Ministry of Finance, Planning and Economic Development (MOFPED)
Ministry of Energy and Mineral Development (MEMD)
Uganda Electricity Transmission Company Limited (UETCL)
The Republic of Uganda

PREPARATORY SURVEY ON GREATER KAMPALA METROPOLITAN AREA TRANSMISSION SYSTEMS IMPROVEMENT PROJECT IN THE REPUBLIC OF UGANDA

FINAL REPORT

SEPTEMBER 2016

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)

YACHIYO ENGINEERING CO., LTD.

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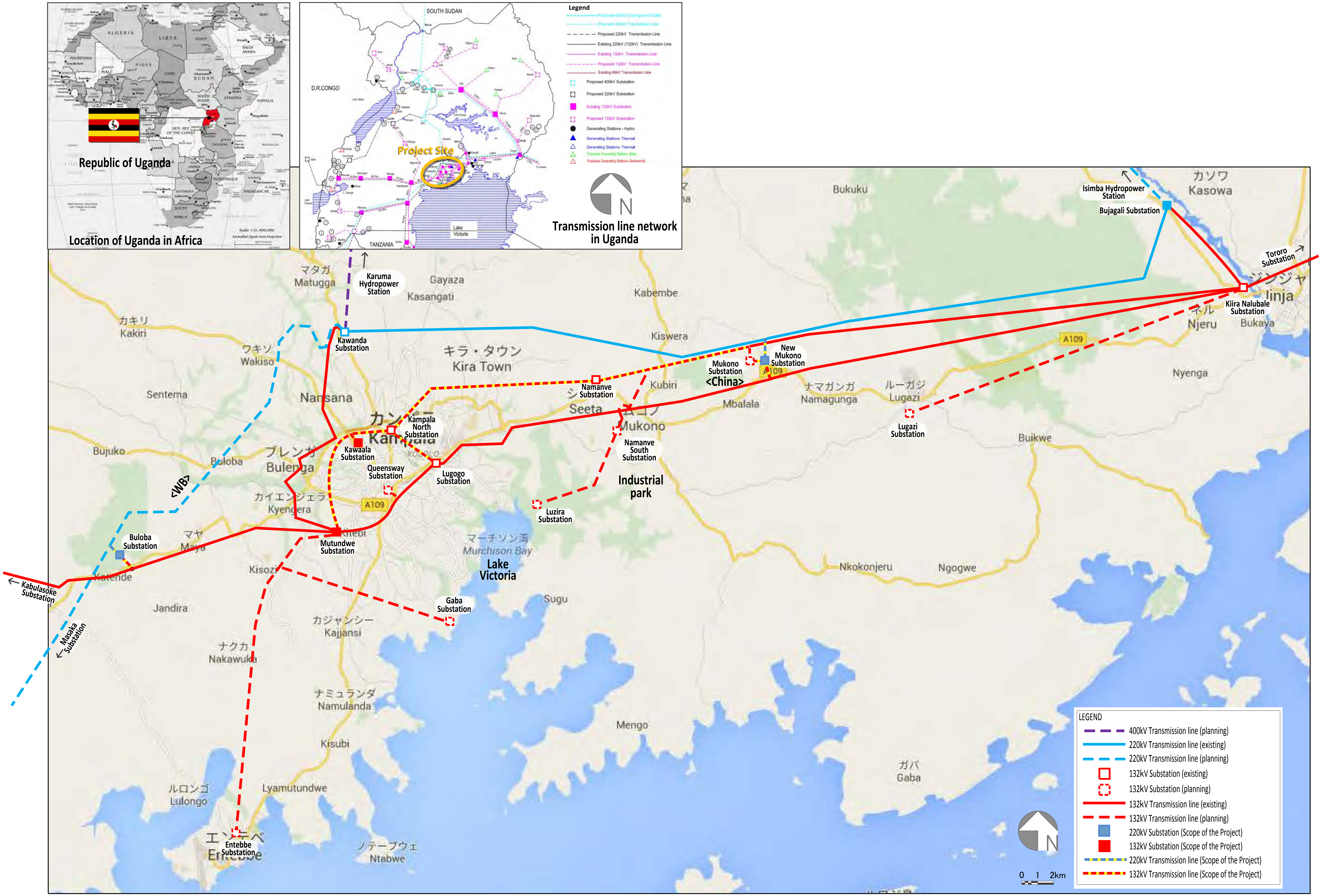

Location of the Project Site

Greater Kampala Metropolitan Area Transmission Systems Improvement Project in the Republic of Uganda

Final Report

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Abbreviation

AAAC	All Aluminum Alloy Conductors
AC	Aluminum-Clad Steel Wire
ACSR	Aluminium Conductor Steel Reinforced
ARAP	Abbreviated Resettlement Action Plan
BID	Best Investment Decision
BS	British Standard
BECS	Bundibugyo Energy Co-operative Society
BST	Bulk Sales Tariff
CAE	Certificate of Approval of EIA
CGV	Chief Government Valuer
CH	Cable Head
CT	Current Transformer
CVT	Condensor type Voltage Transoformer
DLBs	District Land Boards
DLTs	District Land Tribunals
EAPP	Eastern Africa Power Pool
CEO	Chief Executive Officer
EDS	Every Day Stress
EDT	Electricity Disputes Tribunal
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EIS	Environmental Impact Statement
EmoP	Environment Monitoring Plan
EMP	Environment Management Plan
ENPV	Economic Net Present Value
EPC	Engineering, Procurement and Construction
ERA	Electricity Regulatory Authority
EU	European Union
FESL	Ferdsult Engineering Services Limited
FIRR	Financial Internal Rate of Return
FY	Fiscal Year
GDE	Gross Domestic Expenditure
GDP	Gross Domestic Product
GIS	Gas Insulated Switchgear
GKMA	Greater Kampala Metropolitan Area
GSHAP	Global Seismic Hazard Assessment Program
GSW	Galvanized Steel Wire
GZTACSR	Gap Type Super Thermal-resistant Aluminum alloy Conductor Steel Reinforced

HTLS	HighTemperature Low Sag wire
IDA	International Development Association
IEC	International Electrotechnical Commission
IKL	Isokeraunic Level
IPP	Indipendendent Power Producer
IUCN	International Union for Conservation of Nature
JBIC	Japan Bank for International Cooperation
JEC	Japanese Electrotechnical Committee
JICA	Japan International Cooperation Agency
KCCL	Kasese Cobalt Company Limited)
KfW	Kreditanstalt für Wiederaufbau
KIL	Kilember Investments Limited
KPLC	Kenya Power & Lighting Company Limited
MEMD	Ministry of Energy and Mineral Development
MWT	Maximum Working Tension
NARL	National Agriculture Research Laboratories
NARO	National Agriculture Research Organization
NASA	National Aeronautics and Space Administration
NDP	National Developmenbt Plan
NEMA	National Environmental Management Agency
NEA	National Environment Act
NFA	National Forestry Authority
NGO	Non Governmetal Organization
NSLT	Non-Special Load Tariff
OPGW	Optical Fiber Composite Overhead Ground Wire
PACMECS	Pader Abim Community Multipurpose Electric Cooperative Society Limited
PCE	Policy Committee on the Environment
PEAP	Poverty Eradication Action Plan
PGA	Peak Ground Acceleration
P/Q	Prequalification
PRG	Partical Risk Guarantee
PSS/E	Power System Simulation for Engineering
RAP	Resettlement Action Plan
REA	Rural Electrification Agency
REGL	Rwanda Energy Group Limited)
ROW	Right of Way
SCF	Standard Conversion Factor
SE4ALL	Uganda’s Sustainable Energy for All Initiative Action Agenda
SLT	Special Load Tariff
SNEL	Société nationale d'électricité

SNS	Social Networking Service
TANESCO	Tanzania Electric Supply Company Limited
TL	Transmission Line
TOR	Terms of Reference
TRMM	Tropical Rainfall Measuring Mission
UEB	Uganda Electricity Board
UEDCL	Uganda Electricity Distribution Company Limited
UEGCL	Uganda Electricity Generation Company Limited
UETCL	Uganda Electricity Transmission Company Limited
UNSTAT	United Nations Statistics Division
UGX	Uganda Shillings
UMEME	Umeme Limited
UNMA	Uganda National Meteorological Authority
USD	United States Dollar
UTS	Ultimate Strength Tensile
UWA	Uganda Wildlife Authority
VAT	Value Added Tax
WENRECo	West Nile Rural Electrification Company
ZTACIR	Super Thermal-resistant aluminum Alloy Conductor al-cla Invar Reinforced

Chapter 1 Background and Formulation of the Project

1-1 Background of the Project

1-1-1 Necessity and Background of the Project

The economy of the Republic of Uganda (Uganda) is remarkably developing such rate as 7% per year of the Gross Domestic Product (GDP) growth rate, and the power demand is also growing rapidly at 9.7% per year in average between 2007 and 2012 in response to the economic development. Though the Government of Uganda promotes development of power sources in timely manner, development of the transmission system is currently not proceeding in consistency with the power demand growth. However, to achieve independent and sustainable development of socio-economic activity in Uganda, development of the transmission network shall be put high priority on and, especially, the network in the Kampala Metropolitan Area, which is the center of the economic activities of Uganda, shall be put the highest on.

In general, a ring configuration of transmission system in ultra-high voltage range whose voltage class is over 187 kV is introduced to achieve high transmission capacity and reliability of power supply as the demand grows. When the transmission system in Kampala metropolitan area is focused on, it can be said that a ring configuration of transmission system at 132 kV, which is currently the voltage for the trunk transmission lines in Uganda, has been composed in Kampala metropolitan area. However, from the power flow simulation and analysis conducted during this study, it was observed that the current 132 kV ring system will fundamentally lack of the carrying capacity within the medium term (10 to 15 years), when the current growth trend of the power demand is considered.

Uganda Electricity Transmission Company Limited (UETCL), the Implementation Agency of the project, has prepared a Grid Development Plan, showing the transmission system plan for the medium term (10 to 15 years), and updates it every year. The latest Plan published in 2015 targets the period 2014 to 2030.

In the Grid Development Plan 2014 to 2030, though the transmission lines in ultra-high voltage, 220 kV have been developed, it is still at the stage of introduction. The effective use of the 220 kV transmission lines in the Kampala Metropolitan area, such as formulation of the 220 kV ring system, is expected to be included in the next updates of the Grid Development Plan after knowledge and technology for effectiveness of ultra-high voltage system has been accumulated enough in UETCL.

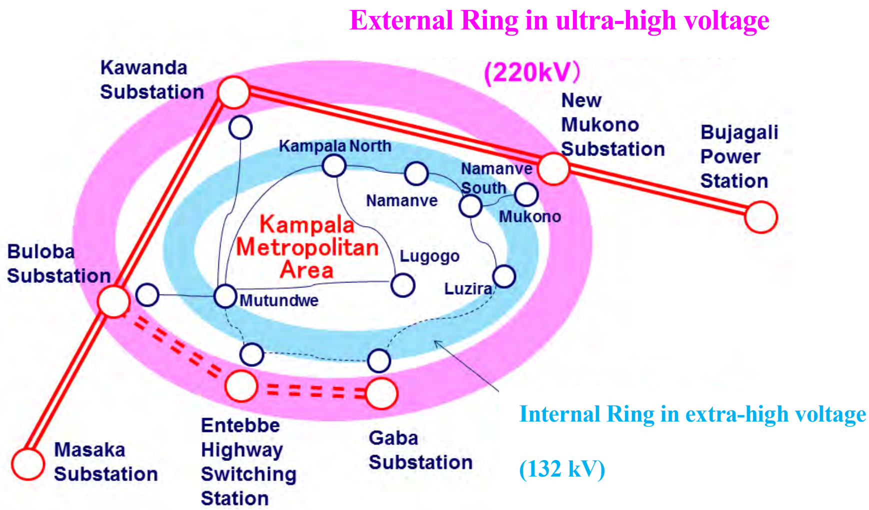
Therefore, in the Preparatory Survey, the issues confirmed in the Grid Development Plan 2014 - 2030 of UETCL regarding Kampala Metropolitan area have been reviewed, the demand forecast for the area for the medium term (10 to 15 years) is prepared, and the transmission system plan targeting 2030 are formulated. The plan overlooks the transmission system in Kampala metropolitan area and realizes the effective use of 220 kV transmission lines for power supply in the area by formulation of the 220 kV ring system outside the existing 132 kV ring system. As a result of the plan, relevance and effectiveness of the Project as a Japanese Yen Loan project is achieved.

This project will construct a part of 220 kV outside ring system through the construction of 220 / 132 / 33 kV Buloba Substation and 220 / 132 kV New Mukono Substation and associated 220 kV and 132 kV transmission lines. Also, existing 132 / 33 substations will be improved and 132 kV transmission lines will be reconductored to bolster the 132 kV inside ring system.

On the other hand, in case of Japanese Yen Loan projects, securement of consistency between the national policy of the recipient country and the Project is required in terms of relevance of the Project. In the National Development Plan II, which is the national development policy of the Government of Uganda for the period 2016 - 2021, "promotion of development of infrastructures" is one of critical areas of focus of the Government in order to achieve the development goals highlighted in the plan. Therefore, it can be said that the Project maintains relevance in terms of consistency to the national policy of the Uganda Government for socioeconomic development.

1-1-2 Formulation of the transmission system plan targeting 2030

As mentioned above, since it is obvious that the current 132 kV ring system will fundamentally lack of the carrying capacity within the medium term (10 to 15 years) when the current growth trend of the power demand is considered, the system configuration with the 220 kV ring system outside the existing 132 kV ring system is observed to be effective. The transmission lines between Bujagali Power Station and Kawanda Substation shown as the double red lines in Figure 1-1-2.1 constructed as 220 kV lines but currently operated as 132 kV transmission lines will be upgraded to 220 kV in 2017. On the other hand, the 220 kV transmission lines between Kawanda Substation - Masaka Substation shown as the double red lines in the same figure will start operation in 2018. To formulate the 220 kV outer ring system, it is effective to use these 220 kV transmission lines as the part of the 220 kV ring system and formulate the ring system as shown as the purple ring in Figure 1-1-2.1.



Remark: Ultra high voltage is over 187 kV and extra-high voltage is over 7 kV.

Source: JICA Study Team

Figure 1-1-2.1 Outline of Outer 220 kV Ring System and 132 kV Ring System in the Kampala Metropolitan Area

The first step for formulation of the 220 kV outer ring system in Kampala metropolitan area is to install substations on the 220 kV lines between Bujagali Power Station - Kawanda Substation and 220 kV lines Kawanda Substation - Masaka Substation, respectively, in consideration of not only technical aspects but also environmental and social aspects.

Since these substations will be installed in the urban area, environmental and social considerations such as minimization of involuntary resettlement shall be paid attention to. In addition, though it is obvious that the existing 132kV internal system will lack of power carrying capacity when the expected demand growth are considered, there is difficulty in new construction of additional transmission lines since the routes shall be located in the densely populated area. Thus, the land acquisition for additional routes as well as the large scale of involuntary resettlement (according to UETCL standards, the width of way leave for 132 kV lines is 30 and one for 220 kV is 40 m) is required. Therefore, it is effective to upgrade capacity of the existing transmission lines by re-conductoring from the existing conductors to High-Temperature Low-Sag (HTLS) conductors while using the existing transmission towers and line corridor.

In the Preparatory Survey, the transmission system plan targeting 2030 is formulated with setting scenarios which is considered as the effective countermeasures for improvement of the transmission system in the Kampala Metropolitan Area, such as new construction of 220 / 132 kV substations and re-conductoring to HTLS conductors. And, based on the formulated transmission system plan, the components of the Project are selected.

In this project, the area covered by Greater Kampala Metropolitan Area[1] is described as the Kampala metropolitan area which consists of Kampala city and its surrounding districts of Wakiso, Mpigi and Mukono. Substations and transmission lines to be constructed under the project except for Bujagali Substation will be located in this area.

1-2 Outline of the Results of the Preparatory Survey

The first field survey was conducted from September to October, 2015, the second survey and the third survey were conducted from November to December, 2015 and from February to April, 2016 respectively. Finally, the fourth field survey was conducted in June, 2016. During the surveys, the team conducted a series of discussions with UETCL and the project components as shown in Table 1-2.1 were selected, which includes the construction of 220 / 132 kV substations, reconductoring of HTLS conductors and procurement of mobile substations.

In general, a ring configuration of transmission system in ultra-high voltage is effective to achieve high transmission capacity and reliability of power supply as the demand grows in the big city. The

[1] Greater Kampala metropolitan area shall include Kampala City and the neighboring districts of Mubigi, Wakiso and Mukono based on Kampala Metropolitan Physical Development Plan of Uganda.
Power demand forecast to be described in the report will consider that substations to be covered by the project will distribute electricity to the whole central area.

transmission system in Uganda is still at the introduction stage of 220 kV transmission lines and these 220kV transmission lines are located or under construction through the Kampala Metropolitan area. Therefore one idea is to consider how to apply them for effective power supply to the Kampala Metropolitan area.

The first step for achievement of the goal is to construct 220 / 132 kV substations on the 220 kV lines between Bujagali Power Station - Kawanda Substation and the 220 kV lines between Kawanda Substation - Masaka Substation, respectively, and to provide the power supply point to Kampala metropolitan area from the 220 kV system. Two substations will thus be constructed for this purpose, namely, Buloba and New Mukono Substations. Since the Project area is the densely populated area and land acquisition is difficult, selection of the Project site is not flexible and Buloba Substation and New Mukono Substation are selected as shown in the item 1 and 2 of Table 1-2.1. The construction of associated 220 kV and 132 kV transmission lines are shown in item 7 and item 8 of this table.

Additionally, in order to enhance supply capacity around supply area of Kampala North Substation where the power demand is increasing remarkably, expansion of Kawaala Substation is selected as a component of the Project as shown in the item 3 of Table 1-2.1 in consideration of the demand forecasted on the bus of the substation.

On the other hand, as shown in the item 4 of Table 1-2.1, in order to achieve effective use of the 220 kV transmission lines, an additional 220 / 132kV transformer to Bujagali Substation has been selected as a component of the Project through power flow analysis.

In terms of improvement of reliability of supply, modification of the bus configuration from the single bus system to the double bus system at Mutundwe Substation, which is an urgent issue in the transmission system in the Kampala Metropolitan Area, is also selected as a component of the Project as shown in the item 5 of Table 1-2.1.

In addition to the above, since necessity of countermeasures for accidents at existing substation is increasing as the demand growth, mobile substations are included as the components of the Project as shown in the item 6 of Table 1-2.1.

Finally, since it is expected that the existing 132 kV transmission system will lack capacity to deliver power to the metropolitan area in the near future, it is essential to increase their capacity. Since the Project area is the densely populated area and land acquisition is difficult, it is effective to enhance the transmission lines by re-conductoring from the existing conductors to High-Temperature Low-Sag (HTLS) conductors while utilizing the existing transmission line towers. As the results of optimization of the sections where HTLS conductors shall be applied, the section is selected as shown in the item 8 of Table 1-2.1.

Table 1-2.1 Components of the Project (Draft)

	Main component	Outline	Contents
Substation	**1. Buloba Substation** (1) 220 / 132 kV Transformer (2) 132 / 33 kV Transformer (3) 220 kV Switchgear (4) 132 kV Switchgear (5) 33 kV Switchgear (6) Control building	 125 MVA×2units 40 MVA×2units 1 lot 1 lot 1 lot 1 lot	New Construction
	2. New Mukono Substation (1) 220 / 132 / 33 kV Transformer (2) 220 kV Gas Insulated Switchgear (3) 132 kV Gas Insulated Switchgear (4) Control building (5) 132 kV transmission line (New Mukono Substation - Mukono Substation)	 125 MVA×3units 1 lot 1 lot 1 lot Approx. 0.3 km×2cct	New Construction
	3. Kawaala Substation (1) 132 / 33 kV Transformer (2) 132 / 11 kV Transformer (3) 132 kV Gas Insulated Switchgear (4) 33 kV Switchgear (5) 11 kV Switchgear (6) Control building	 40 MVA×3units 20 MVA×1unit 1 lot 1 lot 1 lot 1 lot	Renovation
	4. Bujagali Substation (1) 220 / 132 / 33 kV Transformer (2) 220 kV Switchgear (3) 132 kV Switchgear	 250 MVA×1unit 1 lot 1 lot	Upgrade
	5. Mutundwe Substation (1) 132 kV Switchgear	 1 lot	Upgrade
	6. Mobile substation	20 MVA×2 units	Procurement
Transmission	**7. 220 kV Transmission Line** (1) Buloba branch point - Buloba Substation (2) New Mukono branch point - New Mukono Substation (including the modification of 132 kV transmission line betweenNo.77 and No.78)	 Approx. 0.9 km×4cct Approx. 4.2 km×4cct	 New Construction New Construction
	8. 132 kV Transmission Line (1) Buloba branch point - Buloba Substation (2) New Mukono Substation - New Mukono branch point (Southern trunk line)	 Approx.0.8 km×2cct Approx.0.4 km×2cct	 New Construction New Construction
	(3) Mukono branch point (Northern trunk line) - Kampala North Substation (4) Kampala North Substation - Mutundwe Substation (5) Kampala North Substation - Lugogo Substation (6) Kawaala branch point - Kawaala Substation	Approx.25.4 km×1cct Approx.10.2 km×2cct Approx. 5.3 km×2cct Approx.0.1 km×2cct	Re-conductoring Re-conductoring Re-conductoring Cabling

Source: JICA Study Team

This project selected the components based on the power system planning and thus the adequacy from the technical view is identified. In addition, this project complies with the NDP II of the Government of Uganda as well as "the construction of infrastructure such as electricity generation facilities and roads" of the ODA policy of Japan. Finally, according to the economic and financial analysis, indicators such as Financial Internal Rate of Return (FIRR) and Economic Internal Rate of Return (EIRR) proofs adequate benefit. Therefore, this project is concluded to be adequate to be implemented under JICA loan project scheme.

1-3 Composition of the Report

The following chapters after Chapter 1 are composed as follows. Chapter 2 is describing "Social and Economic Situation" of Uganda and Chapter 3 is describing "Background and Circumstances of the Project" of Uganda. They are the situations surrounding the Project. The data shown in this chapter such as the indicators of the population trend, Gross Domestic Product (GDP) and so on of Uganda is applied for the power demand forecast prepared based on econometrics approach. On the other hand, transaction prices of electricity shown in Chapter 3 are applied as basic data for financial and economic benefit, and the inflation rate shown in Chapter 2 is taken into account as the capital cost, which is the hurdle rate for evaluation of profitability in terms of financial aspects.

Chapter 4 is describing the transmission system plan targeting 2030 which is the foundation of the Project and also describing the power demand forecast up to the target year. Based on the formulated transmission system plan, the outline design of each component is described in Chapter 5. Not only the components for upgrading capacity of the equipment but also the components for improvement of reliability of power supply in the Kampala Metropolitan Area are selected such as modification of bus configuration from the existing single bus system to double bus system at Mutundwe Substation (Mutundwe Substation is the only substation where the double bus system is not introduced in the Kampala Metropolitan Area). Chapter 6 and Chapter 7 are describing "Institutional Arrangement for Implementation and Operation and Maintenance of the Project" and "Cost Estimation and Financial Plan of the Project" respectively.

Review of the Project is carried out from Chapter 8 to Chapter 10. In Chapter 8, the Project is reviewed in terms of economic and financial analysis and FIRR and EIRR are introduced as the evaluation indicators. In Chapter 9, the Project is reviewed in terms of environmental and social considerations and the Chapter is describing Abbreviated Resettlement Action Plan and acquisition of the Environmental Permit (EP) from National Environmental Management Authority (NEMA). In Chapter 10, the Project is evaluated in terms of relevance and effectiveness, the operational indicator and the effectiveness indicator are stipulated and the target values in the target year for the Project evaluation are also described.

Chapter 2 Social and Economic Situation

2-1 Macro-economy of Uganda

2-1-1 Overview of Uganda

Republic of Uganda is located in eastern Africa, the East African plateau with the average altitude of 1,100 m. It is a landlocked country, surrounded by Kenya to the east, Tanzania to the south, southwest Rwanda, Democratic Republic of the Congo to the west, and South Sudan to the north (see Figure 2-1-1.1). The total area of the country is about 241,000 square kilometers. However, by excluding water area (approximately 43,900 square kilometers, 20% of the total) such as Victoria Lake, the remaining land area is approximately 197,000 square kilometers.

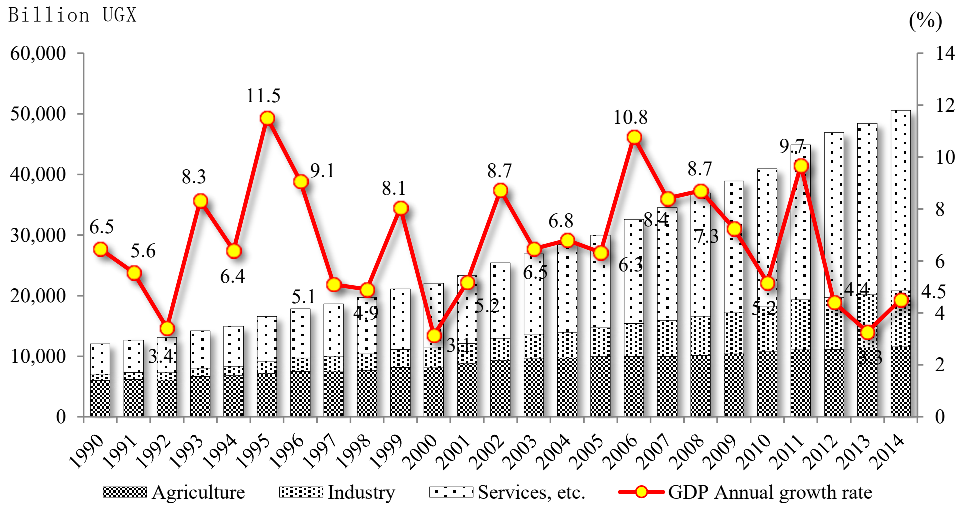
Source: Website of Japan Ministry of Foreign Affairs

Figure 2-1-1.1 Uganda's Map

2-1-2 Gross Domestic Product (GDP)

Since 1990 the economy of Uganda has continuing long-term growth base on the actively consumption and investment by private and government sector. The GDP growth rate has increased by annual average of 6.8% from 1990 to 2014. Figure 2-1-2.1 shows the trend of real GDP growth rate through 1990 to 2014, where the real GDP of 2014 has reached to 50,605 billion UGX (23.2 billion USD[1]) base on the constant price at 2010. The nominal GDP of 2014 reached 68,523 billion Shillings (26.99 billion USD at current price), nominal GDP per capita has reached to 1.81 million UGX (714.57 USD). However, the GDP growth has shown considerably changes over the past 24 years from 3% to 11%. Particularly after year 2012, the annual GDP growth has interrupted in 5%, it is forecasted to recover up to above 5% in 2015.

[1] Converted by the average exchange rate of year 2010. (1 USD = 2,178 UGX)

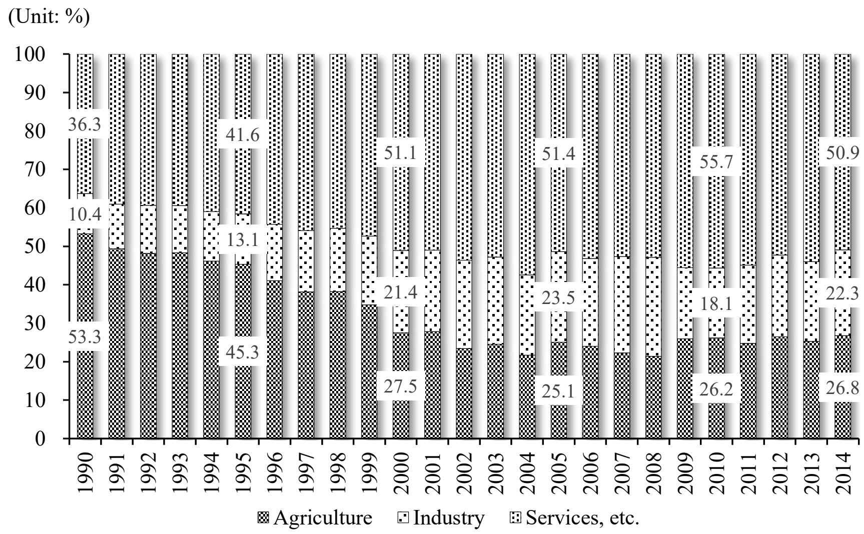


Source: "World Development Indicators", World Bank, January 7, 2015

Figure 2-1-2.1 Real GDP (2010 Constant Price) and Growth Rate Trend of Uganda (1990-2014)

2-1-3 Industrial Structure

Long growth of GDP has significantly led to the result of industrial structure change in Uganda. The most distinctive change is agriculture sector. Figure 2-1-3.1 shows the trend of GDP share of agriculture sector, industry sector and service sector from 1990 to 2014. Agriculture sector is continued to decrease from 53.3% in 1990 to 25.1% in 2005, industry sector and service sector has expanded the share by 13.1% and 15.1% in the same period become 23.5% and 51.4% in 2005. Like many other development economies, Uganda's economy began to shift to capitalist sector from the subsistence sector on the stability of politic since 1990. However, since 2005, the industrial sector shows subtlety change, where agriculture sector's share slight increase from 26.2 % in 2010 to 26.8% in 2014, on the other hand, the industry sector has to shrink slightly from 23.5% in 2005 to 22.3% 2014. As one of the reasons was slowing investment in industrial sector and services sector due to rising oil prices to 147.3 USD per baller after 2008 has effect to the urban area are no longer able to absorb the rural labor force.



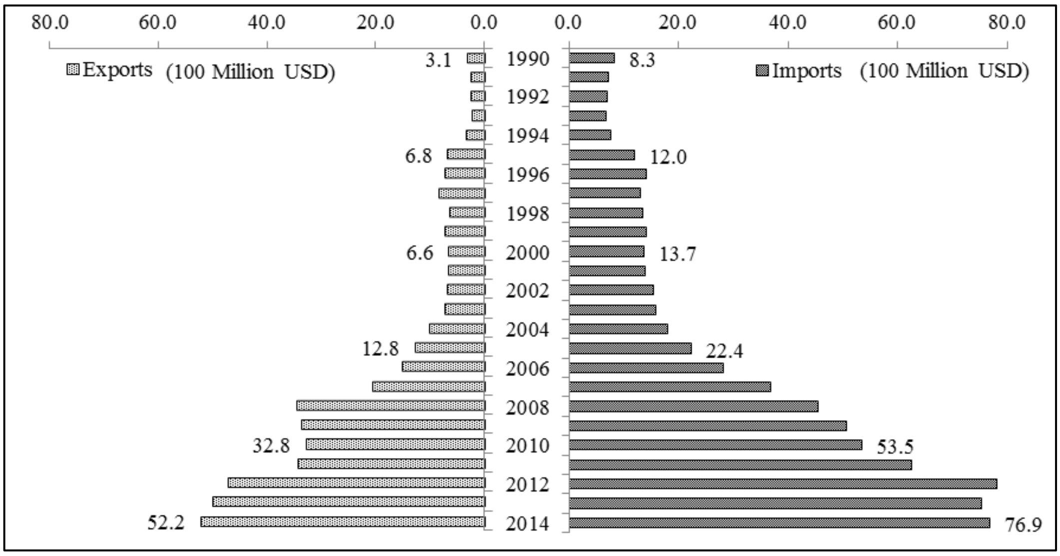
Source: "World Development Indicators", World Bank, 7th January 2015

Figure 2-1-3.1 Industrial Structure Change in Uganda by GDP Share (1990 - 2014)

2-1-4 External Trade

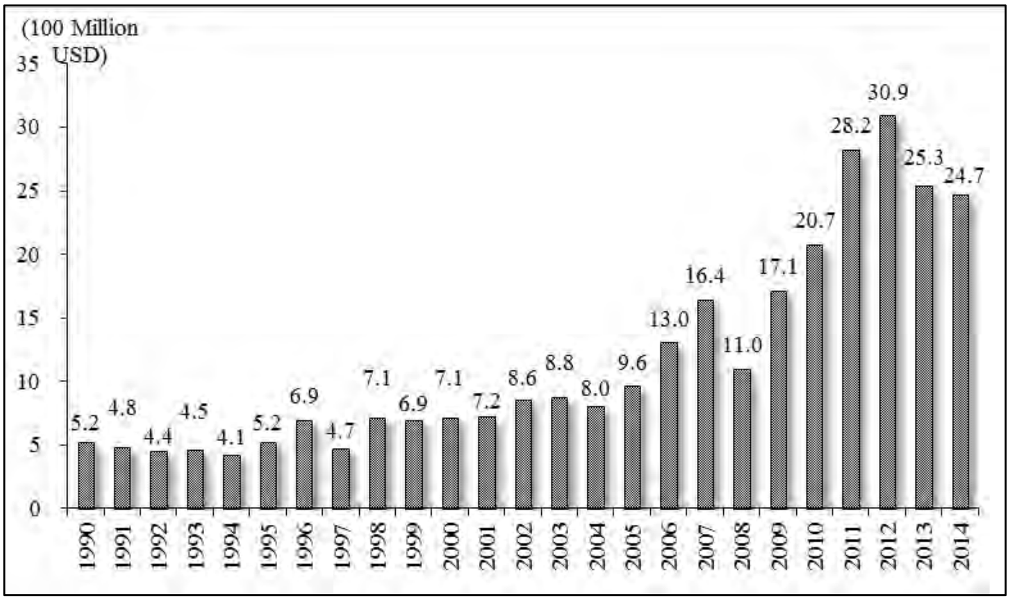
Taking a look at the balance of external trade of Uganda, the country is followed by a 23-year trade deficit after 1990. Figure 2-1-4.1 shows the trade deficit has trend between 0.5 to 1 billion USD from 1990 to 2005, the amount has expanded rapidly after 2005 and reached 3.09 billion USD in 2012.

It is understandable, based on the fact that oil import accounts to more than 60% of total import items in Uganda, the international oil price increase is one of the reasons to influence the trade in the country. The oil price has soared up to 147.3 USD per barrel in 2008 has influence the expansion of trade deficit after 2005 and the deficit keep continued to remain at high levels. However, the trade deficit was slightly reduced in 2013 and 2014 due to sharp drop of international oil price. On the other hand, Uganda's export competitiveness depends on the primary agriculture products such as coffee, cotton, tobacco, etc. where the structure of trade is not stable and strongly influenced by international market price.



Source: "World Development Indicators", World Bank, 7th January 2015

Figure 2-1-4.1 Trend of External Trade of Uganda (1990 - 2014)



Source: "World Development Indicators", World Bank, 7th January 2015

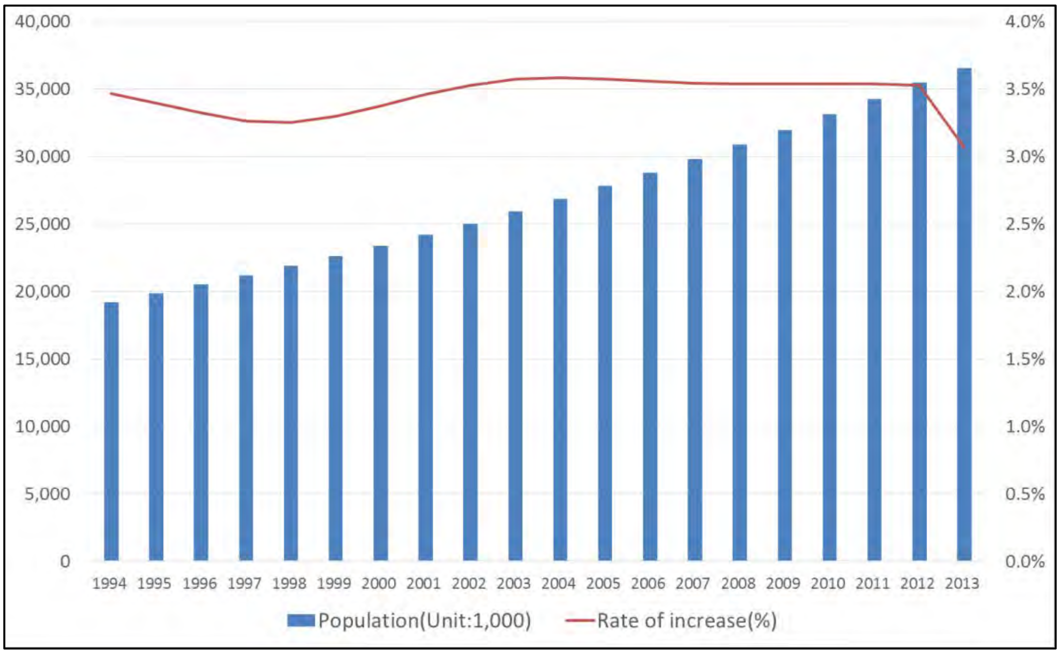
Figure 2-1-4.2 Trend of Trade Deficit of Uganda (1990 - 2014)

In addition, power export has the aspects of the acquisition of foreign currency for Uganda by using the endowment of abundant hydropower resources to contemplate an increase in the export of electric power to neighboring countries such as Kenya and Tanzania. Implementing body for the power export is UETCL. According to the plan of UETCL, although a total of 184 GWh has been exported to the Kenya, Rwanda, Tanzania, and Democratic Republic of Congo in 2014, they are trying to achieve export of 1,872 GWh which is 10 times of now in the year 2025. First, although improvement of still very low electrification rate of the country would be a priority for Uganda, power interchange to other countries have also come to sight.

2-2 Trend of socio-economic indicators

2-2-1 Uganda's Population and Kampala City Population

As shown in Figure 2-2-1.1, the population of the Uganda has rapidly increased. The annual growth rate is more than 3% over the past 20 years, based on the population statistics of World Development Indicator of the World Bank. According to the national census in 2014, the population was 34.86 million. The population reached 39.03 million according to the estimation by the United Nations in 2015. The total fertility rate of Uganda is the 8th highest in the world (5.87 in 2013), and the trend of rapid population increase is expected to continue. According to the World Population Prospects of United Nations (2015 Edition), in moderate cases, the population of Uganda would be 62 million in 2030, and exceed 100 million in 2050. Meantime, as the electrification rate is still low nationwide at 16% in Uganda, there is need for further focus on improvement of the electrification rate to respond the rapid population growth.



Source: "World Development Indicator" World Bank

Figure 2-2-1.1 Transition of Uganda's Population

The population of Kampala City, the capital of the Uganda, was about 0.77 million according to national census in 1991. According to the 2002 census, the population has increased to 1.19 million, and 2014 census shows that it has continued to increase to 1.52 million. In the current estimation of Uganda Bureau of Statistics, it is predicted that in 2016 the population will reach about 1.57 million. Therefore, the population of Kampala City has expanded at the rate of double in the past quarter century. Looking at the Kampala metropolitan area, which includes the surrounding areas, approximately 3.5 million people are estimated to reside in the current

Kampala metropolitan area[2].

2-2-2 Trend of Consumer Prices

Trends in the consumer price (2005 - 2015) of the Uganda as well as the surrounding East African countries are shown in Table 2-2-2.1. The consumer prices of Uganda in the last decade have become about 2.4 times (Kenya about 2.9 times, Tanzania about 2.4 times and Rwanda about 2.0 times).

With the reference to the increase rate of consumer prices in 2014, in Uganda it has raised about 4.6% rise, which is still low comparing with the neighboring countries, Kenya has risen to about 6.9% and Tanzania has risen to about 6.1%. However, when attention is paid on historical experience in Uganda, it is necessary to monitor inflation trend, as there is more than 10% rise in a single year in Uganda time by time (e.g. in 2008, 2009, 2011, 2012).

Table 2-2-2.1 Trends of Consumer Prices

Year	Uganda	Kenya	Rwanda	Tanzania
2005	100.00	100.00	100.00	100.00
2006	107.20	141.98	108.83	107.25
2007	113.71	148.03	118.72	114.79
2008	127.40	170.39	137.05	126.58
2009	144.07	188.37	151.23	141.96
2010	149.78	196.48	154.71	152.17
2011	177.77	224.04	163.48	171.48
2012	202.68	245.05	173.76	198.99
2013	212.36	259.06	181.09	214.57
2014	222.16	276.87	184.33	227.72
2015	234.80	294.39	194.72	240.57

Source: From IMF statistics, the consumer price in 2005 is calculated as a 100

2-2-3 Trends in Interest Rates and Financial Sector

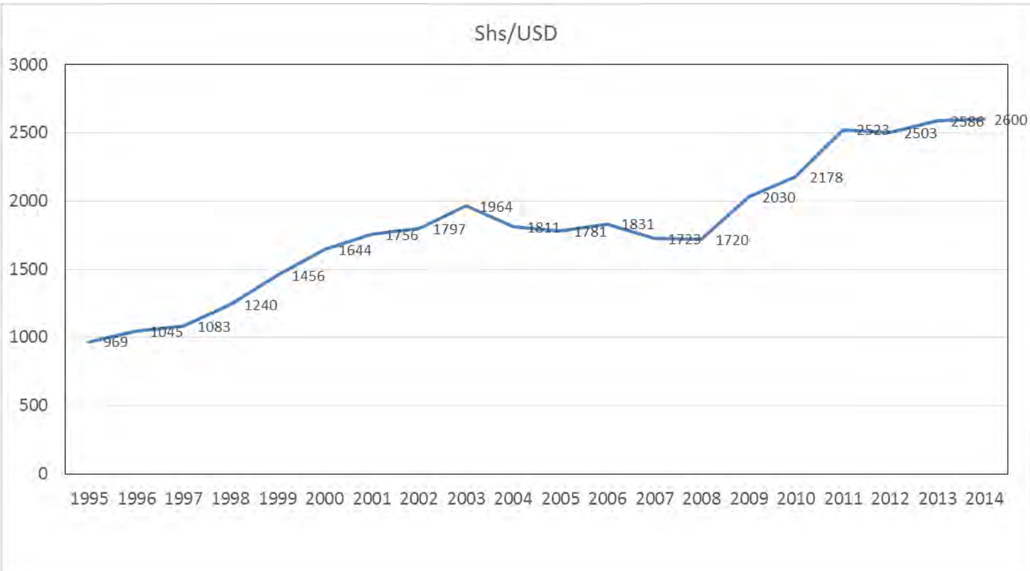
The total deposits of the Bank of Uganda as of the end of 2010 is 8.0235 trillion UGX, only about 22% of the total GDP which was 36.033 trillion Uganda shillings in fiscal year of 2009 / 2010. Therefore, the penetration of banking service still remains low, and the indicator of ratio of saving within total income shows that propensity of saving money in banks is not very common. In general, the total deposits / aggregate amount ratio of GDP (%) of developed

[2] World Bank urbanization survey report (The Growth Challenge: Can Uganda cities get to work?)

countries exceeds 100%. In the middle-income countries it is around 100%. In sub-Saharan countries it is significantly lower than about 100%. In many developing countries of sub-Saharan it is far below 100%. As the savings propensity of Uganda is still low, investment in infrastructure development by utilizing the savings in the bank, like fiscal investment and loan program in Japan, seems difficult.

2-2-4 Exchange Rate

Looking at the long-term general trend, Uganda Shillings declined more than 37% in 19 years even though there were some temporary rises. The average annual rate of decline in the past 19 years is about 5.3%. Due to the extreme cut down in 2015, Uganda Shillings dropped 27% against US dollar. In this way, it should be noted that there is also time when Uganda Shilling depreciation was more than 20% in a single year.



Source: The data was downloaded from the statistics of the website, Uganda Central Bank (https://www.bou.or.ug)

Figure 2-2-4.1 Trend of Exchange Rate of the Uganda Shillings

2-3 Financial Status and External Debt of Uganda

2-3-1 Financial Balance

The change in the budget of Uganda is shown in the table 2-3-1.1. In fiscal year 2013 / 2014 spending was more than tax revenue. The gaps were filled by the grant assistance. In the past few years, the real budget deficit gradually decrease (in FY 2010 / 2011: deficit of 1 trillion 102 billion UGX, in FY 2011 / 2012: deficit of 649 billion UGX, in FY 2012 / 2013: deficit of 305 billion UGX, in FY 2013 / 2014: deficit of 552 billion UGX). For the first time in FY 2014 / 2015, the tax revenue exceeded the expenditure. While the tax revenue was 9 trillion 835 billion shillings, the expenditure was 9,698 billion shillings. This fiscal year, the annual expenditure became 96,980 billion Uganda Shillings against the 10,988 billion Uganda Shillings annual revenue. However, the government anticipated in NDP II that the budget deficit would inevitably continue for a while as a large number of plans is carried out resulting the budget surplus trend not to last long, in order to raise funds for many large-scale infrastructure projects in the future. The expected peak of deficit (filling in gaps of the grant) is 8.6% in FY 2016 / 2017. According to the NDP II, the government of Uganda aims at reducing it to 4.8% by FY 2019 / 2020. The structure of real deficit is expected to extinct after FY 2020 / 2021 in the NDP II. Situation of fiscal balance deficit of Uganda is likely to continue in the same way until 2020, hence, the needs and expectations for funding from a variety of donors including Japan is also considered to remain significant.

The largest expense is subsidy/grant, which was 3,667 billion Uganda shillings in FY 2014, occupying about 37.8% of the total budget. The second largest expense is purchase of goods and services, which are 2,506 billion Uganda shillings, about 25.8% of total budget. Follows by the salary payment of employees, which are 1,763 billion Uganda shillings, about 18.2% of total budget. The payment of interest was 68 billion Uganda Shillings in FY 2014 which is only about 0.7%.

Roughly divided, the annual revenue consists of taxes, grant assistance from outside the country, and other incomes. In FY 2014 / 2015 the revenue level was improved compared to FY 2010 / 2011.

Low collection rate of the value-added tax has been a major problem so far. Uganda has lowest record of value-added tax collection rate which is 28.6%. Therefore, NDP II abolishes the tax exclusion and mitigation system, and intends to increase the revenue by improving efficiency of the value-added tax collection. By doing so, it is expected to increase revenues with the amount equivalent to 1% of GDP, and also improve transparency of tax system.

Table 2-3-1.1 Changes in the revenue and expenditure of Uganda

Unit: Billion UGX

Entries	FY 2010/11	FY 2011/12	FY 2012/13	FY 2013/14	FY 2014/15
Revenue	7,292	7,763	8,277	8,870	10,988
Taxes	6,307	6,528	7,149	8,031	9,835
Social contributions	-	-	-	-	-
Grants	891	1,129	936	702	931
Other revenue	95	106	191	137	221
Expense	7,409	7,177	7,454	8,583	9,698
Compensation of employees	985	1,199	1,403	1,516	1,763
Purchase of goods and services	2,716	2,001	1,709	2,160	2,506
Consumption of fixed capital	-	-	-	-	-
Interest	424	603	890	970	1,213
Subsidies	184	187	29	36	68
Grants	2,645	2,783	2,879	3,257	3,667
Social benefits	203	201	260	229	244
Other expense	252	203	284	415	238
Gross operating balance	(116)	586	822	287	1,289
Net operating balance	(116)	586	822	287	1,289
TRANSACTIONS IN NONFINANCIAL ASSETS:	-	-	-	-	-
Net Acquisition of Nonfinancial Assets	1,400	1,847	2,595	3,060	3,220
Fixed assets	1,364	1,798	2,511	2,791	2,937
Change in inventories	-	-	-	-	-
Valuables	-	-	-	-	-
Nonproduced assets	37	49	84	269	284
Net lending / borrowing	(1,516)	(1,260)	(1,773)	(2,772)	(1,931)
TRANSACTIONS IN FINANCIAL ASSETS AND LIABILITIES (FINANCING):					
Net acquisition of financial assets	1,682	2,760	1,877	(4,434)	(1,212)
Domestic	1,682	2,760	1,877	(4,434)	(1,212)
Foreign	-	-	-	-	-
Monetary gold and SDRs	-	-	-	-	-
Net incurrence of liabilities	3,347	3,689	3,540	(1,936)	615
Domestic	2,623	2,535	2,122	(2,823)	(304)
Foreign	724	1,154	1,418	887	919
Errors and Ommissions	148	(331)	(110)	(275)	(104)

Note: Special Drawing Rights (SDR) was founded by the IMF as international reserve assets in 1969, is a means to complement the reserve assets of member countries.

Source: By JICA study team, data downloaded from the Statistics of the website, Ministry of Finance and Economic Development Planning (www.finance.go.ug)

In addition, the projection on the fiscal balance of Uganda is conducted in the future. Based on the forecast of IMF (estimated by the cooperative work of IMF and the government of Uganda, Ministry of Finance, Planning and Economic Development) in the country report of June 2016, the transition has been predicted as shown in the Table 2-3-1.2.

Basically, the government spending will be likely to be higher than the tax revenue. This trend is predicted to continue in the future until the year 2020. The budget deficit will be sufficed by financial assistance from foreign funds, as well as domestic funds raised by the issuance of government bonds. The proportion of external borrowing is substantially large. In addition, the borrowings from China is rapidly increasing. The borrowing from China has been mainly financed through the Export-Import Bank of China, and the terms and conditions are not so favorable for Uganda, as compared with those of multi-donors of World Bank, African Development Bank, and the bilateral aid from Japan, US and EU countries. Therefore, the repayment for the borrowings from China will become future heavy burden for Uganda.

The Second National Development Plan (NDP II) predicts that the external debt of the Ugandan government will temporarily increase for the fiscal years 2015 / 2016 - 2019 / 2020 in order to strongly propel the development of large-scale infrastructure of transport, energy etc. However, the Ugandan Government will also hope that the heavily-debt-dependent structure will be changed and improved after 2020. However, it does not seem to be an easy task. The Ugandan Government will have to make strenuous effort to change the tendency of depending on borrowings. Once many ministries and public corporations will have been in the habit of easy borrowings, the adjustment and recovery from habitual borrowings will be of great difficulties.

Table 2-3-1.2 Future prediction of Uganda's fiscal balance transition

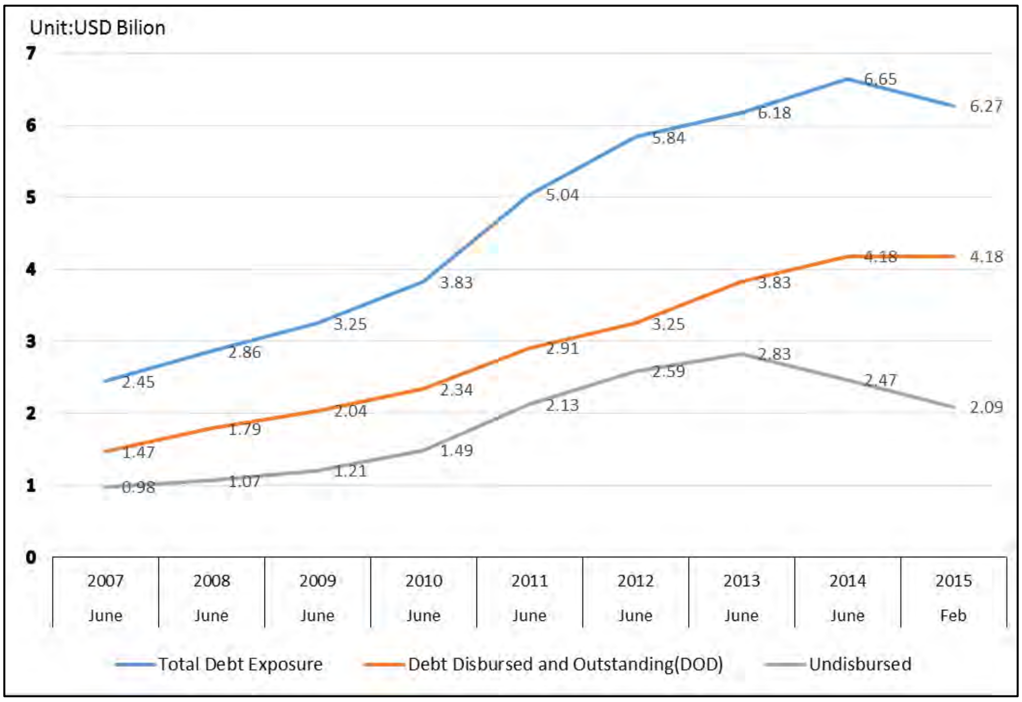
Unit: Trillion UGX

Items	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020
Revenue	13.2	15.1	16.3	18.1	20.6
o/w, Tax revenue	11.7	13.4	15.2	17.3	19.7
o/w, Financial assistance from abroad	1.5	1.7	1.1	0.9	0.9
(o/w, Budget infusion assistance)	0.3	0.3	0.3	0.3	0.3
(o/w, Project assistance)	1.1	1.4	0.8	0.6	0.6
Annual expenditure	18.6	20.9	22.9	25.5	27.1
o/w, Recurrent expenditure	9.0	9.7	10.6	11.9	13.3
o/w, Development expenditure	7.0	9.1	10.1	11.9	12.8
Fiscal balance	-5.4	-5.8	-6.6	-7.4	-6.6
Compensation by finance	5.4	5.8	6.6	7.4	6.6
Finance from abroad	4.0	5.0	5.7	6.3	6.0
o/w, Preferential conditions of borrowing	1.3	2.4	1.5	2.3	1.9
Finance from domestic	1.4	0.8	0.9	1.0	0.6

Note: Predicted value by joint operation of IMF and MoFPED
Source: IMF Country Report No.16/145, June 2016

2-3-2 External Debt

This section pertains to external debt that is related strongly with the fiscal balance issues mentioned in the section 2-3-1. First of all, Figure 2-3-2.1 shows the upsurge trend of the external debt of Uganda for the period between fiscal years 2007 and 2015. Because of the debt waiver of loans to African countries by multinational aid agencies such as World Bank in fiscal year 2007, the public external debt on the disbursed amount basis was reduced significantly. However, since Ugandan government has a strong intention to implement infrastructure development, the external debt have been continuing to gradually increase again since fiscal year 2008 as many of the large-scale infrastructure projects has been carried out under the borrowings from World Bank, African Development Bank, or bilateral aid funds. The annual increase in 2009, 2010 and 2011 were 14%, 15% and 24% respectively. However, the increase speed was temporally down from 2012 to 2015. On the disbursed and outstanding basis, the external public debt of Uganda adversely increased from USD 1.47 billion (2007) to USD 4.88 billion (at the end of December 2015). It has expanded to 3.3 times in 8 years.



