACCRA CENTRAL BSP


Con-TR
200kVA TR
Control Room (3)
Control Room (2)
Control Room (1)
No. 4TR
(Future)
No. 3TR
No. 2TR
No. 1TR
Oil Cooler Rack
Mechanical Pit
Mechanical Pit
Mechanical Pit
Mechanical Pit
Mechanical Pit
Con-TR Section1 S=1:100

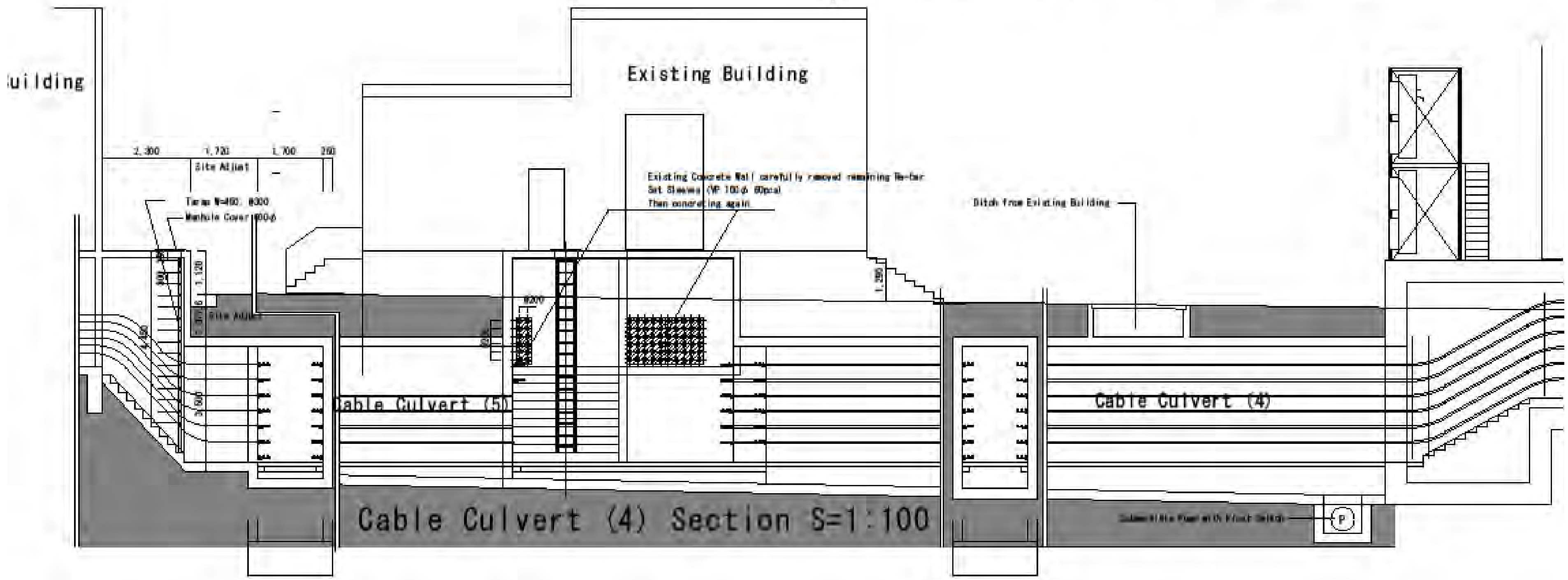


A-13 Con-TR SECTION (2) of ACCRA CENTRAL BSP

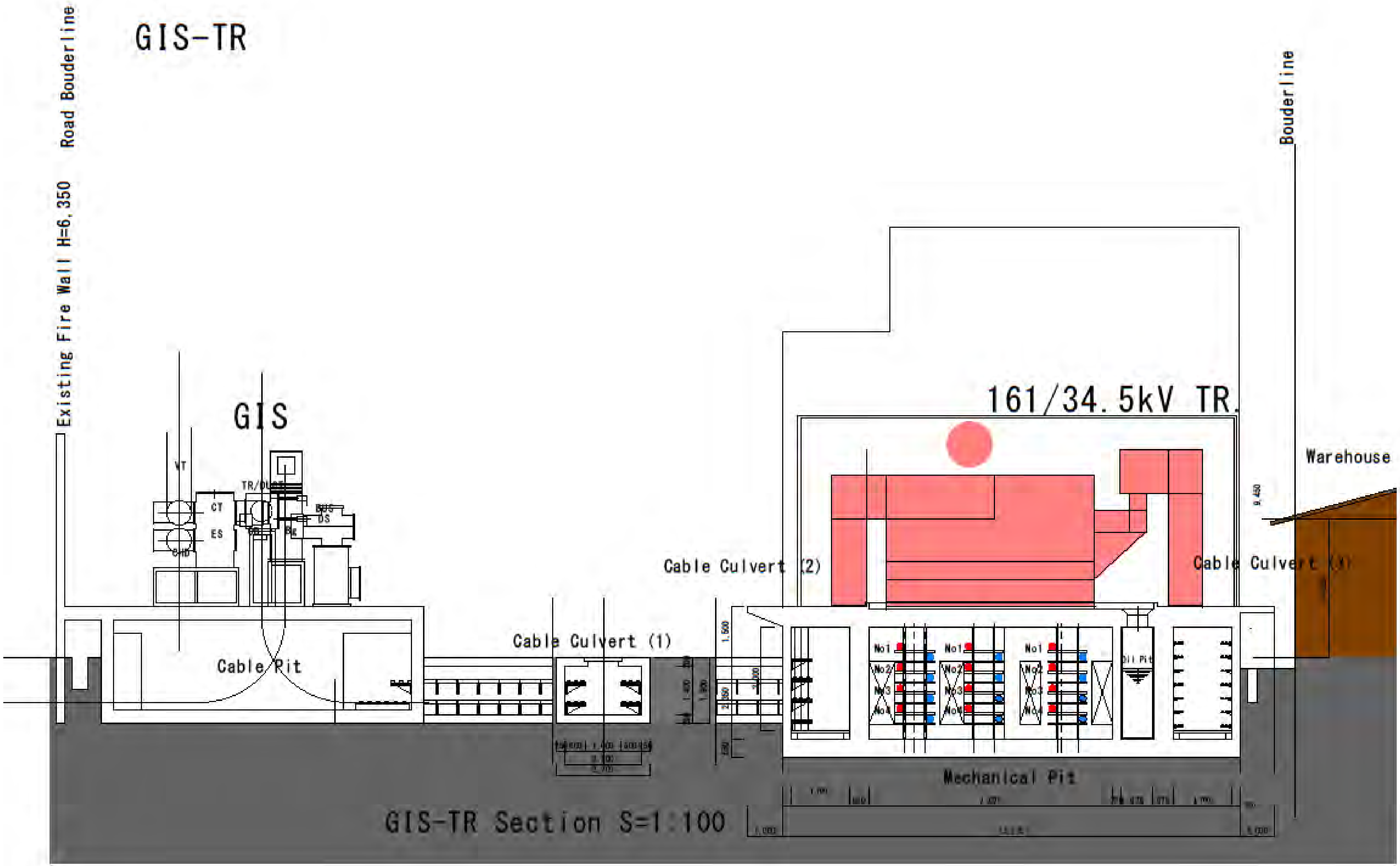
A-14 Culvert (4) SECTION, PLAN of ACCRA CENTRAL BSP



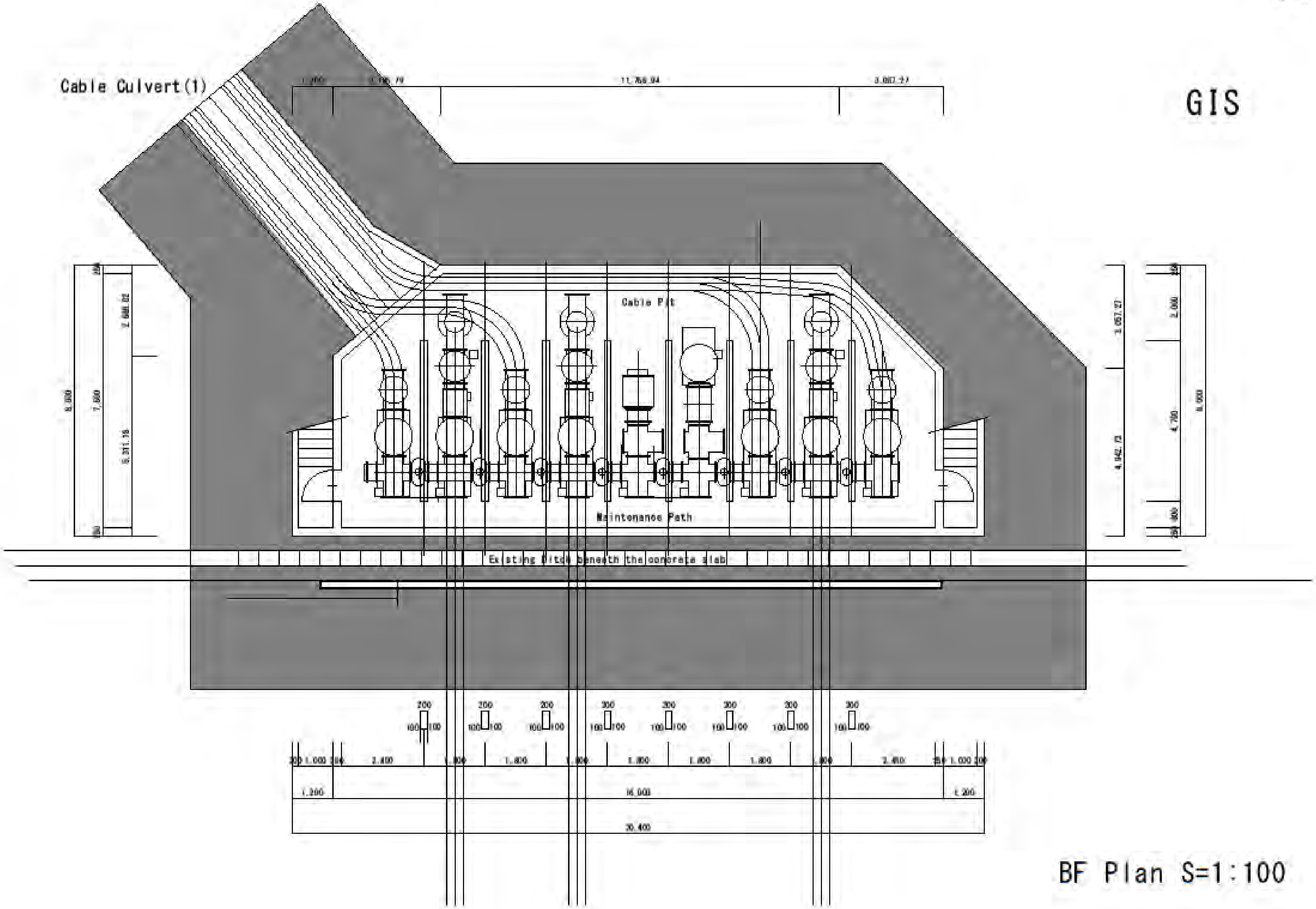
Cable Culvert (4) Plan S=1:100



A-15 GIS-TR SECTION of ACCRA CENTRAL BSP



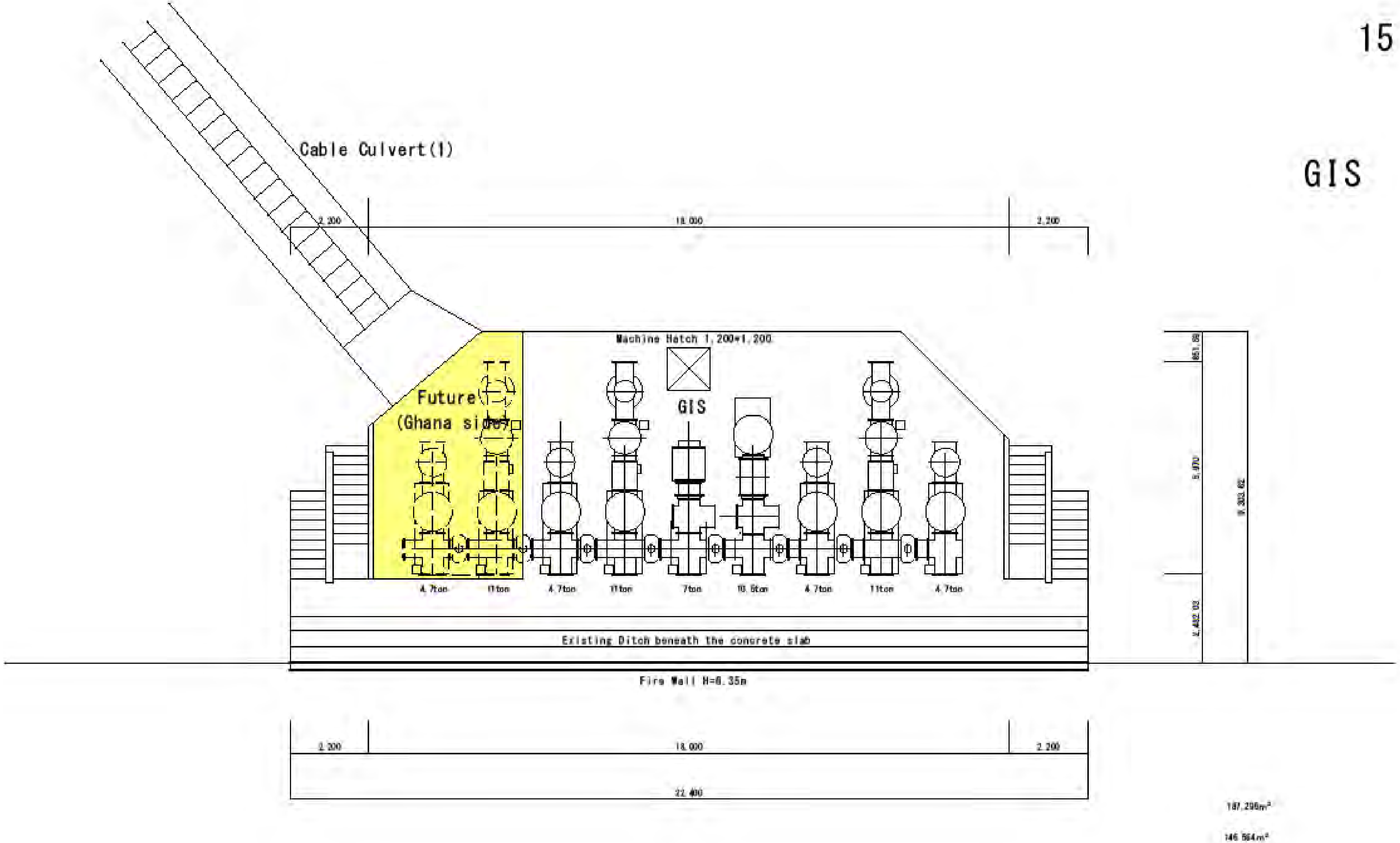
GIS



BF Plan S=1:100

A-16 GIS BF PLAN of ACCRA CENTRAL BSP

GIS



GF Plan S=1:100

A-17 GIS GF PLAN of ACCRA CENTRAL BSP

1. Natural conditions for the equipment and facilities design are described as follows.

Table 2.1.2-1 Climatic Conditions

	Mean Temperature (degrees centigrade)		Mean Total Rainfall (mm)	Mean Number of Rain Days
	Daily Minimum	Daily Maximum		
Jan.	23.4	32.1	10.9	1
Feb.	24.1	32.7	21.8	2
Mar.	24.1	32.5	57.1	5
Apr.	24.2	32.2	96.8	6
May.	23.9	31.2	131.2	10
Jun.	23.1	29.3	221.0	15
Jul.	22.5	28.5	66.0	9
Aug.	22.2	28.0	28.0	7
Sep.	22.4	29.0	67.8	8
Oct.	23.9	30.5	62.4	7
Nov.	23.5	31.6	27.7	3
Dec.	23.4	31.7	16.1	2

[Source] Accra Meteorological Observatory 2014.01 (Average of 30 years from 1961-1990)

2. Comparison of required area for the Bulk supply Points

Accra Central BSP is extremely narrow compared to the other BSP, like Achimota BSP and Mallam BSP as you can see in Table 4-1 Site Area Comparison Table.