Source: Data downloaded from the Statistics of the web-site, Ministry of Finance, planning and economic development (www.finance.go.ug)

Figure 2-3-2.1 Transition of External Debt

As of the end of December 2015, the external debt accounts for 4.88 billion US dollars (62.6% of the total public debt), and domestic debt accounts for 2.92 billion US dollars (37.4% of the total public debt), making the total public debt balance at 7.8 billion US dollars (100%). Especially, it has significantly increased in FY 2015 / 2016. The public debt has increased to 520 million US dollars (about 7.1% increase) only in 10 months from the end of February to the end of December 2015. Looking at the foreign debt, in the same period of 10 months it has increased to 700 million US dollars (about 17% increase). On the other hand, domestic debt has decreased 180 million US dollars in the same period. Percentage of domestic debt accounts higher than the external debt, and the trend has intensified in the fiscal year 2015/2016. The proportion of those debts stock against Uganda's GDP, the external debt stock is 20.2%, and the domestic debt stock is 12.1%, making the total public debt stock 33.2%. Table 2-3-2.1 shows the national debt of Uganda government.

While the external debts are generally provided with low interest, the domestic debts are generally with much higher interest rate. This can be symbolized by the long-term bonds with 18% interest rate for 15-year, issued by the Uganda government. Therefore, looking at the present value of the debt stock, 88% of the annual repayments of the Uganda government is for domestic debt repayment in view of debt repayment base (Uganda government's annual repayments). Therefore, suppressing the domestic debt by taking advantage of external borrowing with low interest rates is important for financial management. This is consistent with the direction set by The Second National Development Plan as well as with the instruction of

International Monetary Fund (IMF) as a part of fiscal management. Therefore, it can be said that loan with low interest rate (e.g. 0.01%) like this project meets the fiscal policy of the Uganda government.

Table 2-3-2.1 National Debt of Uganda Government (as of 2015 the end of December)

Total Public Debt	FY 2014/15 (February 2015)			FY 2015/16 (December 2015)		
	USD Billion	Percentage of GDP	Share of Total Debt	USD Billion	Percentage of GDP	Share of Total Debt
External Debt Outstanding and Disbursed	4.18	15%	57%	4.88	20.2%	62.6%
o/w Bilateral	0.59	2%	8%	1.01	4.2%	13.0%
o/w Multilateral	3.59	13%	49%	3.87	16.0%	49.6%
Domestic Debt	3.10	11%	43%	2.92	12.1%	37.4%
o/w Treasury Bills	1.01	3%	14%	0.82	3.4%	10.6%
o/w Treasury Bonds	2.09	8%	29%	2.09	8.6%	26.8%
Total Public Debt	7.28	26%	100%	7.80	33.2%	100.0%

Source: The data were downloaded from the Statistics of the web-site, Ministry of Finance, planning and economic development (www.finance.go.ug)

The breakdown of the external debt is shown in Table 2-3-2.2. At the end of December 2015, addition to the debt of 4.88 billion US dollars which is already disbursed, there is undisbursed one, which is 4.78 billion US dollars. In total, the debt is 9.66 billion US dollars.

Table 2-3-2.2 Trends of external debt breakdown of the Uganda government (as of end of February to end of December of 2015)

Items	End of February 2015			End of December 2015		
	Disbursed Amount	Amount Not Disbursed	Total	Disbursed Amount	Amount Not Disbursed	Total
Multilateral	3.59	1.65	5.24	3.87	2.44	6.31
Bilateral	0.58	0.44	1.02	1.01	2.34	3.35
o/w, Out of Paris Club	0.50	0.21	0.71	0.89	1.96	2.85
o/w, Paris Club	0.08	0.23	0.31	0.12	0.39	0.51
Commercial creditors	0.00	0.00	0.00	0.00	0.00	0.00
Total	4.18	2.09	6.27	4.88	4.78	9.66

Note: Paris Club, it is also referred to as a major creditor nation conference. To be held once a month in the French Ministry of Finance. The designation of the informal meeting to perform the discussions of the rescheduling of bilateral with major creditor countries and debtor countries.
Source: Data from the statistics of the website of Ministry of Finance, Planning and Economic Development, Bank of Uganda

However, NDP II as policy of the government, specified fiscal management on the basis of the policy of above-mentioned budgetary policy paper, etc., and International Monetary Fund (IMF) has also supported the fiscal management based on the same policy. With the reference to the solvency and liquidity debt-burden indicators, Ugandan Government makes it a principle for managing public debt that the Present value of public and publicly guaranteed debt to GDP must be under 50%. It is also the principle that present value of external debt must be under 30%.

Table 2-3-2.3 shows the current trend and future projection of the two percentage indicators. The source of data is Ministry of Finance Planning and Economic Development. The two indicators are far below the upper limit and the solvency and liquidity principles are safely secured at present. As shown in the Table 2-3-2.3, MOPFED predicts the peak of the present value of the public and publicly guaranteed debt to GDP, 33.9% in FY 2019 / 2020, and the peak of the present value of the external debt to GDP, 23.2% in FY 2020 / 2021.

There are still gaps between the projected peaks and the threshold of the 50% for the public debt and 30% for the external debt. However, we cannot say that the dependency rate for borrowings is very low. It is necessary for Ugandan Government and donors to monitor the indicators.

Table 2-3-2.3 Current trend and near future predictions on the percentage ratio of public debt and external debt of Uganda government to GDP (fiscal year 2015/2016 - 2021/2022)

Items	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2019/2020	2019/2020
Ratio of public debt to GDP (nominal value)	32.7	37.1	38.7	40.8	43.0	42.5	39.6
o/w, Ratio of external debt to GDP (nominal value)	19.4	24.7	26.4	29.1	31.8	31.8	29.8
Ratio of public debt to GDP (net present value)	24.1	27.5	29.6	31.8	33.9	31.8	31.4
o/w, Ratio of external debt to GDP (net present value)	10.7	15.2	17.4	20.1	22.7	23.2	21.0

Source: Hon. Matia Kasaija, Report on Public Debt (Domestic and External Loans), Guarantees and Other Financial Liabilities and Grants for Financial Year 2015/2016, Ministry of Finance, Planning and Economic Development, Government of Uganda

In the following, Uganda is compared with other African countries, looking at the relative positioning of Uganda in terms of external debt. Table 2-3-2.4 shows the comparison of external debt of Uganda with the surrounding East African countries, South Africa, Egypt, etc. The left column is the total of external debt; the middle column is the amount of each country's external debt divided by the population, the amount of external debt per capita. The right column is the coefficient compared GDP of each country and its external debt (the amount of external debt ÷ GDP amount). According to the same table, in reference to the amount of external debt per capita, Uganda's one is 133 US dollars. The majority of other countries who have the track record of yen loan, has heavier burden than Uganda with the exception of Malawi. Therefore at present, it can be said that Uganda's capacity of accepting external debt seems to be larger than those countries with higher external debt per capita.

In addition, as compared with the GDP, external debt of Uganda accounts to 19% of GDP, and this proportion is larger in other African countries (Tanzania, Kenya, Rwanda, Ethiopia, Mozambique, Zambia, Senegal, Egypt, South Africa, etc.) with the exception of Zambia as shown in Table 2-3-2.3. In this respect, similarly from the view point of GDP, Uganda compare to many of the countries with yen loan track record, the burden of the external debt of Uganda is low, therefore, it is determined that capability of receiving external debt is relatively certain.

Considering those two points described above, and comparing the situation of Uganda with other African countries, the burden of external debt of Uganda is still relatively low, and there is capability of receiving foreign debt including the yen loan projects at present.

Table 2-3-2.4 International Comparison of External Debt (Comparison with Uganda and the African Countries)

Country	External Debt(US$million)		Per Capita E.D. (US$/person)	ED/GDP
Uganda	5,135	(2014.Dec)	133	0.19
Tanzania	15,261	(2015.Sept)	327	0.32
Kenya	14,907	(2015.Oct)	347	0.24
Rwanda	1,852	(2015.Dec)	167	0.23
Ethiopia	16,585	(2014.Dec)	188	0.30
Mozambique	7,792	(2014.Dec)	294	0.49
Zambia	3,200	(2013.Dec)	213	0.12
Senegal	5,654	(2014.Dec)	389	0.36
Malawi	1,637	(2014.Dec)	93	0.38
Egypt	39,624	(2014.Dec)	457	0.14
S. Africa	144,005	(2014.Dec)	2,667	0.41

Source: World Development Indicator by World Bank and World Fact Book by CIA of the United States

Looking at the ratio of Uganda’s Debt-Service-Ratio (DSR) with the exports, it was more than 10% in Uganda as of 2000. However, it gradually reduced in 2000s. Since 2010, it has been within the range between 1% and 2%. According to the forecast of IMF, "Debt Sustainability Assessment Report (11 May 2013), however, the DSR is expected to reach to 4% from 3% as a result of the increase of borrowing for large-scale infrastructure development. DSR is expected to gradually rise by 2020. However, it is still considerably lower level from the risk zone, which is between 20% and 25%. Therefore, the risk for the macro-economy in terms of foreign debt is still low. Since Uganda belongs to the category of Least Developed Country (LDC), most of assistance aid is in the form of grant, and the amount of loan assistance is still limited. In addition, as interest rates of loan for LDC are extremely low, and the annual payments to the percentage of the current value amount of the foreign debt is very small. On the other hand, the domestic debt is more risky for Uganda’s finance because the interest rate of national debt is higher based on Uganda government bonds of approximately 20% interest rate, considering those points, large-scale infrastructure projects with yen loan are quite favorable for Uganda.

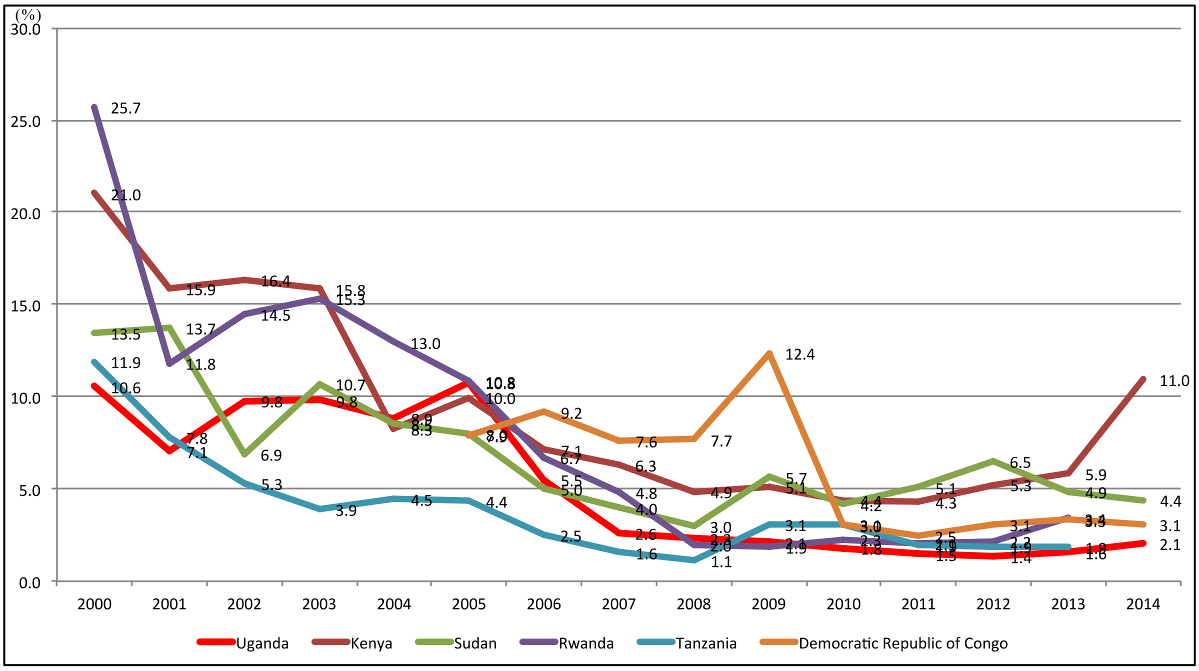
The Table 2-3-2.5 and Figure 2-3-2.2 show the overview of DSR transition of Uganda and neighboring countries from 2000 to 2014. Looking at the overview of DSR transition of Uganda and neighboring countries in the past 15 years, with the exception of Kenya, DSR is less than 5%, and among others Uganda and Tanzania are particularly low. In comparison with the neighboring African countries it suggests a good situation with respect to the situation of foreign debt.

Table 2-3-2.5 International Comparison of Transition of the Debt-Service-Ratio (Uganda and Neighboring Countries)

(Unit: %)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Uganda	10.6	7.1	9.8	9.8	8.9	10.8	5.5	2.6	2.3	2.1	1.8	1.5	1.4	1.6	2.1
Kenya	21.0	15.9	16.4	15.8	8.3	10.0	7.1	6.3	4.9	5.1	4.4	4.3	5.3	5.9	11.0
Sudan	13.5	13.7	6.9	10.7	8.5	8.0	5.0	4.0	3.0	5.7	4.2	5.1	6.5	4.9	4.4
Rwanda	25.7	11.8	14.5	15.3	13.0	10.8	6.7	4.8	2.0	1.9	2.3	2.1	2.2	3.4	N.A
Tanzania	11.9	7.8	5.3	3.9	4.5	4.4	2.5	1.6	1.1	3.1	3.0	1.9	1.9	1.9	N.A
Democratic Republic of Congo	N.A	N.A	N.A	N.A	N.A	7.9	9.2	7.6	7.7	12.4	3.1	2.5	3.1	3.3	3.1

Source: World Development Indicators of World Bank and the World Fact Book of United States CIA



Source: By JICA Study Team from the World Development Indicators of World Bank and the World Fact Book of United States CIA

Figure 2-3-2.2 International Comparison of Transition of the Debt-Service-Ratio (Uganda and Neighbouring Countries)

2-4 Development Policy and Development Plans in the Kampala Metropolitan Area

2-4-1 System of Development Policy

After the independence from the Britain in 1962, Uganda made steady economic growth in 1960s. Then 1970s were the sluggish growth performance years due to political unstableness. However, Uganda got back on the track of good and steady economic growth pace in 1980s. For these years, Ugandan Government has pursued economic growth, and formulated various national economic development policy and plans: Structural Adjustment Program (SAP)"; "Economic Recovery Program (ERP)"; "Poverty Eradication Program (PEAP)". In general, any of these economic plans aims at. In general, in any plan the target setting is made to transform Uganda the one of poorest countries (least developed countries) into a prosperous middle-income country. The role to lead economic development has been given to National Economic Development Plan. Then, occasionally the main theme of economic development has been crowned as plan for economic recovery or poverty eradication. The contents of the plan, begins from the grasp recognition of poverty situation, socio-economic conditions, etc. and the detail has been planned and carried out for contents such as improve the quality of life and income of the poor, administer economic management, obtain competitiveness and increased production, security of disaster prevention, governance, human resources development, public finances, and evaluation and monitoring of the implementation of the plan.

However, systematic planning regime has not been established with a hierarchy of time-span and national prioritization. The comprehensive hierarchy is comprised from the national long term vision/goal for 30 years, further down to 10-year plans and up to 1 to 2 year short term plans.

Thus, a system of planning in accordance with the economic development in 2007 was organized and approved by Congress in the following manner.

- The national overall economic plan
  - ✓ Long-term vision 30 years forecast (Vision 2040)
  - ✓ Mid-term plan such as Five-Year Plan
  - ✓ Short-term plan of one-year or 2-3 years

- Plans affiliated to the national overall medium- and long-term plans by sectors and areas/fields, local governments plan
  - ✓ Sectorial plans such as power sector, education sector, industry sector, etc.
  - ✓ Local government plan by state and city for development

"Vision 2040" is the topmost vertex outlook of the long-term vision to 2040. This vision shows the target image of after 30 years of Uganda as a country to the public. In Vision 2040, the target has been set as a great leap forward to raise the GDP per capita to 9,500 US dollars in 2040 from 506 US dollars in 2010 in order to be able to join the ranks of middle income countries in 30 years. The content of the vision 2040 is mainly composed of the following.

- ✓ Long-term future vision (target image to be reached, the basic principle of long-term plan, necessary reform items)
- ✓ Macro-economic strategy
- ✓ Enhancement measures and important growth areas to support economic growth
- ✓ Reform of the social structure
- ✓ Governance
- ✓ Monitoring indicators of the execution situation

In line with to the above-mentioned Vision 2040, National Development Plan is the medium-term five years plan to be formulated and developed. Six national development plans would correspond for 30 years until 2040. The current five-year plan is the Second National Development Plan fiscal year 2015 / 2016 - 2019 / 2020.

Table 2-4-1.1 Overview of the Poverty Eradication Action Plan and the National Development Plan

The 1st Poverty Eradication Action Plan (PEAP) (1997 / 98 - 2000 / 01)
1. Income improvement of the poor The provision of roads, development of land law, support of agricultural modernization, the development of rural market infrastructure, strengthening of rural financing and financial services, communications, electricity, etc. **2. Improve the quality of life of the poor** Primary health care, water and sanitation, provision of primary education, etc. **3. Strengthen of good governance** Improvement of public security, decentralization, transparency, accountability, participative development, etc.
The 2nd Poverty Eradication Action Plan (PEAP) (2000 / 01 - 2003 / 04)
1. Rapid and sustained economic growth and structural transformation Macroeconomic stability, improvement of resource allocation, private sector development, infrastructure development, etc. **2. Good governance and security** Security maintenance and improvement, protection of human rights, democratization and decentralization, transparency and efficiency of public spending, judicial reform, disclose information, empowerment of the socially disadvantaged, etc. **3. Income improvement of the poor** Access to land, financial services, transportation infrastructure improvements in rural areas, agricultural advice and extension services, job training, small business development, income improvement of the socially disadvantaged, etc. **4. Qualitative improvement of the life of the poor** Health care services, primary and secondary education, adult literacy rate, water and sanitation, housing, psychological support, family planning, etc.
The 3rd Poverty Eradication Action Plan (PEAP) (2004 / 05 - 2008 / 09)
1. Economic management Maintain stable macro-economy, consolidation of public finances, increase of private investment, etc. **2. Improvement of production competitiveness and income** Modernization of agriculture, conservation of natural resources, infrastructure (roads, electricity, railways, etc.), the electricity sector technology and capacity building, etc. **3. Security and conflict resolution and disaster management** End of conflict with the rebels, end of livestock robbery, enhanced support to the internally displaced people, countermeasure strengthen to the kidnapping by the rebels, etc. **4. Good governance** Human rights, democracy, improvement of legal systems, transparency and accountability, fight against corruption, etc.

5.	**Human Development** Elementary and secondary education, improvement of health indicators, promote family planning, community empowerment, including adult literacy, etc.
National Development Plan (NDP) (2010 / 11 - 2014 / 15)	
1.	Improvement of job creation and the quality of the production sector
2.	Improvement of social, economic and investment infrastructure
3.	Development of industries with international competitiveness
4.	Optimal utilization and environmental conservation of natural resources to support economic activity
5.	Improvement of human security and good governance
6.	Improvement of living standard
The 2nd National Development Plan (NDP II) (2015 / 16 - 2019 / 20)	
•	The large target is to aim for GDP per capita crossing more than 1,000 US dollars in the next five year.
•	With the annual average of 6.3% economic growth undergone, the current per capita GDP (743 USD) is expected to push up to 1,039 USD in the FY 2019 / 2020.
In order to achieve this, large direct the investment is prioritized in the following five areas. 1. Agriculture, 2. Tourism, 3. Mineral resources development, oil and natural gas, 4. Infrastructure development, and 5. Human resources development	

Source: MOFPED "Poverty Eradication Action Plan 1997/98～2000/01, 2000/01～2003/04, 2004/05～2008/09", "NDP"

2-4-2 Second National Development Plan (NDP II)

Country development plan to be developed in the time span of five years, as described above, in order to achieve the targets of the long-term vision of the year 2040 for 30-years in advance as Vision 2040, the period of 30 years of 2010 - 2040 is divided into six medium-term five-years plans as stage plan for to promote the execution towards achieving the vision. "Growth for prosperity, employment and socio-economic transformation" has been set as the theme for the first National Development Plan NDP (FY 2010 / 11 - 2014 / 2015), and it has been plotted and put into practice towards realization of purpose, principle, strategy, etc. of Vision 2040. The reflection and lessons learned in the implementation process has been recognized as clarifying the priority of the projects to take up, supplementing with space development plan, such as a national land, regions and cities, which is not sufficient only by economic development plan, supplementing with sectorial and field-based plan, arranging law and institutional and strengthening of the public side governance, strengthening of implementation plan and management structure of the projects, utilizing of local governments, private organizations and companies activities, etc.

Taking into account the above lessons, planning contents has become more specific in order to raise efficiency and effectiveness to achieve the goals in the Second National Development Plan NDP II. In addition, the comparative advantage and strengthening of competitiveness of Uganda is considered and analyzed, and the five strategic developments have been clarified as priority sectors and fields. Such improvements and progress can be seen in the planning technique. Thus, the five priority sectors and fields are listed below.

- Agriculture

With regard to agriculture, increase investment in 12 priorities for crops, strengthening of agricultural research and development, strengthening of agricultural finance, improve the development of agricultural technology

- Tourism

  Progress of marketing related to tourism promotion, increased investment, improvement of tourism services, charm up of tourist destination, and nature protection and animal welfare as tourism resources

- Mining of oil, gas, etc.

  Promotion of mineral development such as iron ore, marble, limestone, copper, cobalt, mineral phosphate, uranium, etc. Pipeline development of crude oil shipping, development of purification plant of oil and gas, etc.

- Infrastructure development improvement

  Standardization of railroad track, development of extending and improving the national highway, infrastructure development renewable energy development and utilization for power generation such as hydro and geothermal, expansion and improvement of power transmission and distribution equipment, development of infrastructure for information and communication, etc.

- Human resource development

  Enhancement of educational institutions and education services in response to the rapid increase in population, and increase of skilled engineers, intellectual workers, etc.

In addition, the core projects to deal with as priority to achieve the goal, the following agricultural development projects, tourism promotion projects, infrastructure development improvement projects, petroleum refining, and human resource development has been listed.

- Hydro Power Plant Projects of Karuma, Isimba, Ayago
- Grid Extension in East-West Project
- Masaka-Mbarara Transmission Line Project
- Kabale-Mirama Transmission Line Project
- Standard Gauge Railway
- Kampala-Jinja Highway
- Hoima Oil Refinery
- Agriculture Cluster Development Project
- Markets and Agriculture Trade Improvement Project

Systematization of such development plan suggests progress of the plan technology, clarification of the goals and strategy, prioritization in order to ensure the effectiveness, setting of the core projects. In addition to the 2040 target, creation of indicators to monitor the progress of the ongoing plan, and evaluation and monitoring technology also has been progressing.

2-4-3 National Industrial Policy and Industrial Sector Development Strategy of Uganda

National Industrial Policy, 2008 (NIP) is to set out Uganda's industrial policy and strategy to boost industrialization in Uganda. It stipulates that industrial development promotion is an important element to function as the base for the economic development of Uganda. In part, it points out that low reliability of power supply is one of the factors to have hindered the development of manufacturing in Uganda. However, this project is likely to have notable positive effect for industrial promotion. Also expectations for the Uganda Industrial Promotion are considered to be large.

Firstly, in view of accelerating industrial development in Uganda, the government recognizes several strengthening factors, among which one of the most important factor is recognized as rich natural endowments. For instance, fertile land, abundant rainfall, terrain suitable for hydroelectric power generation, reserves of oil and natural gas, etc. Therefore, the Government considers that promising are agricultural products processing, food processing, oil and natural gas-related mining, development and promotion of energy-related industries. On the other hand, the factors that hinder the promotion of industry are mainly mentioned as (i) undeveloped infrastructure, (ii) inadequate and prioritized investment in research and development, (iii) limited entrepreneurial and managerial skills, (iv) insufficient finance to support small and medium-sized enterprises, (v) lack of technical capabilities, (vi) lack of engineers and skilled workers, etc. and rectify and improvement of these challenges are required.

The Government enumerates the following seven (7) strategic items to be pursued in order to overcome challenges.

Strategy 1: Strengthening of the organization and institution
Strategy 2: Promotion of Public Private Partnership (PPP)
Strategy 3: Infrastructure development
Strategy 4: Deepening and Widening the Industrial Base
Strategy 5: Science, Technology and Innovation
Strategy 6: Strengthening of the Financial Industrial Sector
Strategy 7: Skills and Human Capital Development

The target industrial clusters for furthermore development will be as follows: four (4) groups.

- Petroleum related industries, cement, fertilizer, etc. based on the endowments of Uganda of resources.
- Agricultural processing and agro-industry for the commodity group with enhanced further value-added agricultural products by utilizing the fertile soil and abundant rainfall.
- Information and communications industry, call centers and chemicals as knowledge-intensive industries

➢ Farm tools, construction material, and crafts

In addition, oil industry development project in the vicinity of Lake Albert has potentiality to become a huge industrial integration in the future. Endowments of oil field in the bottom of the Lake Albert located in the border between the two countries part of Uganda and the Democratic Republic of the Congo (DRC) has been discovered in the 1990s. Then, the negotiations to excavate petroleum and development of petroleum-related industries have been conducted between the two countries to develop oil field with shared ownership. Expectations for this project in both the Democratic Republic of Congo and in Uganda are great. At the same time, there are concerns to develop the oil field without causing environmental degradation, given the fact that the oil field lies in the bottom of the lake.

Figure 2-4-3.1 Location of Lake Albert

2-4-4 Strategy Plan 2014 / 15 - 2018 / 19 (Kampala Capital City Authority)

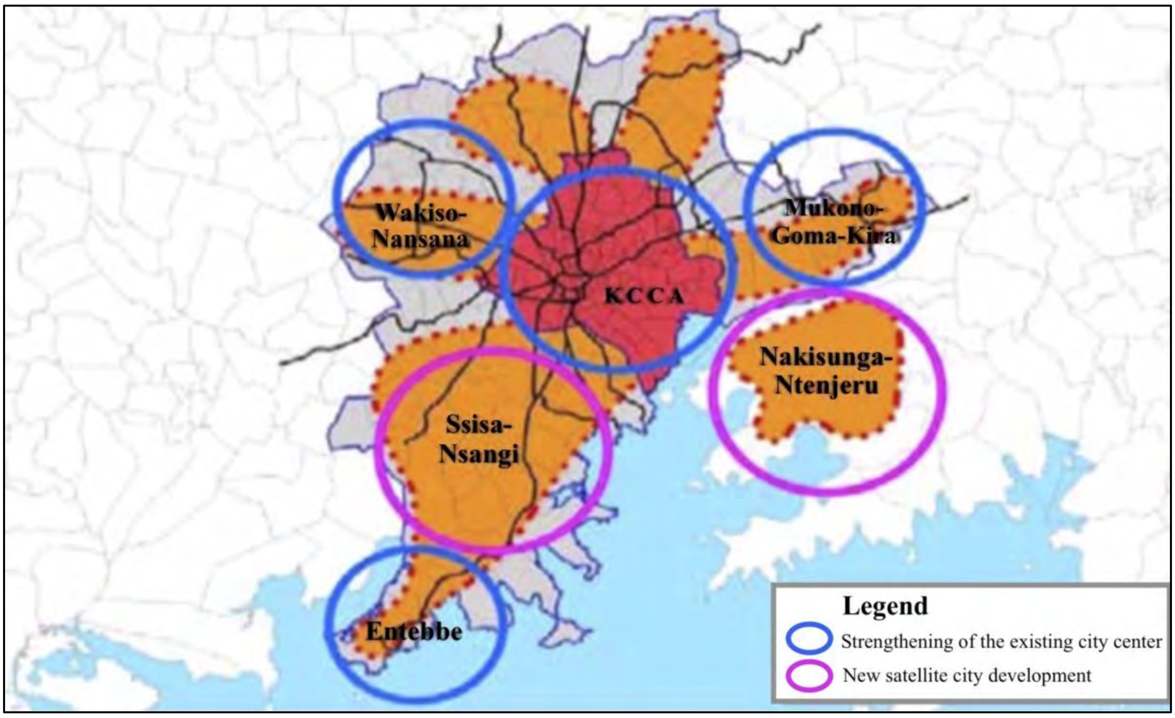
Vision 2040, National Development Plan I and II are upper-ranked plans for the Strategy Plan of KCCA. Based on the national long term goal/ vision and economic development plans, municipalities are required to formulate their development plans by considering about regional and urban economic development and infrastructure development within their jurisdiction areas from its own municipal management viewpoint. In particular, looking into the relationship between the Strategy Plan of KCCA and national development plans, NDP 2010 / 2011 - 2014 / 2015 includes the corresponding items to the Strategy Plan: i) 5.8 of Chapter 5 “Housing Development”, ii) 6.1 of Chapter 6 “Land Management” and iii) 6.6 of Chapter 6 “ Urban and Regional Planning”. NDP II also includes Chapter 13 which pertains to Urban Planning and Regional Planning. The latter half part of the Chapter 13 is relating to the Strategy Plan of KCCA. Municipalities shall formulate their master plans and urban development projects and provides city services to citizens, based on the national instructions. Municipality plans are prepared from the viewpoint of the breakdown from national development plans but also from their own idea and planning to respond to regional issues uniquely set up.

Taking a look at the jurisdiction area, Greater Kampala Metropolitan Area is defined as the area which includes Kampala city as well as the neighboring districts of Mpigi District, Wakiso District, and Mukono District. Under the Kampala Capital City Authority (KCCA) Act, 2010, KCCA shall ensure coordinated planning and implementation of programs across the metropolitan area to maximize benefits of urban development in the jurisdiction area.

In the Strategic Plan 2014/15 - 2018/19 formulated by Kampala Capital City Authority, the Authority advocates “The City Five Year Strategic Agenda”, which is comprised of the following five points.

① Planned and Green Urban Environment
② Economic Growth Development Theme
③ Integrated City Transportation Infrastructure
④ Social Development, Health and Education
⑤ Urban Governance and Operational Excellence

In addition, population increase and expansion of Kampala City will continue. In order to cope with this challenge, the development of basic plan of Kampala Metropolitan Area (Greater Kampala City) is to be finalized. The Strategic Plan is intended to strengthen the function of existing urban centers in Kampala City as well as to develop new satellite cities at the surrounding periphery of Kampala city. In view of integrating the six urban centers, including the two new satellite city development projects is considered to be the main origin of power demand the future

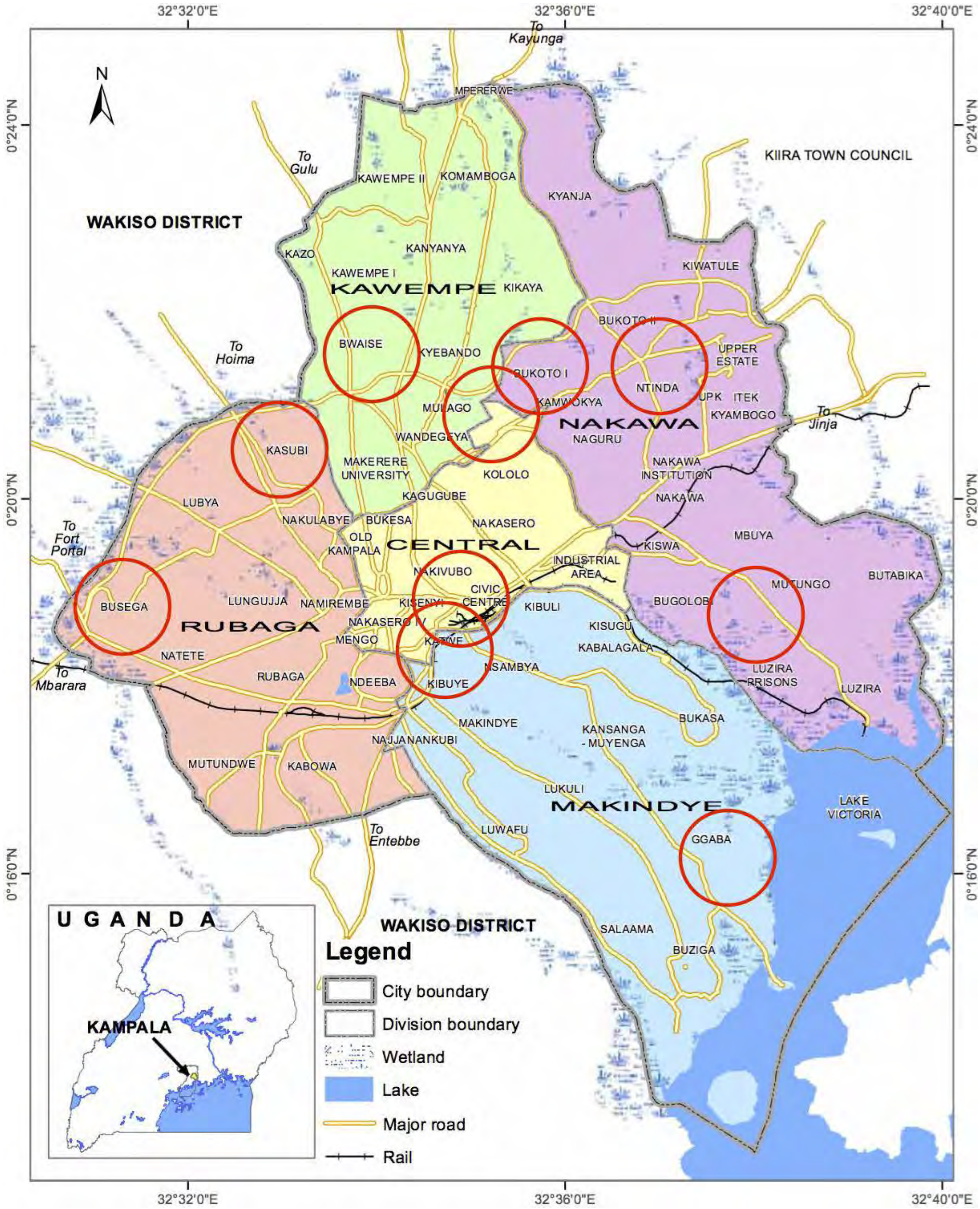


Source: Kampala Metropolitan Area Strategic Plan

Figure 2-4-4.1 Existing City Center and New Satellite City Development Proposed in the Greater Kampala Metropolitan Area (GKMA) Strategic Plan

While currently there are 62 informal residential settlements in Kampala City, urban environment infrastructures (infrastructure of water supply and sewage system, roads, communication, electricity, etc.) have not been developed sufficiently or delayed in those settlements. However, urban environmental improvement has to be made in accordance with the procedure of formalization in the future, and electricity demand is expected to increase. Development of commercial business districts (office area, shopping area) is designated in the Strategic Plan, in order to promote the development of urban economy of Kampala City. Power consumption volume will be usually very high in such commercial business districts. Due to high density and intense economic activity, the development of the commercial business districts will accelerate power consumption increase. The districts planned to development as non-commercial business are listed below. In addition, figure 2-4-4.2 shows the locations for business commercial district development in the future. According to the plan, in order to strengthen existing business centers or develop new commercial business districts are steadily improved, about 100 million USD is required for construction cost, and it is expected to create 22,800 new employments for urban commercial workers.

- Kasubi and Busega in Lubaga District,
- Kitintale, Bukoto, Ntinda and Nakawa market in Nakawa District,
- Gaba and Nalukolongo in Makindye District,
- Kalerwe in Kawempe District, and
- Kamwokya and Usafi market in the Central District.



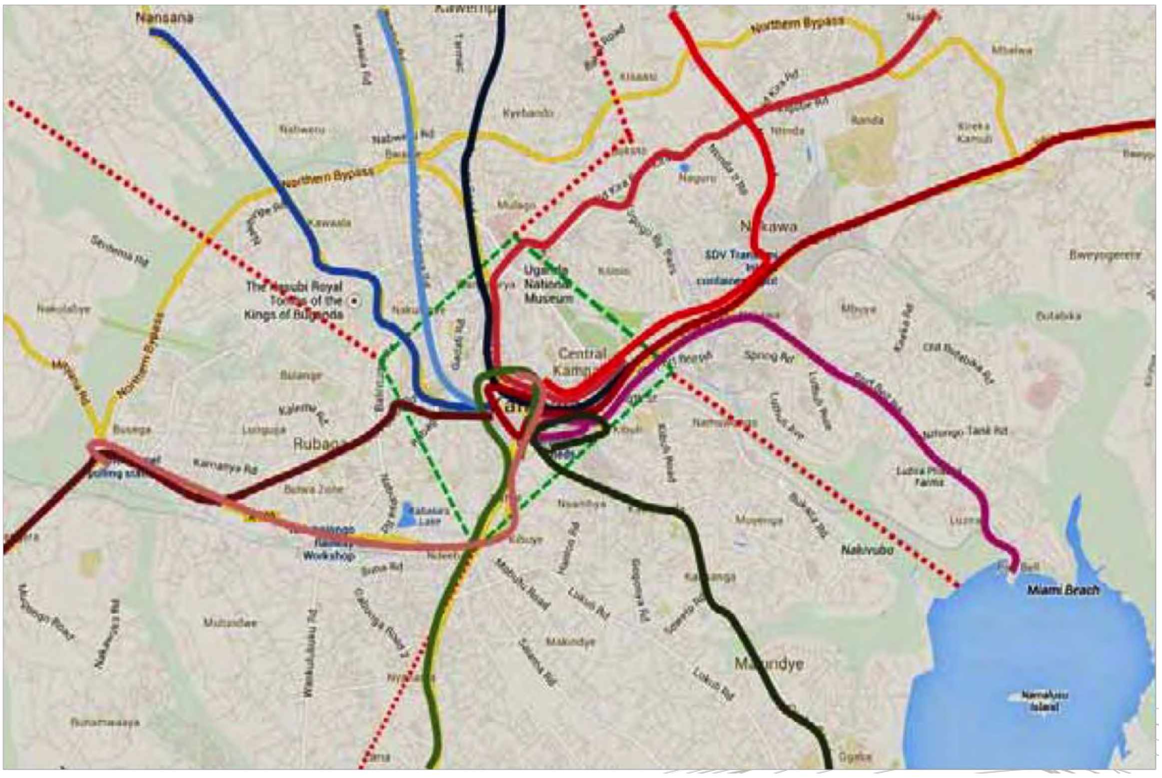
Source: Prepared on the basis of the Kampala Metropolitan Area Strategic Plan

Figure 2-4-4.2 Development of the Commercial Business District Proposed in the Kampala Metropolitan Area Strategic Plan

City infrastructure to support the city economic activity of Kampala City is planned in the Strategic Plan. It will strengthen the urban infrastructure development. The main development items are listed below. Figure 2-4-4.3 shows the future plan for bus route network.

- Improvement of the intersection and flyover-roads
- City bus service improvement and introducing mass transport system based on bus

- Introducing Cable Car System
- Promotion of transportation means available for non-motorized transport such as bicycle, etc.
- Introducing Network of Light Railway Transport (LRT)



Source: Kampala Metropolitan Area Strategic Plan

Figure 2-4-4.3 Bus Route Network Proposed in the Kampala Metropolitan Area Strategic Plan

If the development of urban transport infrastructure is underway in such Kampala Metropolitan area, it leads to the progress of urban development and population growth. Also it would activate economic activities, which all leads to increase in power demand. Therefore, significance of this project will continue to grow.

2-5 Economic Performance of the Uganda Government and Outlook for Future

The annual real GDP growth rate of Uganda was fluctuating below 5% for the period of 2012 - 2014. In FY 2014 / 2015, however, it recovered and slightly rose to 5%, and is likely to stay on the same level of 5% in FY 2015 / 2016. The Government of Uganda currently projects that it will slightly rise to 5.5% in FY 2016 / 2017. At present, Uganda Economy suffers from stagnant performance of industry and service industry, but on the other hand, it is supported by the scaling up of infrastructure investment. The Government intends to exert its effort to boost investment on infrastructure construction, and to attain the goal set for exceeding the level of 1,000 USD per capita in the Year of 2020 through the implementation of NDP II. In particular, the Government has big expectation on the large investment projects: i) standardization of gauge railway, ii) hydro-power generation projects of Karuma Dam and Isimba Dam, iii) oil refinery industry of Lake Albert, iv) electricity transmission projects, v) Upgrading/renovation of the Entebbe Airport, and vi) ICT infrastructure etc.

Under these circumstances, it is deemed as essential for the government of Uganda to promote a balance of aggressive investment expansion attitude and exquisite macro-economic management at the same time. On the other hand, as we have overviewed in the section 2-3 ”Fiscal Balance and External Debt”, expenditure is likely to continue to exceed tax revenue by far until 2020, and the recovery from the fiscal deficit-ridden structure will also remain until 2020. As a result, the dependency on external debt is likely to be strengthened and the increase in public and publicly guaranteed debt will seemingly expand. With the reference to the fiscal operation and management principles which is commonly understood between IMF and Ugandan Government, however, it is projected to be certainly in compliance. The principles are as follows: The ratio of the present value of public and publicly guaranteed debt to GDP shall be kept within 50%; the ratio of the present value of external debt to GDP shall be kept within 30%.

At present, the international major foreign currency reserve is equivalent to around 4 months of Ugandan imports. As this indicator is also monitored carefully at the regular periodical meeting between IMF and Ugandan Government, it will be kept at the same level of 4 months as follows: According to the IMF Country Report No.16/145, 3.9 months (around 2.7 billion US dollars) in 2015 / 2016, 4.0 months (around 2.9 billion US dollars) in 2016 / 2017, 4.1 months (around 3.3 billion US dollars) in 2017 / 2018.

The Debt Service Ratio (DSR) which is the ratio of debt service to exports, currently accounts for around 2%, and it is likely to increase up to around 3% - 4% due to the expansion of external debt for construction of large-scale infrastructure. However, it will be maintained far below the so-called risky zone of 20% - 30%.

In conclusion, we are of the view that Ugandan Government will be able to use the Japanese Yen Credit of this project effectively as well as sustainably, although there are some risk factors of rapid increase in external debt and public and publicly guaranteed debt etc.

Chapter 3   Background and Circumstances of the Project

3-1   Current Condition of Power Sector in Uganda

3-1-1   Implementation Framework of Power Projects

(1)   Structure of the Power Sector

The structure of the power sector is shown in Figure 3-1-1.1. The power business was originally operated by a government-owned company. Then, from 1998 to 1999, it was divided into three companies, Uganda Electricity Generation Company Ltd. (UEGCL) for generation, UETCL for transmission, and Uganda Electricity Distribution Company Ltd (UEDCL) for distribution. Electricity Industry Act of 1999 set a policy of the power industry as government-owned, and 100% of the stocks of UEGCL UETCL, UEDCL are still owned by the government.

Table 3-1-1.1 Structure of Electricity Department in Uganda after the split of UEB

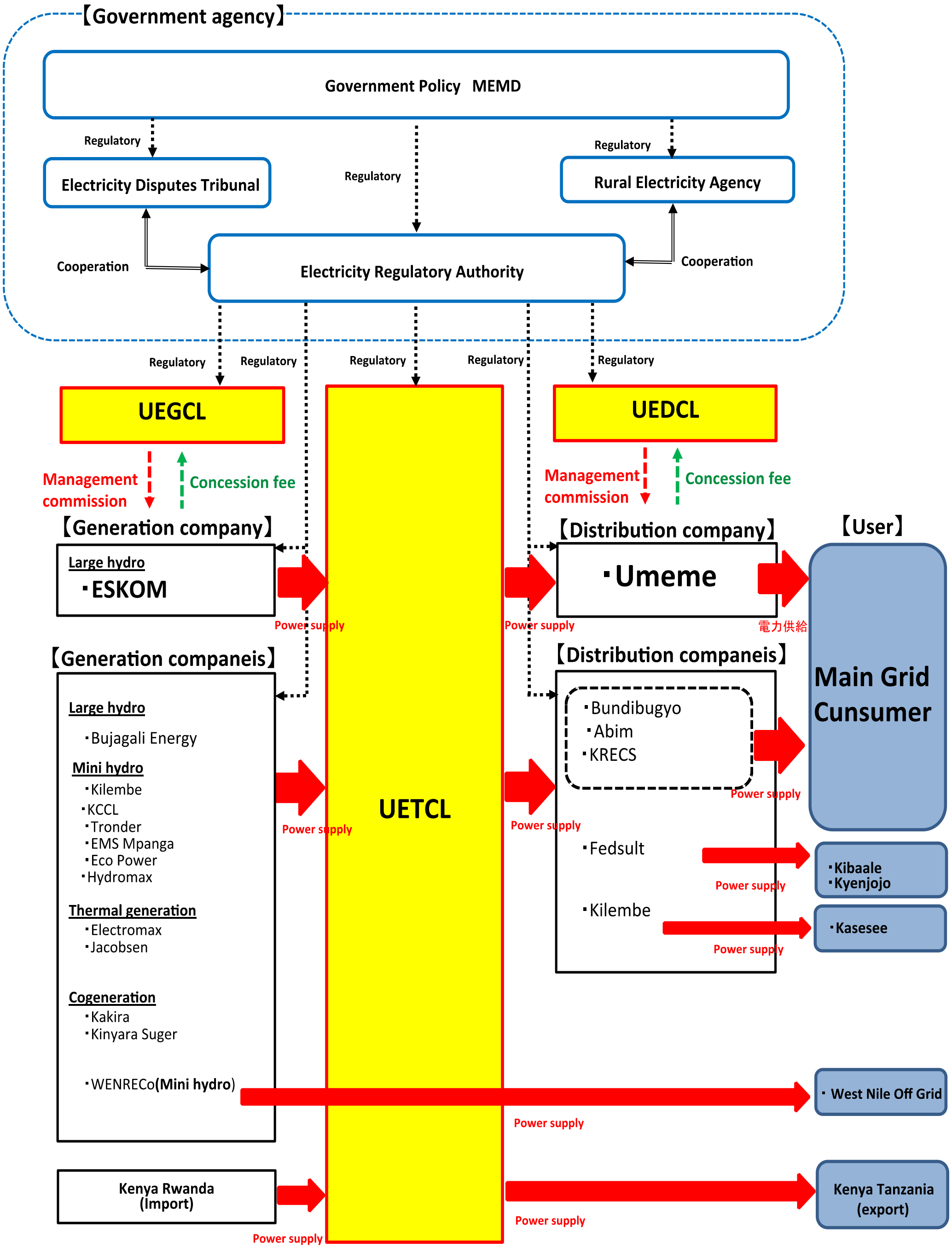
Department	Power provider	Voltage classes
Power Generation	Uganda Electricity Generation Company Limited : UEGCL	-
Power Transmission	Uganda Electricity Transmission Company Limited : UETCL	220 kV, 132kV, etc.
Power distribution	Uganda Electricity Distribution Company Limited : UEDCL	33 kV, 11kV and low voltage

Source: Research Study Team

However, while the management of transmission sector is maintained as neutral, privatization has been underway as for the generation and distribution sectors. Although UEGCL still owns a hydroelectric power plant, the operation of the plant has been entrusted to a private company based on a concession contract that gives the exclusive sales rights. In addition, since 1999, new entries of the power generation business by the private sector have been also approved. Bujagali power plant was originally established by the Uganda government, but after the establishment it has been owned and operated by a private company. In the distribution sector, UEDCL has entrusted the management to a private company, UMEME Corporation.

On the other hand, UETCL owns the transmission facility, and carries out its maintenance. Currently, there is no plan of private consignment of management of UETCL. It is very difficult to hand over the construction, operation and maintenance of transmission network to the private sector, compared to generation and distribution. Therefore the Uganda government has no intention to privatize the operation of power transmission. As the sovereign yen loan is an affair between two countries, it is important to maintain UETCL as a public company at the time being.

Under the current system, power is supplied by many power generation companies to UETCL. Then, UETCL provides power to the distribution companies such as UMEME. Finally, it is provided to consumer by the distribution companies. The off-grid area in West Nile, WENRE Co. is in charge of all the cycle from generation through distribution. The structure of the current Uganda power sector is shown in Figure 3-1-1.1.



Note: Power distribution company Umeme Limited (delegated by UEDCL), leased power distribution facility owned by UEDCL with a concession contract, and Commissioned management in order to operate the power distribution business. On the other hand, the private power distribution companies other than Umeme (delegated by Rural Electrification Agency) carry out power distribution operation by borowing power distribution facility at the concession contract with Rural Electrification Agency. In addition, power generation company, Eskom Inc. (commissioned) also leased the power generation facility owned by UEGCL in concession contract, carry out power generation operation by commissioned. the private power generation companies regardless of concession contract with UEGCL, carry out operation using the power generation facility owned by their company.

Source: Prepared by JICA Study Team based on the two-year business plan of the Electricity Regulatory Authority

Figure 3-1-1.1 Structure of Uganda's Power Sector

(2) Neutrality of the transmission sector

As described above, the privatization of generation sector and distribution sector have been steadily underway. Meantime, the Uganda Electricity Transmission Company Limited (UETCL) has been operated as a state-owned enterprise since the reform of the electricity sector in 2001 following the implementation of the Electricity Act 1999. Up to this day, there are no known plans for participation of private sector or private commission including the its operation and maintenance in the near future.

The Electricity Act, 1999, provides for private sector participation in the power generation and distribution and describing the process and procedures of licensing to the private sector is described in detail. However, such provisions for licensing power transmission to the private sector is not described as there were no plan for privatization. The operation of this project is expected to be carried out by UETCL, as the implementing agency.

In the case of the significant decline of Uganda Shillings in foreign exchange several years ago, it was not possible to reflect all the loss into the end-user price and the state-owned power transmission company played a significant role as a buffer, to avoid raising the price for bulk sales (BST) despite of backwardation. Usually it is difficult for a private company to take such actions reflecting government's intention. Yet, another reason is that in order to promote the entry of private power generation, there is a need for the sense of stability in market and stable purchase of electricity from the power generation operators. Having UETCL as a public corporation monopolizing transmission ensures "feeling of safety" for private generating companies. For these reasons, there is no policy to privatize UETCL at the moment. Even for the Japanese side, having a public corporation as an implementing agency is favorable for yen loan project.

In addition, for expansion of the transmission grid, massive investment is necessary and that is one of the reasons reason to proceed the project by government-led.

3-1-2 Organization, Jurisdiction and Legal Framework of Projects of Energy Administration

(1) Jurisdiction and legal framework for power projects

Recognizing some typical issues and problems in the power sector in developing countries, Ministry of Energy and Mineral Development (MEMD) encourages the use of the private sector in order to improve efficiency in energy development, utilization (use), and provision of services. In order separate power generation, transmission and distribution, the current framework and structure for power related projects was built through enacting and enforcing of the Electricity Act in 1999. Previously, the Uganda Electricity Board (UEB), which belongs to the Ministry of Energy and Mineral

Development (MEMD), had overall responsibility including upstream power generation projects through the downstream power retail. However, in order to improve the efficiency through reforms, the Uganda Electricity Board divided the power operation into generation, transmission, and distribution, creating three entities of Uganda Electricity Generation Company Limited (UEGCL), Uganda Electricity Transmission Company Limited (UETCL), and Uganda Electricity Distribution Company Limited (UEDCL).

Electricity Regulatory Agency (ERA) was established in 2000 as the authority to administrate power projects / business. It has jurisdiction over these three state-owned companies. Providing guidance and regulations related to the power generation, transmission, and distribution, as well as international power trade. Issuance of license to the operators of the power generation, transmission, and distribution, build, update, and maintain the fee structure of power, and also formulation and enforcement of laws, institutions and regulations in accordance with various power projects.

ERA formulated Strategic Development Plan for 10 years (the plan which is currently in operational is the Strategic Development Plan 2013 / 2014 - 2023 / 2024) as a guide to promote and lead the Uganda electricity industry. In line with this strategy and development plan, ERA provided guidance over the three state-owned companies, UETCL, UEGCL and UEDCL. ERA is an authority to issue license of operation to an operator in the power sector. It also has the authority to adjust and approve electricity rates over the three subordinate companies so it has the influence on the management and operation of private power companies under the umbrella of those three companies. In addition, it has the authority to determine rules, laws and procedures in accordance with the details of power operation. ERA can formulate the guiding principles and future direction of the power sector.

(2) Jurisdiction and Organization Overview of the Energy Administration

The Ministry of Energy and Mineral Development has jurisdiction over the energy policy related issues in Uganda. As energy development has great impact on environment, planning and implementation of sustainable energy policy is important for the country.

Although Uganda is endowed with rich energy resources, starting with hydropower, other reserve mineral resources such as oil and gas, etc. energy development and utilization has not progressed. People not being able to enjoy the richness of the energy resources that exist have been recognized as a big challenge. Based on this, the objectives and goals of the energy sector for the Ministry of Energy and Mineral Development (MEMD) is to be able to use the resources sustainably in response to the Uganda national energy needs.

In order to achieve its objectives and goals, the following five policy objectives were set in “Uganda’s Sustainable Energy for All Initiative Action Agenda (SE4ALL)” (June, 2015). Issues have been raised to be addressed strategically.

① Grasp of endowment, availability and demand of energy resources of Uganda
- Development of data base on energy resources and energy consumption patterns
- Promotion of the necessary human resource development and capacity building

② People be able to enjoy the low-cost energy services, enhance the service reliability, and also to contribute to the eradication of poverty
- Ensuring fair and healthy competitive environment in the energy supply business
- Promotion of private operators participation, and quality improvement of energy technology and services
- Improvement of access to energy in region and rural areas
- Moral improvement and awareness about energy conservation

③ Establishment of a management system in accordance with the energy discipline
- Development of framework such as relevant laws and institutions
- Planning of appropriate energy policies and programs, and improvement of capacity development
- Clarification of the roles of relevant organizations and associations and cooperative relationship and system development

④ Contribution to economic development
- Promote competition on the basis of market principles mechanism
- Incentives to revitalize investment in the energy sector
- Improvement of safety and reliability of energy supply

⑤ Observing impact on the environment during energy development
- Utilization promotion of environmentally friendly energy technologies, energy resources
- Awareness for the environmental conservation
- Efficient use of energy resources

1) Policy overview of the electricity Sector

Top priority of the policy of the power sector is the improvement of the electrification rate. Elimination of the non-electrified areas is to expand and improve the power transmission and distribution network. Now in 2014, 618,000 households in urban areas and 4,850,000 households in rural areas have not been electrified. MEMD has set an ambitious goal of eliminating the non-electrified households by 2030 in SE4ALL. For this purpose, currently the increasing pace for newly electrified households in one year reaches almost about 100,000 households a year. However, the pace of increase in newly electrified must pull up to about 667,000 households per year.

As described above, Uganda power sectors are differentiated/specialized into three subsectors of power generation, transmission and distribution. Towards the above-mentioned goals, there is a need for capacity expansion in each, the power generation, transmission distribution aspects.

- The goal set to expand the power generation capacity from 879 MW in 2012 up to 2,400 MW in 2030.
- To promote capacity expansion and management efficiency by utilizing the private sector by concession, etc. along with the promotion of the government side in the field of power generation and distribution.
- To strengthen and expand the power transmission network of UETCL, in the power transmission field.

It should be noted that the level of electricity consumption per capita, is also set to raise from 84 kWh / year at present up to 180 kWh / year by 2030.

2) Policy overview of the oil and gas sector

In Uganda, oil and gas resources have been discovered in the vicinity of Lake Albert that has endowments, and it began resources development and investment by foreign capital from 1998. Number of investment has also annually increased, the total investment of up to 2013 has reached to 2.4 billion USD. Policies related to the oil production sector of the Uganda in response to the intensifying of investment activities in oil and gas resource development, has formulated "Uganda National Oil and Gas Development policy (NOGP)" in 2008. In 2013, the law has been enacted on resource exploration, development, production and refining of oil and gas.

As overall principle in this oil and gas sector, there are the following six items stated in "SE4ALL":

① contribution to social improvement taking advantage of the limited resources
② efficient resource development
③ transparency and accountability
④ conservation of environment and natural diversity
⑤ cooperation spirit
⑥ capacity development and institution building

According to the dominating principle of the policy objectives, the following 10 items are listed.

Goal 1: Efficiently carry out the authorization and approval of the areas where potentially oil and gas resources are believed to be endowments.
Goal 2: Efficient management and operation of oil and gas resources
Goal 3: Efficiently carry out the production of oil and gas
Goal 4: Promote the utilization of oil and gas resources

Goal 5: Efficiency in transportation and shipping of oil and gas

Goal 6: Properly taking advantage of the revenue resulting from oil and gas development

Goal 7: Optimization of the role of country

Goal 8: Capacity building and training of human resources involved in the development and use of oil and gas

Goal 9: Conservation of environmental protection and biodiversity

Goal 10: Building mutual relationship that benefits all stakeholders

3) Policy overview of the renewable energy

MEMD has announced to promote diversification and technological development of the energy supply source in SE4ALL. The followings are to promote.

- Renew the regulatory and framework for renewable energy, and create an easy to pursuit working environment for businesses related to renewable energy.
- Take the financial assistance measures to smoothly carried out investment and financing related to the development of renewable energy.
- Elaborate the use development strategy of renewable energy in consideration to poverty eradication, energy distribution with consideration to social fairness, social services, and gender issues.
- Promote the people's awareness on renewable energy.
- Promote international cooperation, and technology transfer, conducting research and development on renewable energy.
- Promote sustainable Biomass and utilization of bio-fuel.
- Conversion use of garbage such as industrial waste to renewable energy

In particular, promotion of use of hydropower and biomass is largely expected. Uses of Solar, wind power and geothermal are still in the early stages towards the utilization promotion. It is in the research stage rather than a practical promotion.

4) Policy overview of nuclear power

Uganda positioned the nuclear power to one of the five departments of energy, and legislated the atomic energy law in 2008. The nuclear energy unit has established in the Ministry of Energy and Mineral Development in order to perform the guidance management and draft policy and strategy for the use of nuclear energy. The following six items has been set as important issues to be addressed in SE4ALL in the future.

- Draft and legislation of the use of nuclear energy policy
- Establishment of relevant institutions and systems
- Human resource development
- Description consensus to Stakeholders
- Mounting of international cooperation

- Construction of a nuclear power facility

3-1-3 Activities of the other donors

(1) World Bank

The World Bank prepared the country assistance strategy in line with National Development Plan of Uganda and focuses on the following four strategic objectives.

- Promote inclusive and sustainable economic growth
- Enhance public infrastructure
- Strengthen human capital development
- Cross-cutting: Improve good governance and value for money

In terms of improvement of the power transmission network, which is the scope of the Project, the World Bank is currently implementing the Project for installation of 220 kV transmission lines between Kawanda Substation - Masaka Substation. Such enhancement of power infrastructure will especially contribute to “Promote inclusive and sustainable economic growth” and “Enhance public infrastructure” mentioned below by realization of effective use of the transmission lines in the upper voltage level such as 220 kV. Since the Project is including the components (220 / 132 kV New Mukono Substation and 220 / 132 kV Buloba Substation) to provide the drop points of power to 132 kV network of GKMA from the 220 kV transmission lines, synergy effects by the donor are expected by implementation of the Project.

In addition, the project site is located at Kampala metropolitan area, one challenge of power supply in Uganda is the low rural electrification rate as 7% as of 2013. The World Bank has been contributing to the enhancement of rural electrification during the long period. The government of Uganda formulated Rural Electrification Strategy and Plan (RESP), carried out from 2001 to 2010 to equalize the living standards between urban and rural areas. For this project done by Ugandan government, the World Bank carried out the Energy for Rural Transformation Program (ERT Program) three different phases. Through this scheme, the World Bank has been funding approx. 50 million USD from 2001 to 2009 (The First Phase), and approx. 75 million USD from 2009 to 2016 (The Second Phase) to contribute to the rural electrification.

After that, the government of Uganda revised the RESP for its implementation from 2013 to 2020 to achieve the 26% of the electrification rate by 2022. In line with this, the World Bank has been expanding approx. 40 million USD to conduct the third phase of ERT program to assist the rural electrification regardless of the application of the transmission network.

Additionally, the World Bank assists not only the rural electrification but also the promotion of renewable energy. Uganda has abundant hydraulic resources lying the Nile as the primary power source, potential mini hydraulic sources around 5 MW are also identified sparsely in Uganda. Development of dispersed power system is expected to contribute to the promotion of the rural electrification as they will be consumed locally, the World Bank assists the development of mini hydraulic power generations through Guarantee for Renewable Energy Development Program (IDA).

(2) German Assistance

German Development Cooperation for Uganda aims at promoting development in the following three sectors.

- Water and sanitation
- Renewable energy end energy efficiency
- Financial systems development and agricultural finance

KfW, the implementation agency for official development assistance in Germany, is currently implementing the project for construction of 132 / 33 kV Entebbe Substation, which will receive power from Mutundwe Substation, to improve efficiency of power supply in the southern area of GKMA. In the Project, Mutundwe Substation is planned to upgrade the bus configuration from the single to the double, and it will improve the reliability of supply in the southern area of GKMA fundamentally. It is also expected that the Project and the above mentioned project by KfW will provide synergy effects to the power supply in the southern area of GKMA.

(3) African Development Bank (AfDB)

AfDB has prepared “Result-based Country Strategy Paper” for Uganda and is implementing the official development assistance for Uganda. The policy described in the documents aims to achieve “infrastructure development” as Pillar I and “improving capacity skills development for poverty reduction” as Pillar II, and the following goals are indicated in each Pillar. The Project will directly contribute to “Improve generation and distribution of electricity and enhance its affordability and accessibility”

(Pillar I)

- Improve national road network and reduce transport costs
- Enhance marketing of agricultural produce and other merchandise
- Improving access to water and sanitation in rural and urban areas
- Improve generation and distribution of electricity and enhance its affordability and accessibility
- Promotion of health and prevention of disease, and strengthening of health systems

(Pillar II)

- Develop an economically productive knowledge population, with advanced skills which will lead to economic growth that benefit all sectors of society.

AfDB conducts the assistance for the improvement of low electrification rate at rural areas as well as the World Bank. AfDB adopted a loan project amounting to approx. 72 million USD in September 2015. AfDB also proceeds to assist the selection of prioritized rural electrification projects.

(4) Chinese Assistance

Though the Chinese assistance strategy for Uganda is not indicated clearly, the projects for construction of Mukono Substation, Namanve South Substation and Luzira Substation are on-going through the Export-Import Bank of China to assist development of industrial parks in the east side of GKMA in terms of improvement of the power transmission network. These industrial parks are expected to take the significant roles for economic development in Uganda. However, these substations require stable power supply from 220 kV network. The Project is including the components of installation of 220 / 132 kV New Mukono Substation and the connection between 220 / 132 kV New Mukono Substation of the Project and 132 / 33 kV Mukono Substation assisted by China Export Import Bank to enhance the power supply to GKMA fundamentally.

(5) 400 kV interconnection among Uganda, Kenya and Rwanda under Nile Equatorial Lakes Subsidiary Action Program (NELSAP)

East African countries established East African Power Pool to realize the regional integration of the power system in order to combat the power shortage in this region causing poverty and hampering the economic development. In 2011, with funding from the Africa Development Bank and European Commission, the first EAPP Mater Plan was endorsed. As the first step, the interconnection among five countries, namely Ethiopia, Kenya, Tanzania, Rwanda and Uganda is prioritized. The future electricity trade among these countries shall exceed 630 MW, the necessity of 400 kV interconnection line instead of 220 kV transmission line is required.

Against the background, the feasibility study for the construction of double circuit 400 kV transmission line among Kenya, Uganda and Rwanda is underway. Construction costs shall be borne by each country. At present, the basic outline of transmission route and specification of associated substations is designed and the detail work implementation schedule is not yet determined.

Transmission line route from Tororo Substation to Mbarara Substation through Kawanda Substation and Masaka West Substation, total length is approx. 639 km is considered to be adequate from economic view (line length and affected area for the land acquisition) and technical view (transmission loss). Associated substations shall be prepared by either rehabilitation of existing facilities or new construction. The expense to be borne by Uganda is approx. 255 million USD (Substation: 60 million USD, Transmission: 195 million USD).

3-2 Current Condition, etc. of UETCL, implementing agency

3-2-1 Organization system of UETCL

(1) Structure of the implementing agency

This is a project for the transmission and substation facilities, which are under responsibility of UETCL. Therefore, it is expected that the project implementation be carried out within the framework of UETCL. UETCL has good track records of implementation of similar projects. For this reason, this project should take advantage of the organization of UETCL. The organizational structure of UETCL is shown in Figure 3-2-1.1 and Table 3-2-1.1.

UETCL places the most human resource at “Planning and Investment Department” which plans each projects of UETCL and formulates the investment plan. Second in staffing capacity is the “maintenance department” in charge of maintenance and operation the grid (139 staff in “Planning and Investment Department”, and 132 staff in “Operation and Maintenance Department”),. This staffing seems appropriate by reflecting the situation of UETCL for transmission infrastructure investment.

The leadership and direction of UETCL is vested in the Board of Directors of UETCL, who appoints a Managing Director / Chief Executive Officer (MD / CEO) to head and direct the company. Just below the MD / CEO, Deputy CEO is placed.

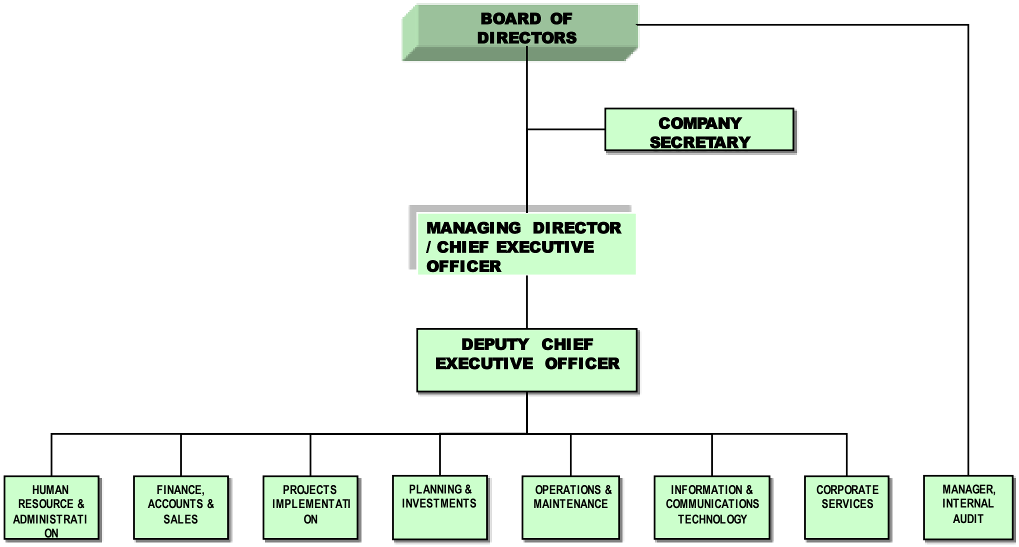
Plans and policy drafted by each sector are presented to the CEO and the Board of Directors provides approval. However, the approval of important matters such as revision of BST fee, etc. cannot be resolved only by the internal decision of UECTL. Reporting and getting approval from ERA is required. Approval of this project also requires the approval of ERA.

Table 3-2-1.1 Organization and Number of Stuffs of UETCL

No.	Department	Staff number on Contract	Staff number on temporary terms	Total number
1	MD's office	7	0	7
2	Human Resource & Administration	21	4	25
3	Finance, Accounts & Sales	10	0	10
4	Project Implementation	37	0	37
5	Planning & Investment	84	55	139
6	Operations & Maintenance	132	0	132
7	Information & Communication	18	4	22
8	Cooperate Services	27	6	33
9	Internal Audit	26	5	31
Total		362	74	436

Remarks: As of September 23, 2015

Source: JICA study team, data obtain from the human resources department of UETCL



Source: JICA study team, data obtain from the human resources department of UETCL

Figure 3-2-1.1 Organization Chart of UETCL

The organization and duties of UETCL, as well as its section structure is shown below in Table 3-2-1.2.

Table 3-2-1.2 Organization and Scope of Responsibility of UETCL

Departments	Scope of responsibility	Section structure
Human resources and management department	To carry out the training of human resources, skills building of staff, organizational changes. ● Formulating policy, method and plan for development of human resources and staff, and implement human resources development ● Formulating employment policy ● Development of reward/ compensation system ● Formulating, implementation and supervision of procedures in line with manual for welfare and management systems of human resources ● Development of performance management system	■ Human resources ■ Management
Financial, accounting and sales department	To formulate and implement plans for purchase and sales of bulk power, maximize the revenue of the assets, implementation of monetary policy, business efficiency, governance, business practices, etc. ● Strengthen compliance with the international accounting standards ● Manage finance of the company ● Manage the relation of finance with the banks and donors ● Build a financial system and processes ● Formulate tax planning ● Manage the budget and audit functions of the company ● Manage purchase, sales and statistics function	■ Expenditure and savings ■ Energy sales and statistics ■ Budget & Finance ■ Project Accounting
Project promotion department	To implement transmission plans to meet the future demand in line with Company Strategic Objectives. ● Development and implementation of a Project Implementation Plan ● Detailed Design Basis and Engineering ● Construction ● Commissioning	■ Environmental ■ Projects ■ Monitoring and evaluation
Planning and investment	To develop power purchase and transmission plans to meet the future demand and provide Transport Services in line	■ Planning ■ Safety and

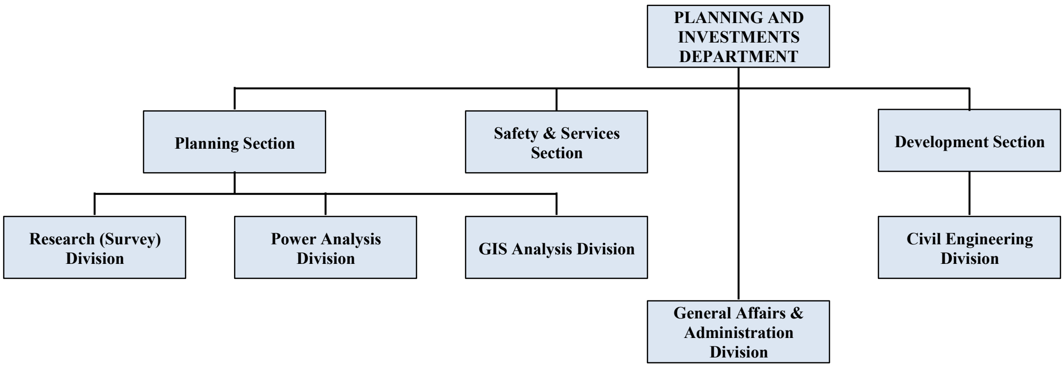
Departments	Scope of responsibility	Section structure
department	with Company Strategic Objectives. This includes implementation of Power Purchase (Single Buyer). ● Grid Development Plan and Grid Investment Plan ● Project Profile and Project Financial Projections ● Feasibility studies and Financing ● Licensing and Outline Design.	Service ■ Development
Maintenance department	To operate and maintain the Transmission Grid Assets and Load Dispatch facilities and to provide in a safe manner in accordance with international Prudent Utility Practices, in order: ● Improve the availability of the transmission network through a planned preventive maintenance strategy ● Maximize system security by improving on the Protection Schemes ● To ensure the accuracy of energy metering systems and dispatch facilities to all UETCL Customers ● To ensure the safety of staff and safeguard Company assets	■ Maintenance ■ Protection ■ Control
Information and communication department	To promote the achievement of the overall goal of UETCL by utilizing and taking advantage of the information and communications technology in ICT department. ● ICT support of important facilities (such as the Control Center) ● Support quality of ICT infrastructure and information of process ● ICT security - Including disaster control ● Ensure the integrity of ICT strategy in corporate strategy and planning ● Corresponding to the life cycle of IT investment ● Lease or rental of large capacity fiber	■ IT ■ Communication
Corporate services department	Corporate Services Department provides legal, procurement, and security services. ● Providing an efficient enterprise services ● Corresponding to the legal needs of the company ● Providing services related to the procurement (commodities, construction works, services) ● Providing security services to protect the company resources	■ Legal ■ Procurement ■ Security

Source: Created by JICA study team, data obtain from the human resources department of UETCL

Planning and Investment Department is responsible for planning of the projects and matters related to the investments. As for equipment design and specifications Planning Department has the jurisdiction, and civil engineering design falls under the jurisdiction of the Development Department. As for the procurement matters such as bidding for contracts and projects, the Corporate Services Department has jurisdiction. It should be noted that, Financial, Accounting and Sales Department is in charge of the funds and financial needed for the project. This department is also in charge of accounting of UETCL. When it comes to the implementation stage of the project, it is under the jurisdiction of Project Implementation/Promotion Department. The team of the Project Management Unit (PMU) requires multiple expertise, therefore, experts from other departments beside the Project Implementation/Promotion Department are added. Each PMU works under the control of Project Implementation/Promotion Department.

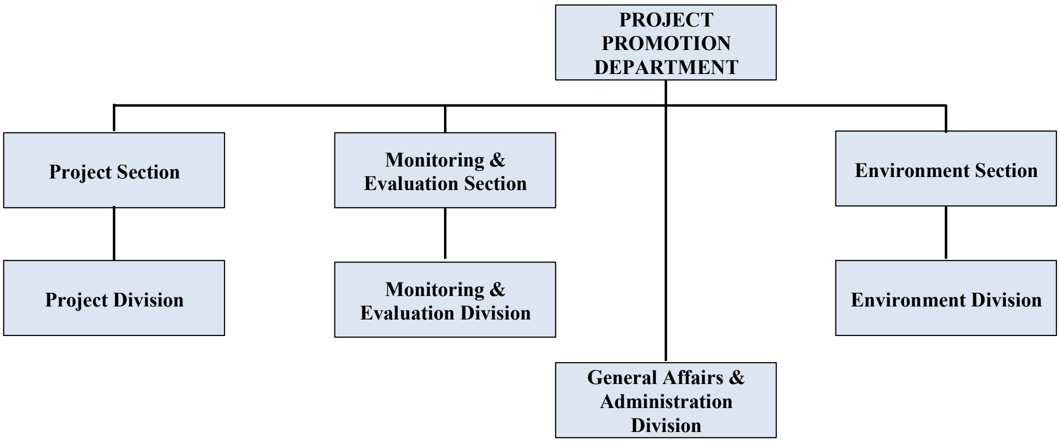
Details of the organizational structure of Planning and Investment Department, Project Promotion Department and Maintenance Department are shown in Figures 3-2-1.2 to 3-2-

1.4.



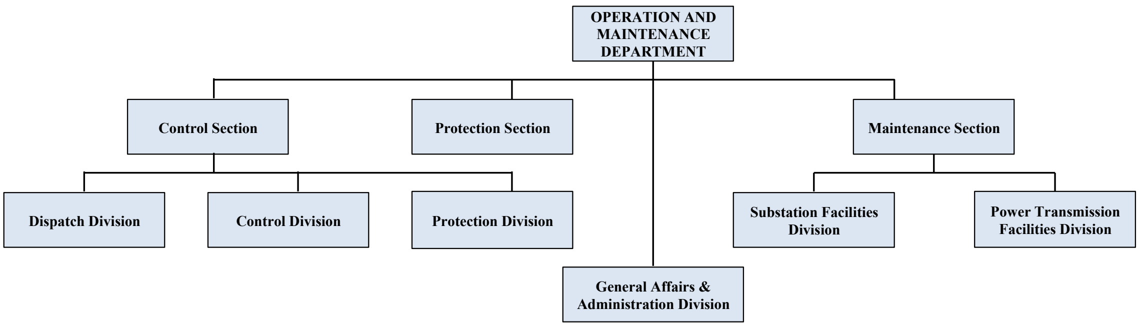
Source: Created by JICA study team, data obtain from the human resources department of UETCL

Figure 3-2-1.2 Organizational Chart of Planning and Investment Department



Source: Created by JICA study team, data obtain from the human resources department of UETCL

Figure 3-2-1.3 Organizational Chart of Project Promotion Department



Source: Created by JICA study team, data obtain from the human resources department of UETCL

Figure 3-2-1.4 Organizational Chart of the Maintenance Department

(2) Financial Status

1) Revenue and Expenses

The revenue and expenditure of UETCL are shown in the Table 3-2-1.3. Since 2013, UETCL has secured sufficient profit, even subtracting the financial expenses such as interest payments, etc. to ensure stable management. In FY 2013, the finance cost reached almost half of the operating profit, which became a major factor to reduce the before-tax profit. In FY 2014, the finance cost status was significantly reduced, as a result of improvement of financial structure such as reduction of borrowings. In FY 2014, the net income came to be very high, partly because of increase of valuation profit as a result of revaluation of plant and equipment. Therefore the earnings per share also became as high as 1,058 Uganda Shilling.

The cost of sales consists of purchase of electricity, fee of third party collection, and fund contribution to the Electricity Regulatory Authority and Rural Electrification Agency. The maintenance costs of grids means the maintenance cost of the transmission and substation facilities. Administrative expenses include not only salary of personnel and transportation, but also depreciation expense.

In relations to depreciation and amortization expenses, most of the tangible assets of UETCL are power transmission facilities and substations. The amortization rate is fixed at 2.8% for wooden-made transmission facilities, 2.5% for metal-made transmission facilities, and 2.5% for substations. Annual depreciation rate of tangible assets is approx. 3%. The depreciation is not heavy burden for business management, as the annual depreciation is only 3% of the total tangible assets.

Table 3-2-1.3 Revenue and Expenses of UETCL

Unit: Million UGX

Entries	2010	2011	2012	2013	2014
Revenue	691,054	900,524	636,858	719,014	750,328
Cost of sales	-626,683	-830,593	-560,486	-588,275	-611,752
Third Party Collection charges	-26,480	-36,613	-21,248	-66,767	-59,330
Gross profit	**37,891**	**33,318**	**55,124**	**63,972**	**79,246**
Foreign exchange gains	-	-	-	29,978	-
Other operating income	12,445	11,170	16,045	18,499	54,994
Total income	**50,336**	**44,488**	**71,169**	**112,449**	**134,240**
Grid maintenance expenses	-23,154	-24,163	-4,079	-4,183	-5,465
Administrative expenses	-13,894	-12,334	-40,976	-64,936	-81,958
Foreign exchange losses	-	-	-23,568	-	-25,017
Operating profit	**13,288**	**7,991**	**2,546**	**43,330**	**21,800**
Finance costs	-47,211	-56,801	-2,588	-23,507	-2,214
Profit before tax	**-33,923**	**-48,810**	**-42**	**19,823**	**19,586**
Income tax (charges)/credit	-11,433	14,637	-2	5,619	-3,262
Profit for the year	**-45,356**	**-34,173**	**-44**	**25,442**	**16,324**
Other comprehensive income					
Fair value gain on revaluation of plant and equipment	-	-	-	-	150,657
Tax on fair value gain	-	-	-	-	-45,197
Total other comprehensive income not to be reclassified to profit or loss in subsequent periods	**-**	**-**	**-**	**-**	**105,460**
Total comprehensive income for the year, net of tax	**-45,356**	**-34,173**	**-44**	**25,442**	**121,784**

Source: Annual Report of Uganda Electricity Transmission Company Limited

Table 3-2-1.4 Depreciation of the Uganda Electricity Transmission Company Limited

Unit: Million UGX

	2010	2011	2012	2013	2014
Depreciation amount	8,100	8,359	11,986	13,484	16,222

Source: Annual Report of Uganda Electricity Transmission Company Limited

The following section analyzes and discusses critical matters for UETCL's sustainable management, which include the electricity price and the subsidy issues from a financial point of view.

At first, subsidies by the government are intended to assist UETCL. They are recorded in the balance of payments statement of revenue of UETCL. In contrast, government contributions in the income statement are the contribution of investment funds for UETCL, and they are recorded in liabilities.

Until 2012, UETCL received subsidy to suppress the sales price for the end-user, (subsidy for adjustment of the sales price). The subsidy was provided per 1 kWh, depending on sales volume. This subsidy was already terminated in 2012. According to the policy change of government, the cost associated with autonomous has changed to the policy of recovery/collection in project revenues.

As mentioned earlier, the Government of Uganda in principle does not have policy to provide subsidies to UETCL. Although hydroelectric power covers the majority of power supply by now, there is a need to maintain thermal power plants to run without any problem in case of emergent situation in the future. The government supports the maintenance cost of inactive thermal power plants for urgent use when necessary

(Capacity charge subsidy). In other words, UETCL makes payment to the claims of thermal power generation companies, and then the same amount of money is paid to the UETCL from the government subsidy.

The Aggreko Inc. (Lugogo and Kiira) part of capacity charge subsidies was obsolete in 2011, and Aggreko Inc. (Mutundwe) part was reduced in 2012.

The subsidies from the government in relations to the total revenue of UETCL, accounted for 35% in 2010, and 73% in 2011. However, in 2012 it became less than 10%. In the third term corporate business plan of UETCL (2014 - 2018), the direction towards autonomous management without depending on subsidies is clear. For that, it is mentioned that the price for distribution companies should be set in way to recover all the cost.

In addition, the recent expansion of hydroelectric power generation had effect on improving the soundness of management. As Bujagali Energy power supply was initiated in 2012, dependence on thermal power which is higher unit price, reduced. (See 3-1-4 (3) power sales volume as described above).

Regarding the power purchase amount of Uganda Electricity Transmission Company Limited in 2011, thermal power accounted for 36.9%, and hydropower was 59.2%. In 2014, the proportion of thermal power became 2.7% and instead, hydropower became 89.6%. Regarding the purchase costs, in 2011 the thermal power accounted for 83.4%, and hydropower was 12.1%. In 2014, however, the proportion of thermal power became 9.7%, and hydropower became 80.1%. Due to this change, despite of large increase in power purchase amount, (from 2,559 GWh in 2011 to 3,203 GWh in 2014), the power purchase cost was greatly reduced from 830,302 million Uganda Shillings to 638,454 million Uganda Shillings in 2012. It seems to be greatly contributes to the financial soundness of UETCL.

Whether UETCL is able to achieve and maintain self-management without subsidies depends on power price structure, which should fully reflect the costs of power generation, transmission and distribution. Electricity Act in 1999, which was based on the power sector reform plan developed two years earlier, set the direction for the electricity enterprises to become a self-managed company based on the market mechanism. Although this goal has not yet been fully realized, the enabling environment is now created for UETCL to challenge this aim due to dramatic developments of hydroelectric power, and attainment of 5 - 6% of real economic growth in the past few years. "Financial Sustainability" is one of the five strategic focuses in the third-term corporate business plan. This should be accomplished in the collaboration with the ERA which is in the position to lead the operation and management of UETCL. The capacity to set appropriate price, to accomplish self-management is desirable.

Table 3-2-1.5 Subsidies from the Uganda Government to UETCL

Period	Capacity charge subsidy	Electricity sales price survey subsidy	Subsidy total	Uganda Transmission Company total revenue	Subsidy ratio
	Unit: Ushs million	Unit: Ushs million	Unit: Ushs million	Unit: Ushs million	%
2010	192,409	87,289	279,698	790,788	35%
2011	552,483	431,330	983,813	1,343,024	73%
2012	-	16,991	16,991	669,894	3%
2013	66,565		66,565	737,513	9%
2014	66,161		66,161	805,322	8%
Total	**877,618**	**535,610**	**1,413,228**	**4,346,541**	**33%**

Source: Prepared by JICA Study Team, data obtained from the finance department of UETCL

Summary of the power purchase sales situation of UETCL is shown in Table 3-2-1.6.

Table 3-2-1.6 Power Purchase and Sales Situation of UETCL

Item	Unit	2010	2011	2012	2013	2014
1. Total Energy purchase Amount	GWh	2,547	2,599	2,867	3,039	3,203
2. Total Energy Purchase Cost	Million UGX	626,555	830,302	538,777	631,103	638,454
3. Average Purchase Unit Price	UGX / KWh	246.0	319.5	187.9	207.7	199.3
1. Total Energy Sales Amount	GWh	2,413	2,544	2,739	2,933	3,099
2. Total Energy Sales Revenue	Million UGX	318,165	308,944	636,858	719,014	750,328
3. Average Sales Unit Price	UGX / kWh	131.9	121.4	232.5	245.1	242.1

Source: Annual Report of UETCL

2) Asset Situation

The balance sheet of UETCL is shown in Table 3-2-1.7. The accounts receivable in FY 2014 accounted for 33.8%, compared to the previous year sales. The accounts payable accounted for 60.0% of the cost of sales of the previous year as well. These ratios are slightly high. However, as the fee collection rate is nearly 100%, there is no problem recovering the accounts payable. From a management point of view, we can say this is favorable.

In 2014 the contributions by the government for the completed projects and debt from the government were converted into the stock of Uganda Electricity Transmission Company Limited. As a result, the new capital of UETCL was increased by 331,059 million Uganda shillings. In the case of large-scale donor-supported projects, Uganda usually is required to share its cost, which is around 10 to 20%. However, as it is difficult for UETCL to fund such amount from its own internal reserves, it is covered by loans from the government. Then it is converted into equity capital at the time of the project completion. Land acquisition to construct power transmission facility is done with the government funds. The ownership of land is transferred to UETCL (equity capital) at the time of completion. The procedure flow is that if each times a large-scale investment projects of UETCL is steadily carried out, it will contribute to the assets situation of UETCL to gradually become stronger. It determines that the status of assets and liabilities in the balance sheet continues to improve.

UETCL does not have capital in its internal reserves to implement large-scale transmission projects one after another. However, this is not the only case of the power sector, but also for other large-scale infrastructure development projects. Therefore the government policy is to utilize low-interest medium- and long-term loan of the World Bank, African Development Bank, and bilateral donors. The remaining part is funded by the Ugandan government.

In such cases, it is important to secure adequate cash flow to return the loans, by collecting the fee. For that, as written in the third-term business plans of UETCL, it is inevitable to build the revenue structure to fully recover the costs. NDP II predicts that the annual growth rate of power demand would be 10% in the future. If the power demand grows as expected, and the supply is expanded, the overall scale of the power business will be huge. In that case it is difficult to respond such growth unless the full market mechanism is in place.

Table 3-2-1.7 Balance Sheet of UETCL

Unit: Million UGX

	2010	2011	2012	2013	2014
ASSETS					
Non-current assets					
Property, plant & equipment	270,859	304,681	346,097	427,737	777,662
Prepaid operating lease rentals	30	29	27	26	19,671
Intangible assets	2,513	2,150	2,026	1,640	1,479
Deferred tax	-	-	1,415	7,034	-
	273,402	**306,860**	**349,565**	**436,437**	**798,812**
Current assets					
Income tax recoverable	6,348	6,849	-	-	2,256
Inventories	4,467	4,046	7,862	9,789	11,589
Trade and other receivables	217,915	402,225	295,790	284,547	243,224
Cash and bank balances	38,577	10,375	61,987	112,391	313,383
Fixed deposit	12,696	12,000	-	-	-
	280,002	**435,495**	**365,639**	**406,727**	**570,452**
Total assets	**553,405**	**742,355**	**715,204**	**843,164**	**1,369,264**
EQUITY AND LIABILITIES					
Equity					
Share capital	57,548	57,548	57,548	57,548	57,548
Share capital pending allotment	-	-	-	-	331,059
Asset revaluation surplus	-	-	-	-	105,460
Accumulated (losses)	-32,373	-66,546	-66,591	-41,149	-24,825
	25,175	**-8,998**	**-9,043**	**16,399**	**469,242**
Non-current liabilities					
Deferred tax	26,722	12,085	-	-	43,816
Contributions by Government of Uganda	41,004	46,372	86,002	122,955	209,743
Capital Gaines	-	-	-	-	55,470
Borrowings	196,461	227,832	198,447	227,450	236,139
	264,187	**286,289**	**284,449**	**350,405**	**545,168**
Current liabilities					
Current income tax payable	-	-	3,471	2,388	-
Borrowings	44,148	55,702	107,247	135,765	-
Trade and other payables	218,406	407,958	327,437	336,347	352,891
Employee benefit obligations	1,488	1,404	1,643	1,860	1,963
	264,043	**465,064**	**439,798**	**476,360**	**354,854**
Total equity and liabilities	**553,405**	**742,355**	**715,204**	**843,164**	**1,369,264**

Source: Annual Report of Uganda Electricity Transmission Company Limited

3) Statement of Cash Flows

The cash flow situation of UETCL is shown in Table 3-2-1.8. The cash outflows by investment activities have been supplemented with cash inflow from financial activities. Generally speaking, for power transmission business, purchase of assets such as expansion of transmission facilities, etc. is necessary. Temporarily cash can be short if it relies on cash obtained from the power transmission business such as BST revenue, etc. This shortage of case is compensated by the government and loan from the donors.

Table 3-2-1.8 Statement of Cash Flows of UETCL

Unit: Million UGX

	2010	2011	2012	2013	2014
Cash generated from (used in) operations	20,190	18,370	79,045	22,463	115,796
Income tax paid	-294	-502	-3,182	-1,083	-2,253
Cash flows from operating activities	**19,896**	**17,869**	**75,863**	**21,380**	**113,543**
Investing activities					
Purchase of Property, plant & equipment	-52,154	-42,184	-53,187	-95,431	-233,078
Purchase of intangible assets	-28	-	-118	-	-240
Purchase of leasehold land	-	-	-	-	-3,763
Proceeds from disposal of Property, plant & equipment	133	10	3	-	139
Net cash flows (used in) investment activities	**-52,049**	**-42,174**	**-53,302**	**-95,431**	**-236,942**
Financing activities					
Government contributions received	15,434	5,368	989	36,954	25,150
Loans received	54,448	37,439	39,630	32,932	-
Interest on long-term loan	-	-	-	24,591	-
Capital grants received	-	-	-	-	24,025
Proceeds from loans	-	-	-	-	166,543
Movement in related parties and short term credit	15,944	5,486	-	-	-
Net cash flow from financing activities	**85,826**	**48,293**	**40,619**	**94,477**	**215,718**
Net increase in cash and bank balances	**53,673**	**23,987**	**63,180**	**20,426**	-
Movement in cash and bank balances					
At start of year	35,462	51,273	22,375	61,987	-
Increase during the year	53,673	23,987	63,180	20,426	-
Effect of exchange rate changes	-37,863	-52,885	-23,568	29,978	-
Net in cash and cash equivalents					92,319
Cash and cash equivalents at 1 January					246,081
Foreign exchenge (loss)/gain					-25,017
At end of year	**51,273**	**22,375**	**61,987**	**112,391**	**313,383**

Source: Annual Report of Uganda Electricity Transmission Company Limited

4) Financial Accounting Indicators

The main financial accounting indicators are shown in Table 3-2-1.9. In FY 2013, the equity ratio is somewhat low. For this reason, the financial leverage and the fixed ratio are high. By allocating the large amount of stock in FY 2014, it financial soundness and stability were increased. The profitability and financial stability can be highly evaluated.

ROA（Return On Assets）ratio was 3.0% in FY 2013 and 1.3% in FY 2014. Although they are not very high, UETCL ensures stable profitability. Just as a benchmark, the average of total capital profit rate of Japanese companies has remained at about 0% to 3%. In the case of Ghana, where electrification rate is growing faster than other Sub-Saharan African countries, the total capital profit rate of Ghana Transmission Company steadily increased to 0.7% in 2014, from 2.6% in 2013, and 4.1% in 2012.

As a large amount of equity capital was allocated, return on equity drastically dropped from about 155.1% in FY 2013 to about 3.5% in FY 2014. However, the financial stability has increased by enhancement of equity capital. As a result, the fixed ratio was reduced from 2661.4% in FY 2013 to 172.4% in FY 2014, and the capital adequacy ratio significantly rose from 1.9% in FY 2013 to 37.5% FY 2014, which can be said that it indicates the growing financial soundness of implementing this project.

Table 3-2-1.9 Financial Accounting Indicators of UETCL

Main financial accounting indicator		2013	2014
ROA（Return On Assets）	= current net income / gross assets	3.02%	1.30%
ROE (Return On Equity)	= current net income / owned capital	155.14%	3.48%
Profit margin on sales	= current net income / net sales	3.54%	2.18%
Total asset turnover	= net sales / gross assets	85.28%	59.94%
Financial leverage	= gross capital / owned capital	5141.56%	266.76%
Current ratio	= current assets / current liabilities	85.38%	124.80%
Capital adequacy ratio	= owned capital / gross capital	1.94%	37.49%
The fixed ratio	= fixed assets / owned capital	2661.36%	172.38%

Source: Annual Report of Uganda Electricity Transmission Company Limited

(3) Operation and maintenance capability

Although UETCL is facing difficulties from the funding of large-scale capital investment such as this project, it has been able to maintain the stable operation of the national power grid. From this fact, it can be said that UETCL's technical level is adequate when it comes to operation of the grid system.

This project involves relatively new technology such as gas insulated switchgear, mobile substation equipment, high-temperature low-sag conductor, etc. Although these technologies are different from existing switchgear and other operation system, it does not significantly exceed current equipment and O&M technology applied in Uganda so far.

Thus, as for the transfer of technology relating to the operation and maintenance of these facilities, the capacity of the Ugandan side should not be a problem if manufacturers carry out reliably technology transfer regarding characteristics, features and specifications of each equipment.

In addition, expansionary development of the transmission facilities is conducted in accordance with the integrated planning. If the incremental capacity planning and the investment planning are done in accordance with the integrated planning manner, it seems that there is no problem concerning the budget allocation because the operation and maintenance costs are also recovered by the electricity tariff revenue.

3-2-2 Trend of Power Demand

(1) Balance of Electric Power Demand and Supply

Table 3-2-2.1 shows the trend of power supply-demand balance table of Uganda from 2008 to 2014. The total electric power supply of Uganda has reached 3,235 GWh in 2014. Among the total, 3,203 GWh is provided by the domestic generators, the share accounted for 99.0% of the total electric power supply. Hydro power has become a main resource in domestic generation mix, where the share has accounted for 90.6% of the total generation. The remained 9.4% is provided by diesel/heavy oil generator and cogeneration[1] are using bagasse[2]. Even though the amount is small, Uganda has imported 29 GWh from Kenya and 4 GWh from Rwanda.

In electricity demand block, the total electric power sale in domestic final sector is 2,303 GWh in 2014, which accounts to 71.2% in demand block. Power transmission and distribution loss is 783 GWh in the same year, and accounting for 25.3% of total demand block. According to UETCL, the company's power transmission loss is 3.3%. Distribution losses are in fairly high level to be 22.0%. Electric power has been exported to 4 countries Kenya, Tanzania, Rwanda and Democratic Republic of Congo in total amount 139 GWh in year 2014, where the amount is accounting for 4.3% of the total demand block.

Table 3-2-2.1 Power Supply-Demand Balance Table of Uganda (2008 - 2014) (GWh)

Items	2008	2009	2010	2011	2012	2013	2014	Compound Annual Growth Rate (%) 2014/2008
Electricity Supply								
1. Total domestic generation	2,088	2,265	2,456	2,578	2,829	2,993	3,203	7.4
Combustible fuels	621	985	1,109	1,018	369	127	302	-11.3
Hydro	1,467	1,280	1,347	1,560	2,460	2,866	2,901	12.0
2. Imports	41	25	29	39	35	46	33	-3.7
3. Total supply (1.+2.)	2,129	2,290	2,485	2,617	2,864	3,039	3,235	7.2
Electricity Demand								
1. Power plant own use	8	8	9	10	10	10	10	3.8
2. Losses	772	776	790	808	830	849	783	0.2
3. Final comsumption by sector	1,282	1,407	1,641	1,747	1,956	2,117	2,303	10.3
Industry	772	830	975	1,129	1,262	1,372	1464	11.3
Households	328	364	420	400	473	482	547	8.9
Commercials	180	210	244	217	219	262	290	8.3
Street lights	2	2	2	1	1	2	2	-0.4
4. Domestic demand (1.+2.+3.)	2,062	2,191	2,440	2,565	2,796	2,977	3,097	7.0
5. Exports	67	99	45	52	68	62	139	12.9
6. Total demand (4.+5.)	2,129	2,290	2,485	2,617	2,864	3,039	3,235	7.2

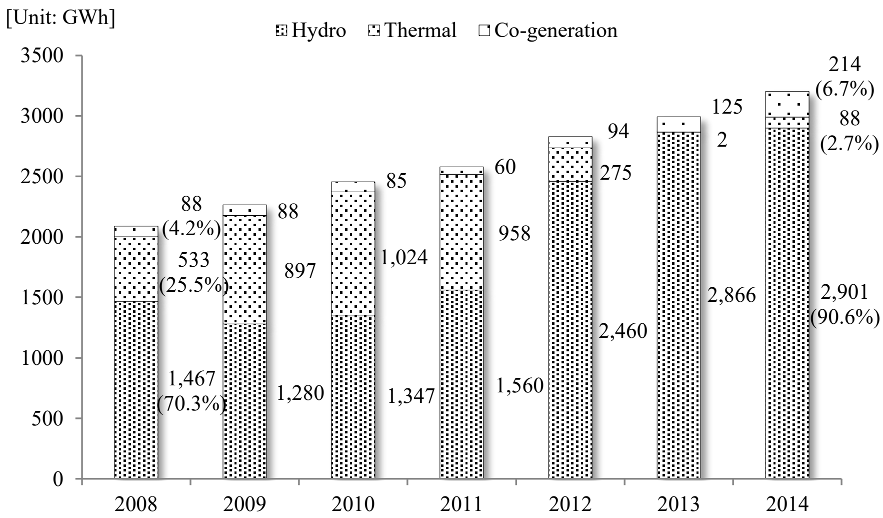
Source: Electricity Supply: United Nation Statistics Division “Energy Balances and Electricity Profiles”, Electricity Demand: UETCL “Annual Power System Report 2008~2014”

[1] Electricity and heat supply system is commonly referred to as cogeneration systems. Because the system can supply electricity and heat (or hot water) at the same time and increase the energy efficiency, most of the sugar factories have been introduced this system on their processing where need a lot of steam.

[2] Two sugar refineries (Kakira Sugar Works (51 MW) and Kinyara Sugar Works (7.5 MW)) have power generation facilities in Uganda. The power generation equipment’s are using the pomace as a fuel discharged from the sugar mill. The pomace is commonly referred to as bagasse.

(2) Electric Power Generation

Electric power generation amount of Uganda has reached 3,203 GWh in 2014, increased by 7.0% compared to the previous year. Figure 3-2-2.1 shows the trend of electricity generation in Uganda from 2008 to 2014. The average annual growth rate in the same period has reached to 7.4 %. Power generation mix in 2014 is divided by hydropower (90.6%), thermal power (diesel and heavy fuel oil) 2.7% and cogeneration (bagasse) 6.7%. Electric power generation by diesel and heavy fuel oil has decreased rapidly since 2011, and only generated 2 GWh electricity in 2013. One the reason is the soaring of international oil price since 2008 has increased the cost of generation by diesel and heavy fuel oil. On top of that, the completion of Bujagali hydro power station has substituted the power generation by thermal. Current generating capacity of an existing diesel and heavy fuel oil is held as a reserve facility for the corresponding emergency.

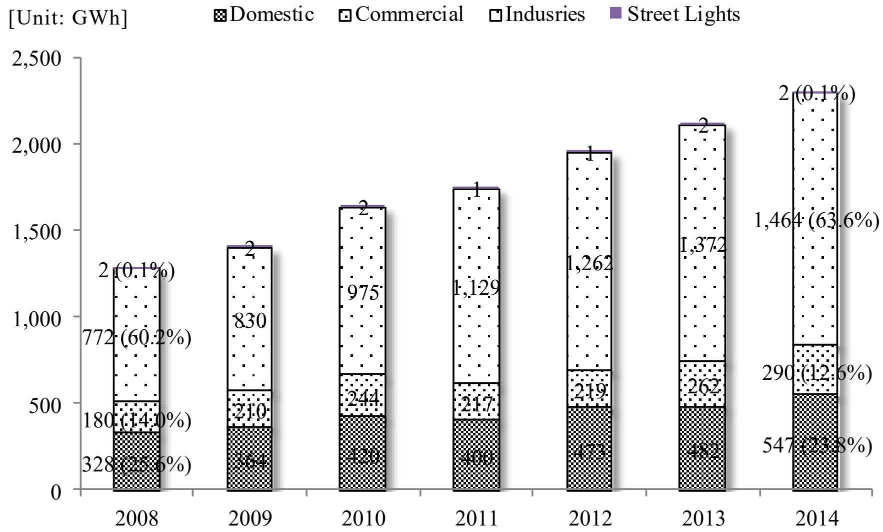


Source: "Annual Power System Report 2008~2014", Uganda Electricity Transmission Company Limited

Figure 3-2-2.1 Trend of Electricity Generation in Uganda (2008 - 2014)

(3) Electric Power Sale

As shows in Figure 3-2-2.2, electric power sales of Uganda are growing rapidly in the past six years from 2008 to 2014. Compared to 2008, the electricity sales in year 2014 have increased to 2,303 GWh at an average annual rate of 10.3%. This amount increase nearly double in the same period. Electric power demand is increasing in recent years of high economic growth by the active private consumption and the inflation rate is stable at around 5%. Particularly expanded significantly growth of electricity demand in the industrial sector, the average annual growth rate of the same period has reached 11.3%.



Source: "Annual Power System Report 2008~2014", Uganda Electricity Transmission Company Limited

Figure 3-2-2.2 Trend of Electricity Sale by Sector in Uganda (2008 - 2014)

When we look at the structure of electric power consumption by sector, the share of electric power consumption in industrial sector has reached to 63.6% in 2014, the share has increased 3.3 points compared to 2008. Electric power consumption for residential sector and commercial sector has dropped 1.8 points and 1.4 point in the same period. Almost 70% of electric power consumption is consumed in Kampala Metropolitan area, of which 63.6% is consumed in the industrial sector. Industrial sector will keep continue to lead the overall power demand in Uganda until the expansion of rural electrification has increasing to reach the high ratio[3].

The distribution grid in Uganda is divided to 14 grids across the country at the end of 2014. Including the Uganda Electricity Distribution Company Limited (UEDCL), they are 7 distribution companies operate in Uganda. UEDCL has 5 regional grid but all the grid are operate by UMEME. UMEME is the largest power distribution company in Uganda by electricity sales 2,277 GWh in 2014. The electric power sales volume of approximately 98.8% in the share is distributed by UMEME. For the other 5 distribution companies are a regional grid, and the selling power mainly in the residential sector. West Nile Rural Electrification Company (WENRECO) is an independent grid operator by a private company until now, but according to their plans, WENRECO is trying to interconnection to the grid of UMEME in order to improve the stability of the grid in end of 2015. WENRECO was founded as a private company to generate and supplies power in eight districts of northern Arua regional in 2003. The company also operates a 1.5 MW generator (heavy fuel oil) and Nyakak I (3.5 MW) hydro power plant.

[3] Uganda's electrification rate in 2013 is 13%, and in the planning of UETCL to raise to 31% by 2030.

Table 3-2-2.2 Trend of Electricity Sale by Distribution Company (2008 - 2014)

	UMEME	FERDSULT	PADER ABIM	BUNDIBUGYO	KILEMBE	WENRECO	Total Sale
2008	1,278	0	0	0	0	4	1,282
2009	1,401	4	0	0	0	2	1,407
2010	1,628	7	0	0	2	5	1,641
2011	1,732	10	0	1	2	3	1,747
2012	1,937	12	0	1	2	3	1,956
2013	2,092	13	1	1	3	7	2,117
2014	2,277	14	2	2	3	7	2,304

FERDSLT: Ferdsult Engineering Services
PADER ABIM: Pader Abim Community Multipurpose Electric Cooperative Society Limited
BUNDIBUGYO: Bundibugyo Energy Co-operative Society
KILEMBE: Kilembe Investments Limited
WENRECO: Westnile Rural Electrification Company
Source: "Annual Power System Report 2008~2014", Uganda Electricity Transmission Company Limited

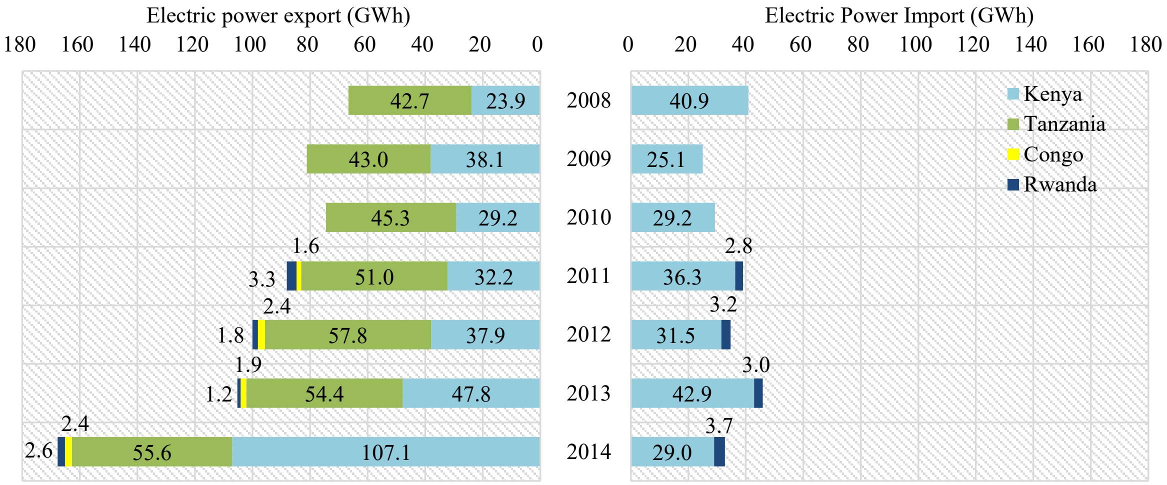
(4) Current Performance and Future Plan of Electric Power Export and Import

The power trade of Uganda has been promoted as an activities of Eastern Africa Power Pool (EAPP)[4], at the same time the promotion of power export as a means of earning foreign currency for Uganda. Uganda will become one of the important power exporters in East Africa base on its 1,822 GWh power export plan by 2030. In end of the year 2014, Tanzania and Kenya is the two countries where the power system grid has connected to Uganda's grid, there have been consolidation of small-scale distribution grid in the part of the border region between Rwanda and Congo. Electric power export to Tanzania is through the Masaka Substation located in southern part of Uganda by 132 kV transmission line where approximately 85 km to the Bukoba Substation in northern Tanzania. On the other hand, the electric power trade between Uganda and Kenya is through Tororo Substation in most western part in Uganda to Lessos Substation in Kenya by 132 kV transmission line about 27 km distance.