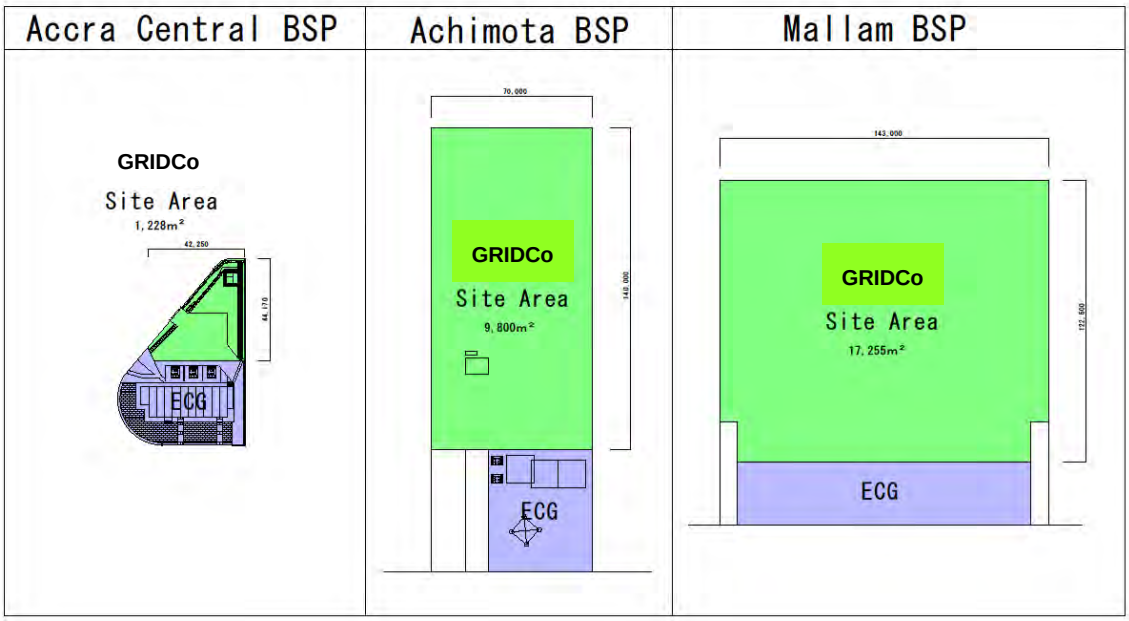


Table4-1: Site Area Comparison

7. Basic Data

Power System Data

(1) Generator

Location	Unit	Type	Rated				Impedance Rated capacity MVA Base
			(MW)	(KV)	(MVA)	PF (%)	Xd" (p.u.)
Akosombo	Akosombo G1	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G2	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G3	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G4	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G5	Hydro	170.5	14.4	179.50	95	0.210
	Akosombo G6	Hydro	170.5	14.4	179.50	95	0.210
Aboadze T1	TAPCo GT1	Gas Turbine	120.4	13.8	141.70	85	0.214
	TAPCo GT2	Gas Turbine	120.4	13.8	141.70	85	0.214
	TAPCo HRSG	Steam Turbine	123.5	13.8	145.30	85	0.220
Aboadze T2	TICo GT1	Gas Turbine	120.4	13.8	141.70	85	0.214
	TICo GT2	Gas Turbine	120.4	13.8	141.70	85	0.214
Aboaze T3	T1-G1	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G2	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G3	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G4	Gas Turbine	31.0	13.8	38.75	80	0.217
	T1-G5 (HRSG)	Steam Turbine	31.0	13.8	38.75	80	0.217
Kpong	Kpong G1	Hydro	45.9	13.8	51.00	90	0.270
	Kpong G2	Hydro	45.9	13.8	51.00	90	0.270
	Kpong G3	Hydro	45.9	13.8	51.00	90	0.270
	Kpong G4	Hydro	45.9	13.8	51.00	90	0.270
Sunon Asogli	Asogri(1) GT1	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(1) GT2	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(1) HRSG	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(2) GT1	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(2) GT2	Gas Turbine	29.0	11.0	36.29	80	0.148
	Asogri(2) HRSG	Steam Turbine	29.0	11.0	36.29	80	0.148
Tema TT1PP	TT1PP GT1	Gas Turbine	113.4	14.4	141.70	80	0.179
	CENIT GT	Gas Turbine	113.4	14.4	141.70	80	0.179
Tema MRP	MRP GT1	Gas Turbine	47.3	11.5	52.50	90	0.171
	MRP GT2	Gas Turbine	20.0	11.5	22.25	90	0.171
	MRP HRSG	Steam Turbine	15.0	11.5	16.70	90	0.171
TT2PP	TT2PP GT1	Gas Turbine	7.8	11.0	9.75	80	0.171
	TT2PP GT2	Gas Turbine	7.8	11.0	9.75	80	0.171
	TT2PP GT3	Gas Turbine	7.8	11.0	9.75	80	0.171
	TT2PP GT5	Gas Turbine	12.9	11.0	13.10	80	0.244
	TT2PP HRSG	Steam Turbine	12.9	11.0	13.10	80	0.244
Bui	Bui1	Hydro	133.0	13.8	147.80	90	0.270
	Bui2	Hydro	133.0	13.8	147.80	90	0.270
	Bui3	Hydro	133.0	13.8	147.80	90	0.270

(2) Transmission Line

Location		Line No.	Voltage	Length	Conductor			Impedance(pu)			Thermal rating	
From	To		(kV)	(km)	Type	Code	Size (mm^2)	R	X	Y	(A)	(MVA)
Akosombo	Old Kpong	A1H(1)	161	16.1	AAC	LILAC	403	0.00510	0.02450	0.01220	764	213
		A4V(1)	161	16.1	AAC	LILAC	403	0.00510	0.02450	0.01220	764	213
	Volta	A2V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
		A3V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
		A5V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
		A6V	161	67.6	AAC	LILAC	403	0.02120	0.10290	0.05128	764	213
	Kpong	Z10A	161	24.6	AAC	LILAC	403	0.00770	0.03810	0.01830	764	213
	Tafo	A7F	161	61.2	AAC	MISTLETOE	282	2.70000	9.70000	2.20000	610	170
		A11F	161	61.2	ACSR	TOUCAN	182 x 2	1.60000	6.80000	3.10000	653 x 2 bundles	182 x 2bundle
	Asiekpe	A9L	161	54.7	AAC	DAFFODIL	177	0.03940	0.08890	0.03870	459	128
	Aflao	A8L	161	124.8	AAC	DAFFODIL	177	0.08837	0.20254	0.08827	459	128
Old Kpong	Volta	A4V(2)	161	51.5	AAC	LILAC	403	0.01620	0.07840	0.03905	764	213
	Achimota	A1H(2)	161	77.2	AAC	LILAC	403	0.02434	0.11751	0.05856	764	213
Achimota	Mallam	H3M	161	12.0	AAC	MISTLETOE	282	0.70000	2.40000	0.60000	610	170
		H4M	161	12.0	AAC	MISTLETOE	282	0.70000	2.40000	0.60000	610	170
Mallam	Cape Coast	C1M	161	119.9	AAC	MISTLETOE	282	0.05336	0.18728	0.08801	610	170
	Winneba	W2M	161	42.9	AAC	MISTLETOE	282	0.02045	0.07182	0.03377	610	170
T3	Winneba	TT1W	161	131.8	AAC	MISTLETOE	282	0.04217	0.16248	0.07654	610	170
	Cape Coast	TT2C	161	57.8	AAC	MISTLETOE	282	0.02356	0.09065	0.04263	610	170

Location		Line No.	Voltage	Length	Conductor			Impedance(pu)			Thermal rating	
From	To		(kV)	(km)	Type	Code	Size (mm^2)	R	X	Y	(A)	(MVA)
Volta	Kpong	Z18V	161	63.2	AAC	HAWTHORN	604	0.01140	0.08430	0.03890	979	273
	New Tema	V9E	161	3.2	AAC	TOUCAN	265 x2	0.00085	0.00358	0.00324	653 x 2bundle	182 x 2bundle
		V10E	161	3.2	AAC	TOUCAN	265 x2	0.00085	0.00358	0.00324	653 x 2bundle	182 x 2bundle
	Smelter Two	V11S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V12S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V13S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V14S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V15S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
		V16S	161	5.2	AAC	LILAC	403	0.00128	0.00646	0.00311	764	213
	A3BSP (Accra East)	V7AE	161	15.0	AAC	LILAC	403	0.00470	0.02290	0.01137	764	213
	Achimota	V8H	161	25.7	AAC	LILAC	403	0.00810	0.03980	0.01950	764	213
		V19H	161	25.7	AAC	LILAC	403	0.00810	0.03980	0.01950	764	213
	Aboadze	TT21V	330	219.5	ACSR	TERN	430 x2	0.90000	5.67000	46.35000	500 x 2bundle	875 x 2bundle
A3BSP (Accra East)	Achimota	AE4H	161	10.7	AAC	LILAC	403	0.00340	0.01630	0.00811	764	213
Aboadze Plant	T3	TT6TT	161	0.1	ACSR	uncoded	400 x2	0.00003	0.00015	0.00007	875 x 2bundle	244 x 2bundle
		TT7TT	161	0.1	ACSR	uncoded	400 x2	0.00003	0.00015	0.00007	875 x 2bundle	244 x 2bundle
	Takoradi	TT3T	161	15.0	AAC	MISTLETOE	282	0.00610	0.02350	0.01100	610	170
		TT4T	161	15.0	AAC	MISTLETOE	282	0.00610	0.02350	0.01100	610	170
	Prestea	TT5T	161	83.0	ACSR	TOUCAN	265 x2	0.01953	0.08532	0.07726	653 x 2bundle	182 x 2bundle

(3) Transformer

Location			Rating			Impedance (%) Rating Power MVA Base	Vector Grope	Load Tap Changer
			Voltage (%)		Power (MVA)			
	From	To	Prim.	Sec.				
Achimota	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.71	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.30	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.30	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.38	YNd11	On-Load
	Achimota 161kV	Achimota 34.5kV	161	34.5	66	11.30	YNd11	On-Load
Mallam	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.38	YNd11	On-Load
	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.34	YNd11	On-Load
	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.06	YNd11	On-Load
	Mallam 161kV	Mallam 34.5kV	161	34.5	66	11.06	YNd11	On-Load
A3BSP	A3BSP 161kV	A3BSP 34.5kV	161	34.5	66	11.51	YNd11	On-Load
	A3BSP 161kV	A3BSP 34.5kV	161	34.5	66	10.19	YNd11	On-Load
Akosombo	Akosombo G1	Akosombo 161kV	14.4	161	200	13.39	YNd1	Off-Load
	Akosombo G2	Akosombo 161kV	14.4	161	200	13.29	YNd1	Off-Load
	Akosombo G3	Akosombo 161kV	14.4	161	180	13.00	YNd1	Off-Load
	Akosombo G4	Akosombo 161kV	14.4	161	200	13.35	YNd1	Off-Load
	Akosombo G5	Akosombo 161kV	14.4	161	200	13.35	YNd1	Off-Load
	Akosombo G6	Akosombo 161kV	14.4	161	180	13.30	YNd1	Off-Load
Aboadze T1	TAPCo GT1	Aboadze 161kV	13.8	169	155	12.60	YNd1	Off-Load
	TAPCo GT2	Aboadze 161kV	13.8	169	155	12.60	YNd1	Off-Load
	TAPCo HRSG	Aboadze 161kV	13.8	169	155	12.60	YNd1	Off-Load
Aboadze T2	TICo GT1	Aboadze 161kV	13.8	161	141	11.45	YNd1	Off-Load
	TICo GT2	Aboadze 161kV	13.8	161	141	11.45	YNd1	Off-Load
Aboadze T3	T1-G12	T3 161kV	13.8	161	62.5	0.10	YNd1	Off-Load
	T1-G34	T3 161kV	13.8	161	62.5	0.10	YNd1	Off-Load
	T1-G5 (HRSG)	T3 161kV	13.8	161	62.5	0.10	YNd1	Off-Load
Kpong G.S.	Kpong G1	Kpong G.S. 161kV	13.8	169	51	10.60	YNd1	Off-Load
	Kpong G2	Kpong G.S. 161kV	13.8	169	51	10.50	YNd1	Off-Load
	Kpong G3	Kpong G.S. 161kV	13.8	169	51	10.40	YNd1	Off-Load
	Kpong G4	Kpong G.S. 161kV	13.8	169	51	10.60	YNd1	Off-Load
Sunon Asogli	G1 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G2 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G3 (HRSG)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G4 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G5 (Gas Turbine)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load
	G6 (HRSG)	Sunon Asogli 161kV	11.0	161	50	7.10	YNd1	Off-Load

Location			Rating			Impedance (%) Rating Power MVA Base	Vector Grope	Load Tap Changer
			Voltage (%)		Power (MVA)			
	From	To	Prim.	Sec.				
Tema TT1PP	TT1PP GT1	TT1PP 161kV	14.4	161	145	14.85	YNd1	Off-Load
	CENIT GT	TT1PP 161kV	14.4	161	145	14.85	YNd1	Off-Load
Tema MRP	MRP Generator	Tema MRP 161kV	11.5	161	165	13.10	YNd1	Off-Load
Tema TT2PP	TT2PP Generator	Tema TT2PP 161kV	11.0	161	75	9.08	YNd1	Off-Load
Bui	Bui G1	Bui 161kV	14.4	161	160	13.13	YNd1	Off-Load
	Bui G2	Bui 161kV	14.4	161	160	13.00	YNd1	Off-Load
	Bui G3	Bui 161kV	14.4	161	160	13.08	YNd1	Off-Load
Aboadze	Aboaze 330kV	Aboadze 161kV	330	161	200 x2	10.00	YNd11	-
Volta	Volta 330kV	Volta 161kV	330	161	200 x2	10.00	YNd11	-

(4) Capacitor

Substation	Voltage (kV)	Bank No.	Rating/bank (Mvar)	Total rating (Mvar)
Achimota	34.5	5	21.8	109.0
New Tema	34.5	2	10.8	21.6
Winneba	34.5	2	21.6	43.2
Cape Coast	34.5	2	10.8	21.2
Accra East	34.5	2	21.6	43.2
Mallam	34.5	2	21.6	43.2

(5) Power Station (existing / planned)

Power Station	Generator	Type	Start of Operation	Capacity
Akosombo	Akosombo G1	Hydro	existing (1965)	170.525 MW
	Akosombo G2	Hydro	existing (1965)	170.525 MW
	Akosombo G3	Hydro	existing (1965)	170.525 MW
	Akosombo G4	Hydro	existing (1965)	170.525 MW
	Akosombo G5	Hydro	existing (1972)	170.525 MW
	Akosombo G6	Hydro	existing (1972)	170.525 MW
Aboadze T1	TAPCo GT1	Gas Turbine	existing (1998)	120.4 MW
	TAPCo GT2	Gas Turbine	existing (1998)	120.4 MW
	TAPCo HRSG	Steam Turbine	existing (1998)	123.5 MW
Aboadze T2	TICo GT1	Gas Turbine	existing (2001)	120.4 MW
	TICo GT2	Gas Turbine	existing (2001)	120.4 MW
	TICo HRSG	Steam Turbine	2015	123.5 MW
Aboadze T3	T1-G1	Gas Turbine	existing (2013)	31 MW
	T1-G2	Gas Turbine	existing (2013)	31 MW
	T1-G3	Gas Turbine	existing (2013)	31 MW
	T1-G4	Gas Turbine	existing (2013)	31 MW
	T1-G5 (HRSG)	Steam Turbine	existing (2013)	31 MW
Aboadze T3 expansion	T2-G	Gas Turbine	2015	120 MW
	T2-HRSG	Steam Turbine	2015	60 MW
Aboadze T4	T4-G1	Gas Turbine	2018	133.3 MW
	T4-G2	Gas Turbine	2018	133.3 MW
	T4-HRSG	Steam Turbine	2018	133.3 MW
Kpong GS	Kpong G1	Hydro	existing (1982)	45.9 MW
	Kpong G2	Hydro	existing (1982)	45.9 MW
	Kpong G3	Hydro	existing (1982)	45.9 MW
	Kpong G4	Hydro	existing (1982)	45.9 MW
Kpone	Kpone GT1	Gas Turbine	2014	120.5 MW
	Kpone GT2	Gas Turbine	2014	120.5 MW
	Kpone HRSG	Steam Turbine	2016	123.5 MW
Asogli	Asogri(1) GT1	Gas Turbine	existing (2010)	29.0 MW
	Asogri(1) GT2	Gas Turbine	existing (2010)	29.0 MW
	Asogri(1) HRSG	Steam Turbine	existing (2010)	29.0 MW
	Asogri(2) GT1	Gas Turbine	existing (2010)	29.0 MW
	Asogri(2) GT2	Gas Turbine	existing (2010)	29.0 MW
	Asogri(2) HRSG	Steam Turbine	existing (2010)	29.0 MW
	Asogri(3) GT1	Gas Turbine	2016	60 MW
	Asogri(3) GT2	Gas Turbine	2016	60 MW
	Asogri(3) HRSG	Steam Turbine	2016	60 MW
	Asogri(4) GT1	Gas Turbine	2016	60 MW
	Asogri(4) GT2	Gas Turbine	2016	60 MW
	Asogri(4) HRSG	Steam Turbine	2016	60 MW
Tema TT1PP	TT1PP GT1	Gas Turbine	existing (2009)	113.4 MW
	CENIT GT	Gas Turbine	existing (2012)	113.4 MW
	TT1PP HRSG	Steam Turbine	2017	113.4 MW
Tema MRP	MRP GT1	Gas Turbine	existing (2007)	47.3 MW
	MRP GT2	Gas Turbine	existing (2007)	20 MW
	MRP HRSG	Steam Turbine	existing (2007)	15 MW
Tema TT2PP	TT2PP GT1	Gas Turbine	existing (2010)	7.8 MW
	TT2PP GT2	Gas Turbine	existing (2010)	7.8 MW
	TT2PP GT3	Gas Turbine	existing (2010)	7.8 MW
	TT2PP GT5	Gas Turbine	existing (2010)	13.1 MW
	TT2PP HRSG	Steam Turbine	existing (2010)	13.1 MW
Bonyere 1	GT1	Gas Turbine	2016	150 MW
	GT2	Gas Turbine	2016	150 MW
	HRSG	Steam Turbine	2016	150 MW
Bonyere 2	GT1	Gas Turbine	2017	150 MW
	GT2	Gas Turbine	2017	150 MW
	HRSG	Steam Turbine	2017	150 MW
Bui	Bui1	Hydro	existing (2013)	133 MW
	Bui2	Hydro	existing (2013)	133 MW
	Bui3	Hydro	existing (2013)	133 MW
Pwalugu	Pwalugu 1	Hydro	2026	24 MW
	Pwalugu 2	Hydro	2026	24 MW
Hemang	Heman 1	Hydro	2020	46.5 MW
	Heman 2	Hydro	2020	46.5 MW
Juale	Juale 1	Hydro	2020	41.5 MW
	Juale 2	Hydro	2020	41.5 MW

(6) 33kV Distribution Lines in Accra Area

Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
E (Graphic Road)	H (Achimota)	existing	33	11.2	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	AD (Adabraka)	existing	33	2.4	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	G (Makola)	existing	33	2	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		existing	33	2	2x(3x 240 CU PILC)	Cable	0.0983 2 bundles	0.1100 2 bundles	397 2 bundles
	F (Kokomlemle)	2017	33	2.9	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		existing	33	2.9	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	D (Avenor)	existing	33	2.6	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	2.6	AAC 265	Overhead	0.1128	0.3254	810
	AW (Awudome)	2017	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2017	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	B (Korle-Bu)	existing	33	7	3x(1x 240 CU XLPE)	Cable	0.0928	0.1100	480
		existing	33	7	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	R (Ridge)	2017	33	9.5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2017	33	9.5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
K (Switchback Road)	R (Ridge)	existing	33	3.2	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
		2016	33	3.2	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	X (Osu)	existing	33	2.7	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
	L (Burma Camp)	existing	33	3.1	2x(3x 240 CU PILC)	Cable	0.0983 2 bundles	0.1100 2 bundles	397 2 bundles
		2016	33	3.1	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		2016	33	3.1	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	AU (Cantonments)	existing	33	5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
AU (Cantonments)	L (Burma Camp)	existing	33	5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
M (Legon)	Ogbodzo	2016	33	3.8	AAC 265	Overhead	0.1128	0.3254	810
		2016	33	3.8	AAC 265	Overhead	0.1128	0.3254	810

Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
ND (Nami Djorn)	T (Adenta)	2016	33	18	AAC 400	Overhead	0.0789	0.315	1066
		2016	33	18	AAC 400	Overhead	0.0789	0.315	1066
	Ogbodzo	2016	33	5.4	AAC 400	Overhead	0.0789	0.315	1066
		2016	33	5.4	AAC 400	Overhead	0.0789	0.315	1066
A3BSP (Accra East)	Ogbodzo	2016	33	5.3	AAC 400	Overhead	0.0789	0.315	1066
		2016	33	5.3	AAC 400	Overhead	0.0789	0.315	1066
	Shiashi	2014	33	8.8	AAC 400	Overhead	0.0789	0.315	1066
		2014	33	8.8	AAC 400	Overhead	0.0789	0.315	1066
	Y (Batsonaa)	2014	33	3	AAC 400	Overhead	0.0789	0.315	1066
		2014	33	3	AAC 400	Overhead	0.0789	0.315	1066
	Adjei Kojo	existing	33	6.7	AAC 400	Overhead	0.0789	0.315	1066
		existing	33	6.7	AAC 400	Overhead	0.0789	0.315	1066
H (Achimota)	Kotobabi	2016	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2016	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	Kisseman	existing	33	5	AAC 400	Overhead	0.0789	0.315	1066
		existing	33	5	AAC 400	Overhead	0.0789	0.315	1066
	M (Legon)	existing	33	7.5	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	7.5	AAC 265	Overhead	0.1128	0.3254	810
	T (Adenta)	existing	33	8.3	AAC 265	Overhead	0.1128	0.3254	810
		2014	33	8.3	AAC 265	Overhead	0.1128	0.3254	810
	AC (Airport City)	existing	33	4.2 3	AAC 265 3x(1x 500 CU XLPE)	Overhead Cable	0.1128 0.0236	0.3254 0.0772	810 831
	L (Burma Camp)	existing	33	8.5	3x(1x 500 CU XLPE)	Cable	0.0236	0.04715	831
		existing	33	4.2 1.5	AAC 265 3x(1x 500 CU XLPE)	Overhead Cable	0.1128 0.0236	0.3254 0.0772	810 831
	K (Switchback Road)	existing	33	4.7	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles

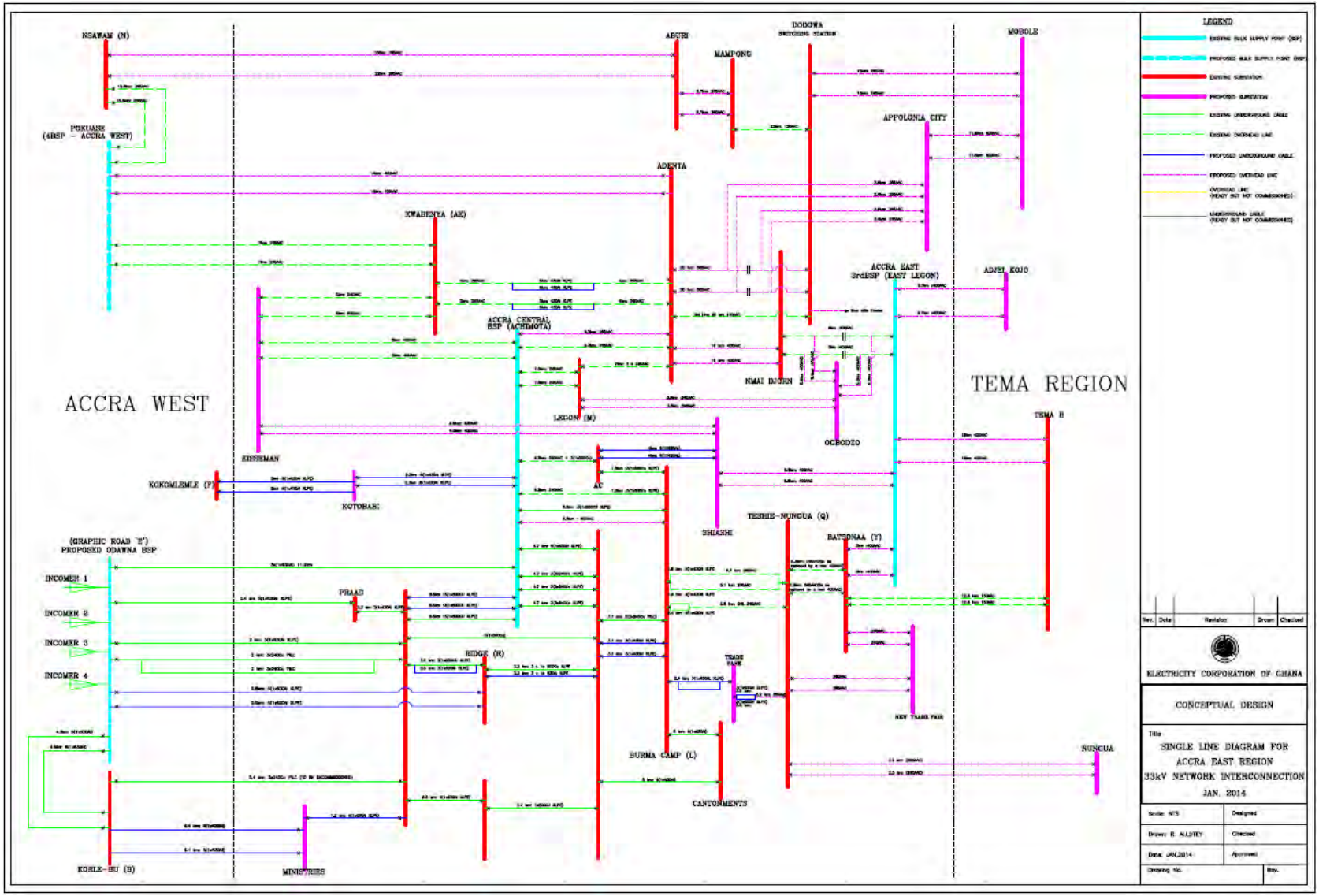
Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
H (Achimota)	K (Switchback Road)	existing	33	4.7	3x(1x 240 CU XLPE)	Cable	0.0983	0.1230	440
		existing	33	4.7	3x(1x 240 CU XLPE)	Cable	0.0983	0.1230	440
		existing	33	4.7	3x(1x 240 CU XLPE)	Cable	0.0983	0.1230	440
	C (Achimota Village)	existing	33	3.9	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	3.9	AAC 265 x 2	Overhead	0.1128 2 bundles	0.3254 2 bundles	810 2 bundles
		existing	33	8.5	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
AC (Airport City)	L (Burma Camp)	existing	33	1.5	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
	Shiashi	2014	33	4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2014	33	4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
L (Burma Camp)	Q (Teshie-Nungua)	existing	33	1.6 5.7	3x(1x 630 AL XLPE) x2 ACC 265	Cable Overhead	0.03712 2 bundles 0.1128	0.044 2 bundles 0.3254	755 2 bundles 810
		existing	33	1.6 5.7	3x(1x 630 AL XLPE) x2 ACC 265	Cable Overhead	0.03712 2 bundles 0.1128	0.044 2 bundles 0.3254	755 2 bundles 810
		existing	33	2.4 5.8	3x(1x 630 AL XLPE) x2 ACC 265	Cable Overhead	0.03712 2 bundles 0.1128	0.044 2 bundles 0.3254	755 2 bundles 810
	Trade Fare	existing	33	2.9	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
Q (Teshie-Nungua)	Trade Fare	existing	33	3.8 5.2	3x(1x 630 AL XLPE) x2 ACC 265	Cable Overhead	0.03712 2 bundles 0.1128	0.044 2 bundles 0.3254	755 2 bundles 810
	New Trade Fair	existing	33	5.3	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	5.3	ACC 265	Overhead	0.1128	0.3254	810
Kisseman	AE (Kwabenya)	existing	33	5	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	5	ACC 265	Overhead	0.1128	0.3254	810
	Shiashi	2014	33	9.9	AAC 400	Overhead	0.2743	0.3568	455
		2014	33	9.9	AAC 400	Overhead	0.2743	0.3568	455
T (Adenta)	M (Legon)	existing	33	7	ACC 265	Overhead	0.1128	0.3254	810
	U (Dodowa)	existing	33	20	AAC 120	Overhead	0.2743	0.3568	455
		2014	33	20	ACC 265	Overhead	0.1128	0.3254	810
		2014	33	20	ACC 265	Overhead	0.1128	0.3254	810

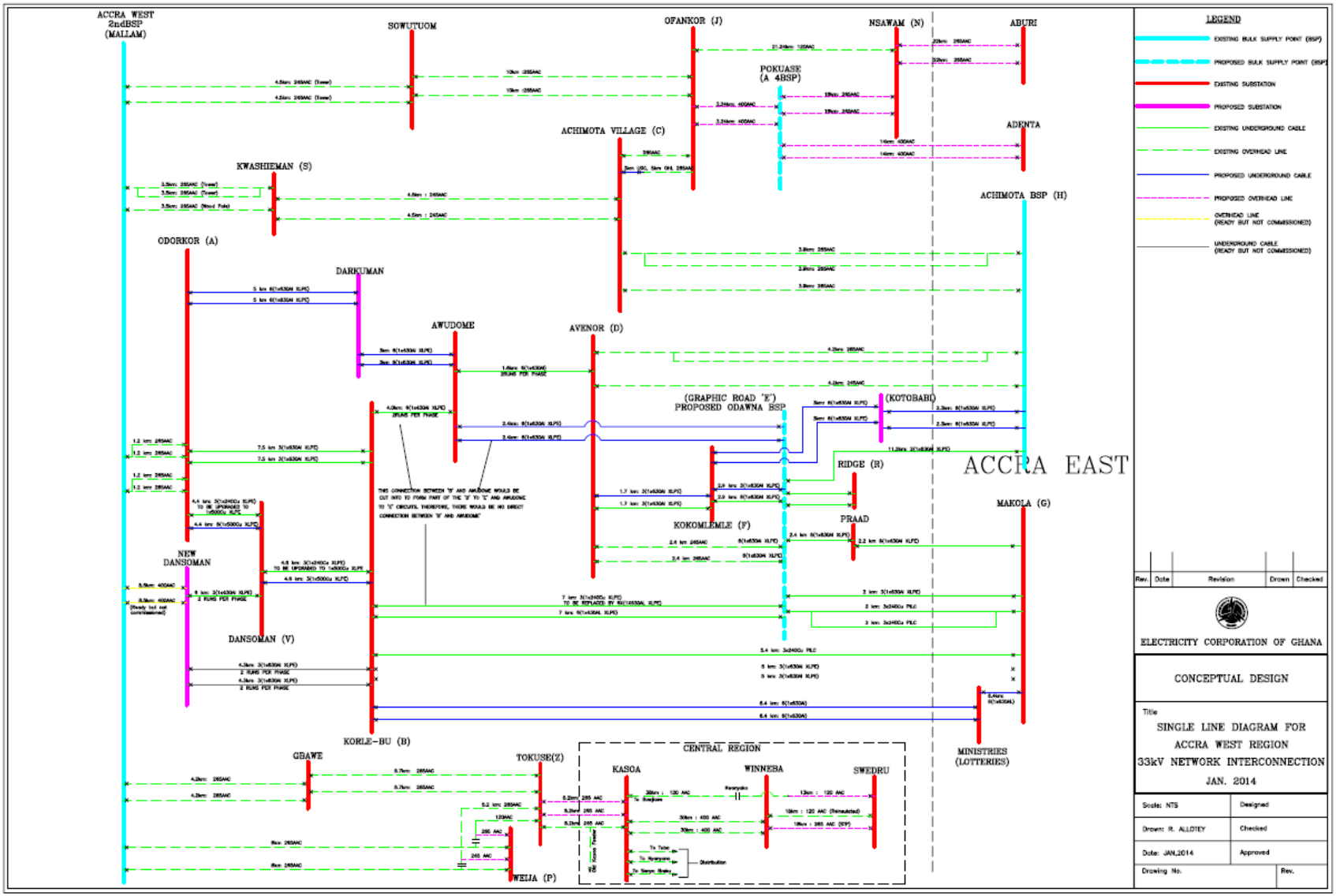
Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
U (Dodowa)	W (Mampong)	existing	33	22	AAC 120	Overhead	0.2743	0.3568	455
W (Mampong)	Aburi	2014	33	8.7	ACC 265	Overhead	0.1128	0.3254	810
		2014	33	8.7	ACC 265	Overhead	0.1128	0.3254	810
Aburi	N (Nsawam)	2014	33	22	ACC 265	Overhead	0.1128	0.3254	810
		2014	33	22	ACC 265	Overhead	0.1128	0.3254	810
N (Naswam)	J (Ofankor)	existing	33	21.2	AAC 400	Overhead	0.2743	0.3568	455
J (Ofankor)	SW (Sowutuom)	existing	33	10	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	10	ACC 265	Overhead	0.1128	0.3254	810
	C (Achimota Village)	existing	33	8	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	8	ACC 265	Overhead	0.1128	0.3254	810
A4BSP (Pokuase)	T (Adenta)	2020	33	14	AAC 400	Overhead	0.0789	0.315	1066
		2020	33	14	AAC 400	Overhead	0.0789	0.315	1066
	N (Nsawam)	existing	33	18	ACC 265	Overhead	0.1128	0.3254	810
		existing	33	18	ACC 265	Overhead	0.1128	0.3254	810
	J (Ofankor)	existing	33	3.2	AAC 400	Overhead	0.0789	0.315	1066
		existing	33	3.2	AAC 400	Overhead	0.0789	0.315	1066
	AE (Kwabenya)	existing	33	7	ACC 265	Overhead	0.1128	0.3254	810
	AE (Kwabenya)	existing	33	7	ACC 265	Overhead	0.1128	0.3254	810
G (Makola)	AD (Adabraka)	existing	33	2.2	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	R (Ridge)	existing	33	3.5	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		2016	33	3.5	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	K (Switchback Road)	existing	33	7.0	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
	X (Osu)	existing	33	8.5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	Ministries	2014	33	1.2	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
Ministries	B (Korle-Bu)	2014	33	6.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles

Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
Ministries	B (Korle-Bu)	2014	33	6.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	X (Osu)	2014	33	2.4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
B (Korle-Bu)	AW (Awudome)	existing	33	4	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	A (Odorkor)	existing	33	7.5	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		existing	33	7.5	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	V (Dansoman)	2014	33	4.6	3x(1x 630 AL XLPE) x2	Cable	0.0236	0.0472	831
		2014	33	4.6	3x(1x 630 AL XLPE) x2	Cable	0.0236	0.0472	831
	New Dansoman	existing	33	4.3	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		existing	33	4.3	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
V (Dansoman)	A (Odorkor)	2016	33	4.4	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
		2016	33	4.4	3x(1x 500 CU XLPE)	Cable	0.0236	0.0472	831
	New Dansoman	existing	33	6	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
D (Avenor)	H (Achimota)	existing	33	4.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	4.2	AAC 265 x 2	Overhead	0.1128 2 bundles	0.3254 2 bundles	810 2 bundles
	F (Kokomlemle)	2017	33	1.7	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
		existing	33	1.7	3x(1x 630 AL XLPE)	Cable	0.03712	0.044	755
	AW (Awudome)	existing	33	1.6	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
Darkuman	AW (Awudome)	2014	33	3	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2014	33	3	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
	A (Odorkor)	2014	33	5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
		2014	33	5	3x(1x 630 AL XLPE) x2	Cable	0.03712 2 bundles	0.044 2 bundles	755 2 bundles
C (Achimota Village)	S (Kwashieman)	existing	33	4.5	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	4.5	AAC 265	Overhead	0.1128	0.3254	810
Mallam	SW (Sowutuom)	existing	33	4.5	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	4.5	AAC 265	Overhead	0.1128	0.3254	810

Location		Year	Voltage	Length	Conductor		Impedance(Ohm per km)		Current (A)
From	To		(kV)	(km)	Type	remark	R	X	Rated Current (Thermal rating)
Mallam	S (Kwashieman)	existing	33	3.5	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	3.5	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	3.5	AAC 265	Overhead	0.1128	0.3254	810
	A (Odorkor)	existing	33	1.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	1.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	1.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	1.2	AAC 265	Overhead	0.1128	0.3254	810
	New Dansoman	2014	33	8.5	AAC 400	Overhead	0.0789	0.315	1066
		2014	33	8.5	AAC 400	Overhead	0.0789	0.315	1066
	Gbawe	existing	33	4.2	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	4.2	AAC 265	Overhead	0.1128	0.3254	810
	p (Weija)	existing	33	8	AAC 265	Overhead	0.1128	0.3254	810
		existing	33	8	AAC 265	Overhead	0.1128	0.3254	810
p (Weija)	Z (Tokuse)	2015	33	5.2	AAC 265	Overhead	0.1128	0.3254	810
		2015	33	5.2	AAC 265	Overhead	0.1128	0.3254	810
AE (Kwabenya)	T (Adenta)	existing	33	9 5	AAC 265 3x(1x 630 AL XLPE)	Overhead Cable	0.1128 0.03712	0.3254 0.044	810 755
		existing	33	9 5	AAC 265 3x(1x 630 AL XLPE)	Overhead Cable	0.1128 0.03712	0.3254 0.044	810 755

(7) 33 kV Distribution Network in Accra Area




ACCRA WEST
2ndBSP
(MALLAM)
SOWUTUOM
OFANKOR (J)
NSAWAM (N)
ABUDI
POKUASE
(A 4BSP)
ADENTA
ACHIMOTA VILLAGE (C)
KWASHIEMAN (S)
ACHIMOTA BSP (H)
ODORKOR (A)
DARKUMAN
AWUDOME
AVENOR (D)
(GRAPHIC ROAD 'E')
PROPOSED ODAWNA BSP
(KOTOBABI)
RIDGE (R)
ACCRA EAST
KOKOMLEMLE (F)
PRAAD
MAKOLA (G)
NEW
DANSOMAN
DANSOMAN (V)
KORLE-BU (B)
GBAWE
TOKUSE(Z)
CENTRAL REGION
KASOA
WINNEBA
SWEDRU
WELIJA (P)
MINISTRIES
(LOTTERIES)
LEGEND
EXISTING BULK SUPPLY POINT (BSP)
PROPOSED BULK SUPPLY POINT (BSP)
EXISTING SUBSTATION
PROPOSED SUBSTATION
EXISTING UNDERGROUND CABLE
EXISTING OVERHEAD LINE
PROPOSED UNDERGROUND CABLE
PROPOSED OVERHEAD LINE
OVERHEAD LINE (READY BUT NOT COMMISSIONED)
UNDERGROUND CABLE (READY BUT NOT COMMISSIONED)
Rev.
Date
Revision
Drawn
Checked
ELECTRICITY CORPORATION OF GHANA
CONCEPTUAL DESIGN
Title
SINGLE LINE DIAGRAM FOR
ACCRA WEST REGION
33kV NETWORK INTERCONNECTION
JAN. 2014
Scale: NTS
Designed
Drawn: R. ALLOTEY
Checked
Date: JAN.2014
Approved
Drawing No.
Rev.

Demand Forecast Data

(1) Year 2013 to 2020 without the Project

Supply BSP	Code Name	Location	Voltage	Status		Capacity	Number	Total	Power Factor	Forecast of Demand																
										2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
			kV			MVA	Units	MVA		MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Achimota BSP		Capacity	MVA						0.87	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
		Demand	MW						0.87	288	245	259	274	291	309	328	348	197	209	222	236	250	266	282	299
		Demand	MVA					660	0.87	331	281	297	315	335	355	377	400	227	241	255	271	288	305	324	344
	C	Achimota Village	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	B	Korle Bu	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	D	Avenor	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	E	Graphic Road	33/11	Existing		20	3	60	0.87	26.15	22.25	23.51	24.94	26.47	28.10	29.82	31.66								
	F	Kokomlemle	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	G	Power House	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	H	Achimota	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	K	Switchback	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	R	Ridge	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	X	Osu	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	AC	Airport City	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	AD	Archives	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
	AW	Awudome	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
		Ministries	33/11	Existing		20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
		Apenkwa	33/11	Proposed	2016	20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
		Kotobabi	33/11	Proposed	2016	20	2	40	0.87	17.43	14.83	15.67	16.63	17.65	18.73	19.88	21.10								
Mallam BSP		Capacity	MVA						0.87	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	230	196	207	219	233	247	262	279	158	167	178	189	200	213	226	240
		Demand	MVA					530	0.87	264	225	238	252	268	284	302	320	181	192	204	217	230	244	259	275
	A	Odorkor	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	J	Ofankor	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	N	Nsawam	33/11	Existing		20	1	20	0.87	8.68	7.39	7.81	8.28	8.79	9.33	9.90	10.51								
	P	Weija	33/11	Existing		5	2	10	0.87	4.34	3.69	3.90	4.14	4.40	4.67	4.95	5.26								
	S	Kwashieman	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	V	Dansoman	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	W	Mampong	33/11	Existing		20	2	40.0	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
	Z	Tokuse	33/11	Existing		10	2	20	0.87	8.68	7.39	7.81	8.28	8.79	9.33	9.90	10.51								
	AE	Kwabenya	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Sowutuom	33/11	Existing		20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Darkuman	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Mataheko	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Gbawe Janman	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		New Dansoma	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
		Aburi	33/11	Committed	2014	20	2	40	0.87	17.37	14.78	15.61	16.56	17.58	18.66	19.81	21.03								
A3 BSP		Capacity	MVA						0.87	132	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	115	196	207	219	233	247	262	279	158	167	178	189	200	213	226	240
		Demand	MVA					560	0.87	132	225	238	252	268	284	302	320	181	192	204	217	230	244	259	275
	L	Burma Camp	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	M	Legon	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	Q	Teshie Nungua	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	T	Adenta	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	Y	Baatsonaa	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	AU	Cantonments	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Nungua	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
	ND	Ngmai Jorn	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Trade Fare	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Adjei Kojo	33/11	Existing		20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Kabekuro	33/11	Proposed	2016	20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Kisseman	33/11	Proposed	2016	20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Shiashi	33/11	Committed	2014	20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								
		Ogbodzo	33/11	Proposed	2016	20	2	40	0.87	8.22	13.98	14.78	15.68	16.64	17.66	18.75	19.90								

(2) Year 2017 to 2019 with the Project

Supply BSP	Code Name	Location	Voltage	Status		Capacity	Number	Total	Power Factor	Forecast of Demand															
										2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
			kV			MVA	Units	MVA		MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Achimota BSP		Capacity	MVA						0.87	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
		Demand	MW						0.87	288	245	259	274	203	215	228	186	197	209	222	236	250	266	282	299
		Demand	MVA					440	0.87	331	281	297	315	233	247	262	214	227	241	255	271	288	305	324	344
	C	Achimota Village	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	H	Achimota	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	K	Switchback	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	M	Legon	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	S	Kwashieman	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	AC	Airport City	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
		Shiashi	33/11	Committed	2014	20	2	40	0.87					18.42	19.55	20.75									
		Darkuman	33/11	Committed	2014	20	2	40	0.87					18.42	19.55	20.75									
		Kotobabi	33/11	Proposed	2014	20	2	40	0.87					18.42	19.55	20.75									
		Apenkwa	33/11	Proposed	2016	20	2	40	0.87					18.42	19.55	20.75									
		Kisseman	33/11	Proposed	2016	20	2	40	0.87					18.42	19.55	20.75									
Mallam BSP		Capacity	MVA						0.87	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	230	196	207	219	162	172	183	149	158	167	178	189	200	213	226	240
		Demand	MVA					370	0.87	264	225	238	252	186	198	210	171	181	192	204	217	230	244	259	275
	A	Odorkor	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
	J	Ofankor	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
	N	Nsawam	33/11	Existing		20	1	20	0.87					8.76	9.30	9.87									
	P	Weija	33/11	Existing		5	2	10	0.87					4.38	4.65	4.94									
	V	Dansoman	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
	W	Mampong	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
	Z	Tokuse	33/11	Existing		10	2	20	0.87					8.76	9.30	9.87									
	AE	Kwabenya	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
		Sowutuom	33/11	Existing		20	2	40	0.87					17.53	18.60	19.74									
		Gbawe Janman	33/11	Committed	2014	20	2	40	0.87					17.53	18.60	19.74									
		Aburi	33/11	Committed	2014	20	2	40	0.87					17.53	18.60	19.74									
Accra Central BSP		Capacity	MVA						0.87					375	375	375	375	375	375	375	375	375	375	375	375
		Demand	MW						0.87					230	244	259	211	224	238	253	268	284	302	321	340
		Demand	MVA					500	0.87					265	281	298	243	258	273	290	308	327	347	368	391
	B	Korle Bu	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	D	Avenor	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	E	Graphic Road	33/11	Existing		20	3	60	0.87					27.63	29.33	31.13									
	F	Kokomlemle	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	G	Power House	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	R	Ridge	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	X	Osu	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	AD	Archives	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
	AW	Awudome	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
		Ministries	33/11	Existing		20	2	40	0.87					18.42	19.55	20.75									
		New Dansoma	33/11	Committed	2014	20	2	40	0.87					18.42	19.55	20.75									
		Mataheko	33/11	Committed	2014	20	2	40	0.87					18.42	19.55	20.75									
A3 BSP		Capacity	MVA						0.87	132	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	115	196	207	219	162	172	183	149	158	167	178	189	200	213	226	240
		Demand	MVA					440	0.87	132	225	238	252	186	198	210	171	181	192	204	217	230	244	259	275
	L	Burma Camp	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	Q	Teshie Nungua	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	T	Adenta	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	Y	Baatsonaa	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	AU	Cantonments	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
		Nungua	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
	ND	Ngmai Jorn	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
		Trade Fare	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
		Adjei Kojo	33/11	Existing		20	2	40	0.87					14.74	15.64	16.60									
		Kabekuro	33/11	Proposed	2016	20	2	40	0.87					14.74	15.64	16.60									
		Ogbodzo	33/11	Proposed	2016	20	2	40	0.87					14.74	15.64	16.60									

(3) Year 2020 to 2027 with the Project

Supply BSP	Name	Location	Voltage	Status		Capacity	Number	Total	Power Factor	Forecast of Demand														
										2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
			kV			MVA	Units	MVA		MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Achimota BSP		Capacity	MVA						0.87	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
		Demand	MW						0.87	288	245	259	274	203	215	228	186	197	209	222	236	250	266	282	299
		Demand	MVA					360	0.87	331	281	297	315	233	247	262	214	227	241	255	271	288	305	324	344
	C	Achimota Village	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
	H	Achimota	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
	K	Switchback	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
	S	Kwashieman	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
	AC	Airport City	33/11	Existing		20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
		Darkuman	33/11	Committed	2014	20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
		Kotobabi	33/11	Proposed	2016	20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
		Kisseman	33/11	Proposed	2016	20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
		Apenkwa	33/11	Proposed	2016	20	2	40	0.87								20.65	21.91	23.26	24.69	26.21	27.82	29.52	31.34	33.27
A4 BSP		Capacity	MVA						0.87								375	375	375	375	375	375	375	375	375
		Demand	MW						0.87								211	224	238	253	268	284	302	321	340
		Demand	MVA					420	0.87								243	258	273	290	308	327	347	368	391
	J	Ofankor	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	M	Legon	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	N	Nsawam	33/11	Existing		20	1	20	0.87								10.05	10.67	11.33	12.02	12.76	13.55	14.38	15.26	16.20
	W	Mampong	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	T	Adenta	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	AE	Kwabenya	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	ND	Ngmai Jorn	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Adjei Kojo	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Kabekuro	33/11	Proposed	2016	20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Ogbodzo	33/11	Proposed	2016	20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Aburi	33/11	Committed	2014	20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
Mallam BSP		Capacity	MVA						0.87	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	230	196	207	219	162	172	183	149	158	167	178	189	200	213	226	240
		Demand	MVA					270	0.87	264	225	238	252	186	198	210	171	181	192	204	217	230	244	259	275
	A	Odorkor	33/11	Existing		20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
	P	Weija	33/11	Existing		5	2	10	0.87								5.51	5.84	6.20	6.58	6.99	7.42	7.87	8.36	8.87
	V	Dansoman	33/11	Existing		20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
	Z	Tokuse	33/11	Existing		10	2	20	0.87								11.01	11.69	12.41	13.17	13.98	14.84	15.75	16.71	17.74
		Sowutuom	33/11	Existing		20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
		Gbawe Janman	33/11	Committed	2014	20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
		New Dansoma	33/11	Committed	2014	20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
		Mataheko	33/11	Committed	2014	20	2	40	0.87								22.02	23.37	24.81	26.34	27.95	29.67	31.49	33.43	35.49
Accra Central BSP		Capacity	MVA						0.87						375	375	375	375	375	375	375	375	375	375
		Demand	MW						0.87						244	259	211	224	238	253	268	284	302	321	340
		Demand	MVA					420	0.87						281	298	243	258	273	290	308	327	347	368	391
	B	Korle Bu	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	D	Avenor	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	E	Graphic Road	33/11	Existing		20	3	60	0.87								30.16	32.02	33.98	36.07	38.29	40.64	43.14	45.79	48.61
	F	Kokomlemle	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	G	Power House	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	R	Ridge	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	X	Osu	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	AD	Archives	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
	AW	Awudome	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
		Ministries	33/11	Existing		20	2	40	0.87								20.11	21.34	22.66	24.05	25.53	27.09	28.76	30.52	32.40
A3 BSP		Capacity	MVA						0.87	132	264	264	264	264	264	264	264	264	264	264	264	264	264	264
		Demand	MW						0.87	115	196	207	219	162	172	183	149	158	167	178	189	200	213	226	240
		Demand	MVA					280	0.87	132	225	238	252	186	198	210	171	181	192	204	217	230	244	259	275
	L	Burma Camp	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
	Q	Teshie Nungua	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
	Y	Baatsonaa	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
	AU	Cantonments	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
		Nungua	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
		Trade Fare	33/11	Existing		20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22
		Shiashi	33/11	Committed	2014	20	2	40	0.87								21.24	22.54	23.92	25.39	26.95	28.61	30.37	32.23	34.22