Figure3-2-2.3 shows the trend of electric power trade in Uganda with the neighboring countries. Basically, Uganda imports and exports electric power to Kenya through the power grid. In 2014, Uganda has exported 107.1 GWh to Kenya and import 29.0 GWh electricity from Kenya. Electric power export to Kenya is not necessarily constant, the total amount will determine by domestic power supply and demand balance. In 2014, electricity exports to Kenya has recorded highest and reached to 78.1 GWh. In particular electric power export to Tanzania is kept about 50 GWh annually, in 2014 the performance has reached 55.7 GWh.

[4] Eastern Africa Power Pool (EAPP) is a regional cooperation organization intended to promote the linkage of the electricity market in the region. EAPP was established in 2005 by seven countries Burundi, Democratic Republic of the Congo, Egypt, Ethiopia, Kenya, Rwanda and Sudan. Tanzania joined in March 2010, Libya in February 2011, Uganda joined as a new member in December 2012.

Only a small amount of electric power is exported to Rwanda and Democratic Republic of Congo start from 2011, the amount of about 1.2 to 3.3 GWh are exported. In the case of Rwanda and Congo, electricity is providing to the village along the border but not consolidated in the power system connected between the countries.



Source: "Annual Power System Report 2008~2014", Uganda Electricity Transmission Company Limited

Figure 3-2-2.3 Trend of Electric Power Trade in Uganda (2008 - 2014)

Uganda has joined EAPP in December 2012, and currently the country is trying to promote the construction of the international system interconnection between the five member countries [5]. Specifically UETCL will conclude the selling contract with neighboring five member countries of the power company.

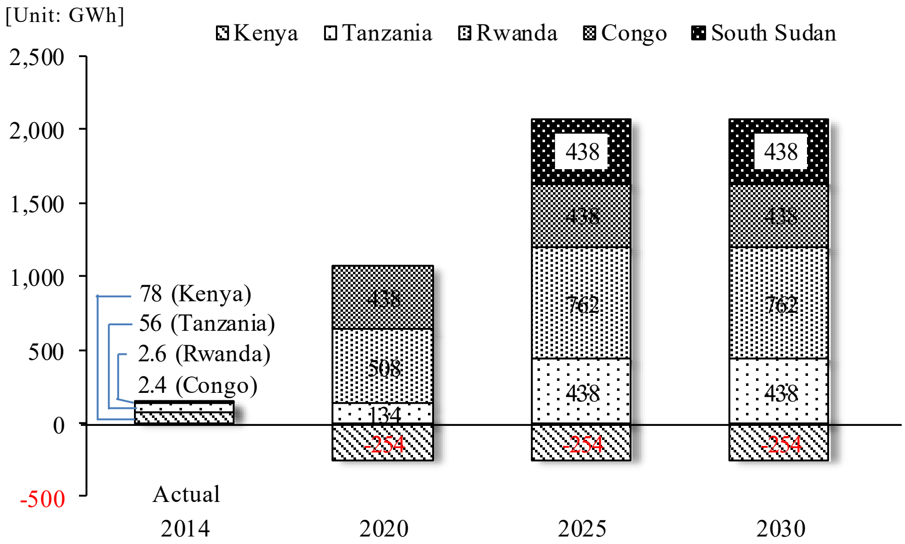
According to the UETCL plan, Uganda will import 254 GWh from Kenya after 2015 by annually, while exporting the same amount to Rwanda[6]. Kenya and Rwanda is concluded an electric power trading agreement at the beginning of 2015 to export amount 254 GWh from Kenya to Rwanda. UETCL play a role on consignment the same amount electric power from Kenya to Rwanda. On the other hand, Uganda also have their own plan to export electric power amount 254 GWh annually to Rwanda beginning in 2019, and will pull up to further 254 GWh in 2023 become total 762 GWh (included the amount from Kenya).

Electric power export to Tanzania is target to reach 438 GWh by 2022 from the current export levels. On the other hand, UETCL is planning to export the amount 438 GWh each year to Democratic Republic of Congo in 2020, and South Sudan in 2022. Ultimately, electric power export of Uganda in 2030 will reach to 1,822 GWh annually. Figure 3-2-

[5] Currently, the 220 kV international transmission line under construction between Kenya and Rwanda is based on the "Nile Equatorial Lakes Subsidiary Action Program (NELSAP）. The expansion in some section will be upgrade to 400 kV in the future.

[6] In end of year 2015, the construction of transmission line between Kenya and Rwanda has not completed yet.

2.4 shows the Uganda power import and export plan.



Source: Uganda Electricity Transmission Company Limited

Figure 3-2-2.4 Electric Power Trade Planning for Uganda (2014 - 2030)

(5) Electric Power Demand in Each Region in Uganda

Uganda is divided into 4 regions called central region, eastern region, western region and northern region. Central region is composed of Kampala City and 23 districts surrounding Kampala. Kampala city is a center of political, economic and culture for Uganda, and this area continues to expand as metropolitan by the progress in economic development in recent years. Currently, construction of four industrial parks (Luzira, Mukono, Iganga, and Namanve South) is being in progress in the eastern part of the Kampala metropolitan area, thus power demand in the industrial sector continues to increase in accordance with the construction of the industrial park in the future.

Electric power demand of central region has reached to 359 MW in 2014, it was 5.2% of the increase by 341 MW of 2013. Electric power demand of the central region is accounted for more than 70% of the total power demand of Uganda. About 70% of the electric power consumption is consumed by industrial sector, and the remaining nearly 30% is consumed in the residential sector and commercial sector. Most of Uganda's manufacturing is concentrated in the central region, especially the metal processing industry are located in the eastern part of Kampala.

According to the population census results by Uganda government in 2014, Kampala City has a population of 1.52 million and form by 418 thousand households. However, when we look at central region, the population has reached to 9.58 million by 2.32 million households. Population growth rate in the metropolitan area is expanding at an annual average of 3.0% by 1990, the potential of the electric power demand in the residential sector is high, and commercial sector is also expected to expand in the future high growth rate on electric power demand[7].

In the eastern region, the electrification has expanded based on the wayside of transmission line from two hydro power plants (Kiira Nalubale and Bujagali) to Kampala metropolitan area. Especially in Jinja area, many manufacturing industries are located. In 2014 the electric power demand of eastern region has reached to 60 MW and accounting for 12.0% of total electric power demand in the country. The annually increase has become 1.7% when compared to 59 MW in 2013. But this growth rate is the lowest in the four regions.

In the western region, the electric power demand of the industrial sector is not high, most of the electric power demand is leading by residential sector. The electric power demand in year 2014 has reached to 55 MW and 17.0% increase from the previous year. The development of the transmission line to system interconnection with Tanzania, Congo and Rwanda in western region has increased the electrification area in the region. The power export activity has become the indirectly factor to increase the electrification along the transmission line.

Northern region has consumed 25 MW electric power in 2014. However, the growth rate in the region of the power demand is the most high across the country. The annual increase rate in 2014 is 38.9% from 18 MW in 2013. After the Gulu substation and Arua substation have been completed, the electric power demand will increase remarkable in near future[8].

As stated in chapter 1, the area covered by Greater Kampala Metropolitan Area is described as the Kampala metropolitan area which consists of Kampala city and the neighboring districts of Mukono, Wakiso and Mpigi Substations and transmission lines to be constructed under the project except for Bujagali Substation will be located in this area. However, the demand forecast is conducted with the consideration that these substations to be constructed by the project will cover the whole central area.

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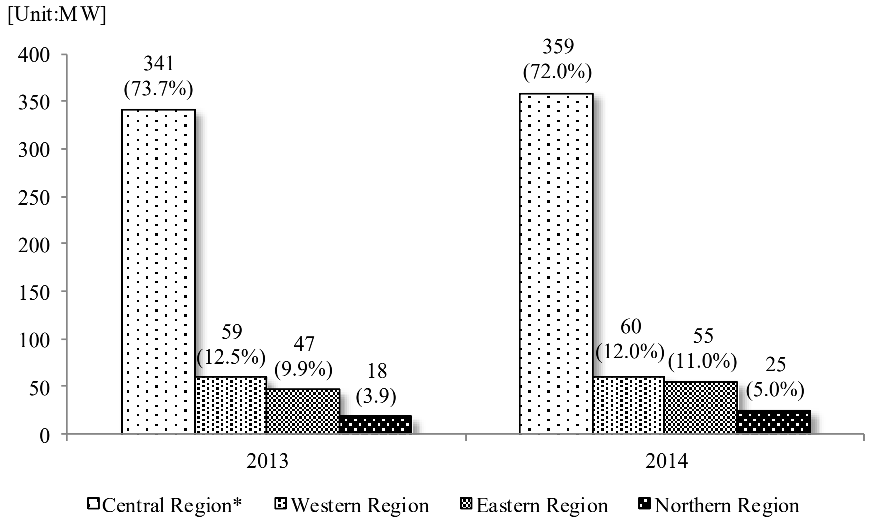
[7] In this section, the power demand of the residential sector of the country was estimated to increase at an annual average of 3.3%, and the commercial sector increase to 4.2% in 2030. For more information see Table 4-1-2.5 Uganda power demand forecast result (2013 to 2030) in Chapter 4.

[8] In the north of Lira substation, the Gulu substation and Arua substation has completed and start to operate in end of 2015



Note: * Composed by Kampala City and 23 Districts.
Source: "System Operation Data 2014", Uganda Electricity Transmission Company Limited

Figure 3-2-2.5 Electric Power Demand in Kampala Metropolitan (2013 - 2014)

3-2-3 Electricity Tariff System

As for electricity tariffs system and the electricity charges in Uganda important issues are discussed in the section of the financial analysis and economic evaluation which come later in this report. The section below is summary and analysis.

(1) Tariff System

There are three types of electricity charges; the fees to purchase power from the generators, fees the distributors pay to the transmission company, and the tariff the final users pay to the distribution companies. Electricity Regulatory Authority (ERA) authorizes all of these fees. The approval is provided at the time of issuance of a license for operation. Each fee is basically determined based on the required operation costs. The price of generator is based on the operating costs of power generation. The price of transmission is based on the operating costs of the transmission and purchase of electricity. The price of distribution is based on the operating costs of power distribution and purchase cost of electricity.

To revise the fee, each power company calculates the costs by applying a predetermined formula, and submits the results to ERA. Then, ERA gives authorization after the assessment.

At present, there is a systematic mechanism to revise the price every quarter, reflecting the cost changes. This is a system to respond to changes in rapid manner.

As described earlier, power sector in Uganda is three-layer structure consisting of power generation, transmission and distribution and the fee structure also reflects at this structure. The three types of tariff are; (A) the rates that power generation companies sell to UETCL (in terms of the financial analysis for UETCL, fee to be directly connected to the electricity purchase cost); (B) the wholesale rate of UETCL to the distribution companies (in terms of the financial analysis for UETCL, the revenue to support the management fee); and (C) the final consumer rate that power distribution companies sell to consumers (the rates which is strongly related to the economic evaluation of this project). As mentioned above, this level of rates are related to the financial analysis and economic evaluation. While (A) and (B) are related to the financial balance of the UETCL, the final consumer price, (C), relates to the benefits of the economic evaluation.

Overviews of the current state of electricity charges at each three layer are explained below.

1) Final User Price

The prices for general households are shown in Table 3-2-3.1. They are slightly different across distribution companies. In the case of UMEME, the largest power distribution company, in the third quarter of FY 2015 the prices have been 558.4UGX / kWh (about 0.153 USD / kWh considering 1 USD = 3650 UGX, and same calculation is used for the followings). By adding the 18% value-added tax (VAT), the final consumers pay 658.9 UGX / kWh, (about 0.180 USD / kWh, Value Added Tax VAT 18% inclusive) which is roughly the same price as electricity charges in Japan.

It should be noted that, in the future, cost cut efforts and price reduction based on full recovery of the cost is the major challenge for power sector including power generation companies, power transmission companies, and power distribution companies throughout the entire company. As described below, the tariff level is set according to the types of customers such as general household, commercial, small-scale industry, and large-scale industry. Looking at the second quarter of 2015, the power distribution company UMEME set the price for general households as 1.0, commercial as 0.911, small-scale industry as 0.865, and large-scale industry as 0.588 respectively. The policy has been set by considering the difference between the supply cost of small customers and large customers. This fee disparity is within the allowable range, taking into account the cost difference, of large customers and general customers.

As described later, the power sales volume in 2014 for large-scale industry was 46.3%, general households were 23.9%, small and medium-sized industries was 17.0%, and commercial was 12.7%. It is worth noting that the price for the large-scale industrial was slightly raised, and in return the price for general household and commercial were lowed. However, international competitiveness of industry also must be taken into consideration.

Table 3-2-3.1 shows the change of price for general households as a result of quarterly review. Looking at the UMEME's price transition, from 2005 to 2006 it was roughly between 200 to 300 UGX / kWh. From 2007 to 2009, it was fixed at 426 UGX / kWh. From 2010 to 2011 it fell to 385.6 UGX / kWh. In the period of 2012 to 2015, it was between 500 and 550 UGX / kWh. Then it greatly increased in the first quarter of 2016. It should be noted that whether it is going to change appropriately flexible in setting prices with the future cost.

Table 3-2-3.1 General Residential Tariff by Power Distribution Companies

Unit: UGX / kWh

Year	Quarter	Umeme	WENRECO	FERDSULT	KIL	BECS	PADER ABIM
2005	Q4	212.5					
2006	Q1	216.9					
2006	Q2	298.2					
2006	Q3	298.2					
2006	Q4	426.1	263.3				
2007	Q1	426.1	244.0				
2007	Q2	426.1	232.0	426.1			
2007	Q3	426.1	246.0	426.1	400.6		
2007	Q4	426.1	251.0	426.1	400.6		
2008	Q1	426.1	274.0	426.1	400.6		
2008	Q2	426.1	353.0	426.1	400.6		
2008	Q3	426.1	360.0	426.1	400.6		
2008	Q4	426.1	360.0	426.1	400.6		
2009	Q1	426.1	360.0	426.1	400.6		
2009	Q2	426.1	360.0	426.1	400.6		
2009	Q3	426.1	360.0	426.1	400.6		
2009	Q4	426.1	360.0	426.1	400.6		
2010	Q1	385.6	360.0	426.1	400.6		
2010	Q2	385.6	360.0	426.1	400.6		
2010	Q3	385.6	360.0	426.1	400.6		
2010	Q4	385.6	360.0	426.1	400.6		
2011	Q1	385.6	360.0	426.1	400.6	400.0	400.0
2011	Q2	385.6	360.0	426.1	400.6	400.0	400.0
2011	Q3	385.6	360.0	426.1	400.6	400.0	400.0
2011	Q4	385.6	360.0	426.1	400.6	400.0	400.0
2012	Q1	524.5	360.0	426.1	400.6	400.0	400.0
2012	Q2	524.5	360.0	512.2	400.6	400.0	400.0
2012	Q3	524.5	360.0	512.2	400.6	400.0	400.0
2012	Q4	524.5	360.0	512.2	509.1	467.4	400.0
2013	Q1	524.5	360.0	512.2	509.1	515.5	400.0
2013	Q2	524.5	360.0	512.2	509.1	515.5	400.0
2013	Q3	524.5	440.4	512.2	509.1	515.5	400.0
2013	Q4	524.5	440.4	512.2	509.1	515.5	498.6
2014	Q1	520.6	440.4	512.2	509.1	515.5	498.6
2014	Q2	517.3	506.5	512.2	517.3	515.5	498.6
2014	Q3	518.0	505.4	511.9	517.3	515.5	561.6
2014	Q4	518.7	514.1	511.9	517.3	515.5	561.6
2015	Q1	531.5	529.3	511.9	517.3	515.5	524.9
2015	Q2	544.9	541.5	511.9	517.3	515.5	561.6
2015	Q3	558.4	557.0	511.9	517.3	515.5	561.6

KEY:
UMEME - Umeme Limited
WENERECO - West Nile Rural Electrification Company
FERDSULT - Ferdsult Engineering Services Limited
KIL - Kilembe Investments Ltd
BECS - Bundibugyo Electricity Co-operative Society
PADER ABIM - Pader Abim Community Multipurpose Electricity Cooperative Society
KRECS - Kyegegwa Rural Electricity Co-operative Society
NOTE:
For companies where data is missing, implies they had not been licensed.

Source: Prepared based on the statistics of Electricity Regulatory Authority website

The commercial electricity tariff is shown in Table 3-2-3.2. There are some differences among the power distribution companies. Except PADER ABIM, the price is set to be lower than domestic one. In the case of UMEME, the largest power distribution company, the latest price is 508.6 UGX / kWh, about 0.139 USD / kWh. By adding the 18% value-added tax (VAT), the end-users pay 600.1 UGX / kWh, about 0.164 USD / kWh.

Table 3-2-3.2 Commercial Tariff by Power Distribution Companies

Unit: UGX / kWh

Year	Quarter	Umeme	WENRECO	FERDSULT	KIL	BECS	PADER ABIM	KRECS
2005	Q4	204.4						
2006	Q1	208.6						
2006	Q2	286.8						
2006	Q3	286.8						
2006	Q4	398.8	301.8					
2007	Q1	398.8	280					
2007	Q2	398.8	266	388				
2007	Q3	398.8	282	388	400.6			
2007	Q4	398.8	288	388	400.6			
2008	Q1	398.8	314	388	400.6			
2008	Q2	398.8	404	388	400.6			
2008	Q3	398.8	412	388	400.6			
2008	Q4	398.8	413	388	400.6			
2009	Q1	398.8	413	388	400.6			
2009	Q2	398.8	413	388	400.6			
2009	Q3	398.8	413	388	400.6			
2009	Q4	398.8	413	388	400.6			
2010	Q1	358.6	413	388	400.6			
2010	Q2	358.6	413	388	400.6			
2010	Q3	358.6	420	388	400.6			
2010	Q4	358.6	420	388	400.6			
2011	Q1	358.6	420	388	400.6	375	375	
2011	Q2	358.6	420	388	400.6	375	375	
2011	Q3	358.6	420	388	400.6	375	375	
2011	Q4	358.6	420	388	400.6	375	375	
2012	Q1	487.6	420	388	400.6	375	375	
2012	Q2	487.6	420	479.8	400.6	375	375	
2012	Q3	487.6	420	479.8	400.6	375	375	
2012	Q4	487.6	420	479.8	400.8	375	375	
2013	Q1	487.6	420	479.8	400.8	375	375	
2013	Q2	487.6	420	479.8	400.8	375	375	
2013	Q3	487.6	433.6	479.8	400.8	375	392.9	
2013	Q4	487.6	433.6	479.8	400.8	375	392.9	
2014	Q1	474.4	433.6	479.8	400.8	375	392.9	448.4
2014	Q2	471.1	477	479.8	400.8	479.7	532.6	448.4
2014	Q3	471.8	475.9	477.2	400.8	479.7	532.6	448.4
2014	Q4	472.5	484.4	477.2	400.8	479.7	532.6	448.4
2015	Q1	484.6	498.5	477.2	400.8	479.7	532.6	448.4
2015	Q2	496.3	509.9	477.2	400.8	479.7	532.6	448.4
2015	Q3	508.6	524.6	477.2	400.8	479.7	532.6	448.4

Source: Prepared based on the statistics of Electricity Regulatory Authority website

Comparing the Table 3-2-3.2 and Table 3-2-3.1, the change of fee for commercial sector and general households show similar trends.

The tariff for small and medium-sized industries (here, the small and medium-sized industries are defined as taking power at low voltage 415 V, with maximum demand of up to 500 kVA) is shown in Table 3-2-3.3 by distribution companies. There are some differences across the distribution companies. The price is set lower than the commercial rates due to political consideration. Looking at UMEME, the largest power distribution company, the latest price is 471.6 UGX / kWh, about 0.129 USD / kWh. By adding the 18% value-added tax (VAT), the final consumers pay 556.5 UGX / kWh, which is 0.152 USD / kWh.

Table 3-2-3.3 Tariff for Small and Medium-sized Industry by Power Distribution Companies

Unit: UGX / kWh

Year	Quarter	Umeme	WENRECO	FERDSULT	KRECS
2005	Q3	178.9	0	0	0
2005	Q4	178.9	0	0	0
2006	Q1	190.2	0	0	0
2006	Q2	261.5	0	0	0
2006	Q3	261.5	0	0	0
2006	Q4	369.7	301.8	0	0
2007	Q1	369.7	280	0	0
2007	Q2	369.7	266	288	0
2007	Q3	369.7	282	288	0
2007	Q4	369.7	288	288	0
2008	Q1	369.7	314	288	0
2008	Q2	369.7	404	288	0
2008	Q3	369.7	412	288	0
2008	Q4	369.7	412	288	0
2009	Q1	369.7	413	288	0
2009	Q2	369.7	413	288	0
2009	Q3	369.7	413	288	0
2009	Q4	369.7	413	288	0
2010	Q1	333.2	413	288	0
2010	Q2	333.2	413	288	0
2010	Q3	333.2	420	288	0
2010	Q4	333.2	420	288	0
2011	Q1	333.2	420	288	0
2011	Q2	333.2	420	288	0
2011	Q3	333.2	420	288	0
2011	Q4	333.2	420	288	0
2012	Q1	458.9	420	288	0
2012	Q2	458.9	420	341.6	0
2012	Q3	458.9	420	341.6	0
2012	Q4	458.9	420	341.6	0
2013	Q1	458.9	420	341.6	0
2013	Q2	458.9	420	341.6	0
2013	Q3	458.9	433.6	341.6	0
2013	Q4	458.9	433.6	341.6	0
2014	Q1	452	433.6	341.6	0
2014	Q2	448.7	477	341.6	0
2014	Q3	449.4	475.9	453.6	524.9
2014	Q4	450.1	484.2	453.6	524.9
2015	Q1	461.6			
2015	Q2	471.6			

Source: Prepared based on the statistics of Electricity Regulatory Authority website

Table 3-2-3.4 shows the tariff for large industry (High voltage 11 kV or maximum demand 500 kVA - 10,000 kVA in 33 kV) by distribution companies. There are some differences across the power distribution company. The price of UMEME Inc. and

FERDSULT are set to be lower than one for small and medium-sized industries. In the case of UMEME, the largest power distribution company, the latest price is 328.7 UGGX / kWh, about 0.090 USD / kWh. Adding the 18% value-added tax (VAT) the end-users pay 387.9 UGX / kWh, about 0.106 USD / kWh.

Table 3-2-3.4 Tariff for Large Industry Tariff by Power Distribution Companies

Unit: UGX / kWh

Year	Quarter	Umeme	WENRECO	FERDSULT
2005	Q4	71.9	0	0
2006	Q1	76.4	0	0
2006	Q2	120.8	0	0
2006	Q3	120.8	0	0
2006	Q4	187.2	301.8	0
2007	Q1	187.2	280	0
2007	Q2	187.2	266	288
2007	Q3	187.2	282	288
2007	Q4	187.2	288	288
2008	Q1	187.2	314	288
2008	Q2	187.2	404	288
2008	Q3	187.2	412	288
2008	Q4	187.2	412	288
2009	Q1	187.2	413	288
2009	Q2	187.2	413	288
2009	Q3	187.2	413	288
2009	Q4	187.2	413	288
2010	Q1	184.8	413	288
2010	Q2	184.8	413	288
2010	Q3	184.8	420	288
2010	Q4	184.8	420	288
2011	Q1	184.8	420	288
2011	Q2	184.8	420	288
2011	Q3	184.8	420	288
2011	Q4	184.8	420	288
2012	Q1	312.8	420	288
2012	Q2	312.8	420	341.59
2012	Q3	312.8	420	341.59
2012	Q4	312.8	420	341.59
2013	Q1	312.8	420	341.59
2013	Q2	312.8	420	341.59
2013	Q3	312.8	433.6	341.59
2013	Q4	312.8	433.6	341.59
2014	Q1	310.4	433.6	341.59
2014	Q2	307.1	477	341.59
2014	Q3	307.8	475.9	316.75
2014	Q4	308.5	484.2	316.75
2015	Q1	315.6	498.5	316.75
2015	Q2	320.5	509.92	316.75
2015	Q3	328.7	524.59	316.75

Source: Download from the statistics of Electricity Regulatory Authority website

Looking at the electricity tariff of large-scale industrial shown in Table 3-2-3.4, the tariff seems to be set to be very favorable for the large-scale industry. At the same time, looking at the quarterly transition over time, the price change shows similar trends with other customers (commercial, small and medium-sized industries, and general household).

2) BST Charges of UETCL (Transmission Company) for Distribution Companies

The sales prices of UETCL for the distribution companies are shown in Table 3-2-3.5. The latest average rates are 231.9 UGX / kWh (excluding VAT). UMEME, for example, for domestic end users, the price is 558.4 UGX / kWh (excluding VAT). The difference between the purchase price from the power transmission company and the sales price to the final user is added as operating costs of UMEME.

As described in detail in 3-2-1 (2) financial situation of UETCL, by 2011 average unit sales price to UETCL was less than the power purchase average unit cost from power generation companies which caused backwardation. UETCL has maintained business by receiving subsidy from the government.

As later, since 2012, the average unit purchase price has fallen because of the launch of power supply by Bujagali Energy. At the same time, the average unit sales price has raised. Consequently, UETCL improved autonomy in its management despite of some remaining subsidy. Although the price level of 2014 is sufficient to ensure the autonomous management of the UETCL, large-scale infrastructure investment is still required in the future in order to improve the electrification rate (currently 16 percent). This project is also a large-scale investment projects in that part. On the other hand, distribution companies are able to perform autonomous management with this current price level. Therefore, it can be concluded that the currently price level is appropriate.

Table 3-2-3.5 Sales Price for Distribution Companies

Unit: UGX / kWh

Year	Quarter	Off-peak BST (Ushs/kWh)	Shoulder BST (Ushs/kWh)	Peak BST (Ushs/kWh)	Weighted average BST (Shs/kWh)
2005	Q3	27.8	50.9	68.7	51.3
2005	Q2	27.8	50.9	68.7	51.3
2005	Q3	33.0	60.4	81.5	60.9
2005	Q4	33.0	60.4	81.5	60.9
2006	Q1	33.0	60.4	81.5	60.9
2006	Q2	51.5	94.7	127.9	95.4
2006	Q3	51.5	94.7	127.9	95.4
2006	Q4	240.4	212.7	240.4	226.5
2007	Q1	166.6	195.4	220.8	196.8
2007	Q2	161.9	189.9	214.6	191.3
2007	Q3	156.3	183.4	207.2	184.7
2007	Q4	176.1	206.5	233.4	208.0
2008	Q1	151.1	180.6	204.0	181.3
2008	Q2	140.0	167.3	189.1	168.0
2008	Q3	150.1	179.4	202.7	180.1
2008	Q4	105.2	125.7	142.1	126.2
2009	Q1	167.5	148.3	123.3	145.0
2009	Q2	108.7	130.7	147.7	131.1
2009	Q3	119.7	143.9	162.6	144.3
2009	Q4	126.1	151.5	171.2	152.0
2010	Q1	121.8	146.0	165.0	146.5
2010	Q2	141.4	169.6	191.6	170.1
2010	Q3	129.3	155.0	175.2	155.6
2010	Q4	195.8	173.3	144.5	169.6
2011	Q1	244.2	292.6	330.6	293.6
2011	Q2	257.2	308.1	348.2	309.2
2011	Q3	229.4	229.4	274.8	242.6
2011	Q4	235.1	281.6	318.3	282.6
2012	Q1	170.0	208.0	235.0	208.0
2012	Q2	190.0	232.6	262.8	232.6
2012	Q3	175.9	215.3	243.3	215.3
2012	Q4	213.9	261.9	295.9	261.8
2013	Q1	192.3	228.2	257.9	229.4
2013	Q2	186.1	220.9	249.7	222.1
2013	Q3	198.5	235.6	266.2	236.8
2013	Q4	222.5	264.1	298.4	265.5
2014	Q1	168.0	227.0	272.4	228.0
2014	Q2	168.2	227.2	272.7	228.2
2014	Q3	162.5	219.5	263.4	220.5
2014	Q4	166.3	224.6	269.5	225.6
2015	Q1	165.6	223.2	267.8	224.2
2015	Q2	167.0	225.0	270.1	226.1
2015	Q3	171.2	230.8	276.9	231.9

Remarks: BST (Bulk Sales Tariff) is the price at which UETCL sells power to Umeme and other distribution companies.
Off-peak: Off-peak hours sale prices
Shoulder: Medium time (peak and off-peak) sale prices
Peak: Peak hours sale prices
Source: Download from the statistics of Electricity Regulatory Authority website

3) UETCL Purchas Price from Power Generation Company

The sales prices paid by UETCL to the power generation companies are shown in Table 3-2-3.6. When UETCL purchase power from the generator companies, the contracts are dollar basis. (Note: To be consistent with the above-mentioned various tariffs, the prices are converted into Ugandan Shillings) There are big gaps across generation companies due to their costs. As mentioned above, the most recent 2015 sales price to the distribution companies by UETCL is 231.9 UGX / kWh and there are many companies exceeding this price. Hydroelectric power plants are relatively inexpensive, while thermal power plants are more expensive because of fuel cost.

Eskom and Bujagali have the largest supply share of hydroelectric power. The sales price of Eskom, in comparison with other power generation companies, is very low. Also the supplies by Bujagali-Energy is also less expensive compared to the thermal power plants, hence this structure is formed.

Kiira-Nalubaale, which is operated by Eskom, was built by UK government during the United Kingdom colonial era before the independence of Uganda and transferred to Uganda government after the independent. Although expansion work has been carried out in 1993, as the initial investment cost was low, the cost for Eskom Company is presumably very low.

Bujagali Energy Limited is a special purpose company, established under initiative of the Uganda government to develop the 250 megawatts hydroelectric power plants of Bujagali. Under the contract with the Uganda government, Bujagali Energy Limited owns the power generation plant, and operation of the power plant for 30-years. Bujagali Energy Limited shall transfer the ownership to the Uganda government after 30 years for 1.00 USD. As it is necessary to recover the investment capital related to the constructions in 30 years, hence the cost is higher compared to Eskom Company.

There are some differences in price among power generation companies by reflecting their generation cost. As described in detail in the section 3-2-1 (2) the financial condition of UETCL, as a whole, the average purchase price of Uganda Electricity Transmission Company Limited has fallen since 2012. Autonomous management of the company became possible in 2014. From this fact, the unit purchase price is reasonable.

Table 3-2-3.6 Unit Price that UETCL Buys from the Power Generation Companies

Unit: UGX / kWh

company name	Classification	2011	2012	2013	2014	2015
Eskom	Large-scale hydropower	34.9	23.2	27.0	24.0	40.2
Bujagali Energy			201.2	306.6	307.5	345.1
Kilembe Mines	Mini Hydro	89.0	87.7	82.8	66.7	87.1
KCCL		66.2	66.2	136.9	144.1	180.9
Tronder		352.2	362.0	213.7	225.0	284.6
EMS Mupanga		231.1	231.1	228.2	240.2	301.5
Eco-Power		338.5	209.4	225.0	236.9	297.3
Hydro Max				240.8	253.6	318.3
Aggreko	Thermal power	770.1	780.5			
Electro Max		710.5	858.0	874.6	766.4	661.1
Jakobusen		665.6	781.3	760.5	615.6	598.5
Kakira	Cogeneration	197.3	194.8	199.8	210.4	294.5
Kinyara Sugar		256.7	242.1	205.3	216.2	271.4
KPLC - Kenya imports	Import		658.9	644.2	678.2	615.4
EWASA- Rwanda - import				209.1	220.2	276.4

Note: Aggreko has not been operating since 2013.
Source: Annual Report of Uganda Electricity Transmission Company Limited

4) Export and Import Prices

The export and import prices of electricity as of 2015 are shown in Table 3-2-3.7. The international trade of electricity is dollar-based contract. The trading prices with Rwanda, Tanzania, and the Democratic Republic of Congo are around 10 cents while the trading price with Kenya is as high as around 20 cents. When UETCL both carry out export and import, the export prices and import prices are equivalent. Compared with the price of domestic power generation companies in Uganda, those international trade prices are higher.

Table 3-2-3.7 Power Prices for Export and Import

Unit: US Cents/kWh

Exports	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15
Kenya (KPLC)	21.62	20.81	21.31	19.92	19.75	20.29
Rwanda (REGL)	8.25	8.25	8.25	8.25	8.25	8.25
Tanzania (TANESCO)	9.54	9.54	9.54	9.39	9.39	9.39
DR Congo (SNEL)	10.01	10.01	10.01	9.89	9.89	9.89

Imports	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15
Kenya (KPLC)	21.62	20.81	21.31	19.92	19.75	20.29
Rwanda (REGL)	8.25	8.25	8.25	8.25	8.25	8.25

Source: Annual Report of Uganda Electricity Transmission Company Limited

5) Cost reflective policy related to pricing (cost recovery policy)

ERA carefully monitor tariff levels to not to make it unnecessarily high, Meantime it pays attention that each operator is able to maintain sound management. There is no longer a policy to keep the tariff low using the government subsidies, which was the case earlier. It is only examined whether the price is appropriate for transmission company, distribution companies, generation companies to maintain operation under the market principle. As a basic policy, in accordance with the "Cost Reflective Policy", all the costs are required to be recovered by the fee in order to maintain the operation. In case of dramatic change such as sudden decline of exchange rate, there should be consideration not to drastically affect the price final consumer. However, the cost recovery policy is still the basic principle, and there is policy not to issue subsidy for UETCL. In other words, electricity pricing for the future will be done in a way to realize autonomous management and operation of power generation, transmission and distribution. Inevitably incurred costs are reflected at each step. The basic direction is to operate without the government intervention.

(2) Fee Collection Rate

1) Fee collection rate of UMEME

The fee collection rate of UMEME, the largest power distribution company, has been improved and as shown in Figure 3-2-3.1, in recent years has a surprisingly high collection rate for a developing country. However, since theft portion is included in the distribution loss, those portions can be considered as lurking behind. Strictly speaking, it cannot be said that toll collection is almost completely performed as still there are challenges left to solve. In addition, matters to work towards improvement of fee collection rate of UMEME are as follows.

The methods to increase fee collection rate conducted by UMEME includes the following.

a) Fee collection method

UMEME has recommended and promoted the installation of pre-paid meters. About 30% of consumers are paying the electricity charges in advance. Electricity meters are installed at contractors at the rate of 100%. There is also a method to send the invoices by Social Networking Service (SNS) to mobile phones, in addition to paper-based mail.

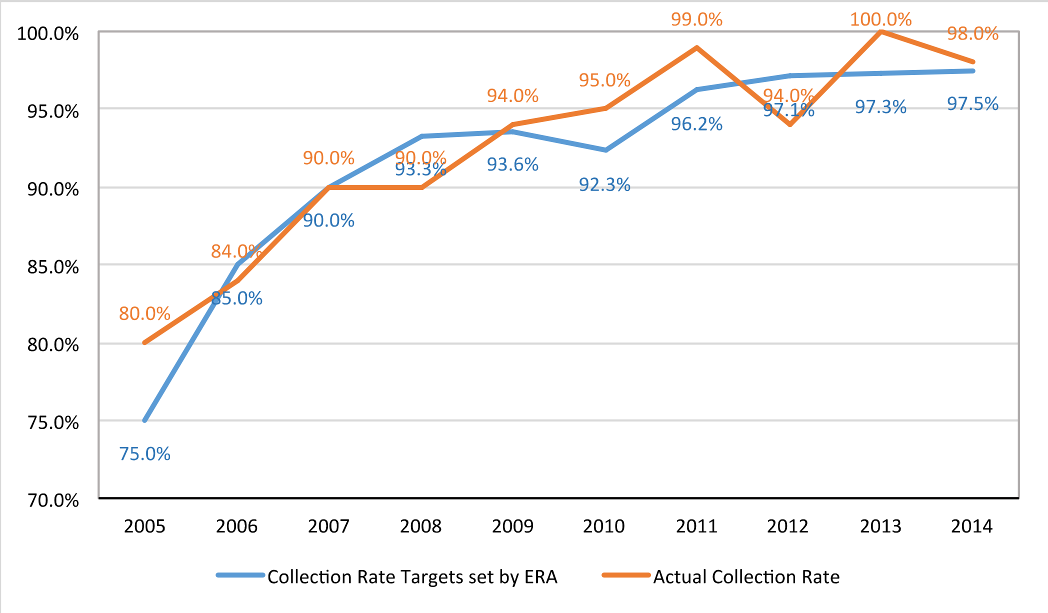
UMEME has enhanced convenience for user through partnership with many banks. In addition through the partnership of mobile phone companies, the users are able to pay by mobile phones. The mechanism of payment by E-money through mobile phone on the spot is developed, when the invoice is sent by SNS.

b) Fee collection rate improvement initiatives

UMEME places a prefecture (region) manager on prefecture base, and implements the fee collection for fixed targets. For example, checking for potential future customers, residences, etc. in houses located in informal residential area, etc. where grid has not been connected yet. Also, the system contacts those who haven't paid yet by SNS with notice of the service suspension date. If the fee is not paid, it is possible to actually suspend the electricity supply.

The system manages databases, such as name, address and telephone number of the customers, and can check for the houses in the region which electricity is not connected. Also it monitors a large number of customers, such as industries in real time by the smart meter, etc.

The fee collection rate has been increased by such strong management. However, power distribution loss is about 20%, which include technical loss and theft (about half of the power distribution losses).



Source: Created from the data downloaded from the statistics of Electricity Regulatory Authority website

Figure 3-2-3.1 Collection Rate Targets and Actual Collection Rate

Table 3-2-3.8 shows the comparison of fee collection rate in Africa, in case of Ghana and Nigeria.

Table 3-2-3.8 Fee Collection Rate Comparisons of African Countries

Country	Fee collection rate (FY 2013 comparison)	Remarks
Uganda	100%	
Ghana	SLT : 94% NSLT : 83% (Collection rate of the distribution sector)	SLT (Special Load Tariff) : The electricity rates in the load of 133A and 100 kVA NSLT(Non-Special Load Tariff) : The electricity rates in the 100 ~ 130A load
Nigeria	Power distribution sector about 70% Power transmission sector about 65% Power generation sector about 60%	

Source: JICA Study Team based on the interviews of Ghana Transmission Corporation, Nigeria Transmission Corporation and report on the toll collection of the ERA

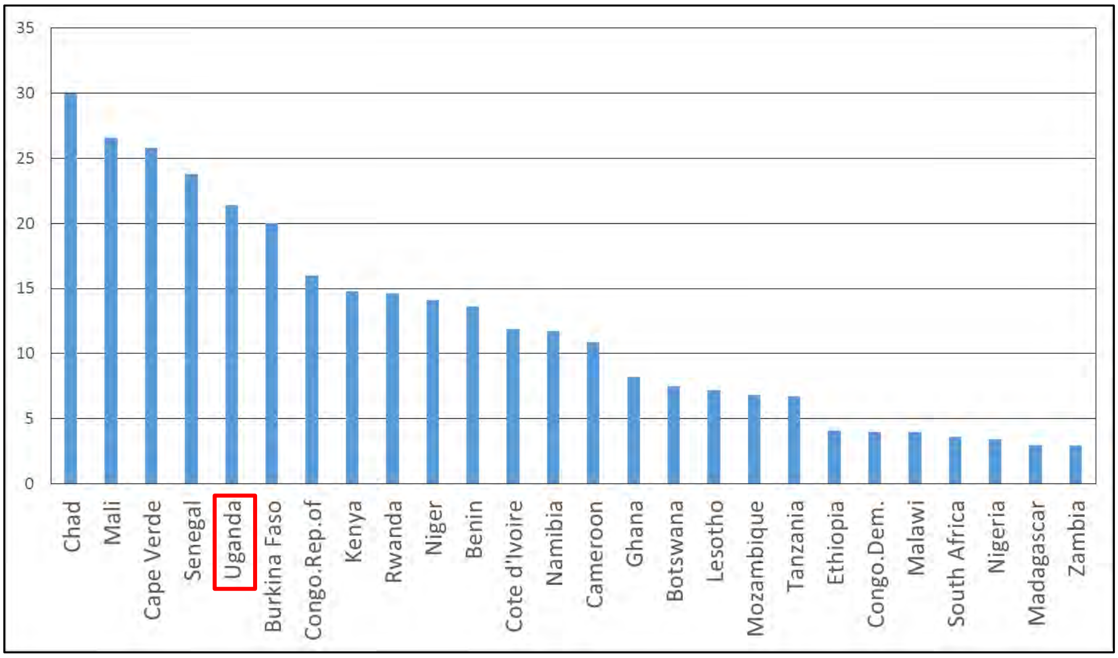
Note 1: By introducing prepaid meters in Ghana, electricity tariff collection rate has improved. Reduction of non-technical losses by consumers patrol program (theft caught), this outcome is in order to improve business operations.

Note 2: Nigeria has taken measures of collection rate improvement, by introducing prepaid meters, and promotion of meter installation to users who do not have meters.

UMEME Company's fee collection rate is higher in comparison to these countries.

2) Price comparison with neighboring countries

Figure 3-2-3.2 shows the price comparison of for residential use (100kWh consumption per month) among African countries. The electricity charge in Uganda is relatively high among African countries.



Source: Africa Infrastructure Country Diagnostic Power Tariff Database

Figure 3-2-3.2 Price Comparison of Countries in Case of 100kWh Consumption in a Month

Table 3-2-3.9 shows the status of cost recovery[9] by the electricity prices (Note: see cost recovery).

This is an indicator to examine to what extent the supply cost of electricity can be recovered by the effective electricity prices. In the table, African countries are listed in the order of their electricity fee. It shows the general tendency when the fee is high, cost recovery rate is also high. Among upper 13 countries, eight countries maintain 1.0 cost recovery rate, which means the cost can be recovered by the electricity charges. 14th or below countries mark less than 1.0, which means that the charges are not at the level to recover the cost.

In the case of Uganda, the cost recovery is 1.00. This means the cost recovery is possible sorely with electricity charges. It indicates that it is possible for the power companies to continue autonomous management. In those countries with low cost recovery rate (less than 1.0), it is impossible to manage companies in sustainable manner only with

[9] Note: Cost recovery. Cost recovery is the measured evaluated as based on the comparison of ratio of the current average effective electricity rate, with the respect to the average cost of power production. In order to evaluate the average cost recovery, the recovery was calculated to be less than 1.00, on the basis of the score that electricity prices to be neutral in the score distribution aspect is 1.00

electricity tariff revenue. Without some kind of support, such as subsidy from the government, the power companies cannot be a sustainably managed.

In the power sector, it is desirable to establish autonomous and independent management without any assistance from the government. With Uganda's tariff level, it seems possible to achieve it. Yet, since the power projects are composed of power generation, transmission and distribution, it is still questionable if the collection of fee at each level is appropriate and if the right balances among them are established. .It seems relatively sufficient profit is ensured by power generation and distribution sector as they have been privatized. However, transmission sector is positioned in-between as a public entity, the difficult position is imposed to fully pursue profit. .

At the same time, considering the fact that the tariff collection rate of Uganda is nearly 100%, the tariff is at sufficiently affordable for users, although the burden might be heavy for the poor. However, as the level of electrification rate is still 16%, the composition suggests that only corporation and high and middle-income households can bear the electricity charges and have access to electricity. Although low-cost electricity tariff has been partly provided for the poor by setting of lifeline prices in the rural electrification operation under the umbrella of REA, UMEME which holds a dominant share in the power distribution sector, requires to consider the long-term benefit of electrification for the entire nation rather than pricing for the poor.

In UMEME's fee structure, which sells electricity to final consumers, fee system to identify the poor does not exist, but there is a fee category called lifeline price. This is the fee category to be applied to the household of the entire common individuals. For example, households that use only a very small amount of electricity, such as mobile phone charging, only slightly use of lighting, etc. benefit from a certain fee system. In other words, the fee for general individual households, which use up to 15 kWh of electricity each month, it is charged only 150 UGX / kWh which is about a quarter of the normal charges 651 UGX / kWh. However, since it is only applied to the use of up to 2,250 UGX (about 0.5 USD) (150 UGX / kWh × 15 kWh = 2,250 kWh), it is believe that this system would not greatly benefit the poor.

On the other hand, in order to spread provide the power supply to the entire nation, it is necessary to continue the efforts of maintaining cost reduction efforts is necessary to lower electricity charges in long-term. In order to achieve the medium to long-term balance of these two perspectives, it is effective to make the power infrastructure by ODA (yen) loan of long-term low interest rates. This project can contribute to strengthen the power supply is considered a necessary project for Uganda.

Table 3-2-3.9 Situation of Cost Recovery by Electricity Charges

Indicator		Tariff level	Cost Recovery
		Effective residential tariff for Level of consumption 100 kWh/month (cents/kWh)	Ratio of average effective tariff to average historic cost
1	Chad	30.0	1.00
2	Mali	26.6	0.79
3	Cape Verde	25.8	1.00
4	Senegal	23.8	1.00
5	Uganda	21.4	1.00
6	Burkina Faso	20.0	1.00
7	Congo.Rep.of	16.0	0.59
8	Kenya	14.8	1.00
9	Rw anda	14.6	0.88
10	Niger	14.1	0.44
11	Benin	13.6	0.72
12	Cote d'Ivoire	11.9	1.00
13	Namibia	11.7	1.00
14	Cameroon	10.9	0.63
15	Ghana	8.2	0.81
16	Botsw ana	7.5	0.54
17	Lesotho	7.2	0.79
18	Mozambique	6.8	0.87
19	Tanzania	6.7	0.52
20	Ethiopia	4.1	0.76
21	Congo.Dem.	4.0	0.80
22	Malaw i	4.0	0.62
23	South Africa	3.6	0.84
24	Nigeria	3.4	0.44
25	Madagascar	3.0	0.93
26	Zambia	2.9	0.44

Source: Africa Infrastructure Country Diagnostic Power Tariff Database

3-2-4 Current Conditions of the Existing Facilities

(1) Substation facilities

1) Substation facilities at Kampala metropolitan area

Primary substations supplying electricity to Kampala metropolitan area are required to have high power supply reliability. Thus, these substations apply 132 kV double-bus arrangement except for Mutundwe Substation and Kawaala Substation where only one unit of power transformer is arranged.

In general, surface of the ground where substation facilities are furnished is covered with gravels at these substations in Kampala metropolitan area. However, some substations such as Kampala North Substation are found that the substation equipment is installed on the ground with soil and grasses. At these substations, prevention of grasses is efficient to avoid any hindrances for the operation and maintenance. Especially, this measure is adequate to be applied nearby equipment to reduce step voltages rise during the earth fault.

In 2014, a large scale accident was happened at Kampala North Substation. Fire occurred at the secondary side of one unit of 132/33 kV transformer and fire was transferred to the bushing of the neighboring 132/33 kV transformers as well. In the end, one unit of power transformer was totally burnt. However, it has not yet been replaced. The distribution line is tentatively connected from the neighboring substations such as Kawanda Substation and Lugogo Substation, and it causes the increase of load to the other substations.

Based on the observation at substations from the view of maintenance condition, silica gel of power transformers remains without being replaced and phase indication board is not attached at busbars at Mutundwe Substation. Furthermore, it is observed that power cables, control cables are not furnished in cable trenches, and thus rain water and soils are flown and small animals entered into the trenches due to faulty cable trench lid.

Document maintenance environment also varies depending on substations. Some substations such as Namanve Substation and Bujagali Substation does not store single line diagram, equipment arrangement diagram etc. In addition, busbar number and/or feeder number stated in the single line diagram does not reflect to the number indicated on the equipment board at Kampala North Substation. The method of storing drawings needs to be reconsidered at substation side.

2) Outline of substation facilities in Kampala metropolitan area

There are five primary substations located at the central area in Kampala: namely, Kawaala Substation, Kampala North Substation, Mutundwe Substation, Lugogo Substation and Queensway Substation (to be completed in 2017). Addition to these five substations, Namanve Substation and Kawanda Substation also supply powers to Kampala metropolitan area and the rest of areas in Central Region. The substation capacities of these 7 primary substations are shown in Table 3-2-4.1. The total substation capacity is 640 MVA (it will increase to 760 MVA after the completion of Queensway Substation.

Table 3-2-4.1 Substation capacities of primary substations at Kampala metropolitan area

No.	Substation / Installed capacity	Voltage (kV)	Capacity	Status
1.	Lugogo Substation	132/11	40 MVA x 2 units	Existing
	160 MVA	132/33	40 MVA x 2 units	Existing
2.	Kampala North Substation	132/33	40 MVA x 2 units	Existing
	160 MVA	132/11	40 MVA x 2 units	Existing
3.	Mutundwe Substation	132/33	40 MVA x 2 units	Existing
		132/33	20 MVA x 1 unit	Under construction
	140 MVA	132/11	20 MVA x 2 units	Existing
4.	Kawaala Substation	132/11	20 MVA x 1 unit	Existing
	20 MVA			
5	Queensway Substation	132/33	(40 MVA x 3 units)	Commissioned in 2017
	(120 MVA)			
6	Namanve Substation	132/33	40 MVA x 3 units	Existing
	120 MVA			
7	Kawanda Substation	132/33	40 MVA x 1 unit	Existing
	40 MVA			
Total installed capacity		-	640 MVA	-

Remark: Total installed capacity includes 20 MVA of emergency transformer under construction at Mutundwe.

Source: JICA Study Team

Four primary substations located at central area of Kampala, except for Queensway Substation, where currently the construction is ongoing. In addition, all the substations in the metropolitan area adopt outdoor type of air insulated switchgear facilities, comprising of 132 kV switchgear and 132/33 kV power transformer and/or 132/11 kV power transformer while Queensway Substation, whose area is quite limited, and Namanve Substation, where the future industrial pollution is assumed, adopted gas insulated switchgears (GIS).

The standard size of power transformer capacity currently used at most of the UETCL substations is 20 MVA and 40 MVA. UETCL select the most appropriate size of the power transformer, based on the present demand and the demand forecast of power distribution area that the substation is in charge of. However, the capacity factor of each substation in Kampala metropolitan area is reaching the full load, as the capacity factor of Kampala North Substation is almost 88% and the factor of Lugogo Substation is about to reach 98%. Furthermore, the capacity factor of Kawanda Substation (40 MVA 132 / 33 kV Power Transformer) has already reached 100%. As these situations show, the current substation capacity of primary substation in the metropolitan area does not fulfill the present power demand. Thus, 20 MVA 132 / 33 kV power transformers are currently under installation at Mutundwe Substation as an emergency substation. Nonetheless, it is observed that UETCL is managing to satisfy the current power demand.