Load Flow Analysis Results

Table1 Case Studies and the Results

Case Study				Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13	Case 14	Case 15
Year				2016	2017	2017	2018	2019	2020	2020	2021	2022	2023	2024	2024	2025	2026	2027
Operation Year				-1	1	1	2	3	4	4	4	5	6	7	7	8	9	10
EVENT	the Request (Accra Central BSP)					●	●	●		●	●	●	●	●	●	●	●	●
(●: Operation)	New 330 kV line between Aboadze and Cape Coast				●	●	●	●	●	●	●	●	●	●	●	●	●	●
	A4BSP									●	●	●	●	●	●	●	●	●
	Volta - Achimota lines upgrade (LILAC => TERN)														●	●	●	●
power factor				0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Load	Accra area	(1)	MW	725.8	771.8	766.4	813.9	863.8	926.5	921.1	978.4	1040.6	1105.8	1174.2	1175.3	1250.7	1328.8	1411.4
	Demand	(2)	MW	713.3	757.1	757.1	803.6	853.0	905.4	905.4	961.0	1020.1	1082.7	1149.3	1149.3	1219.9	1294.8	1374.4
	33kV Distribution Loss	(3)	MW	12.5	14.7	9.3	10.3	10.8	21.1	15.7	17.4	20.5	23.1	24.9	26.0	30.8	34.0	37.0
	(4)=(3)/(1)x100	(4)	%	1.7%	1.9%	1.2%	1.3%	1.3%	2.3%	1.7%	1.8%	2.0%	2.1%	2.1%	2.2%	2.5%	2.6%	2.6%
	Achimota	(5)	MW	277.10	294.40	204.50	217.10	230.50	352.70	187.40	198.90	211.30	224.40	238.40	238.40	253.40	268.90	285.70
	Demand	(6)	MW	274.35	291.20	202.63	215.08	228.30	348.23	185.81	197.22	209.34	222.20	235.85	235.85	250.34	265.72	282.05
	33kV Distribution Loss	(7)	MW	2.75	3.20	1.87	2.02	2.20	4.47	1.59	1.68	1.96	2.20	2.55	2.55	3.06	3.18	3.65
	(8)=(7)/(5)x100	(8)	%	1.0%	1.1%	0.9%	0.9%	1.0%	1.3%	0.8%	0.8%	0.9%	1.0%	1.1%	1.1%	1.2%	1.2%	1.3%
	Mallam	(9)	MW	225.20	239.80	166.50	177.00	187.50	288.60	149.80	159.00	168.90	179.50	190.50	190.50	202.80	215.00	228.40
	Demand	(10)	MW	219.48	232.96	162.11	172.07	182.64	278.58	148.65	157.78	167.47	177.76	188.68	188.68	200.28	212.58	225.64
	33kV Distribution Loss	(11)	MW	5.72	6.84	4.39	4.93	4.86	10.02	1.15	1.22	1.43	1.74	1.82	1.82	2.52	2.42	2.76
	(12)=(11)/(9)x100	(12)	%	2.5%	2.9%	2.6%	2.8%	2.6%	3.5%	0.8%	0.8%	0.8%	1.0%	1.0%	1.0%	1.2%	1.1%	1.2%
	A3BSP	(13)	MW	223.50	237.60	164.60	174.80	185.70	285.20	152.00	161.50	171.80	182.80	194.20	194.20	206.40	219.70	233.80
	Demand	(14)	MW	219.48	232.96	162.11	172.07	182.64	278.58	148.65	157.78	167.47	177.76	188.68	188.68	200.28	212.58	225.64
	33kV Distribution Loss	(15)	MW	4.02	4.64	2.49	2.73	3.06	6.62	3.35	3.72	4.33	5.04	5.52	5.52	6.12	7.12	8.16
	(16)=(15)/(13)x100	(16)	%	1.8%	2.0%	1.5%	1.6%	1.6%	2.3%	2.2%	2.3%	2.5%	2.8%	2.8%	2.8%	3.0%	3.2%	3.5%
	Accra Central	(17)	MW			230.80	245.00	260.10		211.50	224.50	238.40	253.00	268.70	268.70	285.20	302.80	321.40
	Demand	(18)	MW			230.26	244.41	259.43		211.15	224.12	237.89	252.50	268.02	268.02	284.48	301.96	320.51
	33kV Distribution Loss	(19)	MW			0.54	0.59	0.67		0.35	0.38	0.51	0.50	0.68	0.68	0.72	0.84	0.89
	(20)=(19)/(17)x100	(20)	%			0.2%	0.2%	0.3%		0.2%	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%
	A4BSP	(21)	MW							220.40	234.50	250.20	266.10	282.40	283.50	302.90	322.40	342.10
	Demand	(22)	MW							211.15	224.12	237.89	252.50	268.02	268.02	284.48	301.96	320.51
	33kV Distribution Loss	(23)	MW							9.25	10.38	12.31	13.60	14.38	15.48	18.42	20.44	21.59
	(24)=(23)/(21)x100	(24)	%							4.2%	4.4%	4.9%	5.1%	5.1%	5.5%	6.1%	6.3%	6.3%
	Cape Coast		MW	46.29	49.99	49.99	54.61	59.66	59.66	65.18	71.21	79.22	88.14	98.05	98.05	109.08	91.01	96.06
	Old Kpong		MW	32.06	34.63	34.63	37.83	41.33	41.33	45.16	49.33	54.88	61.06	67.92	67.92	75.57	84.07	88.73
	New Tema		MW	258.11	258.11	258.11	258.11	258.11	258.11	258.11	258.11	258.11	258.11	258.11	258.11	258.11	258.11	272.42
	Winneba		MW	20.02	21.62	21.62	23.62	25.80	25.80	28.19	30.80	34.26	38.12	42.41	42.41	47.18	52.48	55.39
	Kpong GS		MW	0.48	0.49	0.49	0.50	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.52
	Akosombo		MW	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.84
	Smelter 2		MW	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00	66.00
	sub total	A	MW	1155.2	1209.1	1203.7	1261.1	1321.7	1384.4	1390.7	1460.8	1540.1	1624.2	1713.7	1714.8	1813.6	1887.5	1997.4
System Loss	Transmission between Akosombo and Aboadze	B	MW	25.34	25.35	24.29	27.66	30.71	48.13	28.55	32.29	38.00	37.80	43.68	38.65	45.00	51.35	55.89
	33kV Distribution in Accra area	C	MW	12.49	14.69	9.29	10.28	10.81	21.10	15.70	17.38	20.53	23.07	24.95	26.05	30.84	34.00	37.05
	Total System Loss (B+C)	D	MW	37.82	40.04	33.58	37.94	41.52	69.23	44.25	49.67	58.53	60.87	68.63	64.70	75.84	85.35	92.93
	Loss rate above (D/F x 100)	E	%	3.2%	3.2%	2.7%	2.9%	3.1%	4.8%	3.1%	3.3%	3.7%	3.7%	3.9%	3.7%	4.1%	4.4%	4.5%
Total (A+D)		F	MW	1180.58	1234.47	1228.01	1288.72	1352.40	1432.51	1419.26	1493.12	1578.05	1662.00	1757.35	1753.41	1858.61	1938.80	2053.24
Remarks					↑ (a)	↑ (b)			↑ (c)					↑ (d)	↑ (d)			

(a) Overload of the 161/34.5 kV transformers that supply electricity in Accra area.
(b) The Request items assumed to be in service.
(c) The assumed loss for the case of not implementing the Project to confirm the system loss reduction effect of the Project.
(d) Overload of the transmission lines between Volta and Achimota. The transmission lines should be upgraded by 2024.

Note: 1) Analysis results based on assumed demands at each primary substation shown on the Attachment A-8. The 33 kV distribution loss may vary depending on the assumed demands.
2) Table 1 above shows a part of losses such as transmission lines, transformers and 33 kV distribution lines in the modeling area and do not represent losses for the entire Ghana.

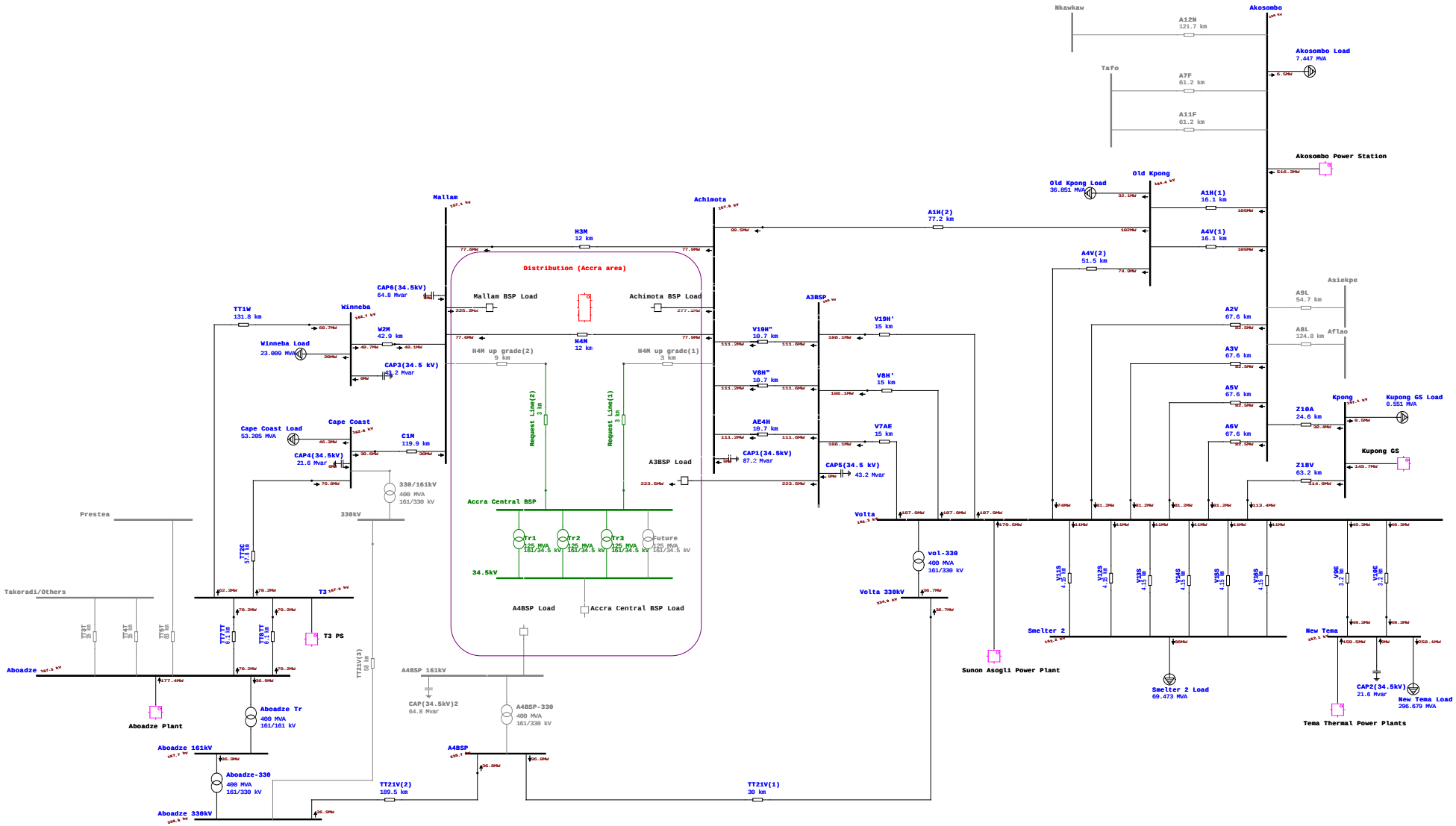


Fig.1 Case 1 (2016, without the Project, A4 BSP and transmission lines upgrade)

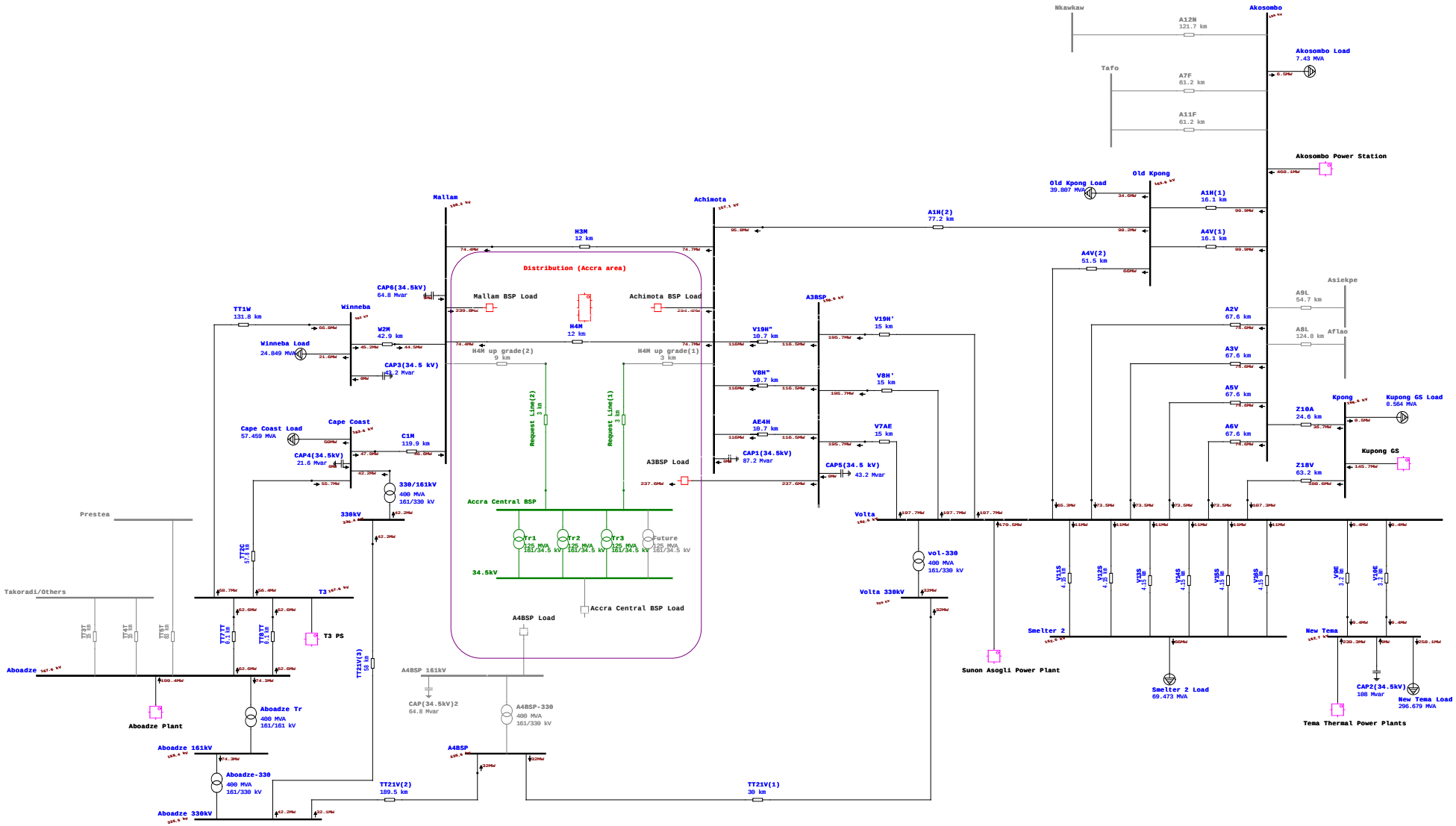


Fig.2 Case 2 (2017, without the Project, A4 BSP and transmission lines upgrade)

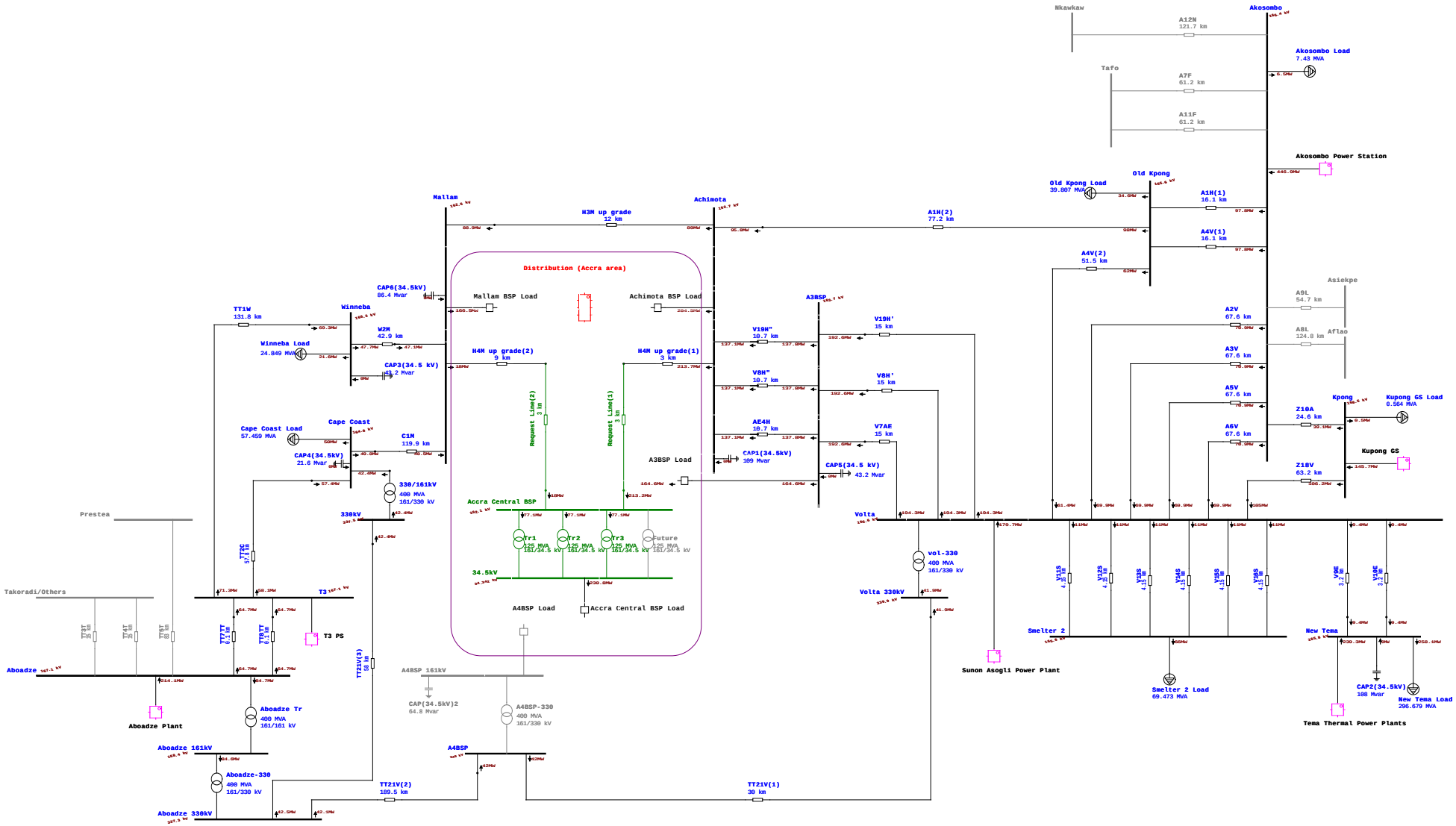


Fig.3 Case 3 (2018, without the Project, A4 BSP and transmission lines upgrade)

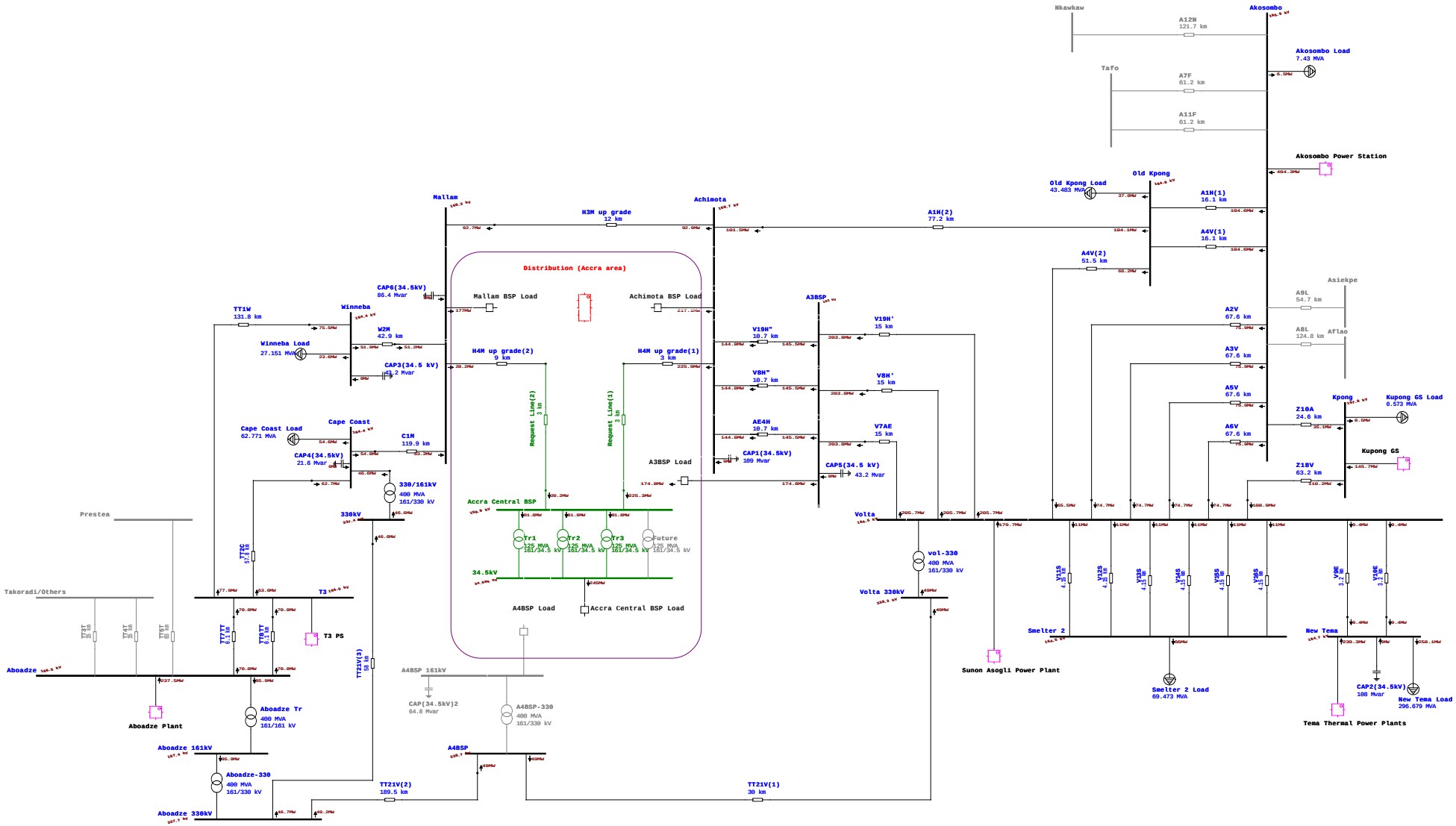


Fig.4 Case 4 (2018, with the Project, without A4 BSP and transmission lines upgrade)

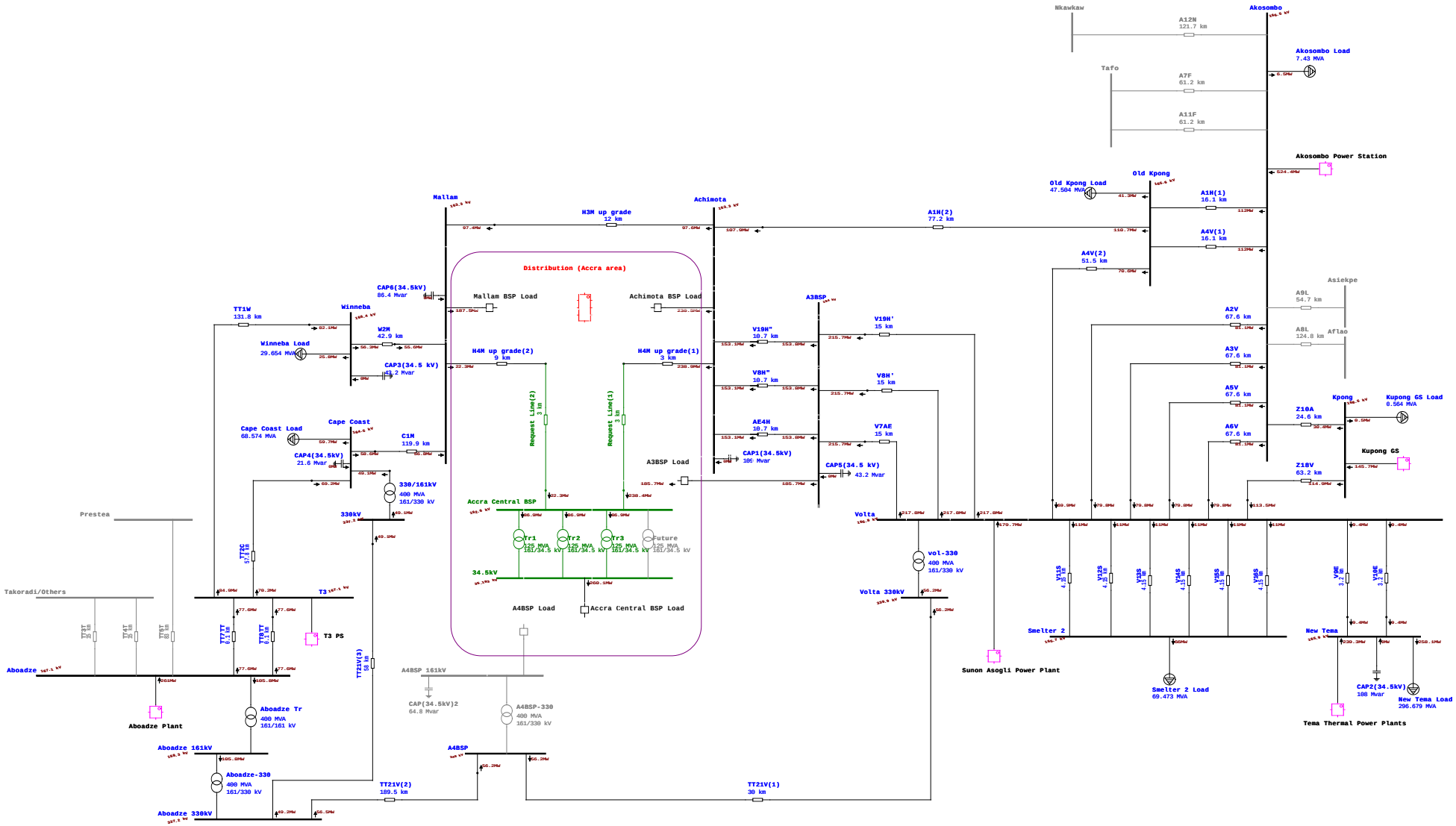


Fig.5 Case 5 (2019, with the Project, without A4 BSP and transmission lines upgrade)

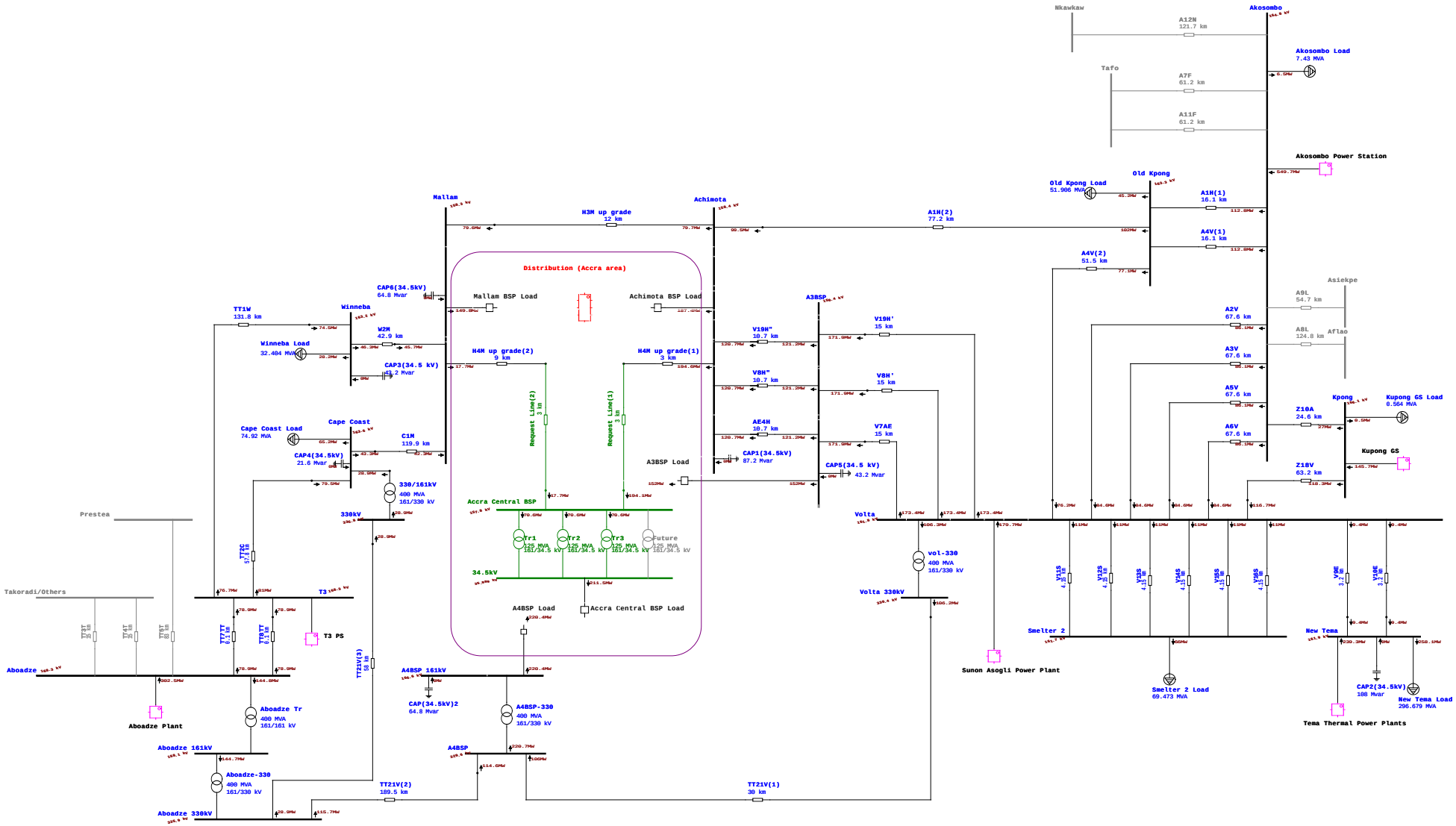


Fig.6 Case 6 (2020, with the Project and A4 BSP, without transmission lines upgrade)

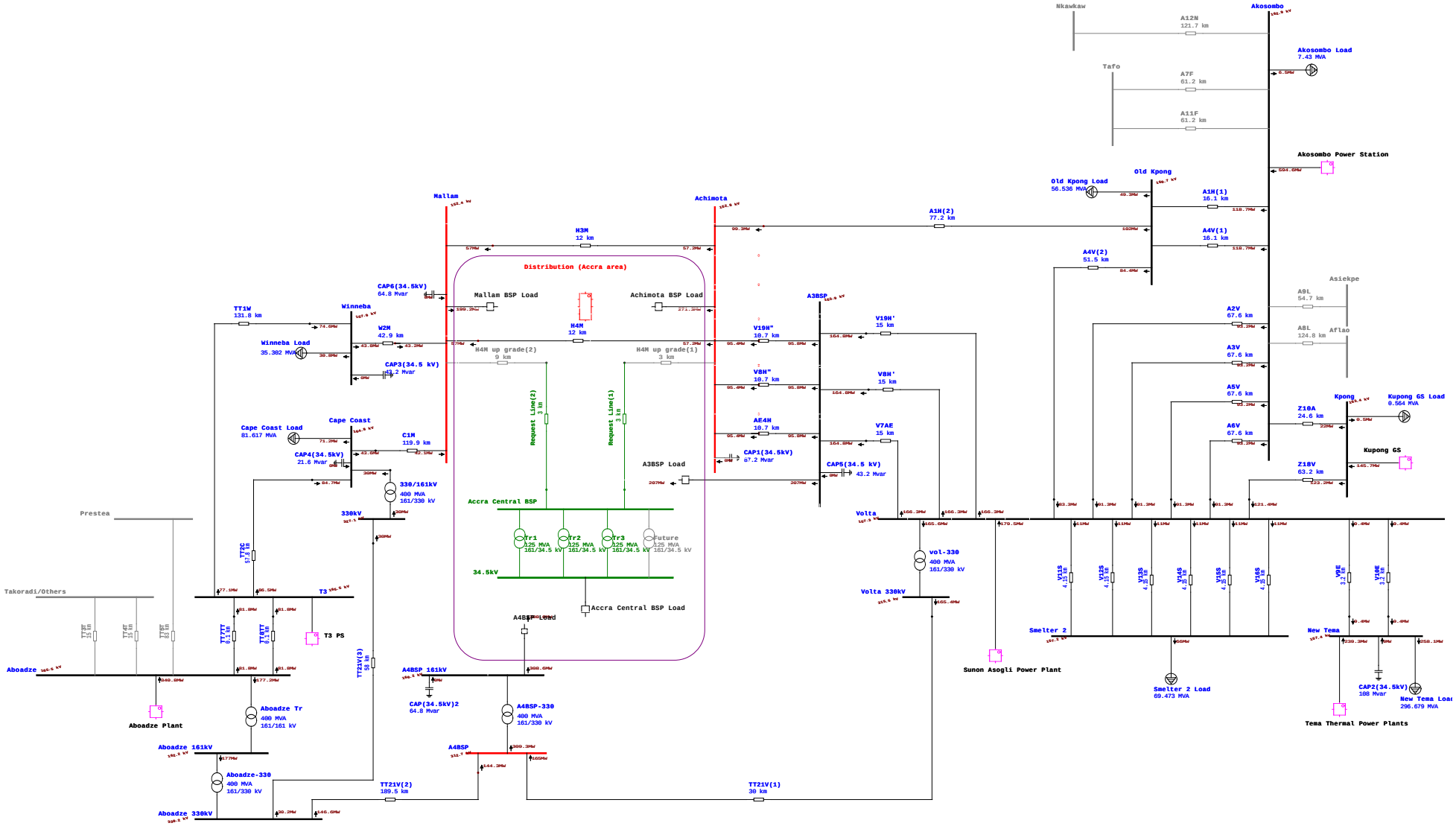


Fig.7 Case 7 (2021, without the Project and transmission lines upgrade, with A4 BSP)