(2) Distribution facilities at Kampala Metropolitan area

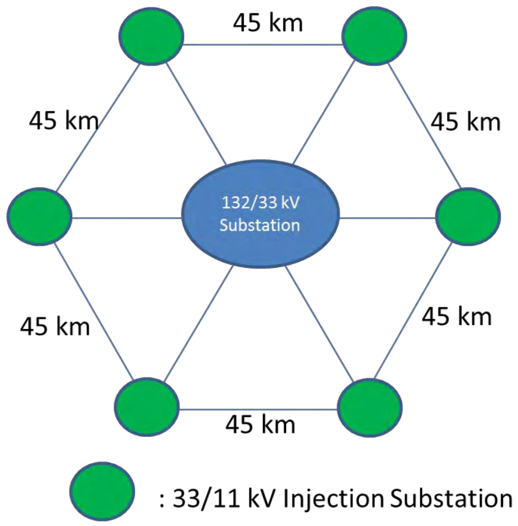
Power supplied by primary substations operated by UETCL is stepped down to either 33 kV or 11 kV. After the former Uganda Electricity Board (UEB) was divided into three entities, Uganda Electricity Generation Company Limited (UEGCL), Uganda Electricity Transmission Company Limited (UETCL) and Uganda Electricity Distribution Company Limited (UEDCL), the power distribution business at Kampala metropolitan area is conducted by UMEME Limited (UMEME) which concluded the concession agreement with UEDCL for the operation and maintenance of the network. UMEME is responsible for the operation and maintenance of 33 kV and 11 kV distribution network and low voltage network. It is also in charge of designing the future distribution network development in line with UETCL activities under the regulation of Electricity Regulatory Authority (ERA).The typical flowchart for UMEME to conduct the new distribution network development is indicated in Table 3-2-4.2.

Table 3-2-4.2 Flowchart for the distribution network development plan and required time at each stage

Order	Contents	Relevant authority	Time required *
1	Designing of the construction of injection substation and distribution feeders	UETCL	12 months
2	Obtaining approval of the construction of new substations and/or distribution network	ERA	6 months
3	Obtaining Environment Impact Assessment (EIA) and Resettlement Action Plan (RAP) (if required)	NEMA	6 months
4	Work implementation	-	6 months

Remark: time required could vary depending on the volume and extent of the work.
Source: Prepared by JICA Study Team based on the discussion with UMEME

In principle, UMEME designs the new injection substations around the primary substations constructed by UETCL. These injection substations will be connected each other to form the distribution network for the realization of stable power supply. This system is called as Wagon-Wheel Model and this idea posits as UMEME's basic policy for the development of new distribution network. Figure 3-2-4.1 illustrates the concept of Wagon-Wheel Model. Each substation is basically connected through 33 kV distribution lines (AAAC 150 mm^2) and the distances among them are primarily 45 km.



Source: UMEME Master Plan (2010)

Figure 3-2-4.1 Concept of the Wagon Wheel Model

Therefore, the construction of primary substations by UETCL is indispensable for UMEME to design the new distribution network development plan. In other words, improper coordination between UETCL and UMEME's future development plans result in malfunctioning of distribution networks.

(3) Transmission

UETCL possesses only overhead transmission lines and the voltage level of the transmission lines is 66 kV and 132kV. The total route length of 132kV transmission lines is about 1,730km and of 66 kV is about 70 km. The total route length of 132 kV and 66 kV is therefore about 1,800 km. (Outline of 132 kV transmission lines is shown at Table 3-2-4.4, Table 3-2-4.5.) The type of supports of transmission liens is steel tower and wooden pole and the type of their insulators is almost glass.

1) Outline of transmission lines in Kampala metropolitan area

The electrical power supplied to Kampala Metropolitan area is generated by hydro power stations located along River Nile. The power is sent through two transmission lines and they are inclined to be overloaded. The transmission line which is designed for 220 kV was constructed in the northern area of the suburb of Kampala Metropolitan area, but the line is still operated as 132 kV line. As the demand of Kampala metropolitan area is expected to increase rapidly, installation of 220 kV transmission lines and reinforcement of 132 kV lines are urgent issues in Kampala Metropolitan area. The outline of transmission lines regarding this project is shown as below.

a) Transmission line between Nalubaale substation, Namanve substation and Kampala North substation

The transmission line was constructed in 1954 when England colonized Uganda, and the route length of the line is 62 km, the voltage is 132 kV (Photo 3-2-4.1). At that time, the type of conductors of the line was ACSR 175 mm^2 and the conductors were configured for 2 circuits, but the type of conductors was changed to two-bundled ACSR 125 mm^2 in 1998 and the bundled conductors were configured for 1 circuit. Since then, the line has been operated as 1 circuit. Namanve Substation was constructed in 2007 between Nalubaale Substation and Kampala North Substation.

JICA Study Team conducted a visual inspection of steel members, tower foundations and insulator assemblies at 6 towers in addition to field survey. The condition of coating of steel members was very good despite the passage of 60 years although there was no sign of painting by UETCL. The result of the thickness of galvanized coating of the line is shown at Table 3-2-4.3 for reference. Mass of galvanized coating on regular members stipulated in Standards for Transmission Tower Design is 550 g/m^2 or more, and when converted it to the thickness, it is approximately 76 μm or more. Therefore it is assumed that the thickness of coating of existing towers is enough. The condition of foundations above the ground is also good and the deterioration by passage has hardly progressed.

Table 3-2-4.3 Average thickness of galvanized coating

Section	Average thickness of galvanized coating [μm]			
	Number of times of measurement	Horizontal member (Inside)	Horizontal member (Outside)	Main leg member (Inside)
Nalubale - Namanve	84.6	106	99.2	110
Namanve - Kampala North	102	106	124	122
Namanve - Kampala North	120	127	125	126
Kampala North - Mutundwe	110	111	145	131
Kampala North - Mutundwe	117	114	106	109

Remark: One tower by each section was selected and the figure on the table shows the average value of five times measurement.

Source: JICA Study Team

Insulators are made of glass and the number of insulators is 9 pieces at a suspension type assembly and 11 pieces at a tension type one. As the result of the visual inspection by binocular, the hardware of insulators keeps good condition and there was no rust on it. And optical line is built up by wrapped fiber-optic cable around the ground wire.

Photo 3-2-4.1 Transmission line between Nalubaale Substation, Namanve Substation and Kampala North Substation

b) Transmission line between Kampala North Substation and Mutundwe Substation

This transmission line was constructed in 1959. The route length is 11.0 km and the operation voltage is 132 kV. The number of circuit is 2. The type of conductors is ACSR 175 mm^2 and the conductors have not been changed since the line commissioned. Seeing the line toward Mutundwe substation from Kampala North substation, the circuit of the left side is operated at 132 kV, but the right side is temporarily operated at 33 kV. From the approximately middle point of the line, the line branches into Kawaala Substation (T-branch) (Photo 3-2-4.2). And optical line is built up by wrapped fiber-optic cable around the ground wire.

JICA Study Team conducted a visual inspection of steel members, tower foundations and insulator assemblies at 8 towers. The condition of coating of steel members was good despite the passage of about 55 years while only one member of a leg close to the ground at one tower was corroded. The defect needs to be fixed. There was no sign of painting by UETCL. The condition of foundations above the ground is also good and the deterioration by passage has not progressed so much. Insulators are made of glass and the number of insulators is 11 to 12 pieces at a suspension type assembly and 10 pieces at a tension type one. As the result of the visual inspection by binocular, the hardware of insulators keeps good condition and there was no rust on it. The T-branch line, which goes into Kawaala Substation from one of the two circuits of No.570 tower, is connected to the gantry of the substation through two wooden poles. The condition of wooden poles was good and there was no corrosion at the part close to the ground. Insulators of the wooden poles are made of glass and the type of the insulator assembly is tension one. The number of insulators is 8.

Photo 3-2-4.2 Transmission line between Kampala North Substation and Mutundwe Substation
(Left: 132 kV wooden poles to Kawaala Right: No.570 tower)

c) Transmission line between Mutundwe Substation and Kabulasoke Substation

This transmission line was constructed in 1963. The route length is 84.7 km and the operation voltage is 132 kV. The number of circuit is 1. The conductors of the line were replaced in 2015 and the type of conductors of the line is now AAAC 200 mm^2. The line consists of wooden poles except the first two supports from Mutundwe Substation are steel towers. Regarding the wooden pole, suspension type consists of 3 poles and tension one consists of 4 poles (Photo 3-2-4.3). Insulators are made of glass and the number of insulators is 8 pieces both a suspension type assembly and a tension type one.

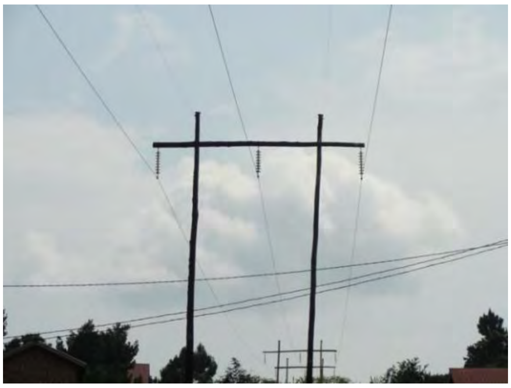


Photo 3-2-4.3 Transmission line between Mutundwe Substation and Kabulasoke Substation
(Left: Suspension type Right: Tension type)

d) Transmission line between Kampala North Substation and Lugogo Substation

This transmission line was constructed in 1997. The route length is 5.3 km and the operation voltage is 132 kV. The number of circuit is 2. The type of conductors is ACSR 175 mm^2 and the conductors have not been changed since the line commissioned. Optical line is built up by Composite Fiber-Optic Ground Wire (OPGW).

JICA Study Team conducted a visual inspection of steel members, tower foundations and insulator assemblies at 6 towers. The condition of coating of steel members was good. The condition of foundations above the ground is also good and the deterioration by passage has not progressed so much.

Insulators are made of glass and the number of insulators is 10 pieces at a suspension type assembly and 11 pieces at a tension type one. As the result of the visual inspection, the hardware of insulators keeps good condition and there was no rust on it.

Photo3-2-4.4 Transmission line between Kampala North Substation and Lugogo Substation

Table 3-2-4.4 Outline of 132 kV transmission lines

From	To	Nominal Voltage (kV)	No. of Circuits	Conductor Type	Line Rating (MVA)	Length (km)	Type	In Service Date	Line Age (Year)
Kampala North	Kawaala	132	1	ACSR 183/42 (Lynx)	79.1	4.4	Steel Tower	1959	54
Lugogo	Kampala North	132	1	ACSR 183/42 (Lynx)	73.2	5.7	Steel Tower	1997	16
Lugogo	Kampala North	132	2	ACSR 183/42 (Lynx)	73.2	5.7	Steel Tower	1997	16
Namanve	Kampala North	132	1	ACSR 125/30 (Twin) (Tiger)	147	56.3	Steel Tower	1954	66
Nalubaale	Namanve	132	1	ACSR 125/30 (Twin) (Tiger)	147	12.6	Steel Tower	1954	59
Masaka West	Mbarara North	132	1	ACSR 300/50 (Goat)	152	130.5	Tower	1995	18
Nalubaale	Lugogo	132	1	ACSR 385/35 (Starling)	180	70.2	Steel Tower	1998	15
Nalubaale	Lugogo	132	2	ACSR 385/35 (Starling)	180	70.2	Steel Tower	1998	15
Lugogo	Mutundwe	132	1	ACSR 385/35 (Starling)	180	10.2	Steel Tower	1997	16
Lugogo	Mutundwe	132	2	ACSR 385/35 (Starling)	180	10.2	Steel Tower	2008	5
Tororo	Opuyo	132	1	ACSR 125/30 (Tiger)	63.1	119.5	Wooden	1963	50
Opuyo	Lira	132	1	ACSR 125/30 (Tiger)	63.1	141.2	Wooden	1963	50
Mutundwe	Kabulasoke	132	1	ACSR 125/30 (Tiger)	63.1	84.7	Wooden	1963	50
Kabulasoke	Nkonge	132	1	ACSR 125/30 (Tiger)	63.1	78.5	Wooden	1963	50
Nkonge	Nkenda	132	1	ACSR 125/30 (Tiger)	63.1	138.9	Wooden	1963	50
Nkonge	Kahungye	132	1	ACSR 125/30 (Tiger)	63.1	100.0	Wooden	1963	50
Kahungye	Nkenda	132	1	ACSR 125/30 (Tiger)	63.1	38.9	Wooden	1963	50
Kabulasoke	Masaka West	132	1	ACSR 125/30 (Tiger)	63.1	60.0	Wooden	1963	50
Tororo	Lessos (Kenya)	132	1	ACSR 125/30 (Tiger)	78	27.0	Steel Tower	1954	59
Tororo	Lessos (Kenya)	132	2	ACSR 125/30 (Tiger)	78	27.0	Steel Tower	1954	59
Masaka West	Bukoba (Tanzania)	132	1	ACSR 125/30 (Tiger)	73.8	84.5	Steel Tower	1994	19
Kawanda	Bujagali	132	1	AAAC 240 (Twin)	205.8	75.0	Steel Tower	2012	1
Kawanda	Bujagali	132	2	AAAC 240 (Twin)	205.8	75.0	Steel Tower	2012	1
Nalubaale (Owen Falls)	Bujagali	132	1	AAAC 240 (Twin)	205.8	8.0	Steel Tower	2012	1
Nalubaale (Owen Falls)	Bujagali	132	2	AAAC 240 (Twin)	205.8	8.0	Steel Tower	2012	1
Tororo	Bujagali	132	1	ACSR 185/30	78	118.0	Steel Tower	1954	59
Tororo	Bujagali	132	2	ACSR 185/30	78	118.0	Steel Tower	1954	59
Mutundwe	Kawanda	132	1	AAAC 240 (Quad)	457	17.0	Steel Tower		
Mutundwe	Kawanda	132	2	AAAC 240 (Quad)	457	17.0	Steel Tower		

Source: Consultancy Services for Namanve South Industrial Park 132 kV TL and Associated 132/33kV S/Ss Power system Analysis Final Report (May 2013)

2) Rules and standards on transmission lines

a) Acquisition and restriction on land

In the case of constructing transmission lines in Uganda, land acquisition and land restriction is required shown as below. The area of land acquisition is called as Corridor and the area of land restriction is called as Right Of Way (ROW).

Corridor for 220 kV: 20 m each from the center of the transmission line, total 40 m.

Corridor for 132 kV: 15 m each from the center of the transmission line, total 30 m.

Table 3-2-4.5 land use limits by voltage class

Voltage class	Distance from the line center
220 kV	20 m (total 40 m)
132 kV	15 m (total 30 m)

ROW for 220 kV and 132 kV: 2.5 m each from the center of the transmission line, total 5.0 m.

b) Restriction on aviation law

In the case of building transmission towers whose height is 60 m or more in Japan, transmission line companies consult with Aviation Bureau and need to install aircraft warning lights on the tower or to paint the towers for daytime obstruction warning based on the aviation law.

According to UETCL, there is no such restriction in the common area far from the airport although there is some restriction of tower height near the airport according to the approach angle of an airplane. In the technical document of a previous transmission line, however, it is stipulated that aviation warning devices whose shape is spherical need to be installed on the ground wires in the vicinity of airfields and on the crossing of main rivers.

c) Restriction on clearance from ground

The clearance between conductors and the ground, overhead lines, trees etc. is stipulated in Technical Standards for Electrical Facility in Japan.

JICA study team asked UETCL of the clearance above mentioned in Uganda and the answer was that there are standards restricting the ground clearances. In the preparatory survey, it is decided to apply examples of previous construction of transmission lines in Uganda in case of the construction of transmission lines or replacement of conductors.

3) Operation and maintenance for existing transmission lines

Maintenance of steel structures is done by Principal Civil Engineer under Manager Planning and Investment. Operation and Maintenance section replaces broken discs, earth wires, and conductors and conducts inspections and checks line clearance.

Operation and Maintenance section conducts the inspection of transmission lines once per year and conducts special inspection when there is an accident. These inspections have been conducted conventionally.

Operation and Maintenance section checks members of towers, foundations, insulators and earth wires etc. and such the contents of the inspection are prepared by them.

Most of the problems on maintenance of transmission lines are vandalism of the members of steel towers and it is handled by Principal Civil Engineer.

According to the UETCL, the number of accidents by the contacts of birds to the lines is less than that of accidents by lightning.

There is a challenge that UETCL doesn’t have engineers who possess the knowledge of maintenance and operation about the high temperature low sag conductor when the conductor is introduced in the near future. To resolve the challenge, education such as technical training during the installation period, and after that the trainee surely need to share the education with other engineers who don’t attend the training.

At this opportunity of the introduction of the conductor, JICA Study Team recommends that UETCL shall revise the maintenance period, the method of transmission lines and the personnel structure of maintenance group, and also shall stipulate them in the UETCL's rules and surely implement the rules.

Chapter 4 Transmission System Plan

4-1 Necessity and Concept of the transmission system Plan

Although purpose of the project is to develop the equipment of the power transmission network in the Kampala metropolitan area, in order to form efficient and effective business, it is necessary to see through transmission system plan of the whole system of the Kampala metropolitan area properly. Since almost all the developments are promoted by the donor assistance in the power sector of the developing countries, and almost all the future plans are uncertain, the transmission system plan are formulated in terms of the medium term (10 to 15 years). From this point of view, UETCL has formulated "Grid Development Plan 2014 - 2030" and will revise it each year.

However, ultra-high voltage system such as 220 kV transmission system is underway to develop in UETCL which is the implementation agency. Since it is still in introduction period, it is indispensable to accumulate technologies for effective use of power system of the Kampala metropolitan area such as ring configuration of the transmission system toward the future. In the preparatory survey, the observation program in Japan was held as part of survey, major engineers of UETCL which is the implementation agency were provided the opportunity to visit central load dispatching center, etc. of electric power company in Japan, and the opportunity to know the current status of the power system which secures reliability and quality of power supply in Japan.

It is important to formulate transmission system plan based on the medium- and long-term power demand forecast by utilizing a methodology of econometrics, in accord with the fact that target area for the plan is in the Kampala metropolitan area which is the one of the largest consumption area, verifying issues in the existing "Grid Development Plan 2014 - 2030" prior to the selection of the components of the Project, taking a panoramic perspective of the whole transmission system in the Kampala metropolitan area such as formulation of ultra-high voltage ring system in the future transmission system in the Kampala metropolitan area,

4-1-1 Issues in the Grid Development Plan 2014 - 2030 of UETCL

Uganda Government, in response to recent increase of power demand due to economic growth, has formulated Hydropower Development Plan, and is advancing power development with a focus on hydro power plants in order to enhance power generation capacity. On the other hand, in the Kampala metropolitan area where is center of demand, since enhancement of transmission and substation equipment are not in progress, power outages occur frequently. In response to this situation, there are problems to enhance transmission and substation equipment in Kampala metropolitan area in the light of power demand in the future.

Uganda Electricity Transmission Company Limited (UETCL) has compiled "Grid Development Plan 2014 - 2030" in 2014, and has formulated power system equipment plan of all across Uganda from the point of view of medium and long term. UETCL has revised the Grid Development Plan which has 15 years' plan every one to two years.

In the Grid Development Plan, enhancement of transmission and substation capacity in Kampala metropolitan area is the high most priority project. Major plans for construction of power system equipment in Kampala metropolitan area is completed until 2020.

The priority projects which are described in "Grid Development Plan 2014 - 2030" in the Kampala metropolitan area are shown in Table 4-1-1.1. The priority projects are explicitly shown in the Table, but clear vision which takes a panoramic perspective of whole plans such as plan of 220 kV outer ring system outside of the 132 kV internal ring system based on the trend of increasing demand is not described in "Grid Development Plan 2014 - 2030". Therefore, it is not clear if power supply will meet demand in the Kampala metropolitan area which will rapidly increase about from 6% to 7% per year in the future. In addition, since the priority projects in the Table 4-1-1.1 are selected and shown without results such as power flow analysis of each year, diagram of the system configuration in the target year and transformation of power transmission system, there are problems that steps for development cannot be verified. In addition, a plan which is judged premature such as introduction of Static VAR Compensator (SVC) has been formulated.

In selection of the components of the project based on the points mentioned above, it is necessary to select the relevant components for the Japanese Yen Loan Project with forecasting the increase of demand in the future based on trend of the economy, etc., then, formulating transmission system plan in medium term (10 to 15 years) by using the demand forecast as pre-condition, then, analysing power flow in middle years.

Table 4-1-1.1 Project Prioritization

Project	Outline	Current Status	Financing Status
Kawanda Upgrade by 1x40 MVA 132/33kV Tx	Provision of Adequate Capacity at the substation	Tender Documents Prepared	Sourcing Financing for EPC
Kawaala Upgrade to 2x40 MVA 132/33kV	Providing Adequate capacity at the Substation to supply the City	Pre-Feasibility	Sourcing Financing for Feasibility Study and EPC
Mutundwe - Buloba 132 kV Line and Buloba 220/132/33kV Substation	Providing adequate Capacity and reliability to supply the City, Buloba Oil Pipeline Terminal	Pre-Feasibility	Sourcing Financing for Feasibility Study and EPC
Mutundwe - Gaba - Luzira 132 kV Line and Gaba 132/33kV Substation	Providing adequate Capacity and reliability to supply the City and Gaba Water Works	Pre-Feasibility	Sourcing Financing for Feasibility Study and EPC

Source: Grid Development Plan 2014 – 2030

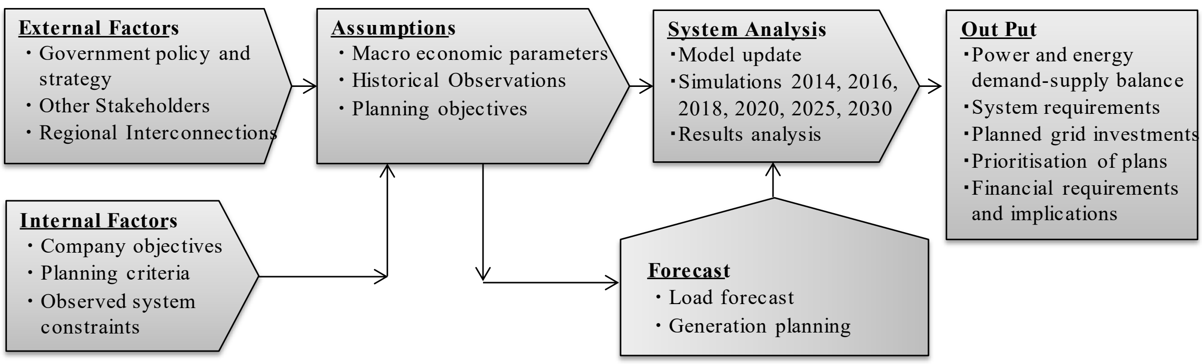
4-1-2 Electric Power Demand Forecast for Uganda and Kampala Metropolitan

(1) Results of the Existing Power Demand Forecast

1) Existing Electric Power Demand Forecast

Existing electric power demand projection of Uganda Electricity Transmission Company Limited (UETCL) is provided by "Grid Development Plan 2014 - 2030" and description by six parts. As shown in Figure 3-1-1.1, three parts of the first half are internal factors (corporate objectives, planning evaluation, and system observation) and external factors (government policies and strategies, stakeholders, and collaboration with local) of UETCL to form the prerequisites. External factors and internal factors from the extracted prerequisites (macro economy, planning goals, the trend of past performance data) is used as an explanatory variable in electric power supply and demand model. Inside the electric power supply and demand model, electric power demand side is performed regression analysis using econometric analysis tool call "E-view", while the electric power supply side is determine by the best power generator mix calculated by using a BID (optimal investment decision) model. Based on these two supply and demand simulation results the "Grid Development Plan 2014 - 2030" of UETCL has been created.

Moreover, four scenarios have been set in the "Grid Development Plan 2013 - 2030". It is, (a) base case, (b) National Development Plan 2010 - 2015 (NDP), (c) 100% electrification in 2035, and (d) 2040 vision. The "Grid Development plan 2013 - 2030" of UETCL has been prepared based on the base case, there is no comparability between the other three scenarios because the assumption is totally difference.



Source: "Grid Development Plan 2014 - 2030", Uganda Electricity Transmission Company Limited

Figure 4-1-2.1 Flow Chart of Electric Power Demand Forecast in "Grid Development Plan 2014 - 2030"

Table 3-1-1.1 shown the assumptions are using in the electric power demand forecast by UETCL. For the population growth rate, during the period 2014 to 2030, it has been fixed at 3.03%. For the economy conditions, GDP growth rate is setting at 8.44% in 2014 - 2015, 8.58% in 2016 - 2020, 8.35% in 2021 - 2025, and 8.17% in 2026 - 2030.

Basically, the GDP growth rate is gradually decreasing every five years after year 2015. This trend is the same configuration that continues to diminishing every five years in the production of commercial sector and industrial sector. However, the level of these growth rates have not been described detailed and no explanation how they apply it.

Table 4-1-2.1 Assumptions for Electric Power Demand Forecasting in "Grid Development Plan 2014 - 2030"

Year	GDP (%)	Commercial Sector (%)	Industrial Sector (%)	Population (%)
2014	8.44	9.3	9.67	3.03
2015	8.44	9.3	9.67	3.03
2016	8.58	9.35	9.52	3.03
2017	8.58	9.35	9.52	3.03
2018	8.58	9.35	9.52	3.03
2019	8.58	9.35	9.52	3.03
2020	8.58	9.35	9.52	3.03
2021	8.35	9.05	9.67	3.03
2022	8.35	9.05	9.67	3.03
2023	8.35	9.05	9.67	3.03
2024	8.35	9.05	9.67	3.03
2025	8.35	9.05	9.67	3.03
2026	8.07	8.85	8.71	3.03
2027	8.07	8.85	8.71	3.03
2028	8.07	8.85	8.71	3.03
2029	8.07	8.85	8.71	3.03
2030	8.07	8.85	8.71	3.03

Source: "Grid Development Plan 2014 - 2030", Uganda Electricity Transmission Company Limited

Based on the above assumptions, the projection results of the electric power demand are shown in Table 4-1-2.2. The total electric power demand of Uganda has increased by annual average of 9.0% from 3,222 GWh in 2014 to 12,857 GWh in 2030. Among the total, domestic electric power demand during the same period is increased at an annual average of 8.2% and power export has expected to expand at an annual average of 23.0%. The system load factor of demand measurement period in “Grid Development Plan 2014 - 2030” is set with 71% in 2014 - 2017, 73% in 2018 - 2020, and 75% in 2021 - 2030. When calculated along this load factor, the domestic electric power demand by load is increase by annual average of 7.9%, the load is increase from 508 MW in 2014 to 1,707 MW in 2030. Transmission loss is assumed that gradually improved from 3.4% in 2014 to 3.0% in 2030 and distribution loss has significantly improved from 20% in 2014 to 14% in 2030

On the other hand, "Grid Development Plan 2014 - 2030” has no detail description about the domestic electric demand by sectoral and regional. In particular, the plan has no detail depiction about the power demand and the demand structure of Kampala

Metropolitan Area. One side, the high target is set to export electric power to neighboring five countries (Tanzania, Kenya, Congo, Rwanda, and South Sudan)[1]. Total electric power export target has been set to 1,642 GWh (250 MW) by 2030, where this amount is accounting for 12.8% of total electricity demand in the same year.

Table 4-1-2.2 Result of Electric Power Demand Forecast in "Grid Development Plan 2014 - 2030"

Year	Domestic Demand (MW)	Export (MW)	Total Demand (MW)	Load Factor (%)	Domestic Demand (GWh)	Export (GWh)	Total Demand (GWh)
2014	508	10	518	71	3,162	60	3,222
2015	548	12	560	71	3,409	74	3,483
2016	653	12	665	71	4,059	77	4,136
2017	708	13	721	71	4,342	80	4,422
2018	771	14	785	73	4,930	90	5,020
2019	838	64	902	73	5,358	410	5,768
2020	915	115	1,030	73	5,851	736	6,587
2021	905	117	1,022	75	5,949	766	6,715
2022	988	220	1,208	75	6,490	1,447	7,937
2023	1,097	270	1,367	75	7,210	1,771	8,981
2024	1,216	220	1,436	75	7,991	1,444	9,435
2025	1,273	250	1,523	75	8,363	1,643	10,006
2026	1,339	250	1,589	75	8,796	1,644	10,440
2027	1,479	250	1,729	75	9,716	1,644	11,360
2028	1,552	250	1,802	75	10,195	1,644	11,839
2029	1,622	250	1,872	75	10,659	1,640	12,299
2030	1,707	250	1,957	75	11,215	1,642	12,857
Compound Annual Growth Rate (%)	7.9	22.6	8.7		8.2	23.0	9.0

Source: "Grid Development Plan 2014 - 2030", Uganda Electricity Transmission Company Limited

2) Issues of Existing Electric Power Demand Forecast

From the hearing of UETCL, although the company has implemented the econometric method on electric power demand forecasting, the calculation is basically base on a linier regression analysis. Based on this estimate of the domestic electric power demand results and the trend of actual load of each substation that UETCL has operated, the load of each substation is forecasted.

There are two major points to be reviewed in electric power demand forecasting of "Grid Development Plan 2014 - 2030".

- Regression equation for each estimation subject is individually effected, they are not mutually irrelevant or the function is no clear.
- Consumption structure of domestic electric power demand has not been presented. Electric power consumption of Uganda has not been performed by sectoral consumption structure and actual consumption analysis.

[1] In October 2015, Uganda as a consignment to transfer the same amount of electricity imported from Kenya and export to Rwanda. In other words, Kenya has signed an international transactions agreement with Rwanda on power trade, Uganda has become a plan to undertake a consignment business between them.

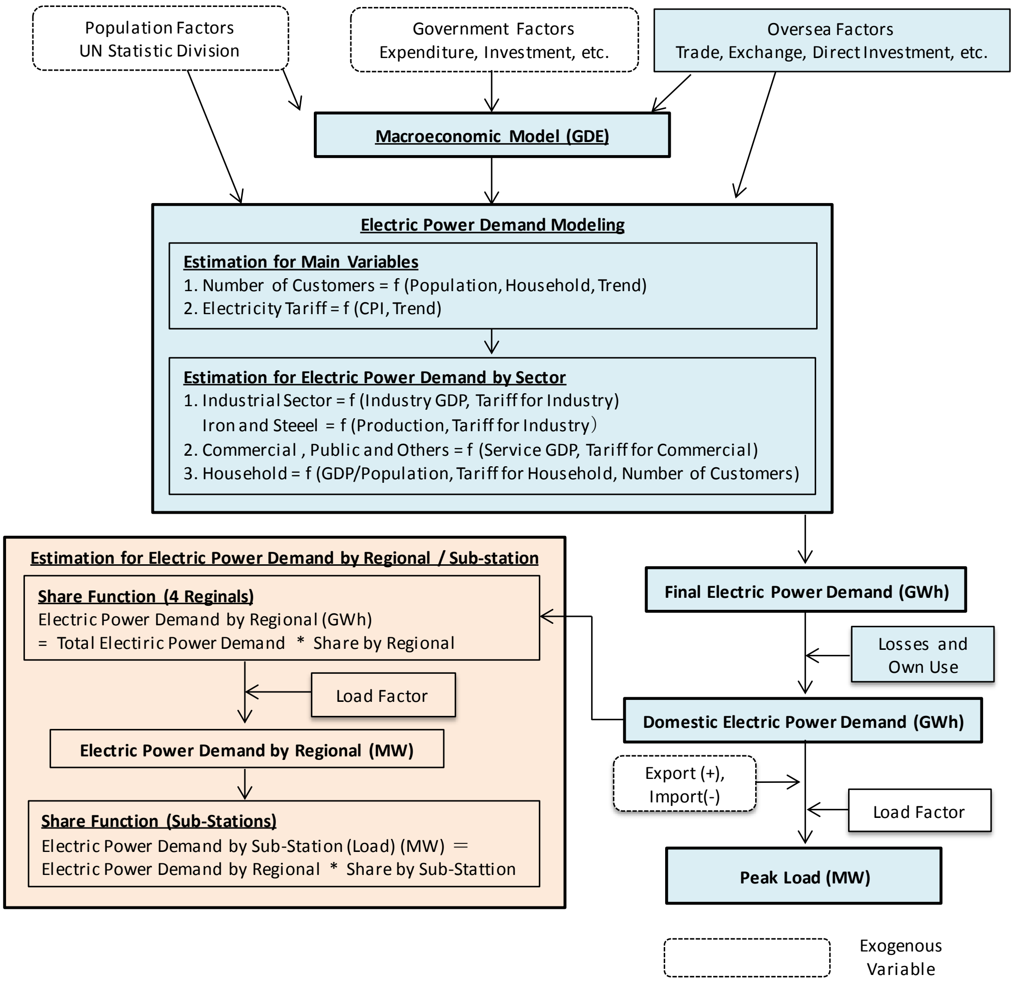
(2) Power Demand Forecast based on Econometric Technique

1) Model Configuration

a) Concept and Structure

To complement the points to be reviewed of the "Grid Development Plan 2014 - 2030", this project is to follow the approach of the econometric model that UETCL is using, the modification is focused on integrate of the economy and the power sector become one structure. In other words, from simple linier regression analysis that conventional UETCL is doing, to assemble a structure by a set of equation where there are related to each other.

The second point is, to introduce the analysis of electric power demand by sectoral. In the current data, the electric power consumption of Uganda is divided mainly industrial, residential (household), and commercial (including the public). This model incorporates the consumption structure in the model to calculate the sectoral future electric power demand. Overall model structure, it is shown in Figure 4-1-2.2.



Source: JICA survey team

Figure 4-1-2.2 Structure of the Model

This electric power demand forecast model is composed of three parts call "Macroeconomic Sub-model", "Electric Power Demand Sub-model", and "Electric Power Estimating by Region and Substation". Through simulation analysis based on the three divisions, we predict the Uganda of electricity demand until 2030. This integrated quantitative analysis model can be easily verified the correlation between macro-economic indicators and electric power demand. Furthermore, there is an advantage which is easy to explain the changes of electric power demand in future by economic activity.

a. Macro-Economy Sub-model

In this study, the national economic growth of Uganda will analyze by Macroeconomic Sub-Model base on gross domestic expenditures (GDE)[2]. Macroeconomic sub-model has constructed by explanation variables like private consumption, government expenditure (investment), import and export to simulate the gross domestic expenditure (GDE). The main characteristic of the model is trade factors (trade partner's economy change, foreign exchange), government factors (government investment, interest rates, etc.) and population factors is given as an external variable to simulated the economic growth rate and production by each sector.

Industrial structure analysis on present point is difficult without the input-output (IO) tables, but the GDP by sector is simulated by share function based on the historical industrial sector trends and changes in the structure to estimate the production value by industry sector, commercial sector and service sector.

b. Electric Power Demand Sub-model

The core part of the entire model is the "Electric Power Demand Sub-model". As an explanatory variable indicators has obtained from the "Macro-economic Sub-model such as the GDP by sector, electricity tariff, population, income and number of customers is used to determine the electric power demand by sector in final sector. The sum of final sector electric power demand, loss, own use[3] and net import-export will became the total electric power demand of Uganda. Peak load (MW) can be calculated when multiplying the load factor to the total electric power demand. Power capacity development plan is created base on this peak load.

[2] The principle of the equivalent of three aspects in macro economy, where the gross domestic product (GDP) = gross domestic expenditure (GDE).

[3] It includes the power consumption within the facilities of power station / substation.

c. Electric Power Estimating by Region and Substation

Domestic electricity demand up to 2030, which was calculated based on the electric power demand model (not including exports) will divided it to four regions (central region, eastern region, western region and northern region) and regional electric power demand will calculate base on the substation load is located in the region. Composition ratio of electricity demand for regional or substation is estimated on the basis of past performance trends. Structural changes in regional or substation of electric power demand is considered to be an extension of past structural change.

b) Projection Period and Model Scale

Projection period of this model is 17 years from 2014 to 2030. The model has total 44 equations composed by 30 function equations and 14 definitional equation. All equation in the model will be calculated by simultaneous equations. Historical data is total of 23 years start from 1990 to 2013.

c) Data

Historical data sources of macroeconomic and power sector is based on data from the World Bank and the United Nations statistic Division (UNSTAT) and data sources of electric power by regional and by substation are provided by UETCL. In addition, electricity tariff is provided by Electricity Regulatory Authority (ERA) and number of customer is provided by UMEME.

2) Assumptions

a) Population Factor

Uganda's population is 37.42 million people in the end of 2013. The population has increased by an annual average of 3.4% from 17.53 million people iN-1990 to 2013. Population growth of this period is a marvel, the total amount has increased 2.1 times compared to 1990. This trend is considered to continue in the future, the growth rate of the middle case of population estimation results of the United Nations from 2014 to 2030 is used in this model as an external variable on electric power demand forecasting. According to the population projections result, Uganda population annual growth rate after 2013 is diminishing gradually from 3.2% in 2014 decreased to 2.9% in 2030. Average annual growth rate of the same period has become 2.86%. Uganda's population is projected to reach 61.93 million people in 2030.

Table 4-1-2.3 Population Projection of Uganda (2014 - 2015)

Year	Population (1,000)	Annual Growth Rate (%)
2014	37,783	3.2
2015	39,032	3.3
2016	40,323	3.3
2017	41,653	3.3
2018	43,021	3.3
2019	44,423	3.3
2020	45,856	3.2
2021	47,321	3.2
2022	48,817	3.2
2023	50,345	3.1
2024	51,904	3.1
2025	53,497	3.1
2026	55,121	3.0
2027	56,777	3.0
2028	58,463	3.0
2029	60,181	2.9
2030	61,929	2.9

Sources: "World Population Prospects: The 2015 Revision", Medium fertility variant (2015-20100), United Nation, Population Division, Department of Economic and Social Affairs

b) Oversea Factor

Overseas factors are mainly from economic trends of trading partners, currency exchange rates and international oil prices. International trade balance of Uganda has continued in deficit and trend of expansion. When we look at the trade balance in 2013, compare to the export value 2.83 billion USD, the import value is 5.87 billion USD, and trade deficit is 3.04 billion USD. Uganda is a primary agriculture commodity exporter in coffee, tobacco, cotton and tea. Especially in the case of coffee, 17.7% of exports value is accounted by coffee. On the other hand, oil and petroleum products import in 2013 has accounted for 22.5% of total imports value, the total amount to pay to oil and petroleum products is 1.31 billion USD in the same year. Fluctuations in international oil prices could lead to a significant impact on the economy of this country.

Exchange rate is an important factor to evaluate the domestic energy costs. Especially as oil-importing countries, foreign currencies have been many outflows.

c) Government Policy

Government policy is the most important key factor in this model analysis. In general, fiscal expenditure of the government is a valid macro policy means in order to promote economic growth. In this model, government expenditure and investment as a driver of economic development, it has incorporated as an external variable in the macro-economic sub-model. By sensitive analysis on changing this variable to calculate the government budget introduced amount required to maintain the growth.

3) Simulation Results

a) Macroeconomic

The table below shows the projection results of the macroeconomic model. As described above, government expenditure of Uganda is used as external variable in macroeconomic sub-model, and this variable will keep continue to increase of 14.0% annually until year 2030. Under this fiscal expansion policy, Uganda's economic growth rate can be maintained at an annual average of 7.5%, the production value by sectoral is also increase at an annual average by 6.6% in agriculture sector, 9.4% in industry sector and 7.2% in service sector.

The share of agricultural sector is decreasing trend in the past is expected to continue in the future until 2030. Market share of agriculture has dropped 5.1 points become 20.2% in 2030 compared to 2013. In contrast, the share of the industrial sector has increased from 20.8 percent in 2013 to 24.6% in 2030. Industrial structure of Uganda is begun to shift to gradually industrialization from reliance on traditional agricultural sector.

Table 4-1-2.4 Macro Economy Sub-model Simulation Results of Uganda (2013 - 2030)

Descriptions	Actual (Million Shilling)			Estimating (Million Shilling)			Compound Annual Growth Rate (%)	
	2000	2010	2013	2020	2025	2030	2020/ 2013	2030/ 2013
Real GDP (2010=100)	20,104	40,946	48,422	72,125	107,050	165,555	5.9	7.5
Annual Growth Rate (%)	3.1	5.2	3.3	7.4	8.7	9.4		
GDP by Sector (2010=100)								
Agriculture	8,112	10,732	11,364	17,270	23,507	33,497	6.2	6.6
Industry	3,251	7,424	8,890	16,792	25,669	40,702	9.5	9.4
Services	10,699	22,791	28,168	38,063	57,873	91,356	4.4	7.2
GDP By Sector by Share (%)								
Agriculture	27.5	26.2	25.3	23.9	22.0	20.2		
Industry	21.4	18.1	20.8	23.3	24.0	24.6		
Services	51.1	55.7	54.0	52.8	54.1	55.2		
Total Share	100.0	100.0	100.0	100.0	100.0	100.0		

Source: JICA survey team

b) Electric Power Demand Forecast

The total electric power demand of Uganda has increased by an annual average of 7.8% from 3,000 GWh in 2013 reach to 10,825 GWh in 2030. According to UETCL's electric power export plan, electric power export to neighboring five countries (Tanzania, Kenya, Rwanda, Congo and South Sudan) has plan to increase by annual average of 19.4% in projection period, from 90 GWh in 2013 expanded to 1,822 GWh in 2030. The share of electric power for export is as high as 16.8% from total electric power demand in year 2030. Electric power export also is one of the important export items in order to earn foreign currency for Uganda.

Table 4-1-2.5 Electric Power Demand Forecast Result of Uganda (2013 - 2030)

Descriptions	Actual (GWh)			Estimating (GWh)			Compound Annual Growth Rate (%)	
	2000	2010	2013	2020	2025	2030	2020/ 2013	2030/ 2013
(1) Final Consumption	843	1,521	2,048	3,523	5,051	7,619	8.1	8.0
Industry	407	959	1,335	2,604	3,977	6,305	10.0	9.6
Households	312	364	460	587	676	803	3.5	3.3
Commercial and others	124	198	253	331	398	511	3.9	4.2
(2) Own use*	6	9	10	12	13	15	2.3	2.3
(3) Losses**	461	791	852	1,065	1,217	1,369	3.2	2.8
Percentage of losses (%)	30	33	28	20	15	13		
(4) Domestic Demand (1)+(2)+(3)	1,310	2,321	2,910	4,600	6,282	9,003	6.8	6.9
(5) Export / Import	251	75	90	826	1,822	1,822	37.3	19.4
(6) Total Electric request (4)+(5)	1,561	2,396	3,000	5,426	8,104	10,825	8.8	7.8
Final Consumption by Share (%)	100.0	100.0	100.0	100.0	100.0	100.0		
Industry	48.3	63.1	65.2	73.9	78.7	82.8		
Households	37.0	23.9	22.5	16.7	13.4	10.5		
Commercial and others	14.7	13.0	12.4	9.4	7.9	6.7		

* Power plant own use.
** Including transmission losses (3.5%) and distribution losses (24.5%) in 2013.
Source: JICA survey team

Domestic electric power demand is increase in the annual average of 6.9% in projection period and become 10,825 GWh in 2030. The detail of the electric power consumption in domestic market is divided to final sector 7,619 GWh, transmission and distribution losses 1,369 GWh, he rest of the 15 GWh has become an electric power consumption of the power plant premises. According to the "Grid Development Plan 2014 - 2030", the transmission loss was 3.5% in 2013, this ratio is gradually improving until 2030 to achieve the target up to 3%. On the other hand, although the transmission and distribution loss of 2013 was significantly higher at 28%, when we compare to the transmission and distribution loss in 2008 has reached 34%, transmission and distribution losses of the last five years has been 8 points improvement. According to interviews with UMEME, the company will continue to promote measures to improve future distribution losses reduce up to 14% in 2030. In this model, the results were estimated based on past trends, from the calculation of modeling, it is possible to reduce the distribution loss up to 10% in 2030.

If we look at the electric power demand in the final sector of 2030, the industry sector will be the largest electric power demand sector by the share 82.8% (6,305

GWh) of final electricity demand. Annual average growth rate of industry sector in the projection period is 9.6% and this is the highest among these sectors. Industrial sector is the sector that has led the growth of electric power demand since 2000, and the share of electricity demand for industry sector in the final sector also continues to expand. In recent years, industrial park, which has been promoted with the assistance by the Chinese government has been under construction plan in several places on the west side of the Kampala Metropolitan Area. Electricity demand in the industrial sector will increase in the future.

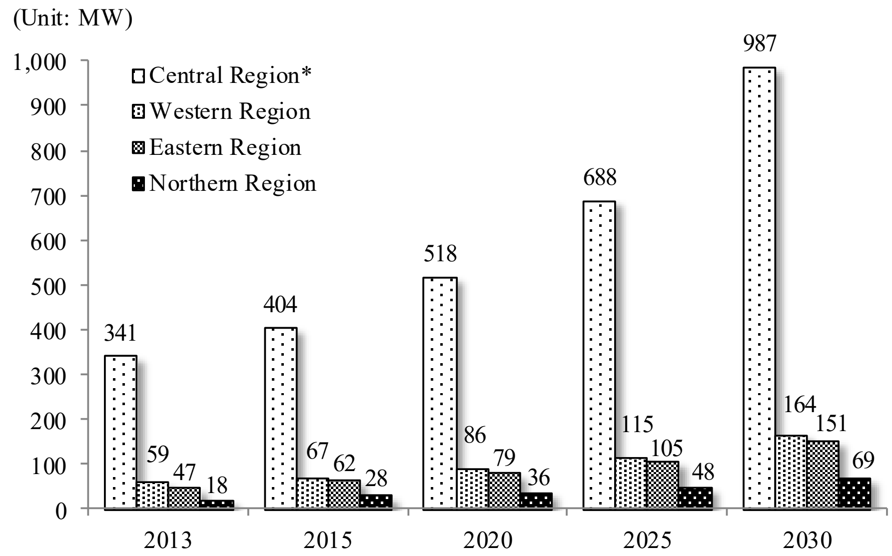
c) Electric Power Demand Forecast of Kampala Metropolitan and by Regions

As shown in Figure 3-1-1.3, the electric power demand of the Kampala Metropolitan Area (central region) has reached to 341 MW in 2013, and this amount will expanded to 987 MW in 2030 by annual average growth rate of 6.4%. Metallurgical industry is it driving the increase in electric power demand of Kampala metropolitan area. Metallurgy industry is located in Kampala Metropolitan Area and adjacent with eastern region Jinja. Metallurgy industry has consumed about 60% of electricity demand in the industrial sector of the country. In addition, Luzira industrial park, Mukono industrial park, Iganga industrial park and Namanve South industrial park are located at the eastern of Kampala Metropolitan Area has been promoted. Increase in electric power demand in the future of Kampala Metropolitan Area is going to continue to grow around the industrial sector.

In the eastern region, there are two hydro power plants Owen Fall and Bujagali. The wayside of the transmission line that is directed to the Kampala Metropolitan Area from the two hydro power plants is a region that is progressing electrification. Especially in the vicinity of the Jinja, many of the manufacturing industry are gathered in this location. In this model, it was projected the electric power demand of eastern region will reached 164 MW in 2030. It has increased by an annual average of 6.2% from 59 MW in 2013.

In the western region, Uganda is border with Tanzania, Democratic Republic of Congo and Rwanda. Transmission line to export electric power to the three countries has been established. In the western region, the demand for electric power in the industrial sector is not very high. Residential sector is the sector where mainly consume the electric power. An estimated result of this model, the power demand of the western region will increase by an annual average of 7.1% in projection period and reach to 151 GWh in 2030.

The electrification rate in the northern region is the lowest in Uganda. Currently only one existing 132 kV transmission line has connected Tororo substation to Opuyo substation and Lira substation in the north part. In northern region, the area has been electrified is limited, and the electric power consumption in 2013 only reached about 18 MW. According to the "Grid Development Plan 2014 - 2030", six solar power plants, three hydro power plants and seveN-132 kV substations is scheduled to construction in the future, the electric power demand is expected to continue to expand at a faster rate in this region. This model, the electric power demand in northern region is continue to increase at an annual average of 8.1% in projection period where this is the higher growth rate in the country. If the electric power demand in the region is widespread, it is assumed that residential sector will become the main consumer in the region.



Source: JICA survey team

Figure 4-1-2.3 Electric Power Demand Forecast by Region (2013 - 2030)

(3) Power Demand per Substations in the Kampala Metropolitan Area

As a result of conducting demand forecast based on the econometrics model, the annual average growth rate in the base case is 6.4% and it is predicted that the demand at each substation will increase with each passing year. Meanwhile, in line with the start of operation at substations that are planned for new construction or upgrading, part of the load of the existing substations will be transferred to these substations via the 33 kV distribution system and 11 kV distribution system that co-exist in the metropolitan area. Table 4-1-2.6 shows the load transfer plan with the UETCL plans based on the current distribution system. Because the secondary side bus is 33 kV at all the substations that are planned for new construction or upgrading, it is planned for the load on 33 kV bus at all the existing substations shown on the right side of the table to be transferred to the load on 33 kV bus at the substations to be newly constructed or upgraded.

As is shown in Table 4-1-2.6, in the case where work on the 132/33 kV Buloba Substation and Kawaala Substation is adopted in the Project and the contract for this is signed in

December 2018, the substations will commence services in 2020. Moreover, because the 220 / 132 kV New Mukono Substation and 132/33 kV equipment of Buloba Substation in the Project are interconnected equipment with the higher level 220 kV system, they will not directly supply load on the distribution system. Moreover, the 132/11 kV equipment (20 MVA) of Kawaala Substation to be installed in the Project will inherit the load of the existing 132/11 kV equipment (15 MVA) at the same substation that will be removed in the Project.

Table 4-1-2.6 Load Transfer from the Existing Substations to the Substations Constructed

Start Operation	Substation Constructed	Capacity	Substation where load is transferred
2017	Queensway Substation	40 MVA×3 units	● Lugogo Substation ● Mutundwe Substation
2018	Luzira Substation	40 MVA×3 units	● Lugogo Substation
	Entebbe Substation	40 MVA×3 units	● Mutundwe Substation
2019	Gaba Substation	40 MVA×3 units	● Lugogo Substation ● Queensway Substation
2020	Buloba Substation (the Project)	40 MVA×2 units	● Mutundwe Substation
	Kawaala Substation (the Project)	40 MVA×3 units	● Kampala North Substation
	Kawanda Substation	40 MVA×1 unit	● Kampala North Substation

Source: Discussion with Planning Department, UETCL

The target year of the transmission system plan in the Project is 2030. Since the projected period is more than 10 years, in conducting regression analysis using the econometrics model as in this case, it is necessary to have past time series of data for an equivalent or longer period of time than this. Although the models are tested from the viewpoint of correlation coefficient and Durbin-Watson ratio, time series of data from 1990 to 2013 was utilized to facilitate review to confirm there is no major disparity with the UETCL demand forecast in “Grid Development Plan 2014 - 2030.” As a result of conducting the comparison, since there was found to be no major disparity with the forecast in “Grid Development Plan 2014 - 2030” as described earlier, the appropriateness of the models was confirmed.

Based on the plan for transfer of load from existing substations to constructed substations as shown in Table 4-1-2.6, Table 4-1-2.7 shows the results of apportioning the demand envisaged in the metropolitan area based on the econometrics model to each substation. As in the UETCL “Grid Development Plan 2014 - 2030,” the prediction period is 2014 to 2030, and the data for 2013 shown in the table is based on actual values. The transmission system plan will be compiled assuming the demand for 2030 shown in Table 4-1-2.7 to be a precondition.

The red figures shown in the top row in Table 4-1-2.7 show the demand for the metropolitan area overall based on the econometrics model, and this is apportioned to the 11 kV bus and 33 kV bus of each substation. The substation names shaded in blue are existing substations as of 2016, while those shaded in green are substations to be constructed in the Project.

Table 4-1-2.7 shows items shaded in yellow, orange and blue respectively. In cases where the same color shading is shown in each year, this indicates that load is transferred from the existing substations to the substations to be newly constructed or upgraded based on the policy indicated in Table 4-1-2.6 in line with the commencement of operation of the substations to be newly constructed or upgraded.

The year with purple shading in Table 4-1-2.7 is the analysis section of the power flow analysis described later. As of 2015, it is planned to adopt the following years as analysis sections: 1) 2018, when the substations that are planned for construction in the Kampala Metropolitan Area under assistance from the Export-Import Bank of China start operation, 2) 2020, which is a key year for commencement of operation in the Project, 3) 2022, which is the target year for the Project evaluation, and 4) 2030, which is the target year of the transmission system plan in the Project.