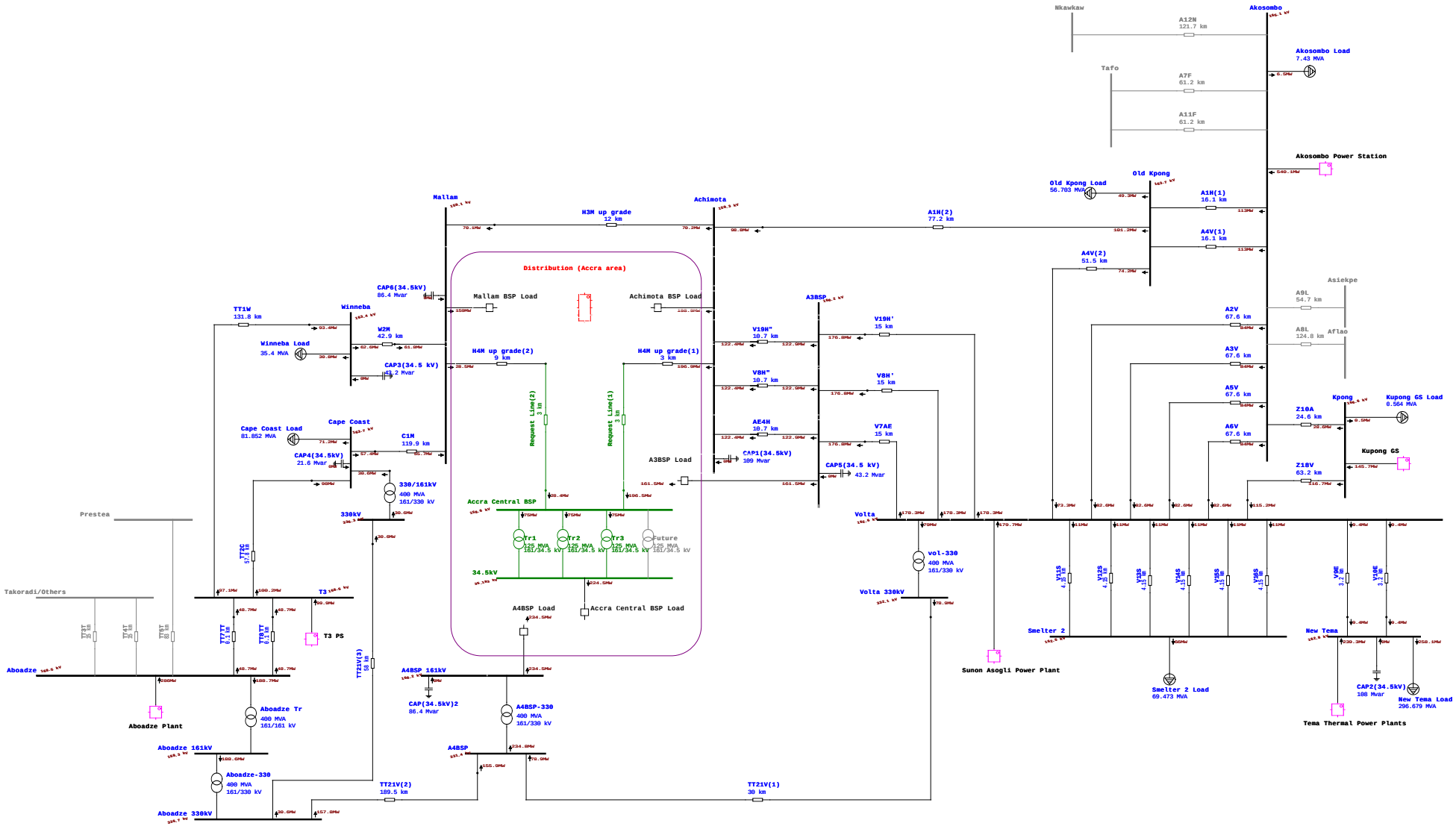


Fig.8 Case 8 (2021, with the Project and A4 BSP, without transmission lines upgrade)

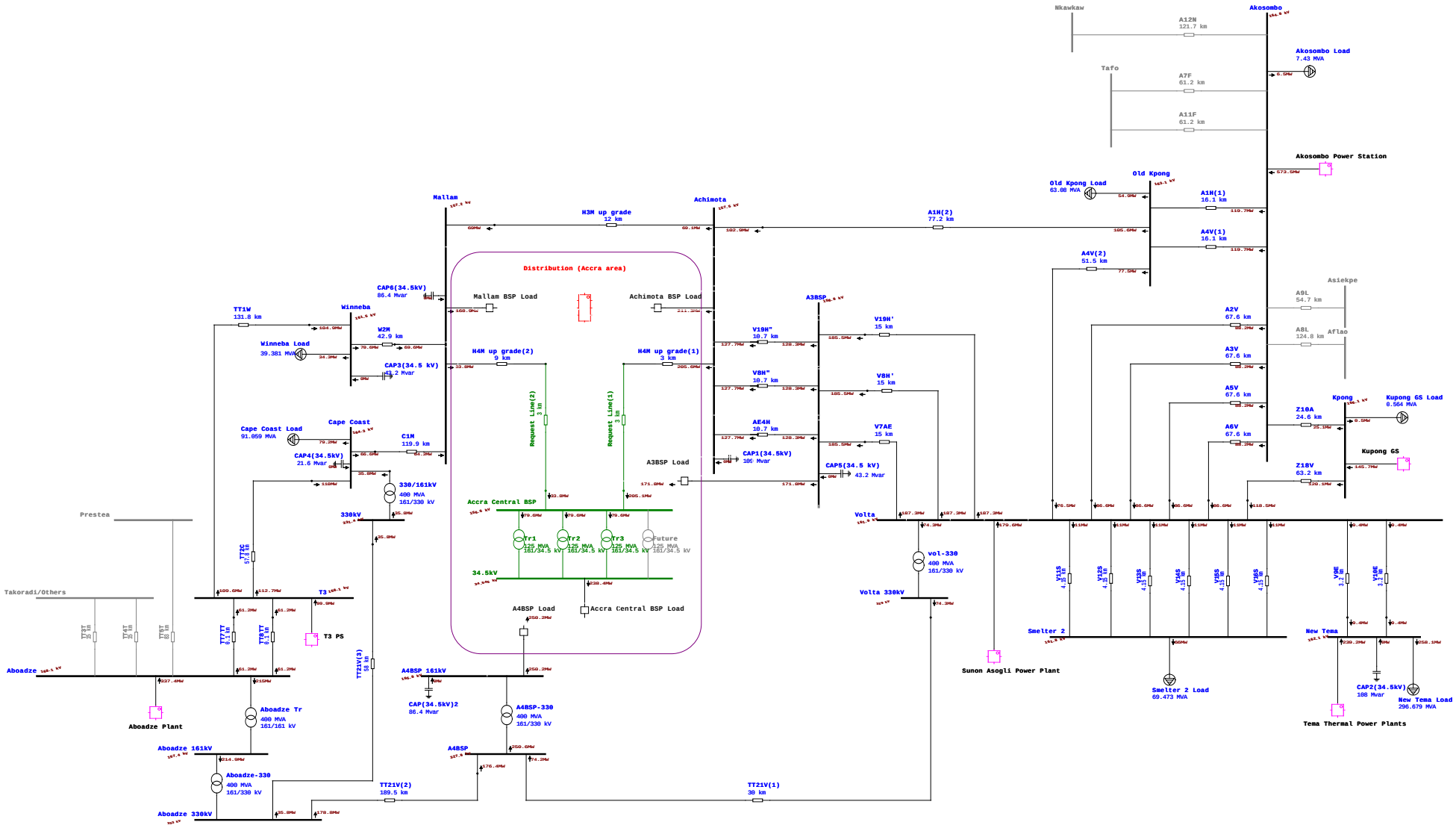


Fig.9 Case 9 (2022, with the Project and A4 BSP, without transmission lines upgrade)

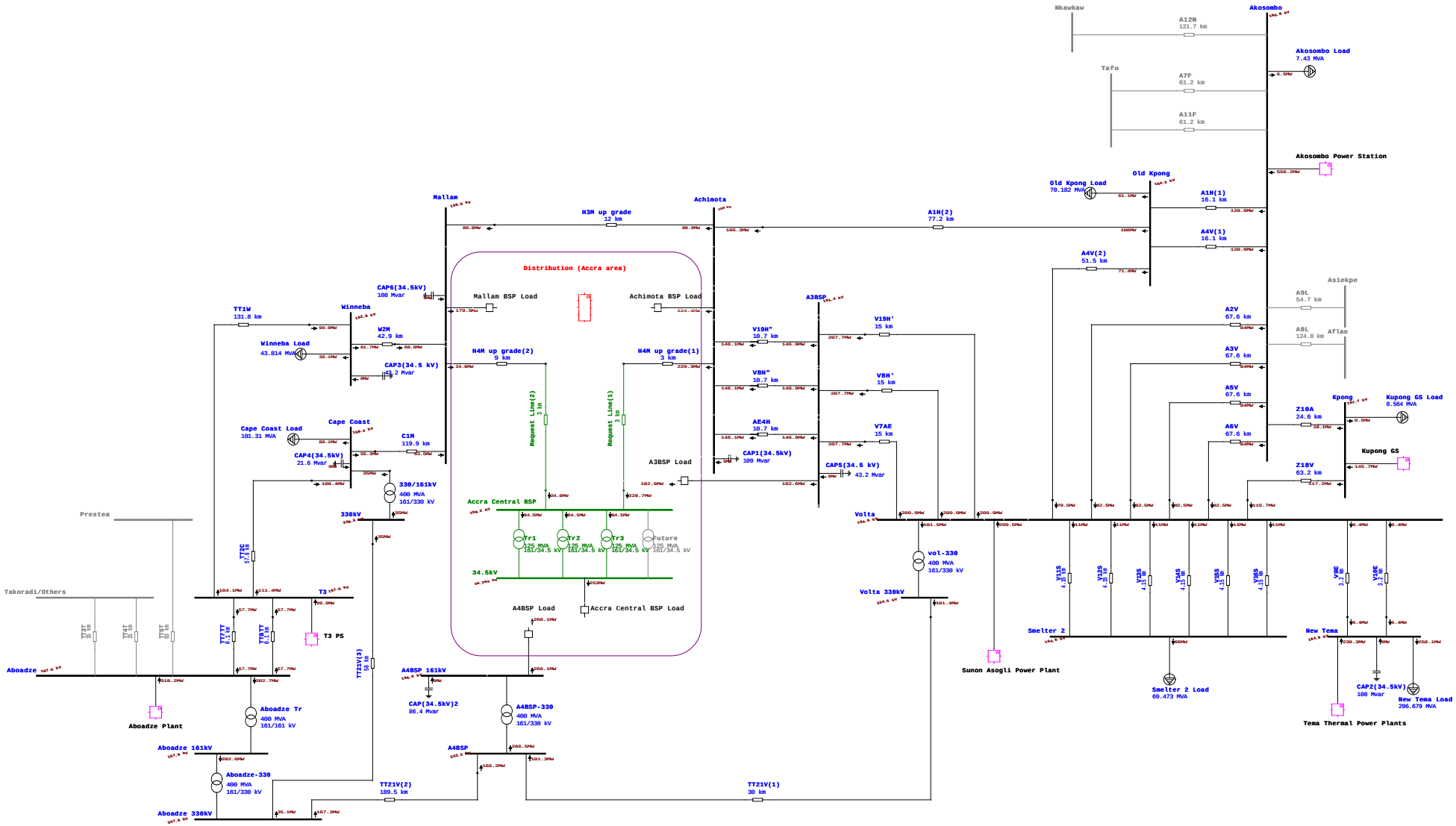


Fig.10 Case 10 (2023, with the Project and A4 BSP, without transmission lines upgrade)

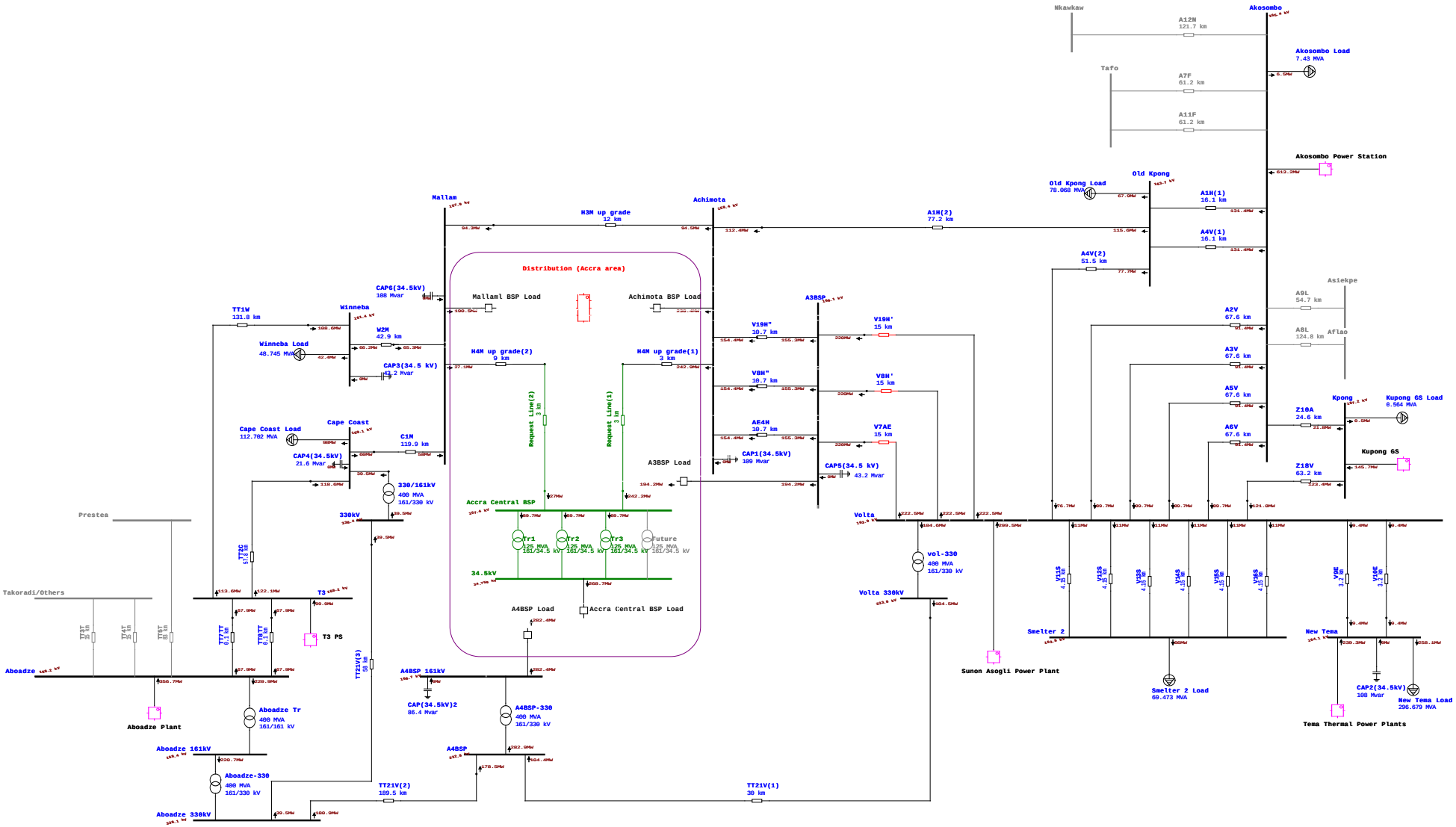


Fig.11 Case 11 (2024, with the Project and A4 BSP, without transmission lines upgrade)

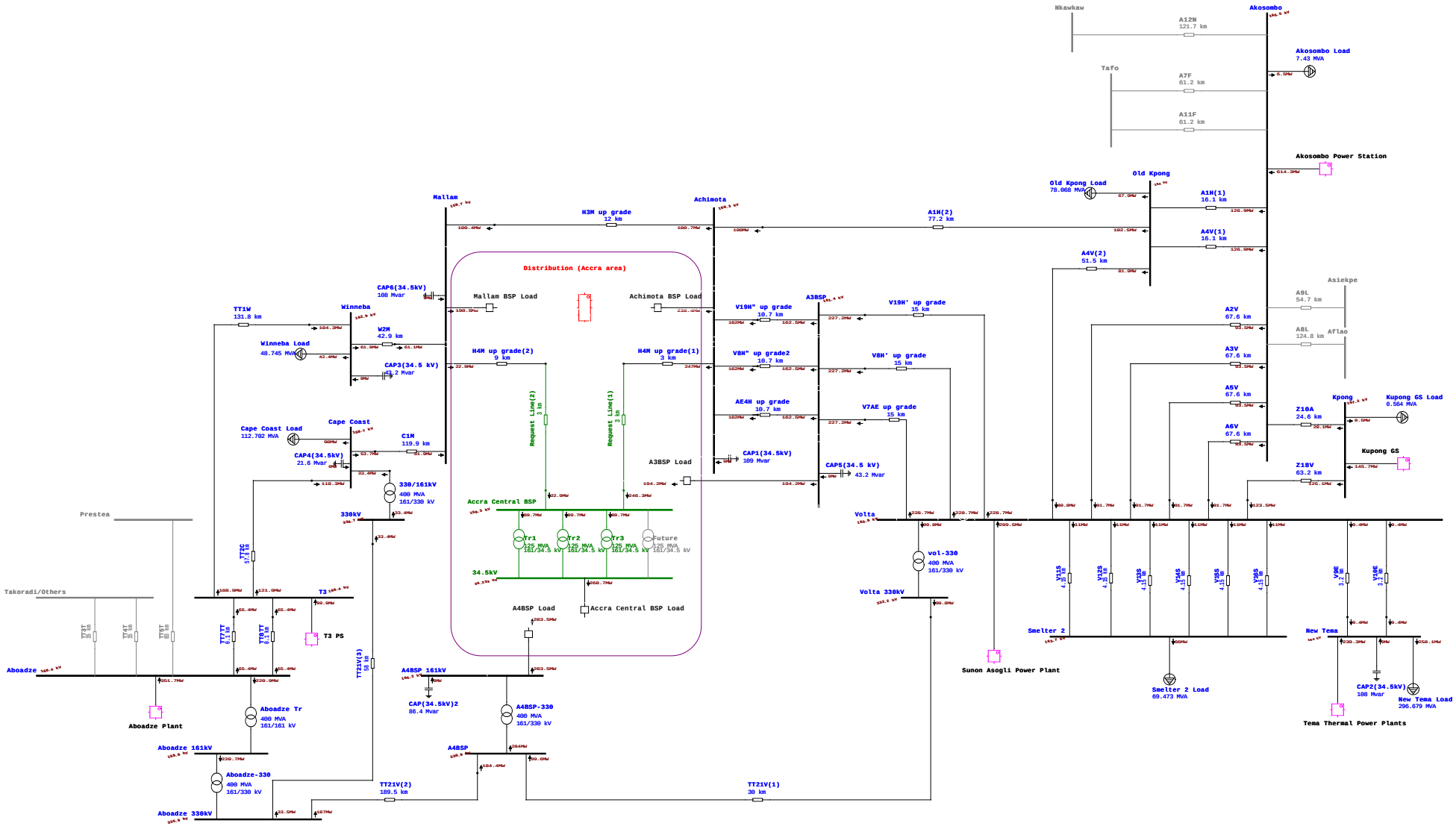


Fig.12 Case 12 (2024, with the Project, A4 BSP and transmission lines upgrade)