Table 4-1-2.7 Demand Distribution in the Kampala Metropolitan Area

Region					Start Operation (Year)	Demand (MW)	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						MW	341	359	404	412	454	465	490	518	534	567	604	644	688	737	791	850	915	987
Lugogo	132/11	40 MVA	2 Units	80 MVA	Existing	1991*1, 1997*3	MW	33	33	45	45	48	48	50	52	52	55	56	56	57	57	57	58	59	60
	132/33	40 MVA	2 Units	80 MVA	Existing		MW	56	61	70	71	53	40	33	38	38	38	38	38	41	44	48	52	56	60
Mutundwe	132/11	20 MVA	2 Units	40 MVA	Existing	1991*1, 1995*1, 2003*2	MW	19	19	21	21	22	22	22	22	23	23	23	24	24	25	25	26	26	27
	132/33	40 MVA	2 Units	80 MVA	Existing		MW	56	61	70	71	53	40	46	31	32	34	34	35	35	36	42	45	49	53
Namanve	132/33	40 MVA	3 Units	120 MVA	Existing	2007*2, 2008*1	MW	42	50	59	64	73	29	34	34	34	37	41	45	50	55	60	66	73	80
Kampala North	132/11	40 MVA	2 Units	80 MVA	Existing	1995*1, 2006*2	MW	48	48	48	48	50	50	50	50	50	50	51	51	51	52	52	52	53	53
	132/33	40 MVA	2 Units	80 MVA	Existing		MW	56	56	58	59	61	63	65	22	24	27	30	33	37	41	46	51	51	52
Kawaala	132/11	15 MVA	1 Units	15 MVA	Existing	1972	MW	7	7	8	8	9	9	10											
	132/11	20 MVA	1 Units	20 MVA	the Project	2020	MW								10	10	10	10	11	11	11	11	12	12	13
	132/33	40 MVA	3 Units	120 MVA	the Project	2020	MW								35	38	41	44	48	52	56	60	65	70	75
Kawanda	132/33	40 MVA	1 Units	40 MVA	Existing		MW	24	24	25	25	25	25	26	13	13	13	14	14	14	15	15	15	16	17
	132/33	40 MVA	1 Units	40 MVA	the Project	2020	MW								13	13	13	14	14	14	15	15	15	16	17
Queensway	132/33	40 MVA	3 Units	120 MVA		2017	MW					60	61	50	55	55	57	61	61	62	63	64	66	72	80
Luzira	132/33	40 MVA	2 Units	80 MVA		2018	MW						14	17	20	20	22	25	28	29	31	33	36	37	40
Namanve South	132/33	63 MVA	3 Units	189 MVA		2018	MW						25	26	31	35	38	42	51	61	69	76	85	98	110
Mukono	132/33	63 MVA	3 Units	189 MVA		2018	MW						25	26	31	35	38	42	51	61	69	76	85	96	110
Entebbe	132/33	80 MVA	2 Units	160 MVA		2018	MW						14	17	20	20	22	26	28	30	36	45	49	55	60
Gaba	132/33	60 MVA	2 Units	120 MVA		2019	MW							18	20	21	24	26	28	30	31	33	36	38	40
Buloba	132/33	40 MVA	2 Units	80 MVA	the Project	2020	MW								21	21	25	27	28	29	31	33	36	38	40

Source: Prepared by JICA Study Team based on the discussion with UETCL

(4) Reference Case

The above scenario is a case when Uganda government will adhere to the continually expanding fiscal policy until 2030 to maintain the high economic growth rate at 7.7%. A reference case has set in this modeling analysis, in case the Uganda government has failed to maintain expand of fiscal finances policy and without any additional measures for operates the economy.

Table 4-1-2.8 Macro Economy Sub-model Simulation Results of Uganda - Reference Case (2013 - 2030)

	Actual (Million Shilling)			Projection (Million Shilling)			Compound Annual Growth Rate (%)	
	2000	2010	2013	2020	2025	2030	2020/ 2013	2030/ 2013
GDP (Constant 2010)	20,104	40,946	48,422	67,137	90,199	123,480	4.8	5.7
Annual Growth Rate (%)	3.1	5.2	3.3	5.6	6.3	6.6		
GDP by Sector (Constant 2010)								
Agriculture	8,112	10,732	11,364	16,075	19,807	24,984	5.1	4.7
Industry	3,251	7,424	8,890	15,630	21,629	30,358	8.4	7.5
Services	10,699	22,791	28,168	35,431	48,763	68,138	3.3	5.3
GDP By Sector by Share								
Agriculture	36.8	26.2	23.5	23.9	22.0	20.2		
Industry	14.7	18.1	18.4	23.3	24.0	24.6		
Services	48.5	55.7	58.2	52.8	54.1	55.2		
Total	100.0	100.0	100.0	100.0	100.0	100.0		

Source: JICA survey team

In the reference case, Uganda's economic was estimated largely dependent on the agricultural sector. Production factors of the industrial sector as land, labor and capital has been gradually formed, but the structure is still fragile. Investment in the industrial sector, must rely on foreign capital than domestic capital. On the other hand, in recent years the external elements like political has been relatively stable, economic management is being carried out smoothly, and the international oil price remained on low levels, is comparatively stable, Uganda's economy is expected to grow steadily. In this model calculation, the GDP of the country is expected to growth at an annual average of 5.5% in the projection period, compared to the base case GDP growth rate has reduce 1.8 point.

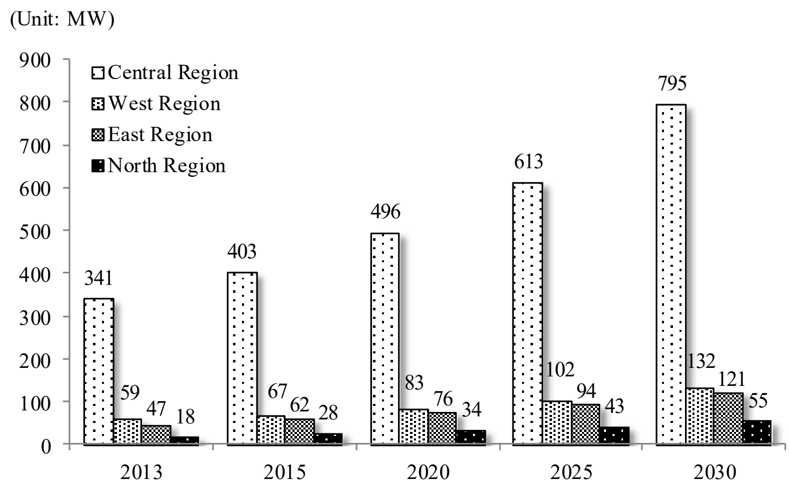
Base on the economic situation of the reference case, the domestic electric power demand has been increasing at an annual average of 5.5 from 2013 to 2030 and reach to 7,251 GWh in 2030, the demand has decreased by 1.4 points compared to the base case. Electric power demand of the industrial sector is becomes relatively slow because of the economic growth has slowed. The growth rate of electricity demand in industry sector is dropped 1.9 points compared to the base case, and the annual average growth rate of 7.7% in same period. Furthermore, the composition ratio of the electric power consumption of the industrial sector in the final sector also slip down 2 points become 80.8%.

Table 4-1-2.9 Electric Power Demand Forecast Result of Uganda - Reference Case (2013 - 2030)

Electric Power Demand	Actual (GWh)			Projection (GWh)			Compound Annual Growth Rate (%)	
	2000	2010	2013	2020	2025	2030	2020/ 2013	2030/ 2013
(1) Final Consumption	843	1,521	2,048	3,330	4,364	5,867	7.2	6.4
Industry	407	959	1,335	2,436	3,372	4,738	9.0	7.7
Households	312	364	460	569	621	689	3.1	2.4
Commercial and others	124	198	253	325	371	439	3.6	3.3
(2) Own use	6	9	10	12	13	15	2.3	2.3
(3) Losses	461	791	852	1,065	1,217	1,369	3.2	2.8
Percentage of losses (%)	29.5	33.0	28.4	20.4	16.4	15.1		
(4) Domestic Demand (1)+(2)+(3)	1,310	2,321	2,910	4,407	5,595	7,251	6.1	5.5
(5) Export and Import	251	75	90	826	1,822	1,822	37.3	19.4
(6) Total Electric Power Demand (4)+(5)	1,561	2,396	3,000	5,233	7,417	9,073	8.3	6.7
Final Consumption by Share (%)	100.0	100.0	100.0	100.0	100.0	100.0		
Industry	48.3	63.1	65.2	73.2	77.3	80.8		
Households	37.0	23.9	22.5	17.1	14.2	11.7		
Commercial and others	14.7	13.0	12.4	9.7	8.5	7.5		

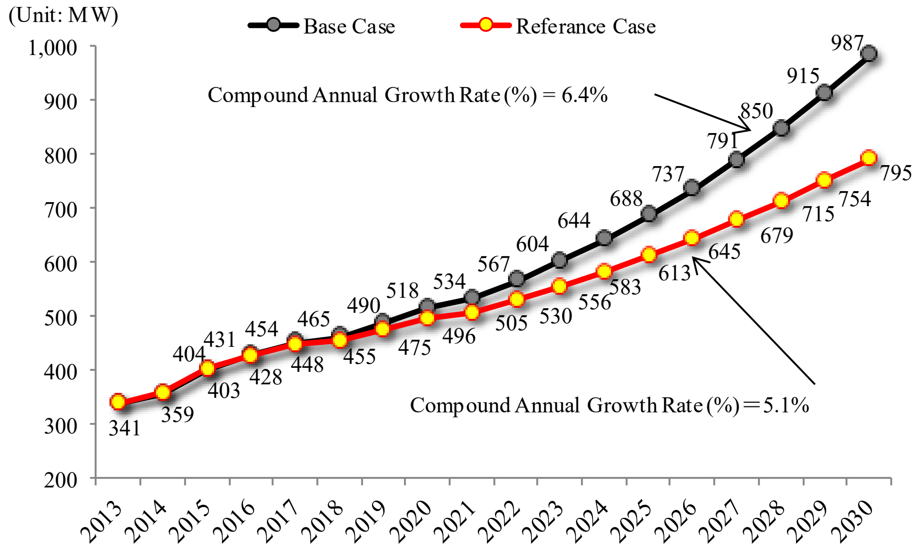
Source: JICA survey team

On the other hand, the electric power demand of Kampala Metropolitan Area (Central Region) is increased at an annual average of 5.1% from 341 MW in 2013 to 795 MW in 2030. Compared to 6.4% of the base case, it is dropped 1.3 points in the reference case. The average annual growth rate of western region, eastern region and northern region has been respectively 4.9%, 5.8% and 6.7%.



Source: JICA survey team

Figure 4-1-2.4 Electric Power Demand Forecast by Region - Reference Case (2013 - 2030)



Source: JICA survey team

Figure 4-1-2.5 Electric Power Demand Forecast in Kampala Metropolitan (2013 - 2030)

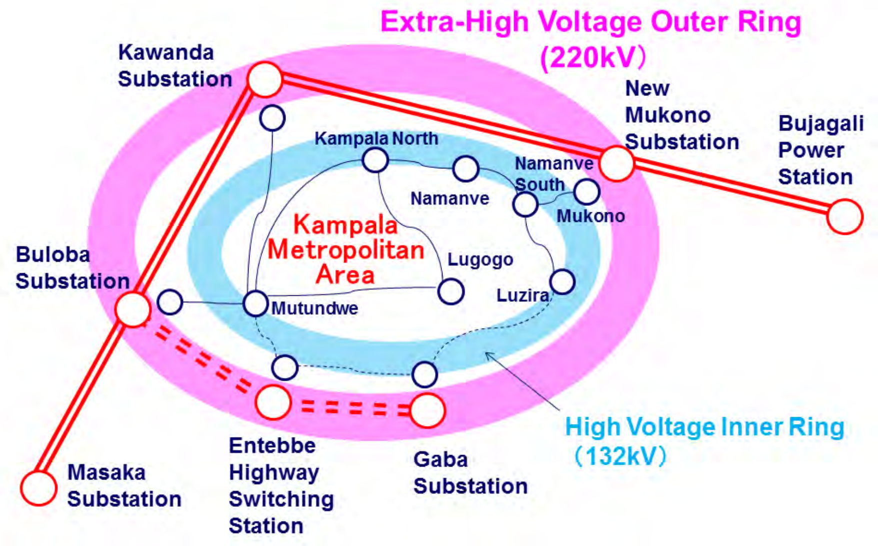
4-1-3 Necessity and Concept of the transmission system Plan

As mentioned above, since the increase of power demand in the Kampala Metropolitan Area is expected in level of 6.4% per year (base case) up to 2030 in average, it is expected that the power supply capacity currently secured by the network composed of 132 kV trunk lines will not be able to meet the demand growth, fundamentally. Therefore, it is obvious that large scale of upgrading of the current transmission system is required even in the medium term (10 to 15 years). In upgrading of the current transmission system, since the transmission system functions as a network, transmission system plan with looking down at the whole system in the Kampala Metropolitan Area is required, such as foreseeing the formulation of a 220 kV outer ring system outside the current 132 kV ring system in conformity with the speed of demand growth. The components of the Project shall be selected based on the transmission system plan.

However, in UETCL's "Grid Development Plan 2014 - 2030", the transmission lines over 220 kV, which is ultra-high voltage, are utilized to evacuate power from large scale of hydroelectric power stations under construction to the area far from the power stations, these transmission lines over 220 kV have not been effectively utilized for power supply in the Kampala Metropolitan Area, where is the most power-consuming area.

In general, a ring configuration of the transmission system in ultra-high voltage is effective to achieve the transmission system securing power supply capacity inconformity with the demand growth in the area and reliability. Though the 132 kV transmission lines in the Kampala Metropolitan Area have been composed in ring system and it can be called as the internal ring system in ultra-high voltage, the system configuration shall be planned to formulate an outer ring system in 220 kV as shown in Figure 4-1-3.1, in case of foreseeing the effective system in the future.

In order to secure sufficient power supply capacity to the metropolitan area for increasing demand, transmission lines between Bujagali power station and Kawanda substation shown in red lines in Figure 4-1-3.1 which have been designed for 220 kV are boosted to 220 kV in 2016. In addition, in 2018, 220 kV transmission lines between Kawanda substation and Masaka substation will be planned to operate, power transmission using 220 kV transmission lines between outer and inner of the metropolitan area will be secured. Utilizing these 220 kV transmission lines as a part of outer ring system in 220 kV, it is effective to configure outer ring system shown as violet circle in Figure 4-1-3.1 and to enhance system configuration which has both of sufficient capacity for demand increase in the metropolitan area and reliability in the future.



Source: JICA Study Team

Figure 4-1-3.1 Outline of Outer 220 kV Ring System and 132 kV Ring System in the Kampala Metropolitan Area

In order to utilize 220 kV transmission lines between Bujagali power station and Kawanda substation and 220 kV transmission lines between Kawanda substation and Masaka substation as a part of outer ring system in 220 kV in the Kampala metropolitan area, it is the first step and the most critical issues that 220 / 132 kV substations are planned to supply power to the metropolitan area considering not only aspects of technology but also environmental and social conditions in the medium term (10 to 15 years) point of view.

Judging by overview of power system in the Kampala metropolitan area, in order to enhance power supply to the southwestern area of the Kampala metropolitan area where demand of commerce and general residences have increased rapidly, it is considered effective to secure the supply point from 220 kV transmission lines to the metropolitan area by constructing 220 / 132 kV substations in the western area of the Kampala metropolitan area. And, it is judged effective to secure the supply point from 220 kV transmission lines to the metropolitan area by constructing 220 / 132 kV substations in the eastern area of the Kampala metropolitan area where industrial parks are planned to develop in the future. In addition, it is certain that capacity of the existing 132 kV internal ring system will not meet demand in the future, but it is difficult to construct additional transmission lines considering environmental and social conditions. Therefore, it is judged that countermeasure constructions will be needed to re-construct transmission lines and to increase the capacity to meet demand increase in the future, utilizing the existing transmission towers, upgrading the existing conductors to High-Temperature Low-Sag conductors (HTLS conductors).

Transmission system plan for 2030 as the target year shall be formulated setting upgrading projects of the equipment of the transmission system as multiple scenarios which are considered to be effective from the current situation in the area, such as these construction of 220 / 132 kV Substations in the Kampala metropolitan area, upgrading 132 kV transmission lines using HTLS conductors etc..

It should be noted that the plans which are already proceeding to the implementation stage such as construction of transmission lines between Kawanda substation and Masaka substation by the World Bank, construction of Mukono substation, Namanve South substation and Luzira substation by the support of the Export-Import Bank of China, etc., are reflected in this transmission system plan, and thus, transmission system plan of up to 2030 section will be formulated. The transformation of the power transmission systems is formulated on five analysis sections: 2015, 2018(operation starting year of major projects of other donor in the metropolitan area, such as Namanve South substation, Luzira substation, Mukono substation, etc.), 2020(operation starting year of the Project equipment), 2022 (after two years of operation starting year of the Project equipment and the target year of the Project evaluation) and 2030 (the target year of the transmission system plan).

4-1-4 Scenarios for the Transmission System Planning in the Kampala Metropolitan Area

As mentioned above, in order to configure the 220 kV outer ring system, it is an important issue to plan 220 / 132 kV substations on the 220 kV outer ring for a supply point to the metropolitan area. It should be noted that based on the aspect which new land acquisition is difficult in the metropolitan area, it is indispensable to consider not only technical aspects but also the environmental and social conditions in order to formulate feasible plans. In accord with this, scenarios are set based on the following policy.

It should be noted that, when setting scenarios, the transmission routes to the Kampala metropolitan area as shown in Figure 4-1-4.1 are referred to as North route, the Southwest route and the East route for convenience.

Source: JICA Study Team

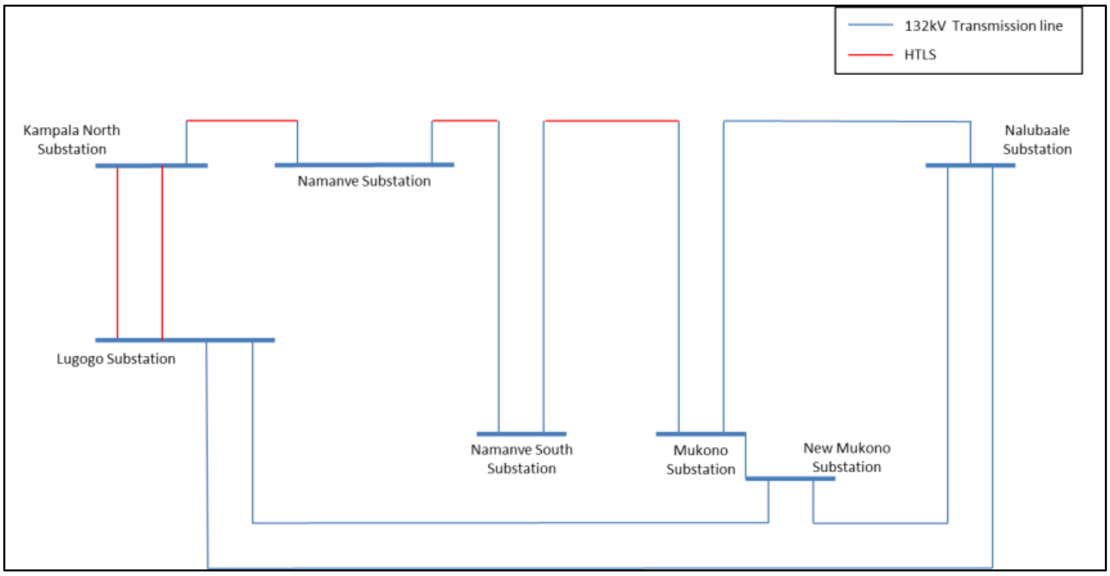
Figure 4-1-4.1 3 routes toward Kampala metropolitan area

(1) Scenarios for 220 / 132 kV New Mukono Substation (Consideration for the Eastern System in the Kampala Metropolitan Area)

Judging from the overview of the Kampala metropolitan area, since industrial parks are planned on the East Route in Figure 4-1-4.1, it is effective to construct 220 / 132 kV substations around it. However, since planning target area is the metropolitan area as pre-conditions, the degree of freedom is not high in relation to selection of the Project site. As a result of consultation with UETCL, it became the policy of scenario setting as one of the pre-conditions to locate 220 / 132 kV New Mukono Substation of the Project within 132/33kV Mukono substation supported by the Export-Import Bank of China.

When supplying the power to the metropolitan area through 220 / 132 kV New Mukono substation, since it is certain for the existing 132 kV transmission lines around it to be overloaded, it is indispensable to plan upgrading of 132 kV transmission lines around it together. As mentioned above, since it is difficult to secure new transmission route for the upgrading of the 132 kV transmission lines in the metropolitan area, it is considered effectual to upgrade capacity by upgrading the existing conductors to HTLS conductors. In accord with this, the transmission line sections which use HTLS conductors are optimized by using power flow analysis considering the construction of 220 / 132 kV substations as pre-conditions.

It should be noted that with regard to the 220 / 132 kV New Mukono substation, as Figure 4-1-4.2, in order to ensure the incoming lines from 132 kV transmission lines between Nalubaale substation and Kampala North substation, 132 kV busbar of 220 / 132 kV New Mukono substation of the Project and 132 kV busbar of 132/33kV Mukono substation of the Export-Import Bank of China shall be connected with bus connection lines. In addition, 132 kV transmission lines which are planned to be upgraded to HTLS conductors are shown in red line in Figure 4-1-4.2.



Source: JICA Study Team

Figure 4-1-4.2 Plan on 220 / 132 kV New Mukono Substation

In addition, in order to utilize 220 kV transmission lines between Bujagali substation and Kawanda substation effectively, it is needed for power system to be operated so as to supply power from Bujagali power station and Isimba power station to the metropolitan area through these 220 kV transmission lines. However, considering impedance of 220 / 132 kV transformer of Bujagali substations, there is a possibility that most of the power is supplied to the metropolitan area through 132 kV transmission lines between Nalubaale substation and Kampala North substation and Lugogo substation without passing through the 220 kV transmission lines. In order to avoid this problem, there is an operational method to utilize 220 kV transmission lines by opening 132 kV transmission lines between Nalubaale substation and Bujagali power station. When transmission system plan is formulated, this operation shall be also considered.

In accord with mentioned above, scenarios related to 220 / 132 kV New Mukono substation are set as below, transmission system plan is formulated. These scenarios from 1-1 to 1-3 related to 220 / 132 kV New Mukono substation are positioned not to compare verification with each other, but to identify scenarios from 1-1 to 1-3 step by step and to formulate optimal transmission system plan.

- Scenario 1-1: 132 kV transmission lines between Bujagali power station and Nalubaale substation are "Close" operation, and adopting HTLS conductors to all 132 kV transmission lines which will not have enough capacity in the metropolitan area.
- Scenario 1-2: 132 kV transmission lines between Bujagali power station and Nalubaale substation are "Open" operation, and adopting HTLS conductors to all

132 kV transmission lines which will not have enough capacity in the metropolitan area.

- Scenario 1-3: Optimizing adoption of HTLS conductors in Scenario 1-2

Incidentally, importance of optimizing adoption of HTLS conductors is as follows.

In general, since HTLS wire has high capacity with equivalent conductor size and weight as existing wire, HTLS wire has advantage that significant increasing capacity of transmission line can be obtained avoiding reconstruction of existing towers etc. However since HTLS wire realizes high capacity with small cross - sectional area, resistance of HTLS is higher than ACSR wire which has same transmission capacity and a few times larger cross - sectional area. Therefore, especially when HTLS wire is adopted to long section of transmission line, it causes large transmission loss.

For example, since HTLS wire ZT187 (maximum current capacity: 999A) has one - third of cross - sectional area compare to ACSR610 (maximum current capacity: 1,059A) which has almost same capacity, resistance of ZT187 is approximately three times as that of ACSR610 at 20 degrees centigrade. That is, at the same current, transmission loss of ZT187 is also approximately three times as that of ACSR610 at 20 degrees centigrade. Incidentally, if maximum current flows on both wire in actual operation (temperature of ZT187: 210 degrees centigrade, temperature of ACSR610: 90 degrees centigrade), resistance of ZT187 is approximately four times as that of ACSR610.

That is, transmission loss of ZT187 is also approximately four times as that of ACSR610. Though, this difference of transmission loss does not become a serious problem in short section of transmission line, it becomes obvious as a big problem (huge monetary loss) iN-132 kV northern trunk line which is about 70km long, Therefore it is necessary to consider countermeasures to limit transmission loss which is constantly(not temporarily) generated. They are effective for countermeasures to minimize section of HTLS wire, and to flow electric power as much as possible on 220 kV transmission line which needs less current thaN-132 kV transmission line.

Incidentally, assume that using same wire and transmitting same amount of electric power, transmission loss by using 220 kV transmission line is 0.36(= $(132/220)^2$) times as that of 132 kV transmission line. In addition, transmission loss is inversely proportional to the square of voltage value, or transmission loss is proportional to the square of current value.

(2) Scenarios for 220 / 132 kV Buloba Substation (Consideration for the Southwestern System in the Kampala Metropolitan Area)

Judging by overview of power system in the Kampala metropolitan area, in order to enhance power supply to the southwestern area of the Kampala metropolitan area where demand of commerce and general residences have increased rapidly, it is effective to construct 220 / 132 kV substations around the Southwestern Route in Figure 4-1-4.1 form the view point of securing supply point from 220 kV transmission lines which are transmission system of the upper level to the metropolitan area. On the other hand, since planning target area is the metropolitan area as pre-conditions, the degree of freedom is not high in relation to selection of the Project site. As a result of the site survey with UETCL, it became the policy of scenario setting as one of the pre-conditions to locate 220 / 132 kV Buloba substation around intersection of 220 kV transmission line between Kawanda substation and Masaka substation and 132 kV transmission lines between Mutundwe substation and Kabulasoke substation.

Assuming this 220 / 132 kV Buloba substation is one of the pre-conditions, it is important to find out what voltage level or route should be optical or be employed to supply power to edge areas such as Gaba and Entebbe. Regarding voltage, specifically, it is needed to find out whether power supplied by 132 kV transmission lines is enough or not, whether 220 kV transmission lines are required or not. Regarding route, it is needed to find out whether transmission lines which supply Gaba of Entebbe should go through Mutundwe substation which has heavy load or not.

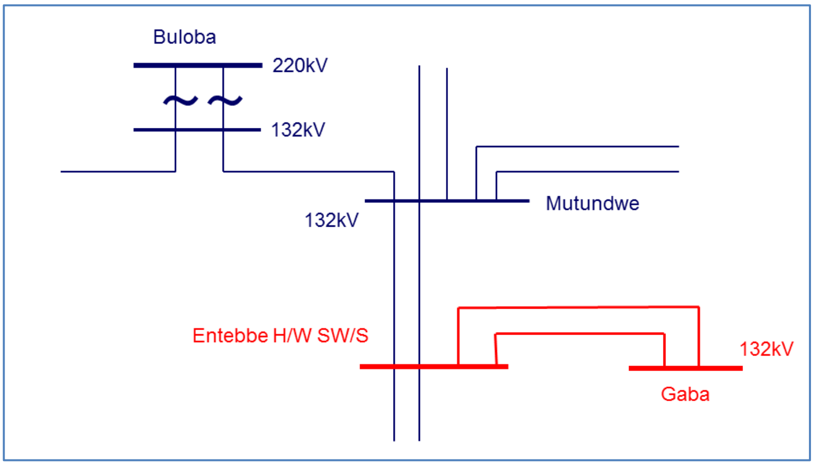
Incidentally, it is particularly difficult to secure the transmission route because of many houses around Gaba substation, but since there is a plan of new road construction from around Gaba substation toward the west, it is effectual to build new transmission route along the road. And, since this road intersects 132 kV transmission lines which are planned to construct between Mutundwe substation and Entebbe substation in the near future, as Scenario 2-1 in Figure 4-1-4.3, if new transmission lines branch from the transmission lines, regardless of going through Mutundwe substation, it is possible to build 132 kV transmission route to Gaba substation relatively easily. In addition, as result of power flow analysis, if it is impossible to supply to the edge of 132 kV transmission lines and it is necessary to 220 kV transmission lines, in particular, in the section from the branch point above to Gaba substation where the land acquisition is difficult, it is possible to can reduce land acquisition in the future by using transmission lines with 220 kV designed and 132 kV operated.

Regarding this branch point, placing switch station is assumed when setting scenario. Hereinafter this switch station is referred to as Entebbe Highway switch station.

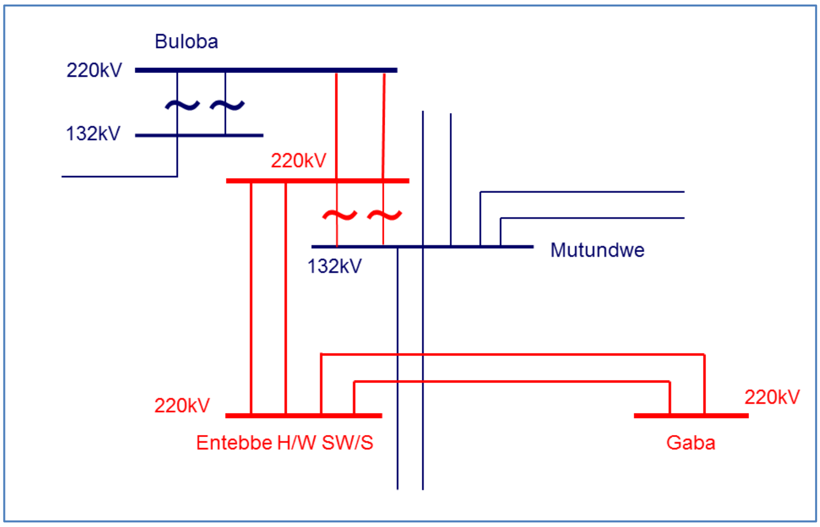
Based on the above, scenarios regarding 220 / 132 kV Buloba substation are set as follows. Scenarios related to Buloba substation (southwest transmission system) are illustrated as Figure 4-1-4-3.

- Scenario 2-1: 132 kV transmission lines between Mutundwe substation and Entebbe substation which will operate in 2017 are branched at Entebbe Highway switch station to Gaba substation.

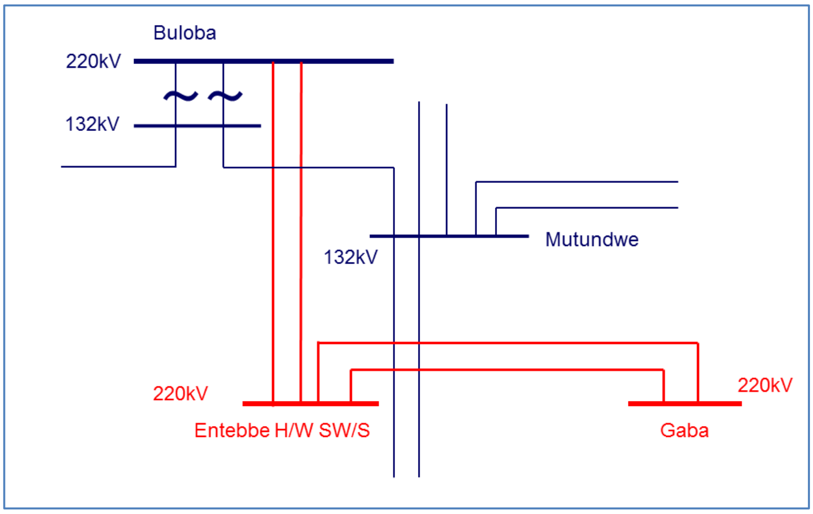
- Scenario 2-2: Leading-in 220 kV transmission lines from Buloba substation to Mutundwe substation. And Leading-in 220 kV transmission lines from Mutundwe substation to Gaba substation via Entebbe Highway switch station.
- Scenario 2-3: Leading-in 220 kV transmission lines from Buloba substation to Gaba substation via Entebbe Highway switch station. (Not going through Mutundwe substation to avoid urban area)



Scenario 2-1



Scenario 2-2



Scenario 2-3

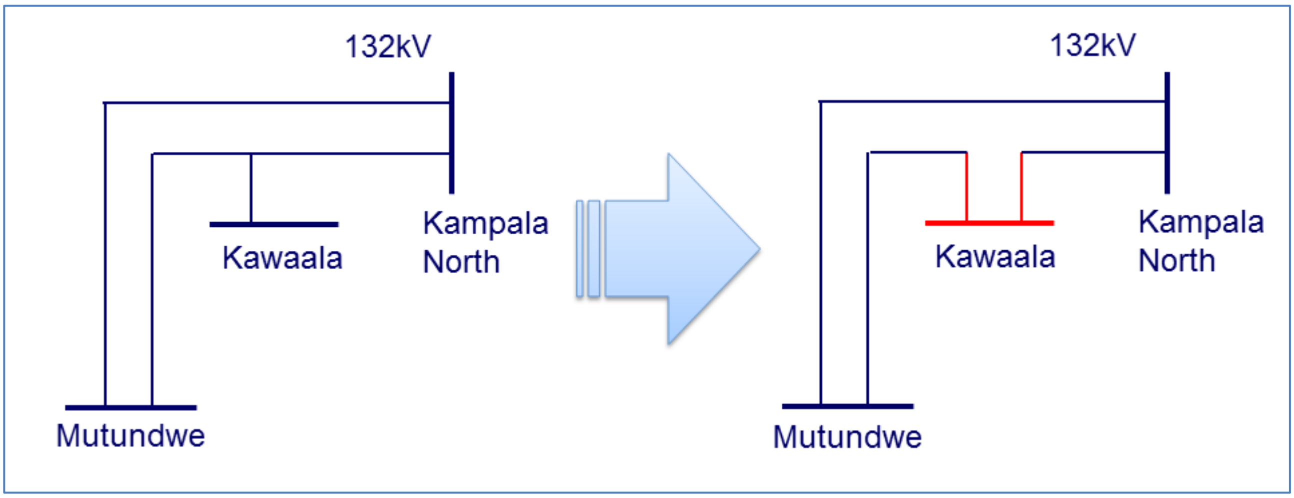
Source: JICA Study Team

Figure 4-1-4.3 Scenarios for Buloba Substation (Southwestern System in the Kampala Metropolitan Area)

(3) Preconditions for Kawaala Substation

Kawaala substation which has voltage level of 132/11kV and capacity of 15 MVA needs to upgrade equipment in the current situation, because load forecast on 33kV is 75MW and load forecast on 11kV is 13MW even taking into account interchange power from Kampala North substation where load is tight in 2030.

In addition, since 132 kV transmission lines between Kampala North substation and Mutundwe substation are led-in Kawaala substation in T-branch, Kawaala Substation is forced to power outage by any contingencies at connected transmission line. Considering the growing demand described above, in order to avoid power outage caused by single contingency at transmission line, since it is indispensable to improve reliability of power supply by changing lead-in from T-branch shown left side in Figure 4-1-4.4 to Open-Pi-branch shown right side in Figure 4-1-4.4, this change needs to be considered when transmission system plan is formulated.



Source: JICA Study Team

Figure 4-1-4.4 132 kV Transmission Lines from Mutundwe Substation to Kampala North Substation

On the other hand, regarding capacity of introduced 132/33kV transformer, considering N-1 contingency of transformer and the demand of 75MW, it is conceivable that total capacity of 120MVA is appropriate by using 3 transformers with capacity of 40 MVA which is general in Uganda. Substation is planned to upgrade removing the existing equipment with small capacity and saving space by using Gas Insulated Switchgears due to constraints of the site. Even if Gas Insulated Switchgears are introduced, since two 60 MVA transformers are oversize in length for the site, three 40 MVA transformers are forced to be introduced. Taking into account the above, upgrading equipment are planned one 132/11kV transformer capacity of 20MVA and three 132/33kV transformers capacity of 40 MVA utilizing Gas Insulated Switchgears in the existing site of Kawaala substation.

4-2 Power Flow Analysis

The optimum transmission system plan having 2030 as the target year will be compiled so as to verify the configured scenarios. The power flow diagrams are attached to the end of Chapter 4 as Figure 4.1 through Figure 4.14 for convenient reference.

4-2-1 Basic Policy on Power Flow Analysis

The scenarios for verification that were set in 4-1-4 Setting of Scenarios for Compiling the Transmission System Plan for the Metropolitan Area are summarized as shown in Table 4-2-1.1. In order to verify the scenarios, it is necessary to construct the power flow analysis model and implement power flow analysis assuming the demand forecast for each substation to be the precondition. UETCL uses Siemens PSS/E as the software for power flow analysis, and the Preparatory Study Team also used this software to conduct power flow analysis. Concerning the line constants and other basic data, the power flow analysis model constructed by UETCL in the Transmission Network Development Plan 2014 - 2030 was used as a base. At the same time, as is shown in Table 4-2-1.1, since construction of a more effective system for the metropolitan area is considered while taking a panoramic view of the entire area including introduction of the 220 kV outer ring system and so on, this is also reflected in the power flow analysis.

First, in order to optimize the transmission system plan, assuming the demand in 2030 to be the precondition, the system model for each scenario is constructed and power flow analysis is conducted in order to identify the optimum scenario. Once the optimum transmission system plan for the 2030 section demand is identified, power flow analysis for the interim period prior to 2030 (the target year of the transmission system plan) is conducted and the effectiveness of the equipment upgrading and construction components included in the transmission system plan is verified at each section.

Table 4-2-1.2 shows the assessment standards, etc. for the power flow analysis results. The standards for adoption of N-1 standard, failure overload and permissible scope of voltage shall be in conformance with the Transmission Network Development Plan 2014 - 2030.

Table 4-2-1.1 Scenarios reviewed by the Power Flow Analysis

Area	Scenarios	Contents
Scenarios related to New Mukono Substation (Examination related to the eastern system)	1-1	Scenario in which the Nalubaale - Bujagali 132 kV transmission line is operated as “Closed” and HTLS conductors are adopted on all 132 kV transmission lines where there is concern over insufficient capacity in the metropolitan area.
	1-2	Scenario in which the Nalubaale - Bujagali 132 kV transmission line is operated as “Open” and HTLS conductors are adopted on all 132 kV transmission lines where there is concern over insufficient capacity in the metropolitan area.
	1-3	Scenario in which the Nalubaale - Bujagali 132 kV transmission line is operated as “Open” and HTLS conductors are adopted on all 132 kV transmission lines where there is concern over insufficient capacity in the metropolitan area.
Scenarios related to Buloba Substation (Examination related to the	2-1	Scenario in which the Mutundwe - Entebbe 132 kV transmission line that is scheduled to commence service in 2017 is branched to Gaba Substation at Entebbe Highway Switch Station.

southwestern system)	2-2	Scenario in which 220 kV transmission line is extended from Buloba Substation to Mutundwe Substation, and a 220 kV transmission line is extended from Mutundwe Substation via Entebbe Highway Switch Station to Gaba Substation
	2-3	Scenario in which 220 kV transmission line is extended from Buloba Substation, via Entebbe Highway Switch Station, to Gaba Substation without passing through Mutundwe Substation.

Source: JICA Study Team

Table 4-2-1.2 Criteria for Review of Results of Power Flow Analysis

Target scope	・Kampala Metropolitan Area (However, the system simulation is for the entire country)
Voltage	・substations and transmission lines of 132 kV and 220 kV in the target scope (including the 33 kV and 11 kV bus of the transmission substations).
Demand	・Demand forecast carried out by the econometrics models in the section 4-1-4 ・Power factor: 95%※1
Analysis sections	・2015 (Current Conditions) ・2018 Commencement of operation of the substation by the Chinese assistance the 220 kV lines ・2020 (Completion of the Project) ・2022 (Target Year of the Project Evaluation) ・2030 (Target Year of the System Planning)
Assessment contents	The following assessments were implemented on each scenario setting: ・Flow distribution ・Voltage distribution
Definition of overload ratio	According to "Transmission Network Development plan 2014 - 2030" ・Normal times：100% and over is overload ・At times of failure：120% and over is overload
Scope of Analysis for N-1 failure	・Transmission Lines： 132 kV Lines and 220 kV Lines in the Kampala Metropolitan Area ・Substations： 220 / 132 kV Bujagali Substation, 220 / 132 kV Kawanda Substation, 220 / 132 kV Buloba Substation, 220 / 132 kV New Mukono Substation
Allowable range of voltage	According to "Transmission Network Development plan 2014 - 2030" ・220 kV：±5% ・132 kV：±5%
SVC	The phase modulation equipment envisaged in the power flow analysis model data compiled by UETCL (2013, 2015, 2018, and 2020) is assumed to be pre-existing, and the minimum capacitors or reactors are installed if needed in operation.

Source: JICA Study Team

※1 Mean power factor based on actual peak demand

4-2-2 Results of Power Flow Analysis of Each Scenario

(1) Results of Analysis of the Scenarios for 220 / 132 kV New Mukono Substation (Consideration for the Eastern System in the Kampala Metropolitan Area)

1) Consideration for Effective Use of 220 kV Lines Between Kawanda - Masaka

The results of power flow analysis for Scenarios 1-1 through 1-3 concerning the 220 / 132 kV New Mukono Substation shown in Table 4-2-1.1 are indicated together with the system configuration outline drawings in Figures 4.1 through 4.3.

The metropolitan area also receives power from hydropower stations in eastern Uganda, for example, Bujagali Power Station and Ishimba Power Station. However, due to impedance in the Bujagali Power Station 220 / 132 kV transformer (Bujagali substation transformer on the left side of Figure 4-2-2.1), this power imparts a major load on 132 kV transmission lines to the metropolitan area despite the fact that a 220 kV transmission line is operated between Bujagali and Kawanda. As is shown in Figure 4.1, overload is occurring on the 132 kV transmission line between Nalubaale and Kampala North. Moreover, as a result of implementing power flow verification in the case of N-1 failure, as is shown in Table 4-2-2.1, the evaluation criteria limit of load ratio 120% is exceeded, suggesting that Scenario 1-1 is not effective.

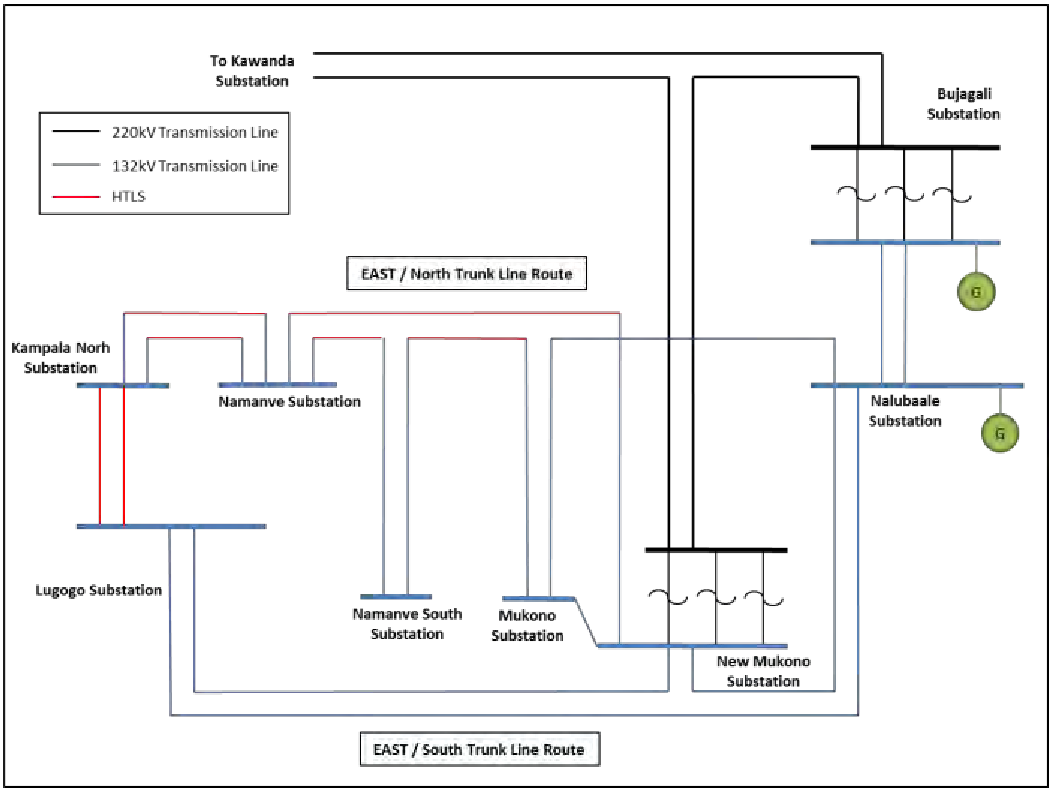
Table 4-2-2.1 East Scenario 2-1: Overload in event of N-1 failure (Over 100%)

N-1 failure transmission line	Voltage [kV]	Overload transmission line	Overload ratio [%]
Nalubaale ~ Mukono, South Trunk Line	132	Nalubaale ~ Mukono, North Trunk Line	126.60

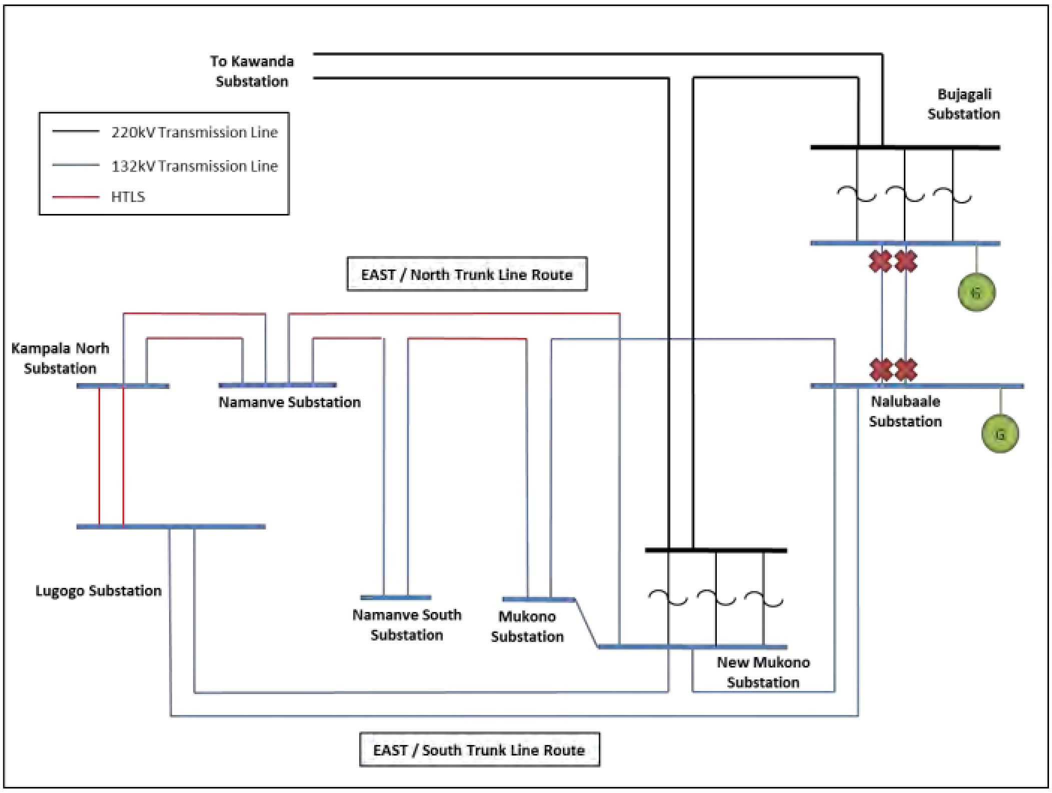
Source: JICA Study Team

In order to resolve overload, it is possible to upgrade capacity through adopting HTLS conductors and so on, however, the 132 kV transmission line between Nalubaale and Mukono, on which overload is occurring, is 40 kilometers long. As was described in section 4-1-4 Setting of Scenarios for Compiling the Transmission System Plan for the Metropolitan Area, upgrading of capacity based on re-conductoring of the existing conductors to HTLS conductors makes it possible to upgrade transmission capacity without acquiring new land, however, because remarkable upgrading is sought on conductors that have small cross section, the transmission loss is large, and this impact is even more significant on long sections. Therefore, in the case where HTLS conductors are adopted on the section between Nalubaale and Kampala North, major transmission loss is forecast, and it is deemed inappropriate to upgrade capacity through adopting HTLS conductors both in technical and economic terms.

In order to effectively utilize the 220 kV transmission line between Bujagali and Kawanda, in addition to the equipment-based approach of upgrading transmission capacity through adopting HTLS conductors on the 132 kV transmission line as described above, a system operation-based approach can be considered. As is shown on the left side of Figure 4-2-2.1, the power generation equipment of Bujagali Power Station is connected to the 132 kV bus. Moreover, although this figure doesn’t show the power generation equipment of Ishimba Power Station, this power station is also connected to Bujagali Power Station’s 132 kV bus via 132 kV transmission line, and power is supplied via this bus. In order to connect power from Bujagali Power Station and Ishimba Power Station to 220 kV transmission lines, as is shown on the right side of Figure 4-2-2.1, it is possible to operate the system through opening the 132 kV transmission line between Nalubaale and Bujagali. This constitutes Scenario 1-2 in Table 4-2-1.1.



Scenario 1-1

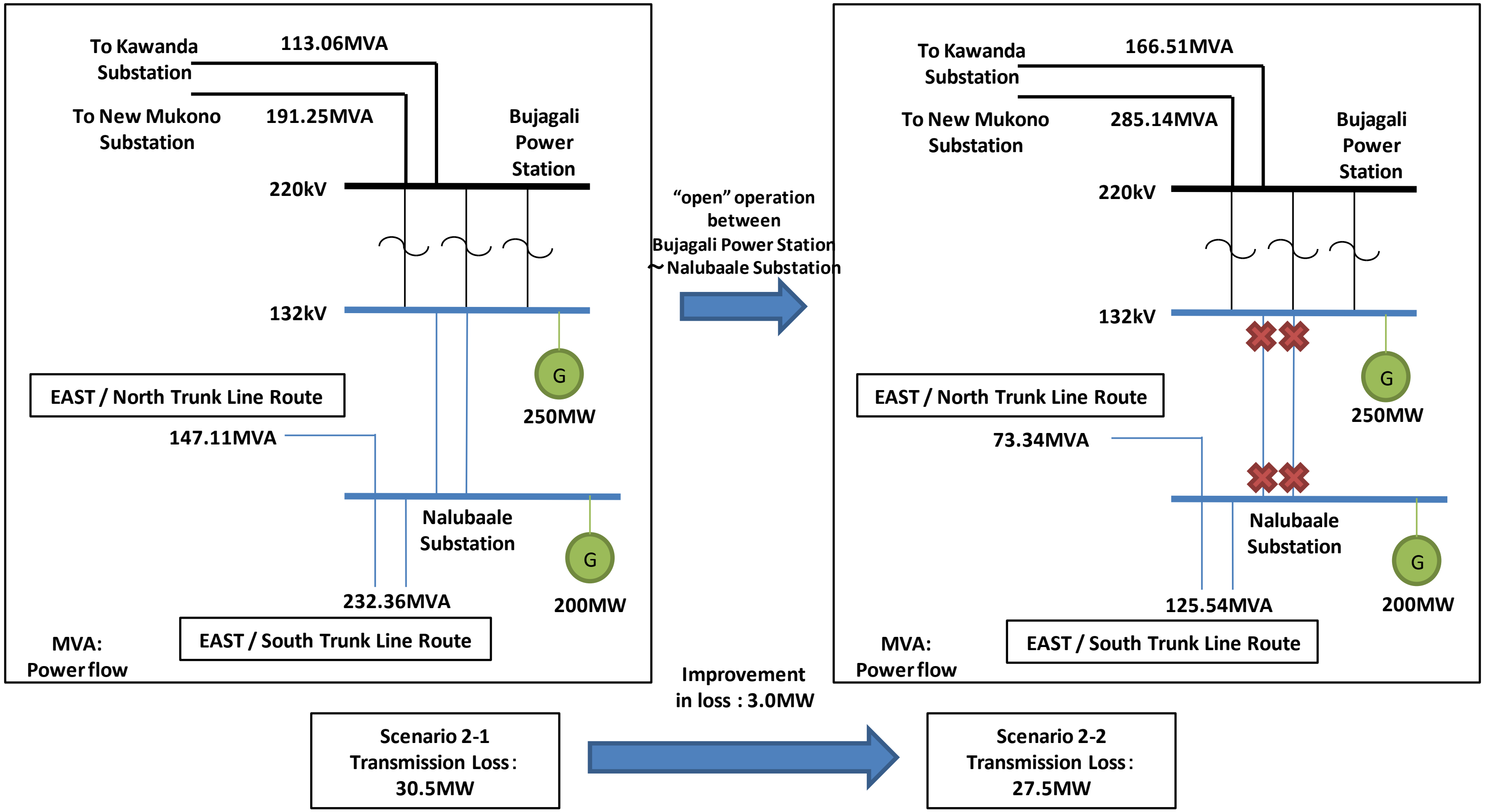


Scenario 1-2

Source: JICA Study Team

Figure 4-2-2.1 Outlines of Transmission System of Scenario 1-1 and 1-2

The results of power flow analysis for Scenario 1-2 are shown in Figure 4.2. As is shown in the figure, in the case where open operation of the 132 kV transmission line between Nalubaale and Bujagali is adopted (Scenario 1-2), the overload on the 40-kilometer 132 kV transmission line between Nalubaale and Kampala North that arose in the case of closed operation (Scenario 1) is resolved. In addition, as is shown in Figure 4-2-2.2, in the case where open operation is adopted (Scenario 1-2), compared to the case of closed operation (Scenario 1), total power flow on the 220 kV transmission line between Bujagali and Kawanda rises to 150 MVA, indicating that the situation is improved in terms of transmission loss too. This figure also shows the improvement in terms of transmission loss in Scenario 1-1 and Scenario 1-2 (transmission loss is calculated up to Bujagali Power Station on the eastern side, up to Kawanda Substation on the northern side, and up to Kabulasoke substation on the western side). As is shown in this figure, power loss is improved by roughly 3.0 MW after the adoption of open operation. As a result of the power flow analysis, from the viewpoint of effectively utilizing the 220 kV transmission line between Bujagali and Kawanda, it is confirmed to be valid to adopt open operation on the 132 kV transmission line between Nalubaale and Bujagali.



Source: JICA Study Team

Figure 4-2-2.2 Improvement of Transmission Loss by Open Operation between Bujagali and Nalubaale

Concerning Scenario 1-2, Table 4-2-2.2 shows the equipment that is overloaded in event of N-1 failure. As is shown in the table, the 220 / 132 kV transformer at Kawanda Substation becomes overloaded in event of N-1 failure, however, because it doesn't exceed 120%, there is deemed to be no problem with Scenario 1-2 from the viewpoint of the evaluation criteria for the results of power flow analysis

Table 4-2-2.2 Eastern Scenario 1-2: Overload in event of N-1 failure (Over 100%)

N-1 failure transmission line or transformer	Voltage [kV]	Overload transmission line	Overload ratio [%]
Kawanda transformer	220/132	Kawanda transformer	104.73

Source: JICA Study Team

2) Optimization of the Sections Utilizing HTLS Conductors

As was mentioned previously, transmission capacity can be upgraded through re-conducting existing conductors to HTLS conductors without acquiring new land, however, because capacity upgrading is sought on conductors with small cross section, the transmission loss is large. Accordingly, in order to mitigate the transmission loss in the transmission network, it is necessary to limit the section on which capacity is upgraded through HTLS conductors as much as possible. Table 4-2-2.3 shows the eastern system 132 kV transmission lines where it is thought that transmission capacity can be upgraded through re-conductoring existing conductors to HTLS conductors. In Scenarios 1-1 and 1-2, as is shown in Table 4-2-2.3, it is proposed that HTLS conductors be adopted on all 132 kV transmission lines where transmission capacity can be upgraded through re-conductoring existing conductors to HTLS conductors. In contrast, Scenario 1-3 entails optimizing the sections for adopting HTLS conductors with a view to minimizing the transmission loss (the "Not add another Circuit" sections in the table are described later). Moreover, concerning Scenario 1-1 and Scenario 1-2, the sections where HTLS conductors are adopted in Table 4-2-2.3 are shown by red lines in Figure 4-2-2.3.

Table 4-2-2.3 List of Conductor Types in Each Section for Eastern System

Section (Substation)	Scenario 2-1	Scenario 2-2	Scenario 2-3
Nalubaale ~ Mukono	ACSR125 Double	ACSR125 Double	ACSR125 Double
Mukono ~ Namanve South	HTLS	HTLS	HTLS
Namanve South ~ Namanve	HTLS	HTLS	HTLS
New Mukono ~ Namanve	HTLS	HTLS	Not add another Circuit
Namanve ~ Kampala North	HTLS	HTLS	HTLS
Namanve ~ Kampala North	HTLS	HTLS	Not add another Circuit
Lugogo ~ Kampala North	HTLS	HTLS	HTLS
Lugogo ~ Kampala North	HTLS	HTLS	HTLS
Mutundwe ~ Kawaala	HTLS	HTLS	HTLS
Kawaala ~ Kampala North	HTLS	HTLS	HTLS
Kampala North ~Mutundwe	HTLS	HTLS	HTLS
Bujagali ~ Nalubaale	AAAC240 Double	Open operation	Open operation

Source: JICA Study Team

Moreover, in Scenario 1-2 it is confirmed that adoption of HTLS conductors on the 41-kilometer 132 kV transmission line between Nalubaale and Mukono is averted through conducting open operation of the 132 kV transmission line between Nalubaale and Bujagali, and that the demand in the 2030 section can be satisfied through conducting transmission through the existing ACSR 125 mm2, 1-phase, 2-wire, single circuit line. Therefore, in Scenario 1-3 too, the policy shall be to utilize the existing conductor on this section.

Similarly, transmission can be conducted through the existing ACSR 125 mm2, 1-phase, 2-wire, single circuit line on the 132 kV transmission line between Mukono and Kampala North. In Scenarios 1-1 and 1-2, as is shown in Figure 4-2-2.1, one circuit is added and one circuit is re-conductored to HTLS conductors concerning the 132 kV transmission line between Mukono and Kampala North. However, even if the transmission line on this section is expanded, since the specifications cannot be changed at Mukono Substation currently under construction, there is no switchgear equipment for conducting connection at this facility. Accordingly, concerning this section, if it is possible to satisfy the demand in the 2030 section by re-conductoring the existing one circuit without adding HTLS conductors, it will be possible to compile a transmission system plan that is compatible with the existing plans. Accordingly, concerning optimization of the section for re-conductoring to HTLS conductors, first concerning the 132 kV transmission line between Mukono and Kampala North, the pre-condition is that only one circuit of the existing ACSR conductor is re-conductored to HTLS conductors without adding another circuit. If examination of optimization of the section for re-conductoring to HTLS conductors shows there is no need to install additional circuits, the policy shall be to re-conductor the existing one circuit to HTLS conductors.

In the case where the maximum power flow on each target section indicated in Table 4-2-

2.4 exceeds the capacity of existing transmission lines in the event of N-1 failure, the optimization of HTLS conductors is secured since it is deemed appropriate to upgrade capacity through re-conductoring to HTLS conductors. Conversely, if the maximum power flow on each target section does not exceed the capacity of existing transmission lines in the event of N-1 failure, there is deemed to be no need to re-conductor to HTLS conductors.

Table 4-2-2.5 shows the maximum power flow on each target section and transmission capacity of existing conductors in the event of N-1 failure. As a result of conducting power flow analysis, except for the sections where "addition of HTLS conductors on the 132 kV transmission line between Mukono and Kampala North is not conducted" is set as the precondition, it was confirmed that re-conductoring to HTLS conductors is required on all sections.

Table 4-2-2.4 Eastern Scenario 1-3: Appropriate Conductor Types for Each Section

Section (Substation)	Distance [km]	Max Flow [MVA]	Current Capacity [MVA]	Max Flow [MVA]	Necessity of HTLS
Nalubaale ~ Mukono branch	41.00	107.47	147	107.47	Not required
Mukono branch ~ Namanve South branch	16.36	230.69	147	230.69	Required
Namanve South branch ~ Namanve	0.14	157.25	147	157.25	65.52
New Mukono ~ Namanve	16.5	-	-	-	Not add another Circuit
Namanve ~ Kampala North	12.6	230.82	147	230.82	Required
Namanve ~ Kampala North	12.6	-	-	-	Not add another Circuit
Lugogo ~ Kampala North	5.70	100.14	73.2	100.14	Required
Lugogo ~ Kampala North	5.70	100.14	73.2	100.14	Required
Mutundwe ~ Kawaala	5.6	138.77	79.1	138.77	Required
Kawaala ~ Kampala North	5.4	127.88	79.1	127.88	Required
Kampala North ~Mutundwe	10.2	107.94	79.1	107.94	Required

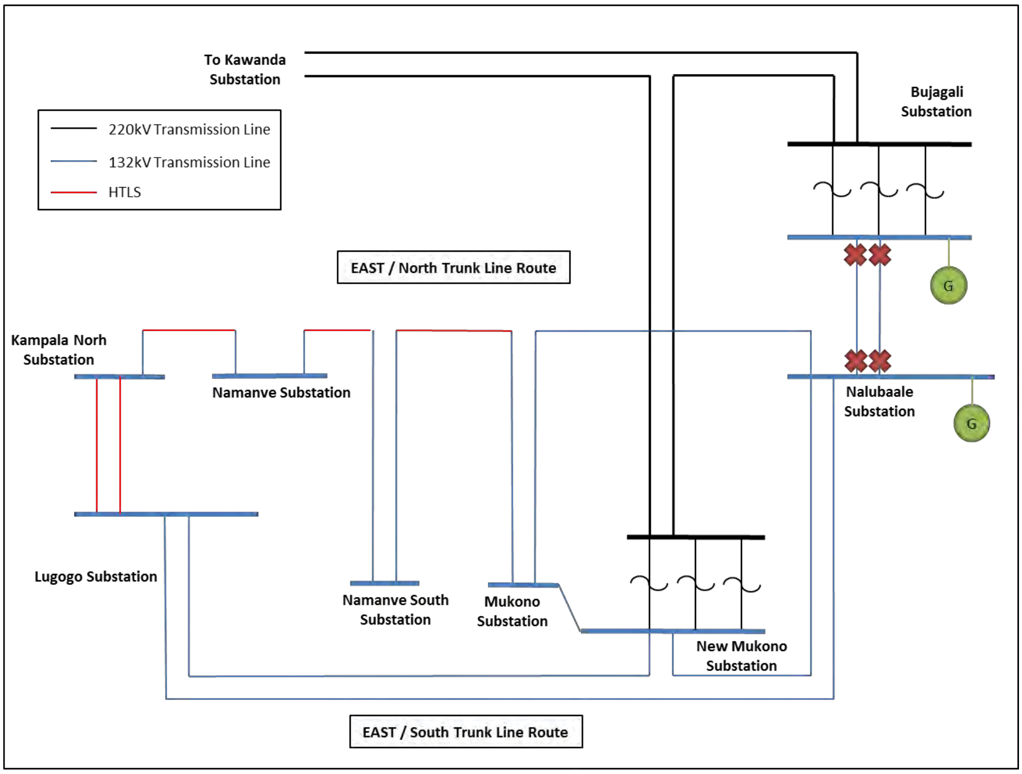
Source: JICA Study Team

Regarding the capacity of HTLS conductors, in the case where HTLS conductors are designed assuming the existing steel tower conditions of ACSR conductors and wire diameter Lynx so as to avoid rebuilding steel towers, roughly 240 MVA can be secured. In consideration of this, Table 4-2-2.5 shows the equipment load ratio with respect to maximum power flow on each target section in the event of N-1 failure. Even assuming maximum power flow, it is confirmed that overload does not occur on any of the sections. Therefore, concerning the eastern system, the following transmission system plan will be compiled: 1) concerning the 132 kV transmission line between Mukono and Kampala North, only one circuit of the existing ACSR conductor is re-conductored to HTLS conductor without adding another circuit, and 2) concerning the other sections, Scenario 1-3 is adopted whereby two circuits are re-conductored to HTLS conductors. Incidentally, concerning Scenario 1-3, the sections where the HTLS conductors shown in Table 4-2-2.4 are adopted are shown by red lines in Figure 4-2-2.3.

Table 4-2-2.5 Eastern Scenario 1-3: Max Flow on Each Section in event of N-1 failure

Section (Substation)	Distance [km]	Conductor Type	Capacity [MVA]	Max Flow [MVA]	Load Ratio [%]
Nalubaale ~ Mukono branch	41.00	ACSR125 Double	147	107.47	73.11
Mukono branch ~ Namanve South branch	16.36	HTLS	240	230.69	96.12
Namanve South branch ~ Namanve	0.14	HTLS	240	157.25	65.52
New Mukono ~ Namanve	16.5	Not add another Circuit	-	-	-
Namanve ~ Kampala North	12.6	HTLS	240	230.82	96.17
Namanve ~ Kampala North	12.6	Not add another Circuit	-	-	-
Lugogo ~ Kampala North	5.70	HTLS	240	100.14	41.72
Lugogo ~ Kampala North	5.70	HTLS	240	100.14	41.72
Mutundwe ~ Kawaala	5.6	HTLS	240	138.77	57.82
Kawaala ~ Kampala North	5.4	HTLS	240	127.88	53.28
Kampala North ~Mutundwe	10.2	HTLS	240	107.94	44.98

Source: JICA Study Team



Source: JICA Study Team

Figure 4-2-2.3 Outline of Transmission System of Scenario 1-3

Moreover, concerning the planned 132 kV transmission line that branches from the 132 kV transmission line between Nalubaale and Kampala North and extends to Mukono Substation and Namanve South Substation (under planned assistance by the Export-Import Bank of China), complex AAAC conductor with wire diameter of 405 mm2 is adopted and two circuits with transmission capacity of 275 MVA are secured. Therefore, re-conductoring to HTLS is required on the existing 132 kV transmission line between Nalubaale and Kampala North, but there is no need to re-conductor to HTLS on the 132 kV transmission line lead-in to Mukono Substation and Namanve South Substation that is planned under assistance by the Export-Import Bank of China.

Concerning Scenario 1-3, Table 4-2-2.6 shows other overloaded equipment in the event of N-1 failure. Overload was confirmed in the 220 / 132 kV inter-connection transformer at Kawanda Substation, however, because it doesn’t exceed 120%, there is deemed to be no problem from the viewpoint of the evaluation criteria for the results of power flow analysis shown in Table 4-2-1.2.

Table 4-2-2.6 Eastern Scenario 1-3: Overload in event of N-1 failure (Over 100%)

N-1 failure transmission line or transformer	Voltage [kV]	Overload transmission line	Overload ratio [%]
Kawanda transformer	220/132	Kawanda transformer	109.55

Source: JICA Study Team

(2) Results of Analysis of the Scenarios for 220 / 132 kV Buloba Substation (Consideration for the Southwestern System in the Kampala Metropolitan Area)

The results of power flow analysis for Scenarios 2-1 through 2-3 concerning the 220 / 132 kV Buloba Substation shown in Table 4-2-1.1 are indicated together with the system configuration outline drawings in Figures 4.4 through 4.6. As a result of conducting power flow analysis, assuming the forecast power demand in the metropolitan area in 2030, which is the target year of the transmission system plan, concerning power supply from Buloba Substation to end users, it has been confirmed that ample capacity can be secured without adopting a 220 kV transmission line system configuration as set in Scenarios 2-2 and 2-3. In other words, adequate capacity can be secured in the system configuration as set in Scenario 2-1, where the 132 kV transmission line between Mutundwe and Entebbe is branched to Gaba Substation via Entebbe Highway Switch Station. The evaluation here was conducted using the criteria shown in Table 4-2-1.2. In other words, even assuming that all evaluation criteria including N-1 standard, voltage control scope, permissible load, etc. are satisfied, the system configuration set in Scenario 2-1 can satisfy the forecast power demand in the metropolitan area in 2030. Table 4-2-2.7 shows the overload of the transmission lines and overload factor in the event of N-1 failure in the Scenario 2-1 system configuration. As is shown in the table, there is no N-1 failure where the overload factor exceeds 120%.

Table 4-2-2.7 South-western Scenario 2-1: Overload in event of N-1 failure (Over 100%)

N-1 failure transmission line or transformer	Voltage [kV]	Overload transmission line	Load Ratio [%]
Kawanda transformer	220/132	Kawanda transformer	107.91
Mutundwe ~Buloba	132	Mutundwe ~Buloba	106.63

Source: JICA Study Team

In this way, Scenario 2-1 was confirmed to be valid assuming the forecast conditions in 2030, the target year of the transmission system plan. However, in the case where 220 kV transmission lines are utilized with a view to addressing conditions after the target period of the transmission system plan, comparison is conducted with Scenarios 2-2 and 2-3 while considering feasibility (environmental and social considerations, etc.) to determine whether or not it is best to supply via Mutundwe Substation.

When comparing based on the results of power flow analysis, concerning Scenario 2-2, whereas the transmission capacity per circuit from Mutundwe Substation to Gaba

Substation is 380 MVA, the demand at Gaba Substation in 2030 will only be approximately 80 MVA, meaning that ample capacity can be secured. Similarly, in Scenario 2-3 too, power supply from Buloba Substation to Gaba Substation via Entebbe Highway Switch Station will only comprise the demand at Gaba Substation. As was mentioned above, upgrading to 220 kV transmission lines is an effective means of responding to increased demand in the future, however, it is hard to envisage this being effective in either Scenario 2-2 or Scenario 2-3 in 2030. When comparing based on environmental and social considerations, concerning Scenario 2-2, which proposes to extend 220 kV transmission line from Buloba Substation to Mutundwe Substation and from there to Gaba Substation, it will be difficult to secure land for a new transmission route in consideration of the fact that Mutundwe Substation is situated in a residential area. Even assuming the case where existing 132 kV transmission line is removed and replaced with 220 kV transmission line on the same site, it will still be necessary to secure more land because greater way leave is required along a 220 kV transmission route (whereas the way leave is 30 meters for a 132 kV transmission line, it is 40 meters for a s 220 kV transmission line).

On the other hand, concerning Scenario 2-3, which proposes to extend 220 kV transmission line from Buloba Substation to Gaba Substation via Entebbe Highway Switch Station without passing through Mutundwe Substation, the load in terms of land acquisition is lighter than in Scenario 2-2.

(3) Transmission System Plan Formulated through Power Flow Analysis

As was mentioned above, as a result of power flow analysis, the best future plan for the Kampala Metropolitan Area system is deemed to entail formation of a 220 kV outer ring system that partially comprises the 220 kV transmission line between Bujagali Power Station and Kawanda Substation and the 220 kV transmission line between Kawanda Substation and Masaka Substation. Accordingly, as the basic policy, it has been decided to compile the transmission system plan based on the assumptions of constructing the 220 / 132 kV Buloba Substation in the western area of the Kampala Metropolitan Area, and the 220 / 132 kV New Mukono Substation in the eastern area with the objective of strengthening supply capacity in the southwestern part of the Kampala Metropolitan Area. In view of this, as a result of setting and examining the scenarios shown in Table 4-2-2.8, it was confirmed that Scenario 1-3 should be adopted for the eastern system and Scenario 2-1 should be adopted for the southwestern system. The system configuration that combines these scenarios shall be the transmission system plan having 2030 as the target year.

Moreover, concerning construction of the 220 / 132 kV Buloba Substation and the 220 / 132 kV New Mukono Substation, interconnection with the 220 kV system was examined on the assumption of open-pi connection, however, as a result of holding discussions with

UETCL, it was decided to adopt double-pi connection in consideration of the reliability of supply. Considering this, power flow analysis is conducted for the section of each year.

Table 4-2-2.8 Adapted Scenarios to Transmission System Plan as the Results of Power Flow Analysis

Formation of the 220 kV outer ring system, etc.	Scenario	Contents	Adoption in the transmission system plan
Scenarios related to New Mukono Substation (Examination related to the eastern system)	1-1	Scenario in which the Nalubaale - Bujagali 132 kV transmission line is operated as “Closed” and HTLS conductors are adopted on all 132 kV transmission lines where there is concern over insufficient capacity in the metropolitan area.	Do not adopt
	1-2	Scenario in which the Nalubaale - Bujagali 132 kV transmission line is operated as “Open” and HTLS conductors are adopted on all 132 kV transmission lines where there is concern over insufficient capacity in the metropolitan area.	Do not adopt
	1-3	Scenario in which the Nalubaale - Bujagali 132 kV transmission line is operated as “Closed” and HTLS conductors are adopted on all 132 kV transmission lines where there is concern over insufficient capacity in the metropolitan area.	Adopt
Scenarios related to Buloba Substation (Examination related to the southwestern system)	2-1	Scenario in which the Mutundwe - Entebbe 132 kV transmission line that is scheduled to commence service in 2017 is branched to Gaba Substation at Entebbe Highway Switch Station.	Adopt
	2-2	Scenario in which 220 kV transmission line is extended from Buloba Substation to Mutundwe Substation, and a 220 kV transmission line is extended from Mutundwe Substation via Entebbe Highway Switch Station to Gaba Substation	Do not adopt
	2-3	Scenario in which 220 kV transmission line is extended from Buloba Substation, via Entebbe Highway Switch Station, to Gaba Substation without passing through Mutundwe Substation.	Do not adopt

Source: JICA Study Team

4-2-3 Additional Considerations for Transmission System Plan

(1) Required Number of Units of 220 / 132 kV Transformers in Each Substation

In the Project, since introduction of the 220 kV outer ring system and other elements of the 220 / 132 kV system transformers in the metropolitan area are important, the necessary quantity of 220 / 132 kV system transformers within the system configuration in the target year of 2030 that was compiled as a result of the transmission system planning was verified. Under the Project, 220 / 132 kV system transformers will be installed at Bujagali Substation, Kawanda Substation, Buloba Substation, and New Mukono Substation. Table 4-2-3.1 shows the unit capacity and number of installed units at each substation in the 2030 system configuration that was compiled in the transmission system plan. In the event where verification is conducted according to the N-1 standard and overload of 120% or more arises, it will become necessary to install additional 220 / 132 kV system transformers.

The target year sections shall be 2022 (the target year of the Project evaluation), when indicators of the Project operating effect will be confirmed, and 2030, which will be the final year of the transmission network development plan.

Table 4-2-3.1 Number of Units in Each Substation Formulated Models

Substation	Capacity [MVA]	Bank
Bujagali Power Station	250	2
Kawanda Substation	250	2
Buloba Substation	125	2
New Mukono Substation	125	2

Source: JICA Study Team

< Target Year of Project Evaluation: 2022 >

On conducting verification of conditions in the event of N-1 failure in the transformers indicated in Table 4-2-3.1 with respect to demand in the 2022 section, since two transformers at Bujagali Power Station will be 125.41% overloaded, it was confirmed that three transformers will be needed. Table 4-2-3.1 shows the results of conducting verification of conditions in the event of N-1 failure in the transmission lines and transformers in the case where three transformers are installed at Bujagali Power Station. As a result of the analysis, none of the 220 / 132 kV system transformers envisaged in the 2022 system configuration that was compiled in the transmission system plan were found to experience load ratio in excess of 120%, which is the standard for transmission system planning. Accordingly, it is deemed that the number of transformers indicated in Table 4-2-3.1 is needed with respect to the demand in the 2022 section.

Table 4-2-3.2 2022 Section: Number of Units and Max Load Ratio in Event of N-1 Failure

Substation	Capacity [MVA]	Bank	Max Load Ratio [%]
Bujagali Power Station	250	3	69.24
Kawanda Substation	250	2	65.27
Buloba Substation	125	2	41.48
New Mukono Substation	125	2	79.19

Source: JICA Study Team

< Target Year of Transmission System Plan : 2030 >

On conducting verification of conditions in the event of N-1 failure in the transformers indicated in Table 4-2-3.2 with respect to demand in the 2030 section, since two transformers at New Mukono Substation will be 139.16% overloaded, it was confirmed that three transformers will be needed. Table 4-2-3.3 shows the results of conducting verification of conditions in the event of N-1 failure in the transmission lines and transformers in the case where three transformers are installed at New Mukono Substation. As a result of the analysis, none of the 220 / 132 kV system transformers envisaged in the 2030 system configuration that was compiled in the transmission system plan were found to experience load ratio in excess of 120%, which is the standard for transmission system planning. Accordingly, it is deemed that the number of transformers indicated in Table 4-2-3.3 is needed with respect to the demand in the 2030 section. The number of transformers shown in Table 4-2-3.2 will be reflected in the transmission system plan.

Table 4-2-3.3 2030 Section: Number of Units and Max Load Ratio in Event of N-1 Failure

Substation	Capacity [MVA]	Bank	Max Load Ratio [%]
Bujagali Power Station	250	3	73.83
Kawanda Substation	250	2	112.90
Buloba Substation	125	2	83.67
New Mukono Substation	125	3	97.41

Source: JICA Study Team

(2) Upgrading to the Double Bus Configuration of 132 kV Bus at Mutundwe Substation

The 132 kV bus of Mutundwe Substation is currently a single bus. When bus failure occurs, it is a single bus failure and this causes power outage over a wide range of substations that obtain power from Mutundwe Substation. Despite having an international airport and other important load destinations nearby and being in an area of advancing commercial development, Mutundwe Substation is the only substation in the metropolitan area that does not have 132 kV double bus configuration. It is urgently necessary to remedy this situation from the viewpoint of reliability of supply. In the case where double bus configuration is adopted at Mutundwe Substation, the reliability of supply in the surrounding area will improve dramatically. The methodology for this is examined in the following paragraphs.

1) Methodology of Introduction of Double Bus Configuration

In introducing double bus configuration to Mutundwe Substation, it is necessary to examine the bus configuration while ensuring compatibility with the existing plans of UETCL. Plans are being advanced by the German aid agency KfW to install two 132 kV transmission lines to Entebbe with a view to expanding the existing 132 kV bus on vacant land to the southwest of Mutundwe Substation. The double bus configuration here will be realized through expanding the bus in these construction works. In this case, two circuits each will be connected to Mutundwe Substation from five nearby facilities, namely Lugogo Substation, Kampala North Substation, Kawanda Substation, Buloba Substation, and Entebbe Substation, meaning that 10 transmission line circuits will be led-in to

Mutundwe Substation. Moreover, Queensway Substation is situated on the 132 kV transmission line one circuit from Lugogo Substation, and Kawaala Substation, etc. is located on the 132 kV transmission line one circuit from Kampala North Substation. In light of this, as is shown in Figure 4-2-3.1, a single circuit is extended from the left side of the connecting lines to each surrounding substation in the figure, and a single circuit 132 kV transmission line is extended from the right side.

In Figure 4-2-3.1, the right side from connecting lines shows the existing 132 kV bus, and the left side shows the 132 kV bus to be constructed. In this figure, single circuit 132 kV transmission lines extend from the left side of the connecting line to five substations on the left side bus, and similarly five single circuits lead-in to five substations on the right side bus. This bus configuration ensures that a double bus configuration is achieved, however, it will be necessary to verify whether or not demand in 2030, the target year of the transmission system plan, can be covered in the event of bus failure on a single side.

Moreover, as is shown in Figure 4-2-3.1, out of the two 132/33kV transformers with existing capacity of 40 MVA and two 132/11 kV transformers with capacity of 20 MVA, it is envisaged that one transformer each will be connected to the bus on the side to be expanded.

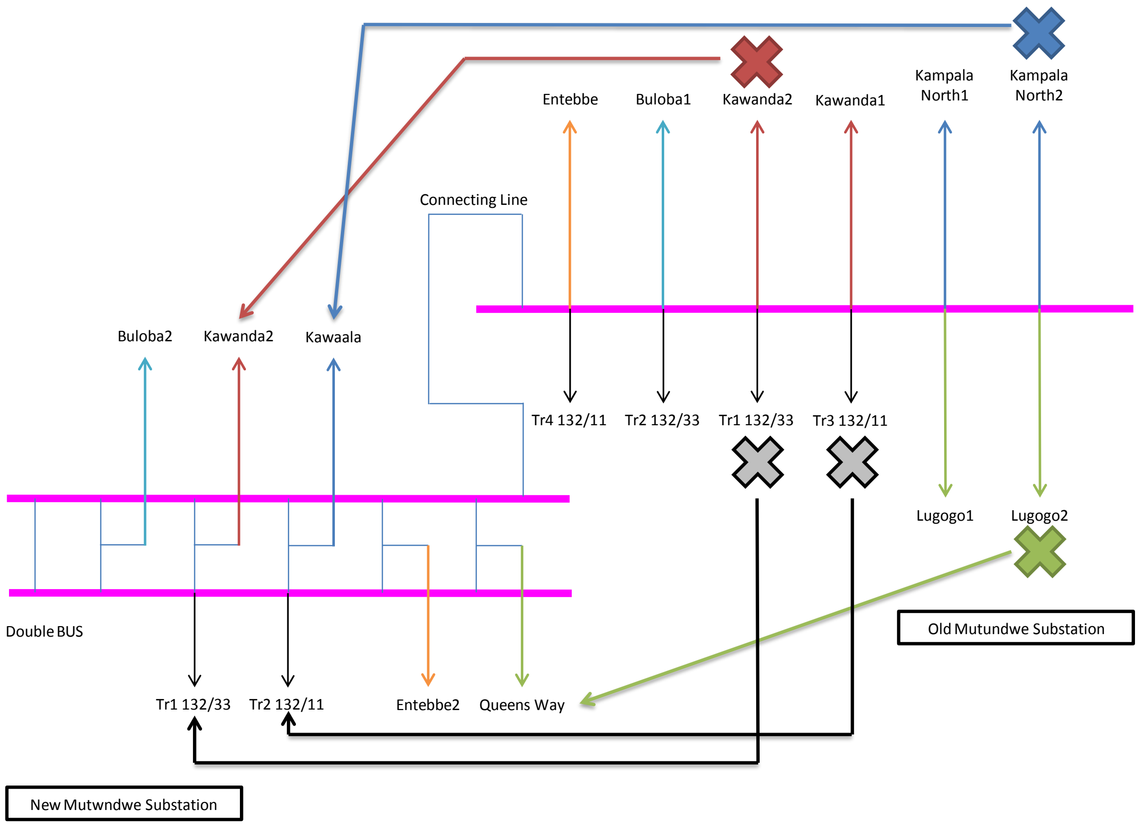


Figure 4-2-3.1 Connection schematic of Mutundwe Substation

2) Power Flow under the condition of Single Bus Failure

In Figure 4-2-3.1, power flow analysis in the case of single bus failure was conducted assuming occurrence of failure on the existing bus side (right side) of the connecting line. Figure 4.7 shows the results of power flow analysis under normal conditions, while Figure 4.8 shows power flow in the event of single bus failure. Verification was conducted to determine whether or not the maximum power flow can be handled in the case of single bus failure. Table 4-2-3.4 shows the transmission lines where the load ratio is 100% or higher. As this table shows, the load ratio on the 132 kV transmission line between Buloba Substation and New Mutundwe Substation is higher than 120%, indicating the need for countermeasures based on either system operation or equipment upgrading. Figure 4.7 shows the power flow diagram in normal conditions, and Figure 4.8 shows the power flow diagram in the event of single bus failure.

Table 4-2-3.4 Overload in event of Single Bus Failure at Mutundwe Substation

Subject contingency	Target transmission line	Voltage [kV]	Overload rate[%]
Single bus contingency of the old Mutundwe substation	Buloba substation - New Mutundwe substation	132	125.29

3) Countermeasure for Overload of 132 kV Lines between Buloba - Mutundwe in Terms of System Operation

As was mentioned above, five substations obtain transmission lines from Mutundwe Substation, and even if overload caused by single bus failure occurs on some of these, there is a possibility that overload can be averted through conducting open operation and supplying power through other routes that have larger transmission capacity. In order to confirm this, power flow analysis was conducted on the system model that entails open operation of the 132 kV transmission line between Buloba Substation and New Mutundwe Substation in Figure 4.8.

Figure 4.9 shows the results of power flow analysis, while Figure 4-2-3.2 shows the power flow situation around Mutundwe Substation. As can be seen in this figure, the 135 MW placed on the 132 kV transmission line between Buloba Substation and New Mutundwe Substation before open operation falls entirely on the 132 kV transmission line between Kawanda Substation and Mutundwe Substation and the power flow becomes roughly 350MW in the case where open operation is implemented. However, since this section has transmission capacity of 457MVA and is able to accommodate this, power can be supplied. Moreover, since there is no voltage drop or overload at this time, the multiple bus operation in this configuration is deemed to not be a problem.

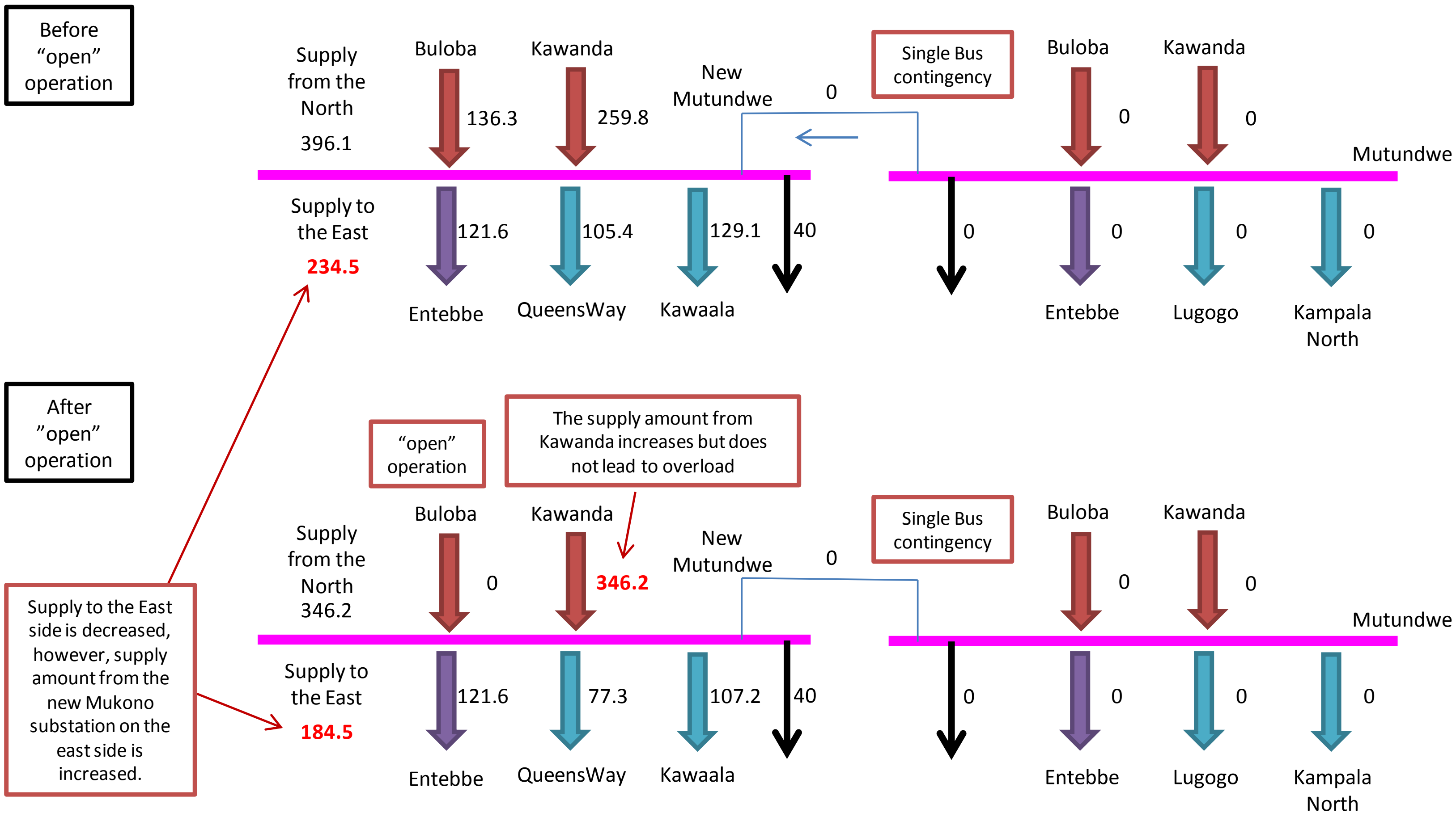


Figure 4-2-3.2 Power Flow around Mutundwe Substation before and after the “open” operation-132 kV Lines between Buloba - Mutundwe

4) Countermeasure for Overload of 132 kV Lines between Buloba - Mutundwe in Terms of Upgrading of Equipment

It was confirmed that overload can be averted through taking the system operation measures described above. In this case, it is necessary to conduct switching of transmission lines and so on. If a transmission line with ample capacity is adopted as the 132 kV transmission line between Buloba Substation and New Mutundwe Substation, where overload of approximately 26% was confirmed in the model shown in Figure 4.9, the cause of the overload can be fundamentally resolved.

The 132 kV transmission line between Mutundwe and Kabulasoke substations currently comprises an AAC 200mm2 line with transmission capacity of 110 MVA. In the event of single bus failure at Mutundwe Substation, since transmission capacity of approximately 140 MVA is required in each circuit, overload can be prevented by adopting a transmission line with higher capacity than this. Accordingly, in constructing Buloba Substation, concerning the section from the pi branch point of the 132 kV transmission line between Mutundwe and Kabulasoke substations to Buloba Substation, two conductors of AAAC 240mm2, which allow transmission capacity of 205 MVA to be secured, will be adopted in each circuit.

Moreover, in the case where UETCL adopts two circuits and steel towers on the 132 kV transmission line between Mutundwe and Kabulasoke substations, it will be necessary to secure the compatibility of plans based on the same specifications.

4-2-4 Power Flow Analysis for Analysis Sections

As was mentioned above, transmission systems with an ultra-high voltage ring configuration that combines supply capacity with reliability are generally adopted in the major cities of advanced nations. In the Kampala Metropolitan Area too, it is becoming necessary to configure an ultra-high voltage 220 kV ring configuration transmission system through making use of the city’s 220 kV transmission lines on the outer side of the existing 132 kV ring system. In order to form the 220 kV ring system, it is necessary to construct 220 / 132 kV substations that can act as points for supplying power from the 220 kV transmission lines to the metropolitan area. Considering that it is not so easy to acquire land inside the metropolitan area, based on discussions with UETCL, it was decided to select the 220 / 132 kV Buloba Substation and New Mukono Substation as the 220 / 132 kV substations for the area. Assuming this as a precondition, power flow analysis was conducted with a view to formulating the transmission system plan including optimization of the sections re-conductored to HTLS conductors from the existing conductors and so on.

Prior to conducting the power flow analysis for each year section, Table 4-2-4.1 shows the enhancement plan of the transmission lines in each analysis section based on the formulated transmission system plan, while Table 4-2-4.2 shows the enhancement plan of the substation equipment in each analysis section including the equipment enhancement plan which UETCL has already scheduled for implementation. The power flow analysis in each analysis section is implemented based on these equipment enhancement plans.

Table 4-2-4.1 Enhancement plan of the transmission lines

Planned Transmission Line										
	Transmission Line	Voltage [kV]	cct	Conductor Type	Line Rating [MVA]	Year cross-section 2015	2018	2020	2022	2030
Kampala Metropolitan										
	Kampala North - T-Kawaala	132	1	ACSR183	79.1	●	-	-	-	-
⇒	Kampala North - Kawaala	132	1	ACSR183	79.1		●	-	-	-
⇒	Kampala North - Kawaala	132	1	HTLS	240			●[Replacement]	⇒	⇒
	Kawaala T-Kawaala - CB-Mutundwe	132	1	ACSR183	79.1	●	-	-	-	-
⇒	Kawaala - Mutundwe	132	1	ACSR183	79.1		●	-	-	-
⇒	Kawaala - Mutundwe	132	1	HTLS	240			●[Replacement]	⇒	⇒
	Kampala North - Mutundwe	132	1	HTLS	240			●[Replacement]	⇒	⇒
	Nalubaale - T-Mukono	132	1	ACSR125	147	●	-	-	-	-
⇒	Nalubaale - Mukono		1	ACSR125	147		●	⇒	⇒	⇒
	T-Mukono - T-Namanve South	132	1	ACSR125	147	●	-	-	-	-
⇒	Mukono Branch Namanve South Branch	132	1	ACSR125	147		●	-	-	-
⇒	Mukono Branch Namanve South Branch	132	1	HTLS	240			●[Replacement]	⇒	⇒
	T-Namanve South - Namanve	132	1	ACSR125	147	●	-	-	-	-
⇒	Namanve South Branch - Namanve	132	1	ACSR125	147		●	-	-	-
⇒	Namanve South Branch - Namanve	132	1	HTLS	240			●[Replacement]	⇒	⇒
	Namanve South Branch - Namanve	132	2	AAAC400(Double)	400		●	⇒	⇒	⇒
	Namanve - Kampala North	132	1	ACSR125	147	●	⇒	-	-	-
			1	HTLS	240			●[Replacement]	⇒	⇒
	Lugogo - Kampala North	132	2	ACSR183	73.2	●	⇒	-	-	-
⇒	Lugogo - Kampala North	132	2	HTLS	240			●[Replacement]	⇒	⇒
	Namanve South - Luzira	132	2	ACSR125	147		●	⇒	⇒	⇒
	Lugogo - Mutundwe	132	2	ACSR385	180	●	⇒	-	-	-
⇒	Lugogo - T-QueensWay - Mutundwe(Open pi)		1+1	ACSR385	180			●	⇒	⇒
	Nalubaale - Lugogo	132	2	ACSR385	180	●	⇒	-	-	-
⇒	Nalubaale - Mukono - Lugogo(Open pi)		1+1	ACSR385	180			●	⇒	⇒
	Mutundwe - Kawanda	132	2	AAAC240(Quad)	457	●	⇒	⇒	⇒	⇒
	Bujagali - Kawanda	220	2	AAAC240(Double)	205.8	●[132kV operation]	-	-	-	-
			2	AAAC240(Double)	381		●[220kV operation]			
⇒	Bujagali - New Mukono - Kawanda(Double pi)	220	2	AAAC240(Double)	381			●	⇒	⇒
	Kawanda - Masaka West	220	2	AAAC240(Double)	381		●	-	-	-
⇒	Kawanda - Buloba - Masaka West(Double pi)		2	AAAC240(Double)	381			●	⇒	⇒
	Buloba - Kabulasoke	220	2	AAAC240(Double)	381			●	⇒	⇒
	Nalubaale - Bujagali	132	2	AAAC240(Twin)	205.8	●	⇒	"Open" operation	"Open" operation	"Open" operation
	Bujagali - Tororo	132	2	ACSR185	82	●	-	-	-	-
⇒	Bujagali - Iganga - Tororo(Open pi)		1+1	ACSR185	82		●	⇒	⇒	⇒
	Entebbe - Mutundwe	132	2	AAAC240	110		●	-	-	-
⇒	Entebbe - Entebbe HW -Mutundwe		2	AAAC240	110			●	⇒	⇒
	Gaba - Entebbe HW	132	2	AAAC240(Twin)	205.8			●	⇒	⇒
	Mutundwe - Kabulasoke	132	1	AAAC240	110	●	⇒	-	-	-
⇒	Mutundwe - Buloba - Kabulasoke(pi)	132	1→2	AAAC240	110			●[1cct]	⇒	●[2cct]

[Notes] ●: Installed or Existing, ⇒: Same as the previous year,
- : Removed (Load is relocated to the new equipment), Blank: Not installed, Blue: the Project

[Source] JICA Study Team

Table 4-2-4.2 Enhancement plan of the substation equipment

Planned Substation								
Substation	Voltage [kV]	Capacity [MVA]	Bank	Year cross-section				
				2015	2018	2020	2022	2030
Kampala Metropolitan Area								
Bujagali	220/132	250	2	●	⇒	⇒	⇒	⇒
Bujagali	220/132	250	1			●	⇒	⇒
Kawanda	220/132	250	2	●	⇒	⇒	⇒	⇒
Buloba	220/132	125	2			●	⇒	⇒
	132/33	40	2			●	⇒	⇒
New Mukono	220/132	125	3			●	⇒	⇒
Lugogo	132/11	40	2	●	⇒	⇒	⇒	⇒
	132/33	40	2	●	⇒	⇒	⇒	⇒
Mutundwe	132/11	20	2	●	⇒	⇒	⇒	⇒
	132/33	40	2	●	⇒	⇒	⇒	⇒
Namanve	132/33	40	3	●	⇒	⇒	⇒	⇒
Kampala North	132/11	40	2	●	⇒	⇒	⇒	⇒
	132/33	40	2	●	⇒	⇒	⇒	⇒
Kawaala	132/11	15	1	●	⇒	–	–	–
Kawaala	132/11	20	1			●	⇒	⇒
	132/33	40	3			●	⇒	⇒
Kawanda	132/33	40	1	●	⇒	⇒	⇒	⇒
	132/33	40	1			●	⇒	⇒
Queens Way	132/33	40	3		●	⇒	⇒	⇒
Luzira	132/33	40	2		●	⇒	⇒	⇒
Namanve South	132/33	63	3		●	⇒	⇒	⇒
Mukono	132/33	63	3		●	⇒	⇒	⇒
Entebbe	132/33	80	2		●	⇒	⇒	⇒
Gaba	132/33	60	2			●	⇒	⇒

[Notes] ●: Installed or Existing, ⇒: Same as the previous year,
- : Removed (Load is relocated to the new equipment), Blank: Not installed, Blue: the Project

[Source] JICA Study Team

< 2015 > Current Section (Figure 4.10)

In the 2015 section, the power situation is tight, however, because exported power to neighboring countries is still at a low level, power supply is possible based on the current configuration of the power system. However, considering growth in the power demand of 6~7% per year as envisaged in the econometrics approach, since the bus voltage and load ratio of the transmission lines will exceed the management range in 2030 (the target year of the Project evaluation), the Project is essential for power supply in the Metropolitan Area as indicated below.

[Capacitor and Reactors]

Namanve Substation 33kV : 48 MVar

Lugogo Substation 33kV : 10 MVar

[Power analysis results]

① Bus Voltage

Voltage drop seen in Kabulasoke substation (0.9365 p.u.) and Masaka substation (0.9305 p.u.).

(If overload of the transmission lines that avoids, falls within the proper range)

② Transmission line

Overload (100%) can be seen between the Kabulasoke substation and Masaka substation.

(Operation that targeted export volume to Tanzania via Masaka substation, it is possible to avoid overload of the transmission line)

③ Transformers

No overload can be seen.

< 2018 > Commencement of Operation of the Substations Funded by the Chinese Assistance and 220 kV Transmission Lines (Figure 4.11)

In the 2018 section, thanks to completion of the installation work of the substation under aid from the Export-Import Bank of China, Namanve South Substation (with Luzira Substation on its secondary side), Mukono Substation, etc. will be connected on the 132 kV transmission line between Nalubaale Substation and Kampala North Substation, thereby increasing power flow over this section. There are not overloaded transmission lines in the normal condition or in the event of the N-1 failure, however, under this configuration of the power system, it is envisaged that the transmission lines will become overloaded in the event of the N-1 failure under the demand forecast a few years into the future. Therefore, the existing transmission lines in the section of ACSR 125, double-conductor of transmission capacity 147 MVA shall be re-conductored to HTLS conductors in the Project.

Moreover, on the section between Kampala North Substation and Mutundwe Substation, because the existing capacity of the transmission lines is equivalent to 80 MVA, which is insufficient to cope with the said future demand growth and in the event of N-1 failure, it is necessary to conduct re-conductoring to HTLS conductors.

[Capacitor and Reactors]

Kampala North Substation 132 kV : 40 MVar

Namanve Substation 132 kV : 40 MVar

Lugogo Substation 132 kV : 40 MVar

[Power analysis results]

① Bus Voltage

Within the proper range.

② Transmission line

No overload can be seen.

③ Transformers

No overload can be seen.

< 2020 > Commencement of Operation of the Equipment of the Project (Figure 4.12)

As the Project expects the installation work to be completed in 2020, the Project equipment will commence operation from this section. Therefore, concerning this section and beyond, power flow analysis was carried out based on simulating configuration of the transmission system in the case where the Project is implemented and in the case where the Project is not implemented.

As was also described for the 2018 section, thanks to completion of the installation work of the substation under aid from the Export-Import Bank of China, Namanve South Substation (with Luzira Substation on its secondary side), Mukono Substation, etc. will be connected on the 132 kV transmission line between Nalubaale Substation and Kampala North Substation, thereby increasing power flow over this section while also increasing the power demand of each substation.

In the case where the 220 / 132 kV New Mukono Substation is constructed and the 132 kV transmission lines from Mukono Substation to Kampala North Substation and from Kampala North Substation to Mutundwe Substation are re-conductored to HTLS conductors in the Project, it was confirmed that the bus voltage and load ratio of the transmission lines that deviate from the management range in the case of no implementation will be held in the management range.

Moreover, concerning N-1 failure, no overload can be seen in the section. Concerning why, since the target year of the transmission system plan is 2030 and the equipment enhancement plan is compiled to ensure conformity with the demand at this time, the equipment still has ample capacity with respect to the power demand in 2020. Moreover, through opening operation of the 132 kV transmission line between Bujagali Substation and Nalubaale Substation, it is possible to direct the power flow going to the 132 kV transmission lines to the 220 kV transmission lines which can reduce transmission loss, thereby making it possible to promote rationalization of energy use, however, for this it is essential to construct the 220 / 132 kV New Mukono Substation in the Project. In addition, thank to completion of installation work of the 220 / 132 kV Buloba Substation in the Project, it becomes possible to supply load on the distribution network from Buloba Substation.

[Gist of which was formulated system configuration]

① Southwest Route

Transmission line route to Gaba Substation:

Mutundwe Substation ~ Entebbe Highway Switching Station ~ Gaba SubstatioN-132 kV transmission line

Lead - in of 220 kV transmission line from Buloba Substation: None

② East Route

Section of 132 kV transmission line <Nalubaale Substation - Kampala North Substation>

: Optimum configuration shown in Figure 4-2-2.3 (east scenario 1-3)

[Capacitor and Reactors]

Open

[Power analysis results]

① Bus Voltage

Within the proper range.(±5%)

② Transmission line

No overload can be seen.

③ Transformers

No overload can be seen.

< 2022 > Target Year of the Project Evaluation (Figure 4.13)

As in the 2020 section, in the case where the 220 / 132 kV New Mukono Substation is constructed and the 132 kV transmission lines from Mukono Substation to Kampala North Substation and from Kampala North Substation to Mutundwe Substation are re-conductored to HTLS conductors in the Project, it was confirmed that the bus voltage and load ratio of the transmission lines that deviate from the management range in the case of no implementation will be held in the management range.

Moreover, if the Project is implemented, concerning N-1 failure, no overload can be seen in this section. Concerning why, since the target year of the transmission system plan is 2030 and the equipment enhancement plan is compiled to ensure conformity with the demand at this time, the equipment still has ample capacity with respect to the power demand in 2022. Moreover, through opening operation of the 132 kV transmission line between Bujagali Substation and Nalubaale Substation, it is possible to direct the power flow going to the 132 kV transmission lines to the 220 kV transmission lines which can reduce transmission loss, thereby making it possible to promote rationalization of energy use, however, for this it is essential to construct the 220 / 132 kV New Mukono Substation in the Project. In addition, thank to completion of installation work of the 220 / 132 kV Buloba Substation in the Project, it becomes possible to supply load on the distribution network from Buloba Substation.

Moreover, concerning this cross section, under the configuration of the transmission system in the case of no Project implementation, it was found that the transmission capacity is insufficient in the event of N-1 failure. Therefore, it is necessary to complete the Project installation work by 2022, and from this viewpoint it is valid to commence operation of the Project equipment from 2020.

[Gist of which was formulated system configuration]

① Southwest Route

Transmission line route to Gaba Substation:

Mutundwe Substation ~ Entebbe Highway Switching Station ~ Gaba Substation-132 kV transmission line

Lead - in of 220 kV transmission line from Buloba Substation: None

② East Route

Section of 132 kV transmission line <Nalubaale Substation - Kampala North Substation>

：Optimum configuration shown in Figure 4-2-2.3 (east scenario 1-3)

[Capacitor and Reactors]

Open

[Power analysis results]

① Bus Voltage

Within the proper range.

② Transmission line

No overload can be seen.

③ Transformers

No overload can be seen.

< 2030 > Target Year of the Transmission System Plan (Figure 4.14)

Since 2030 is planned as the target year of the transmission system plan, it was reconfirmed that the bus voltage and load ratio of the transmission lines and transformers are held within the management range under both the normal condition (N-0) and in the event of N-1 failure. Concerning the 220 / 132 kV transformers, since the number of transformer units in New Mukono Substation and Bujagali Substation is optimized in consideration of the 2030 section, they can be operated without overload. In the case where the Project is not implemented, in the 2030 section, it has been confirmed that the bus voltage and load ratio of the transmission lines deviate from the management range in the normal condition (N-0), while the bus voltage and load ratio of the transmission lines and transformers deviate from the management range in the event of N-1 failure. It was thus confirmed that failure to implement the Project will impart major difficulties on the power supply

[Gist of which was formulated system configuration]

① Southwest Route

Transmission line route to Gaba Substation:

Mutundwe Substation ~ Entebbe Highway Switching Station ~ Gaba Substation-132 kV transmission line

Lead - in of 220 kV transmission line from Buloba Substation: None

② East Route

Section of 132 kV transmission line <Nalubaale Substation - Kampala North Substation>

：Optimum configuration shown in Figure 4-2-2.3 (east scenario 1-3)

[Capacitor and Reactors]

Kampala North Substation 132 kV : 80 MVar

Kampala North Substation 33kV : 10 MVar

Namanve Substation-132 kV : 40 MVar

Namanve Substation 33 kV : 48 MVar

Lugogo Substation 132 kV : 60 MVar

Lugogo Substation 33 kV : 10 MVar

Namanve South Substation 33kV : 30 MVar

[Power analysis results]

① Bus Voltage

Voltage at Tororo Substation on the eastern side is greater thaN-1.05 p.u..

② Transmission line

No overload can be seen.

③ Transformers

No overload can be seen.

By implementing the present system plan from the above, it was confirmed in the operation target range to the target year are possible system operation.

Table 4-2-4.3 sums up the results of power flow analysis in each section. In this table, under the third column from the left entitled “Project Component”, the rows that show “without” envisage the configuration of the transmission system in the case where the Project is not implemented, and the rows showing “with” denote the configuration of the transmission system in the case where the Project is implemented. Since the Project is envisaged for implementation in 2020, the configuration of the transmission system in the case where the Project is not implemented is not considered for 2015 and 2018.

As is indicated in Table 4-2-4.3, in the case where the Project is not implemented, as was mentioned above, in event of N-1 failure in 2022 (the year of the Project evaluation), overloaded transmission lines can be seen and operation of the transmission system is hindered, thus confirming the need to implement the Project before then and to complete the installation work for the components of the Project by around 2020. As is shown in the table, in the case where failure arises in the 132 kV transmission line between Nalubaale - Namanve, overload occurs on the 132 kV transmission line between Kampala North - Lugogo, where it is planned to conduct re-conductoring to HTLS conductors in the Project.