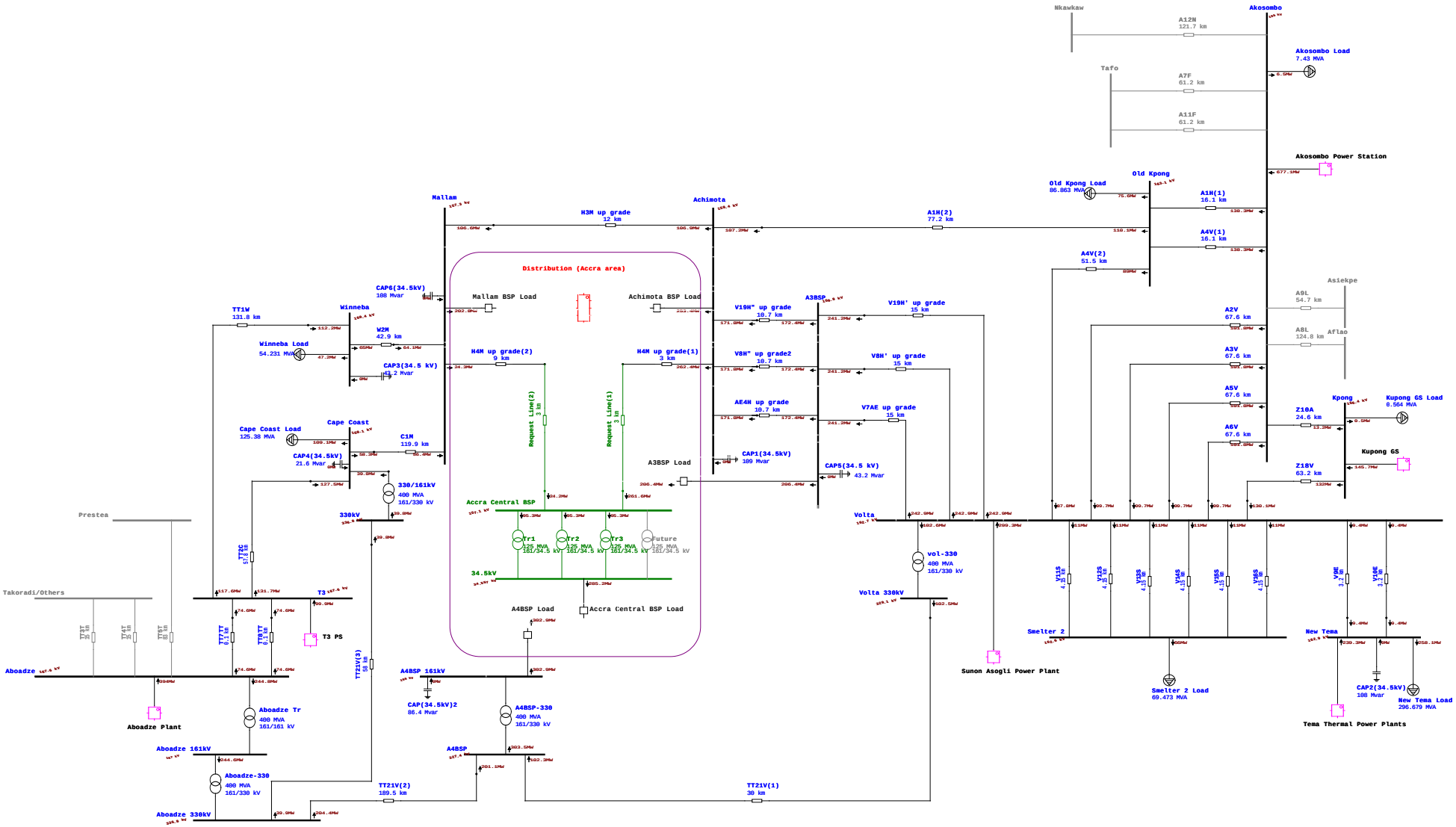


Fig.13 Case 13 (2025, with the Project, A4 BSP and transmission lines upgrade)

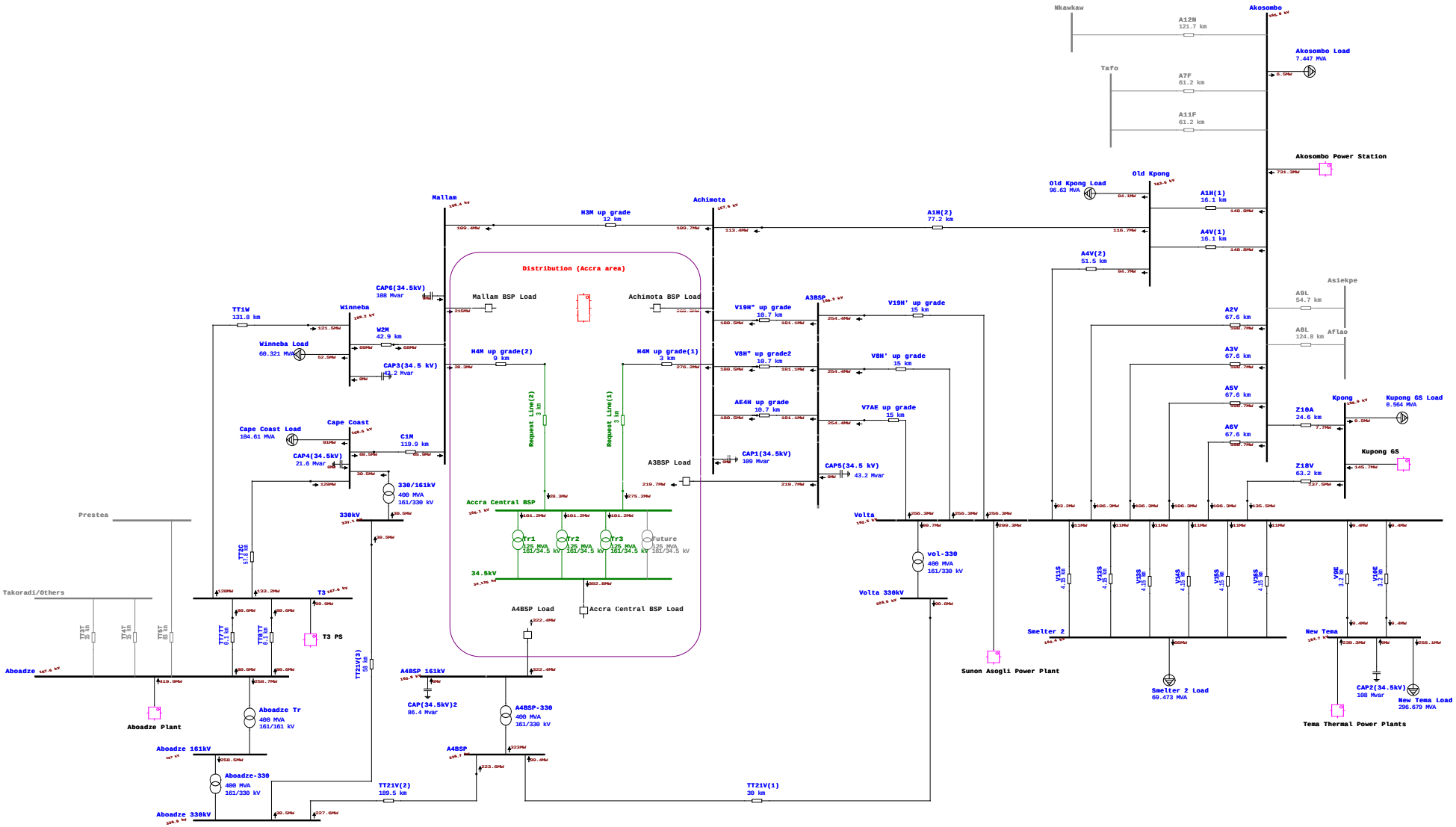


Fig.14 Case 14 (2026, with the Project, A4 BSP and transmission lines upgrade)

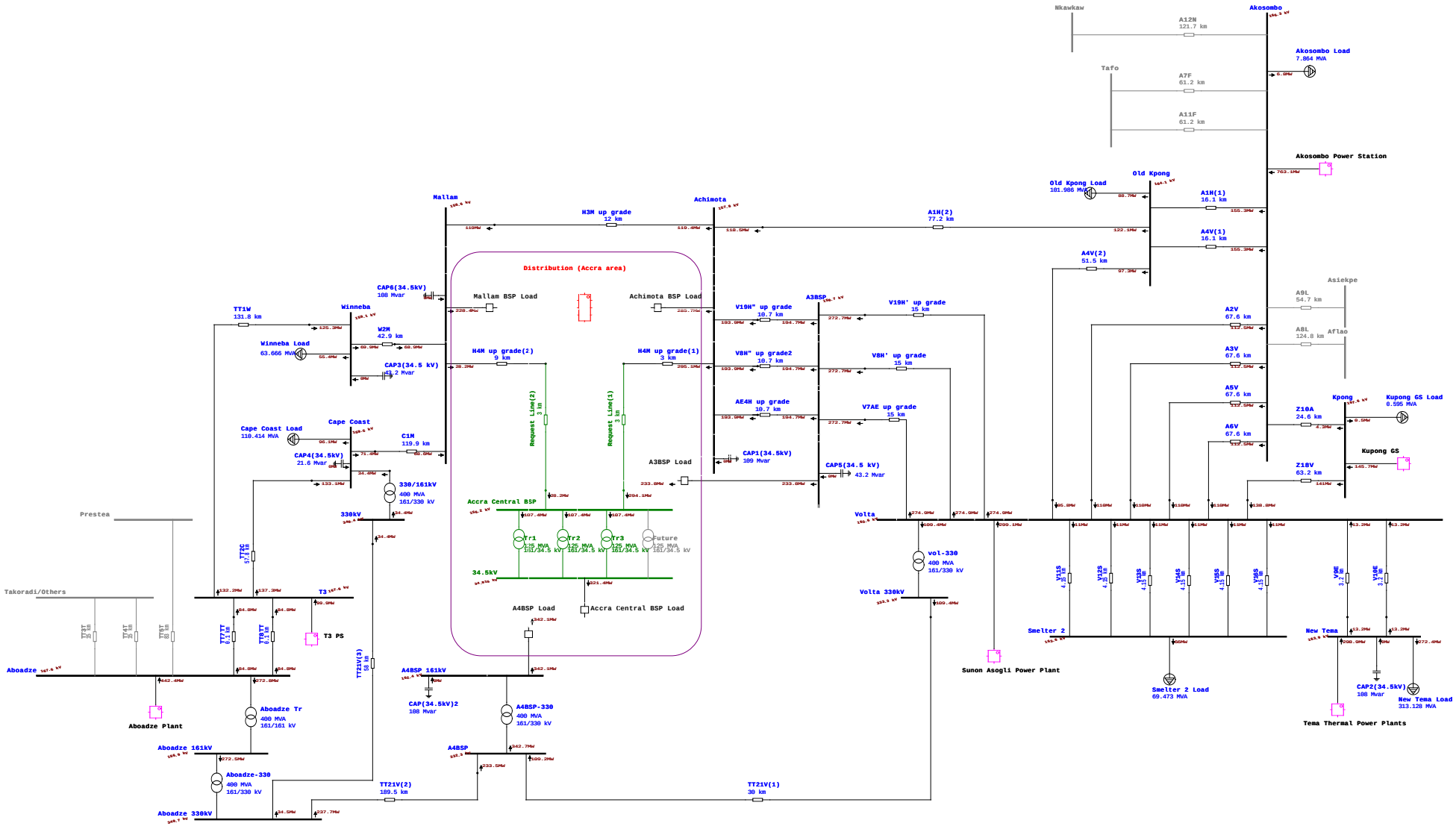


Fig.15 Case 15 (2027, with the Project, A4 BSP and transmission lines upgrade)

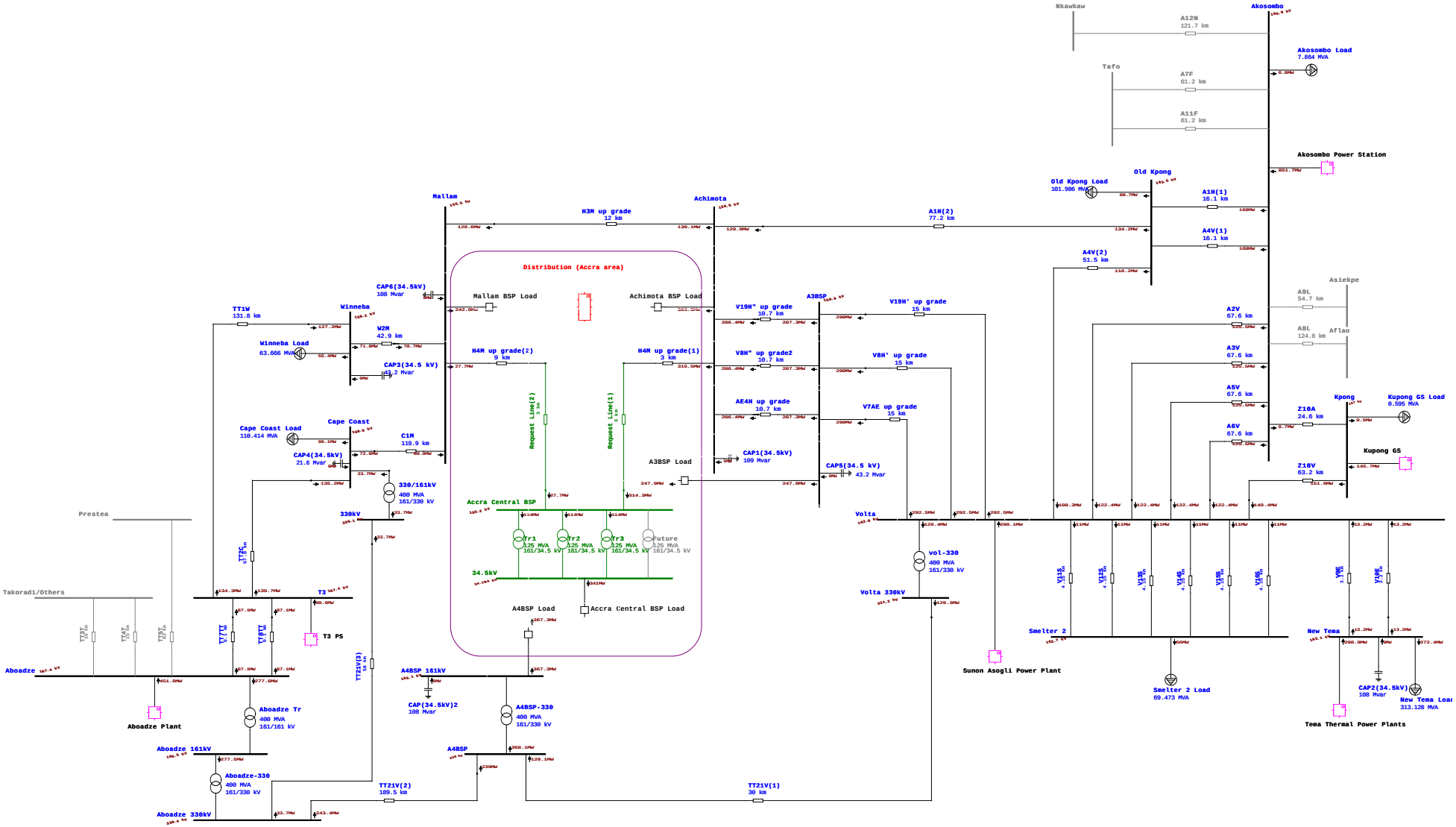


Fig.16 Case 16 (2028, with the Project, A4 BSP and transmission lines upgrade)