Moreover, in 2030, which is the target year of the transmission system plan in the Project, in the case where the Project is not implemented, as is indicated in Table 4-2-4.3, load ratio of 180%, exceeding the permissible limit, has been confirmed on the 132 kV transmission lines where it is planned to conduct re-conductoring to HTLS conductors in the Project between Kawaala Substation and Mutundwe Substation, between Nalubaale Substation and New Mukono Substation, and between Kampala North Substation and Lugogo Substation, even under the normal condition (N-0). In addition, in the event of N-1 failure, the bus voltage and load ratio of the transmission lines and transformers deviate from the management range.

To sum up, as was concluded in the transmission system plan, in the case where power demand is envisaged in 2030, the target year of the transmission system plan, it has been confirmed that the components of the Project are essential for power supply in the Kampala Metropolitan Area.

Table 4-2-4.3 Summary of the results of power flow analysis in each section

Year	Cross section	Project Component	Failure	Bus Voltage	Transmission line	Transformers	State
2015	Current cross section	with	N-0	×	×	○	By adjusting the volume of exports to Tanzania, which is the operation in a proper range possible.
			N-1	×	×	○	Overload can be seen at the time of N-1 failure ＜Transmission line of the N-1 failure ⇒ Overload tranmission line : Overload rare＞ ・N-1 failure of Nalubaale and Namanve ⇒ Overload rare between Kampala North and Lugogo : 123[%]
2018	Completion of the substation of Chinese support, operation start cross-section of the 220kV transmission line	without	N-0	○	○	○	It can be operated in a proper range
			N-1	○	○	○	It can be operated in a proper range
2020	Completion of the plan	with	N-0	○	○	○	It can be operated in a proper range
			N-1	○	○	○	It can be operated in a proper range
		without	N-0	○	○	○	It can be operated in a proper range
			N-1	○	○	○	It can be operated in a proper range
2022	Project Evaluation Annual of the plan	with	N-0	○	○	○	It can be operated in a proper range
			N-1	○	○	○	It can be operated in a proper range
		without	N-0	○	○	○	It can be operated in a proper range
			N-1	○	×	○	Overload can be seen at the time of N-1 failure ＜Transmission line of the N-1 failure ⇒ Overload transmission line : Overload rare＞ ・N-1 failure of between Nalubaale and Mukono ⇒ Overload rate between Kampala North and Lugogo : 125[%] ・N-1 faulure of between Nalubaale and Mukono ⇒ Overload rate between Kawaala and Mutundwe : 121[%]
2030	The target year of the power system cross-section of the plan	with	N-0	○	○	○	It can be operated in a proper range
			N-1	○	○	○	It can be operated in a proper range
		without	N-0	×	×	○	Overload can be seen at all times ＜Overload transmission line : Overload rate＞ ・Kawaala - Mutundwe : 177[%] ・Nalubaale - Mukono : 169[%] ・Kampala North - Lugogo : 137[%]
			N-1	×	×	×	Seen a lot of overload transmission line

Project Component/Without : "Open" operation between Bujagali and Nalubaale was "Close" operation.

Remark: Without case of this project assumes the close operation at Bujagali - Nalubale Substation
Source: JICA Study Team

4-3 Conclusions and Suggestions

4-3-1 Conclusions

As was mentioned above, considering that the Project target area is the metropolitan area, which is a major consumer area, before selecting the components of the Project, the transmission system plan was compiled based on the medium-term power demand forecast utilizing the econometrics approach while surveying the whole transmission system in the Kampala Metropolitan Area including the ring configuration in the future metropolitan area transmission system. Through verifying the results of power flow analysis in the sections of the power flow analysis, the components indicated in Table 4-3-1.1 were specified as the Project plan.

Generally, with respect to the urban transmission system which power demand has increased, in order to configure transmission system that combines sufficient supply capacity and supply reliability, it is effectual method to configure ring system of extra-high voltage transmission lines. Regarding transmission system in Uganda, it is in the introductory phase of 220 kV transmission lines, and development is underway by passing through the Kampala metropolitan area, and they are expected to operate soon. Therefore, based on tendency of rapid increase about from 6% to 7% per year in the metropolitan area, the most important issue of the Kampala metropolitan area in medium term (10 to 15 years) is to utilize 220 kV transmission lines passing through the metropolitan area for supplying power to there. As the first step, it is important to introduce 220 / 132 kV substations on 220 kV transmission lines passing through the metropolitan area such as 220 kV transmission lines between Bujagali power station and Kawanda substation and 220 kV transmission lines between Kawanda substation and Masaka substation, and to secure power supplying point from 220 kV transmission system to the Kampala metropolitan area. Since new land acquisition is difficult in the Kampala metropolitan area and the degree of freedom is not high in relation to selection of the Project site, as a result of consultation with UETCL, Buloba substation and New Mukono substation are selected as shown in Table 4-3-1.1.

In addition, combined with development of substations above, since the capacity of the existing 132 kV transmission system is also expected to lack fundamentally, it is indispensable to increase the capacity of 132 kV transmission lines. Since new land acquisition for transmission lines in the metropolitan area also difficult, it is effectual to enhance the transmission capacity by upgrading the existing conductors to High-Temperature Low-Sag conductors (HTLS conductors) and utilizing the existing transmission tower. Setting scenario as described above, the result of optimizing adoption section of HTLS conductors as shown in Table 4-3-1.1.

On the other hand, as shown in Table 4-3-1.1, from the point of view for effective use of 220 kV transmission lines, addition of a 220 / 132 kV transformer in Bujagali substation has been selected as one of the Project components by the result of power flow analysis.

And, upgrading to double busbars which should be tackled immediately in Mutundwe substation has been also shown in Table 4-3-1.1 as one of the Project components by the result of power flow analysis. In addition, in order to enhance supply capacity of Kampala North substation where increases demand especially, the expansion plans of Kawaala substation in accordance with the demand forecast of the substation unit was included as the Project component as shown in Table 4-3-1.1.

Moreover, because the needs for equipment for countermeasures in cases of accidents at each substation in the metropolitan area are becoming increasingly acute, Table 4-3-1.1 includes "mobile substation" as a component of the Project under item No. 6.

Table 4-3-1.1 Components of the Project (Draft)

Main component		**Outline**	**Contents**
Substation	**1. Buloba Substation**		New Construction
	(1) 220 / 132 kV Transformer	125 MVA×2units	
	(2) 132 / 33 kV Transformer	40 MVA×2units	
	(3) 220 kV Switchgear	1 lot	
	(4) 132 kV Switchgear	1 lot	
	(5) 33 kV Switchgear	1 lot	
	(6) Control building	1 lot	
	2. New Mukono Substation		New Construction
	(1) 220 / 132 / 33 kV Transformer	125 MVA×3units	
	(2) 220 kV Gas Insulated Switchgear	1 lot	
	(3) 132 kV Gas Insulated Switchgear	1 lot	
	(4) Control building	1 lot	
	(5) 132 kV transmission line (New Mukono Substation - Mukono Substation)	Approx. 0.3 km×2cct	
	3. Kawaala Substation		Renovation
	(1)132 / 33 kV Transformer	40 MVA×3units	
	(2)132 / 11 kV Transformer	20 MVA×1unit	
	(3)132 kV Gas Insulated Switchgear	1 lot	
	(4)33 kV Switchgear	1 lot	
	(5)11 kV Switchgear	1 lot	
	(6)Control building	1 lot	
	4. Bujagali Substation		Upgrade
	(1) 220 / 132 / 33 kV Transformer	250 MVA×1unit	
	(2) 220 kV Switchgear	1 lot	
	(3) 132 kV Switchgear	1 lot	
	5. Mutundwe Substation		Upgrade
	(1) 132 kV Switchgear	1 lot	
	6. Mobile substation (132 / 33 - 11 kV)	20 MVA×2units	Procurement
Transmission	**7. 220 kV Transmission Line**		
	(1) Buloba branch point - Buloba Substation	Approx. 0.9 km×4cct	New Construction
	(2) New Mukono branch point - New Mukono Substation (including the modification of 132 kV transmission line betweenNo.77 and No.78)	Approx. 4.2 km×4cct	New Construction

Main component		Outline	Contents
	8. 132 kV Transmission Line		
	(1) Buloba branch point - Buloba Substation	Approx.0.8 km×2cct	New Construction
	(2) New Mukono Substation - New Mukono branch point (Southern trunk line)	Approx.0.4 km×2cct	New Construction
	(3) Mukono branch point (Northern trunk line) - Kampala North Substation	Approx.25.4 km×1cct	Re-conductoring
	(4) Kampala North Substation - Mutundwe Substation	Approx.10.2 km×2cct	Re-conductoring
	(5) Kampala North Substation - Lugogo Substation	Approx. 5.3 km×2cct	Re-conductoring
	(6) Kawaala branch point - Kawaala Substation	Approx.0.1 km×2cct	Cabling

Source: JICA Study Team

4-3-2 Suggestions

On implementation of this project, matters which are revealed in association with studies considered in 4-1 and 4-2 are as follows.

(1) Reinforcement and operation method of transmission line between Bujagali power station and Nalubaale substation

Since overload by commissioning of Ishimba power station in 2018 and demand increase of Kampala metropolitan area Transmission line between Bujagali power station and Nalubaale substation is expected as mentioned in Grid Development Plan of UETCL, it is necessary to implement enhancement of capacity of the transmission line.

New Mukono substation became source of power supply to Kampala metropolitan area after its commissioning around 2020 and there become less need to exist transmission line between Bujagali power station and Nalubaale substation. Therefore, in order to reduce transmission loss in normal state and to utilize 220 kV transmission, JICA study team recommend to UETCL that the transmission line between Bujagali power station and Nalubaale substation should be normally "OFF" and utilized only when contingency will occur.

(2) Specifications of towers of 132 kV transmission line which is outgoing from Buloba substation to Buloba branch point

There is no validity of 220 kV transmission line between Buloba substation and Mutundwe substation.

On the other hand, 132 kV transmission line between Mutundwe substation and Buloba substation is planned to upgrade from 1cct to 2ccts after countermeasures for social impact regarding changing wooden pole to steel tower between Mutundwe substation and Kabulasoke substation is established. Therefore, steel towers between Buloba substation and Buloba branch point which are components of this project should be specified to be able to string 132 kV 2 lines to Mutundwe substation and 132 kV 1 line to Kabulasoke substation.

(3) Enhancement of transmission lines between Mutundwe substation and Buloba branch point, and between Buloba branch point and Kabulasoke substation

Since 132 kV transmission line from Mutundwe substation to Kabulasoke substation via Buloba branch point is one circuit transmission line which is supported by wooden poles, in the near future, this transmission line will require rebuilding due to aging or demand increasing. This reconstruction is not included in components of this project, but JICA study team recommend to UETCL that necessity of rebuilding period and changing to 2 circuits should be considered independently by using power system data used in this project.

(4) Introduction of 132 kV transmission line to Gaba substation

As the results of study in4-1-6 (2) 1), 132 kV transmission line to Gaba substation via Entebbe Highway switching station should be introduced, but it is not included in components of this plan, In this case, since there is a possibility that the remaining line is overloaded when N-1 contingency of transmission line occurs between Mutundwe substations and Entebbe Highway switching station, JICA study team recommend to UETCL that necessity of countermeasures such as upgrading wire should be considered by using power system data used in this project.

(5) Introduction of 220 kV to Gaba substation

As the results of study in4-2, it is considered that there is no need to introduce 220 kV to Gaba substation until 2030. Therefore, considering social impact for Gaba substations and related transmission lines, they are not included in components of this project. But at the stage when easing countermeasures for social impact will be able to be established, JICA study team recommend to UETCL that necessity of introduction of 220 kV to Gaba substation should be considered by using power system data used in this project.

(6) Cancellation of power flow limit of 132 kV southern trunk line after commissioning of 220 / 132 kV new Mukono substation

Regarding 132 kV southern trunk line, though it has relatively large capacity (ACSR385mm^2, 180MVA/cct), but from the fact that route length increases Ali voltage drop of about 70km, Lugogo substation voltage of maintenance of the load end. Therefore, UETCL operates to limit power flow under 100MVA/cct (when it exceeds, transmission line is tripped by overload relay).

However, after commissioning 220 / 132 kV new Mukono substation, since voltage drop problem is expected to be solved due to connecting 220 / 132 kV new Mukono substation at the middle of 132 kV southern trunk line as source of voltage, JICA study team recommend to UETCL that Cancellation of power flow limit of 132 kV southern trunk line should be considered by using power system data used in this project.

(7) Configuration of Connection of Transmission Lines around Entebbe Highway Substation

As method for branch at Entebbe Highway point where 132 kV transmission line is branched to Gaba substation, open-pi branch, t-branch and Switching Station can be considered. In this report it has been examined consistently as 132 kV Switching Station. This is because distance from the branch point to Entebbe substation is relatively long of about 30km and reliability and operability(minimizing span of influence of contingencies and maintenances and avoiding voltage drop) of power system are took priority over cost. Basically, unless there is problem about voltage drop and N-1 criteria, any Method for branch will do.

For this branch, since it is not a component of JICA project, JICA study team recommend to UETCL that method for branch should be determined by taking into account cost and future plans, etc. comprehensively.

It should be noted that points of studies are as follows.

- Entebbe feasibility of switching station site secure at highway point

  If no site can be ensured, candidate of switching station is eliminated.

- Supply method to southwest (near Entebbe Highway point) in Kampala metropolitan area

  If it is determined that power supply is needed around Entebbe Highway point, switching station must be changed to substation. In this case, introduction of 220 kV to Gaba substation will be postponed at the moment.

- Reliability and operability of power system

  If there are no switchgears at Entebbe Highway point, simulation of voltage drop and installation of capacitors will be required if necessary. Because power is supplied only by 1cct long-distance 132 kV transmission line at a time of contingencies or maintenances, and problems of voltage drop can be easily occurred at Entebbe substation.

In addition, regarding 220 kV at Entebbe Highway point, it has been examined as 220 kV Switching Station taking into account supply to 132 kV in the future as a premise in this report. However, if there is no plan to supply to 132 kV, 220 kV Switching Station is not required.

JICA study team recommend to UETCL that necessity for supplying power from 220 kV to 132 kV should be judged by taking into account study results for 132 kV above and future plans, etc. comprehensively.

(8) Enhancement of capacitors and reactors

In power flow analyses of this project, in some cases of N-1 contingency, Voltage dropped significantly or voltage collapse occurred. Results of power flow calculation do not always indicate accurate voltage value, but they are very useful to know tendency and distribution of voltage. Therefore, since enhancement of capacitors and reactors was one step behind compare to enhancement of equipment for increase of demand in the other country, reinforcement of capacitors and reactors also should be recommended to be studied and planned.

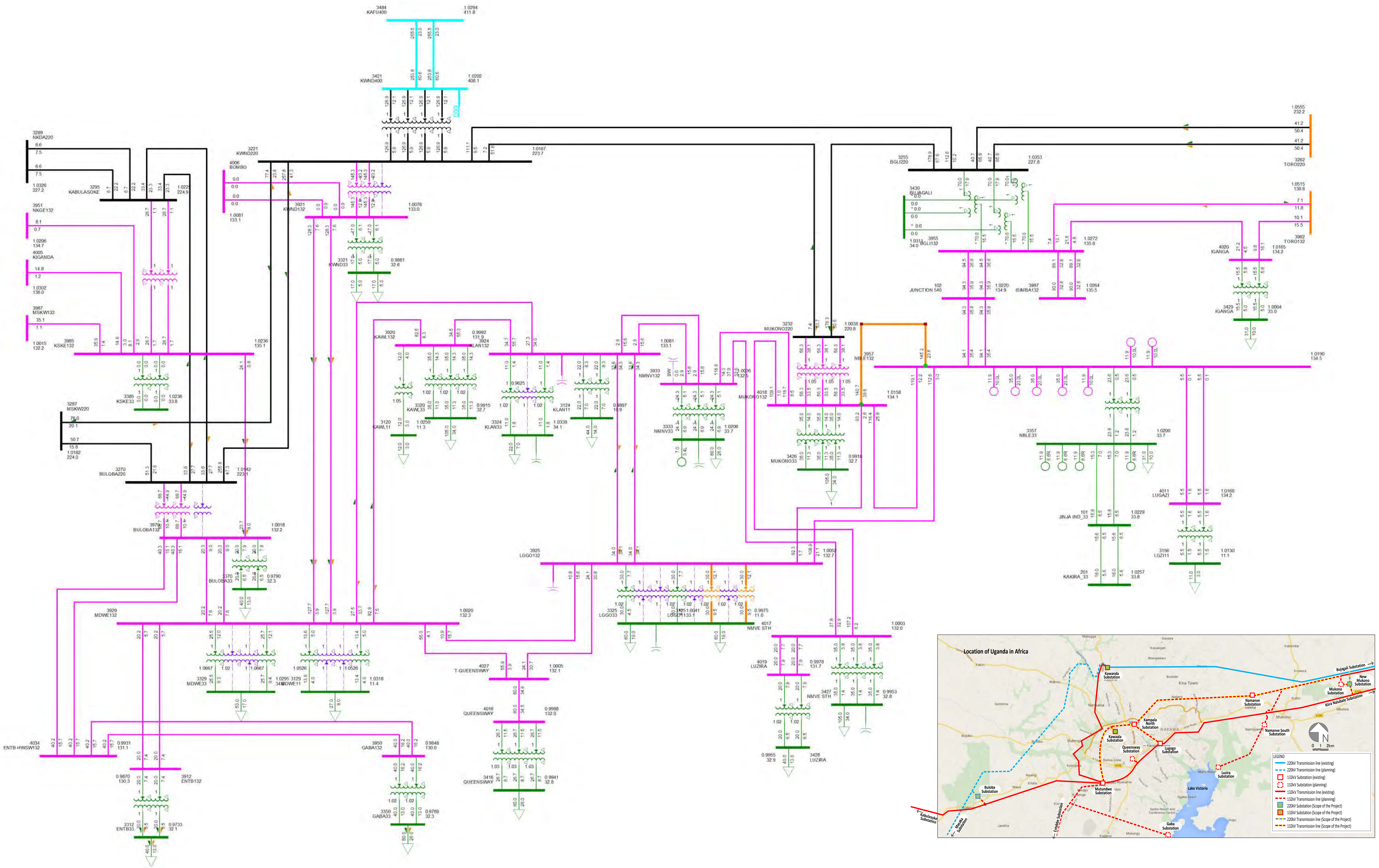


Figure 4.1 Scenario for the Eastern Transmission System of the Kampala Metropolitan Area : Scenario 1-1

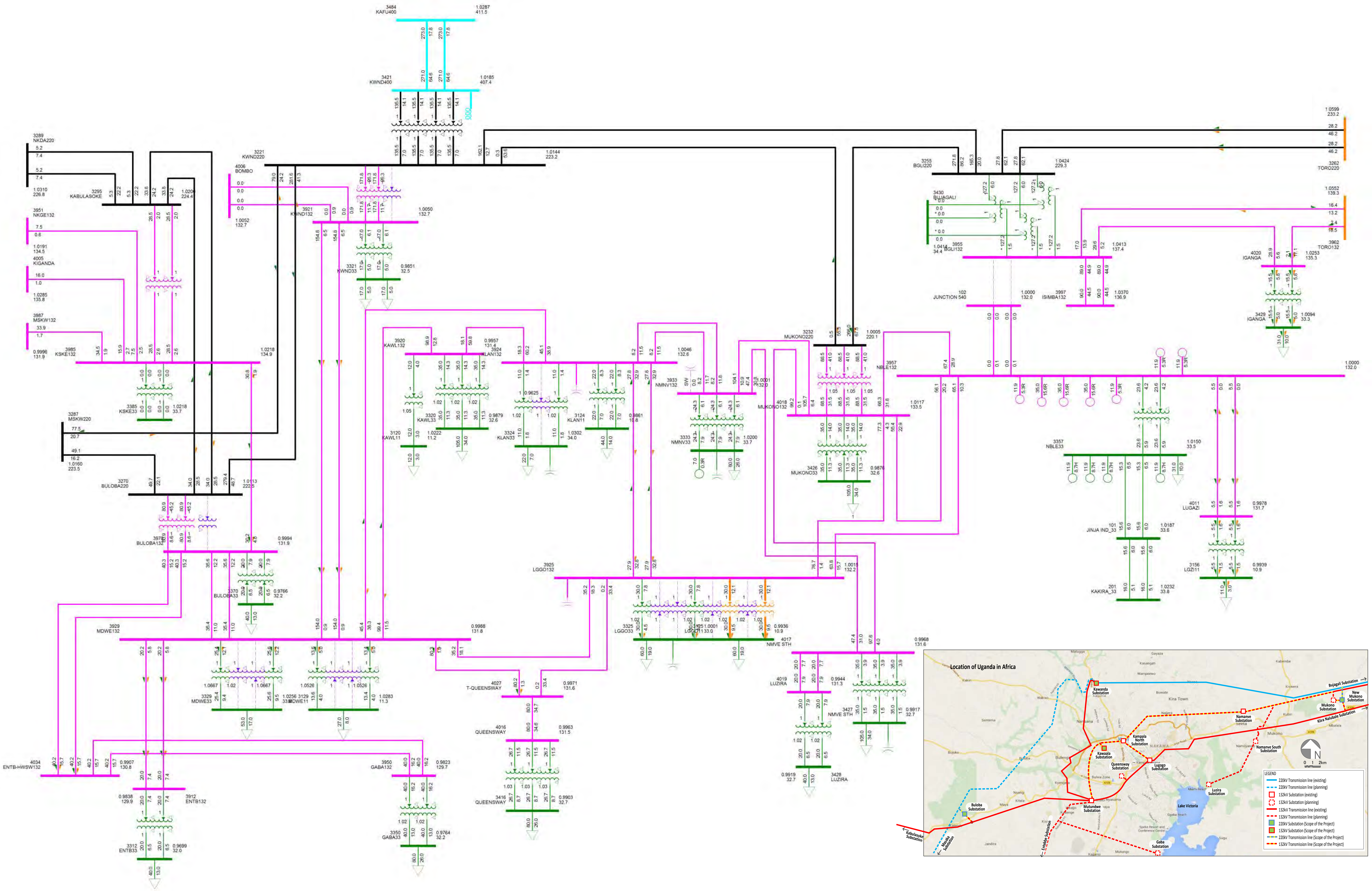


Figure 4.2 Scenario for the Eastern Transmission System of the Kampala Metropolitan Area : Scenario 1-2

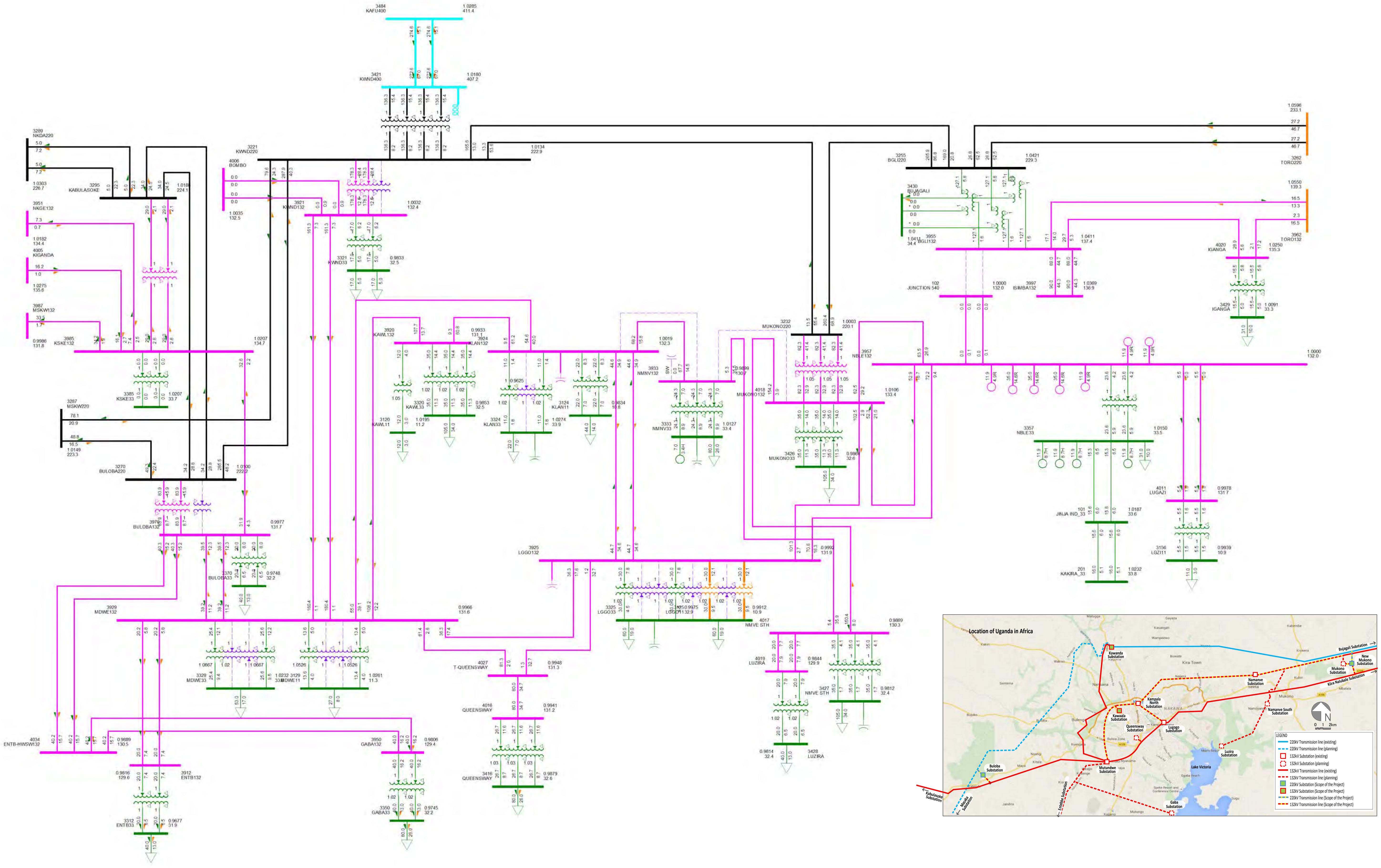


Figure 4.3 Scenario for the Eastern Transmission System of the Kampala Metropolitan Area : Scenario 1-3

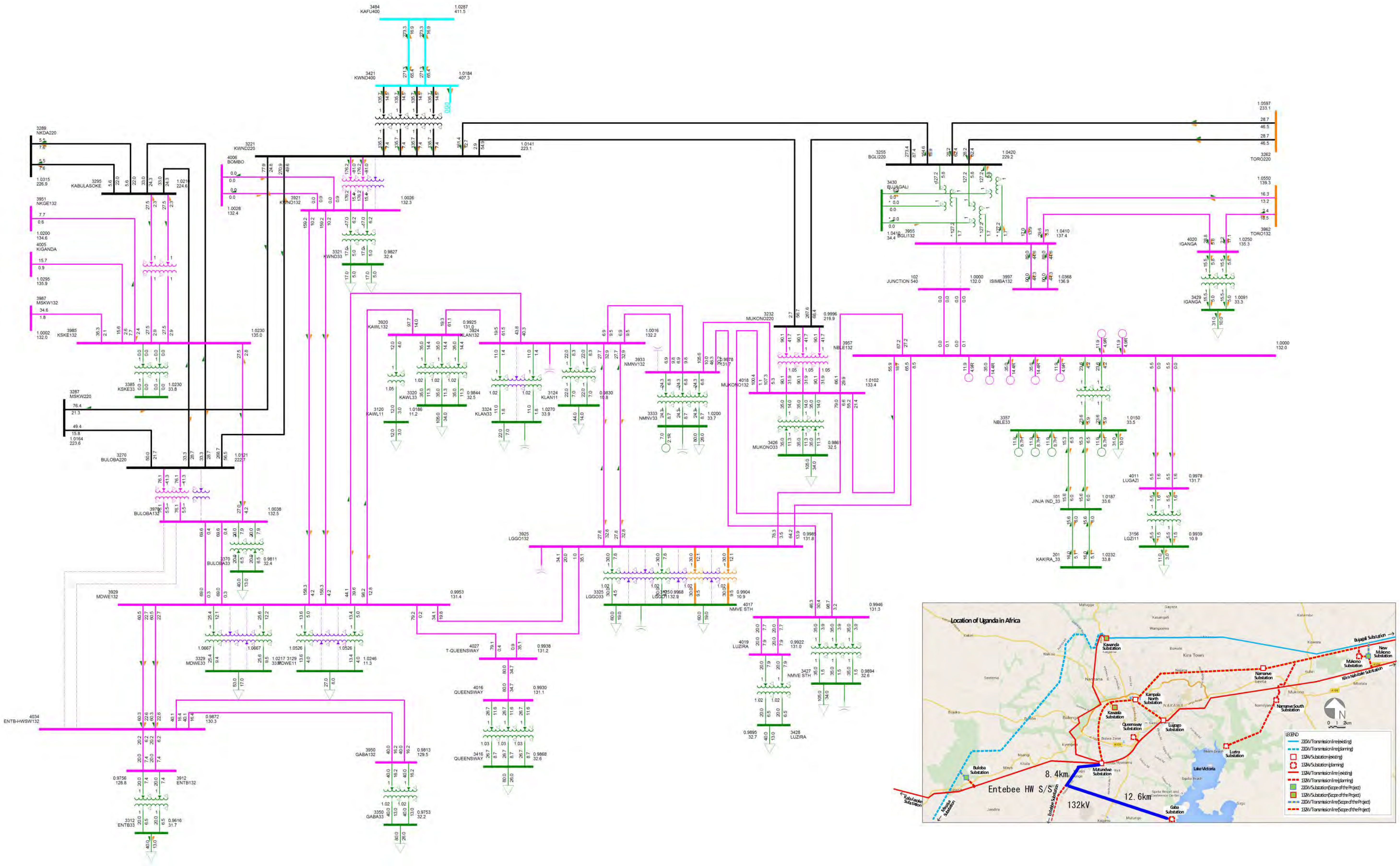


Figure 4.4 Scenario for the Southwestern Transmission System of the Kampala Metropolitan Area : Scenario 2-1

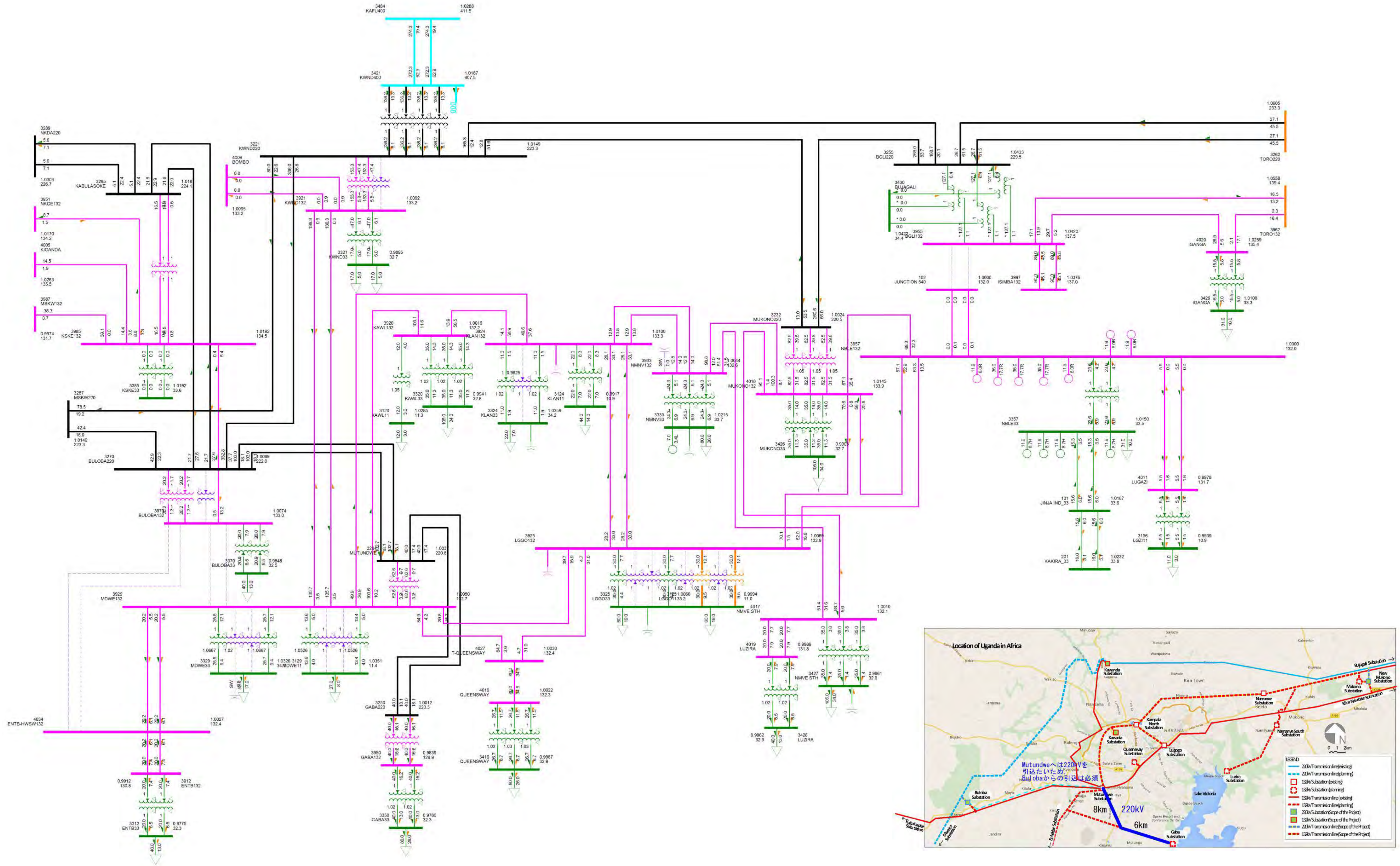


Figure 4.5 Scenario for the Southwestern Transmission System of the Kampala Metropolitan Area : Scenario 2-2

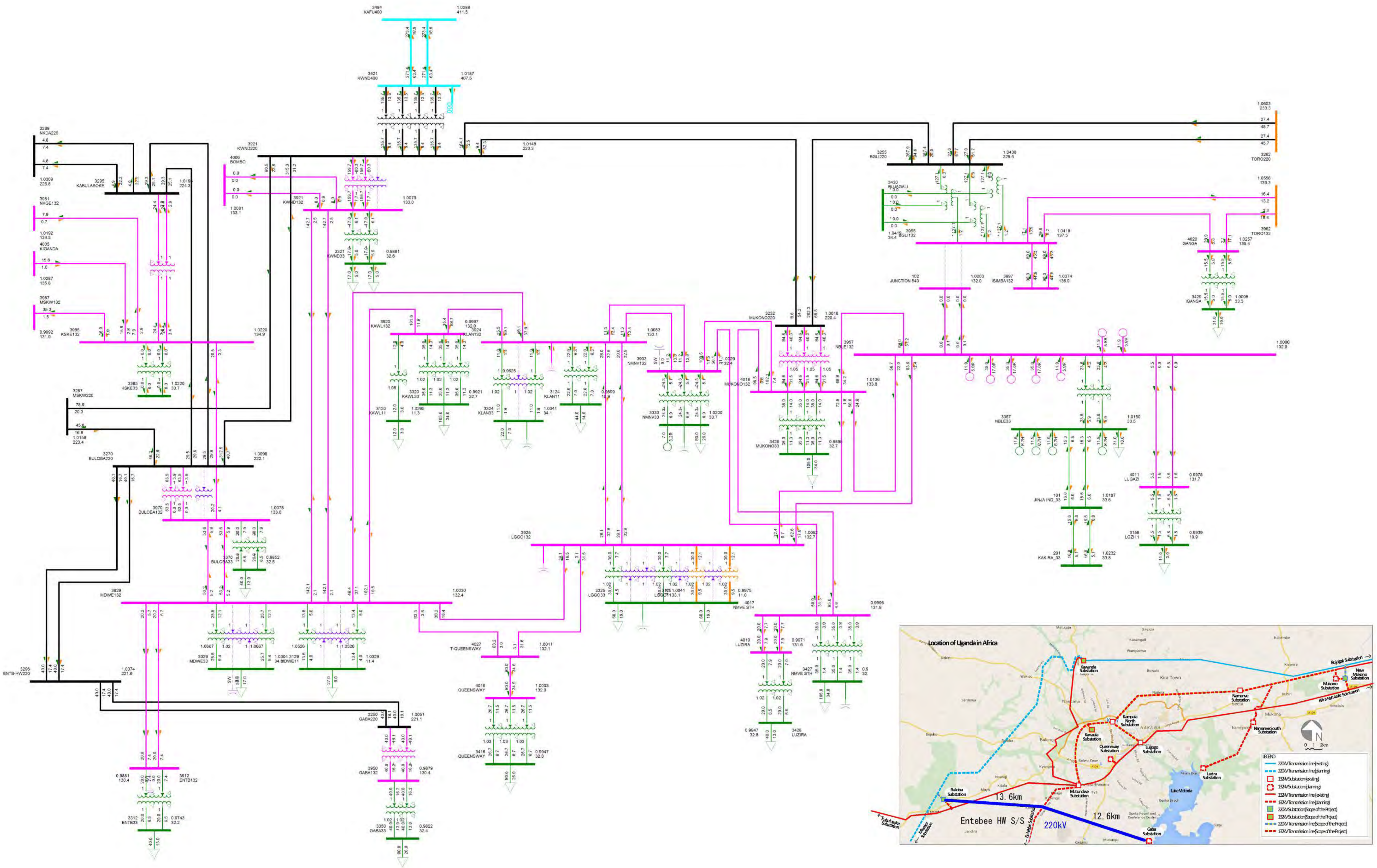


Figure 4.6 Scenario for the Southwestern Transmission System of the Kampala Metropolitan Area : Scenario 2-3

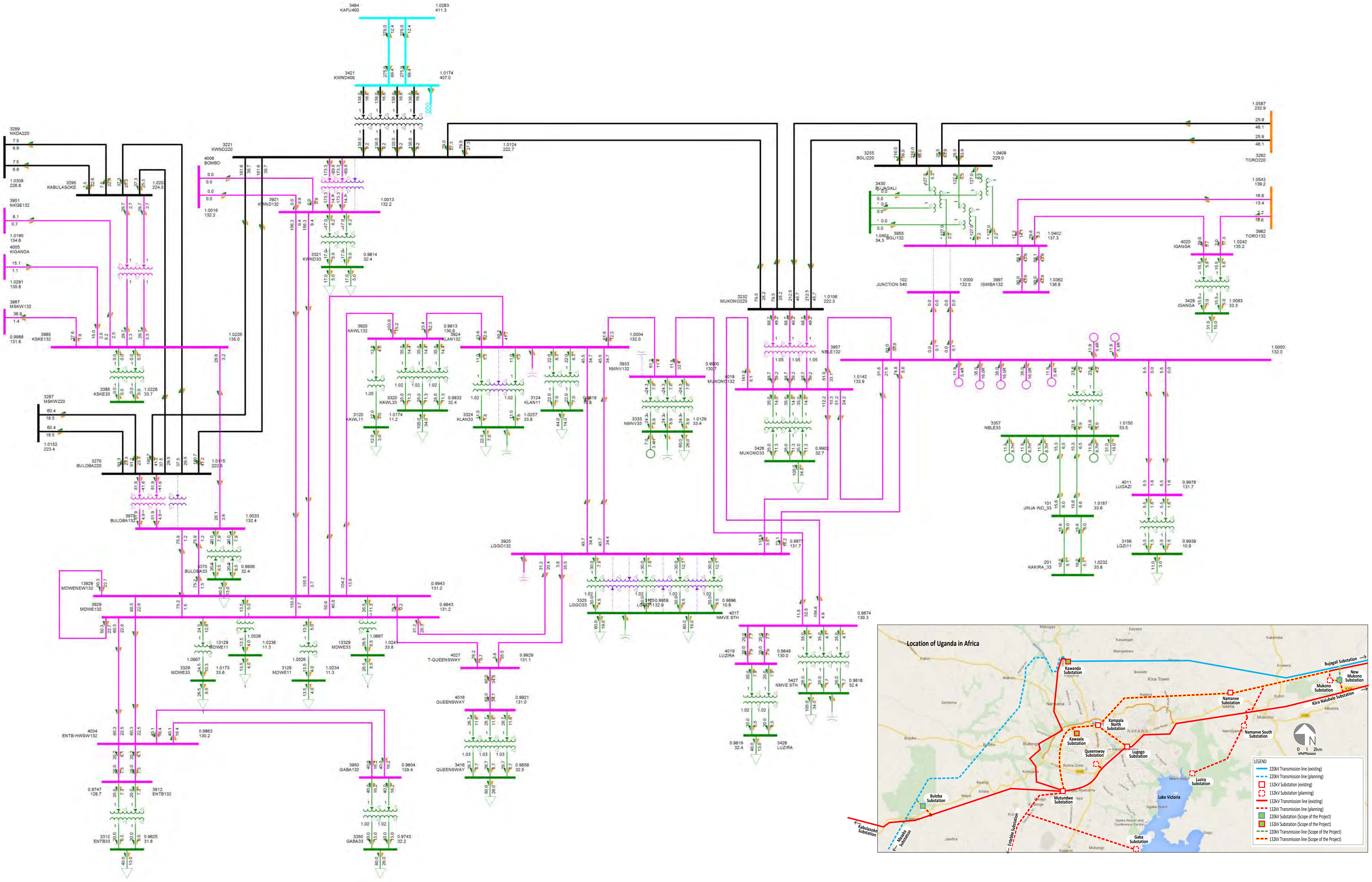


Figure 4.7 Review of Power Flow under the Condition of Single Bus Failure at Mutundwe Substation : Normal Condition

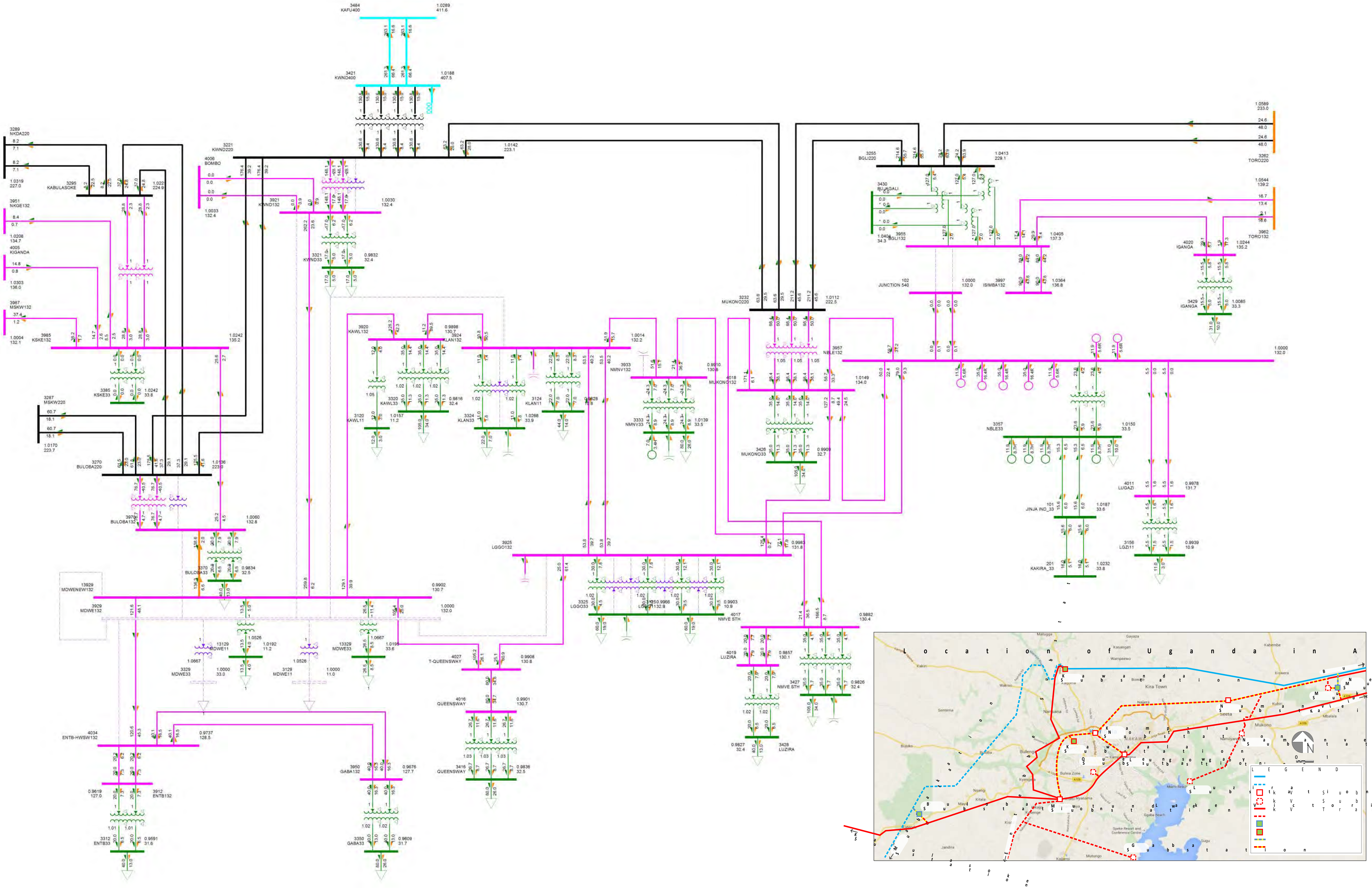


Figure 4.8 Review of Power Flow under the Condition of Single Bus Failure at Mutundwe Substation : Single Bus Failure Condition

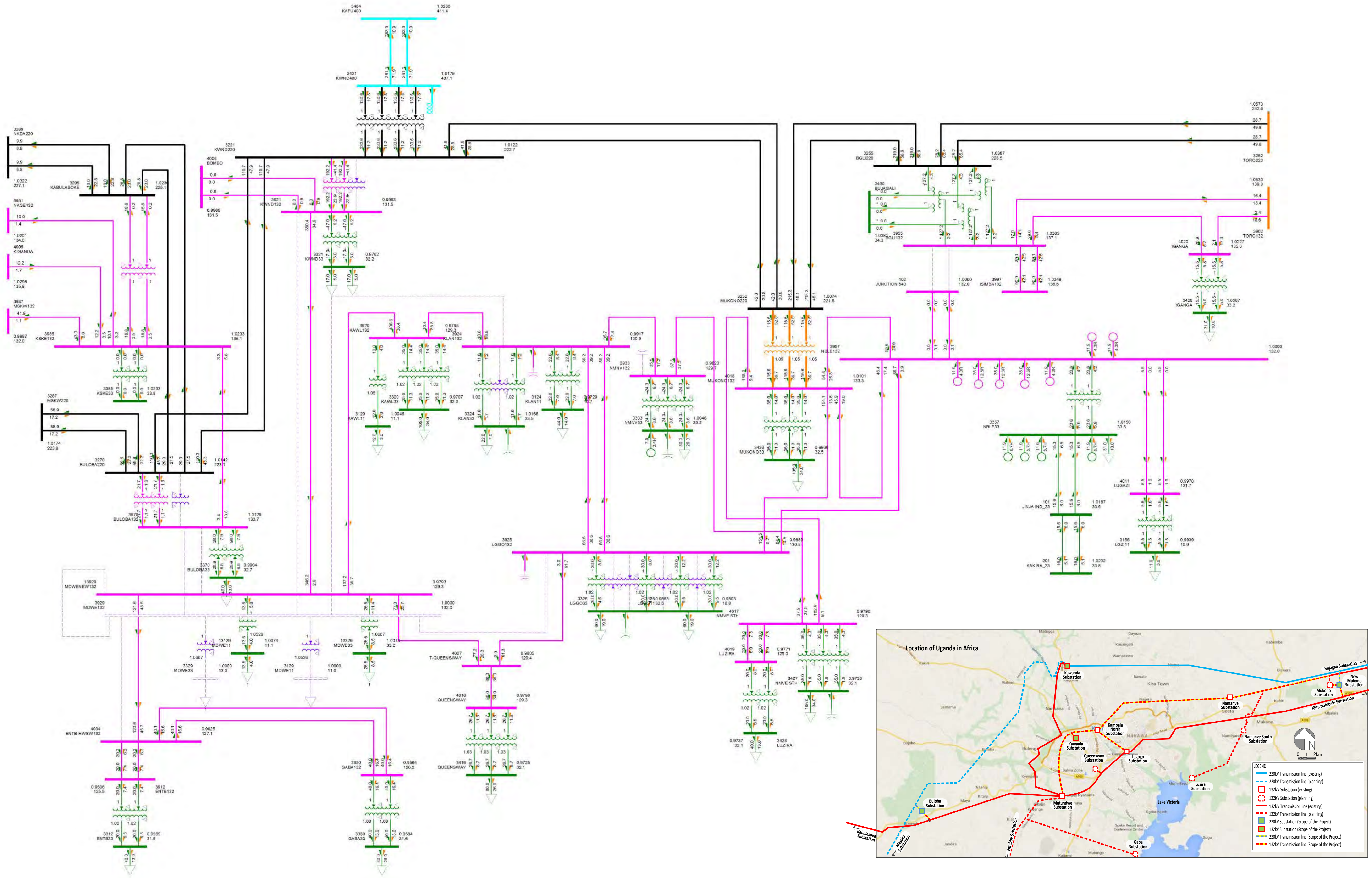


Figure 4.9 Review of Power Flow under the Condition of Single Bus Failure at Mutundwe Substation : Single Bus Failure Condition Countermeasure by System Operation

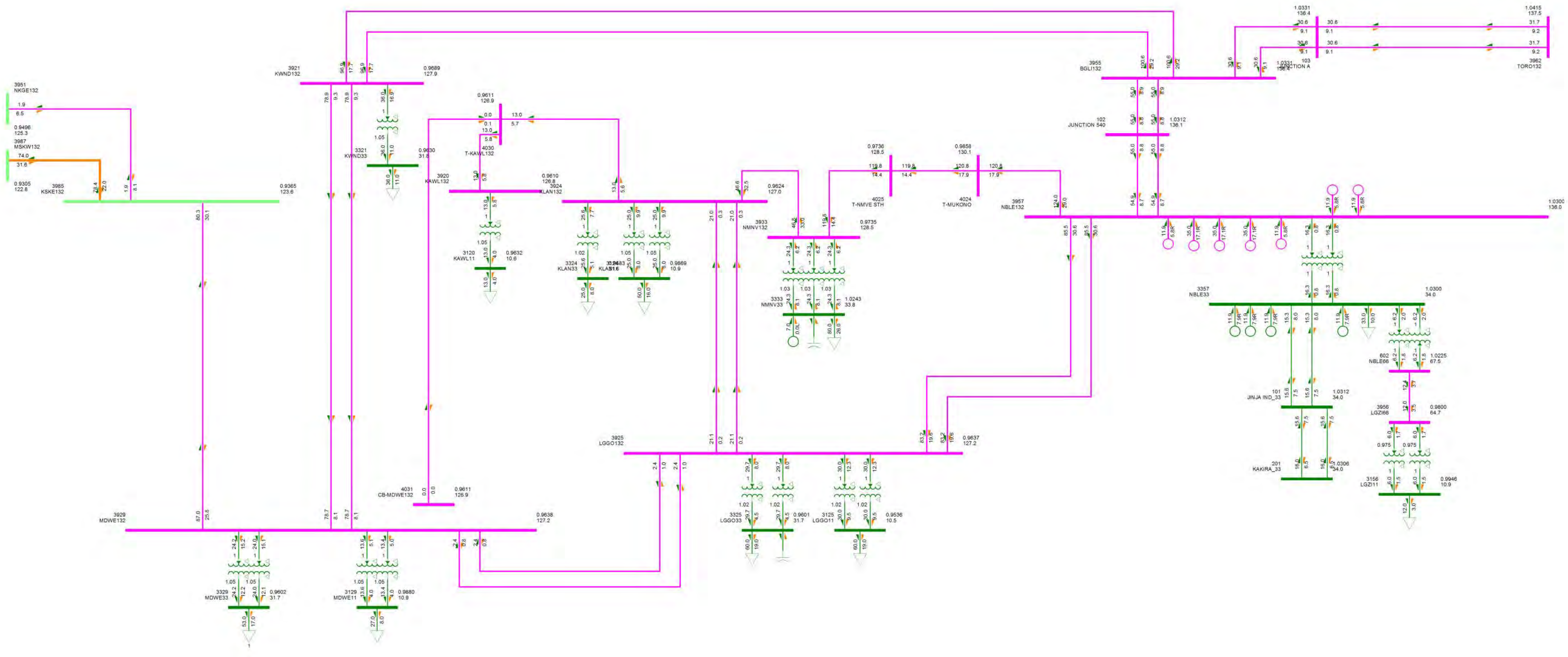


Figure 4.10 Power Flow in the Section of 2015 : Normal Condition

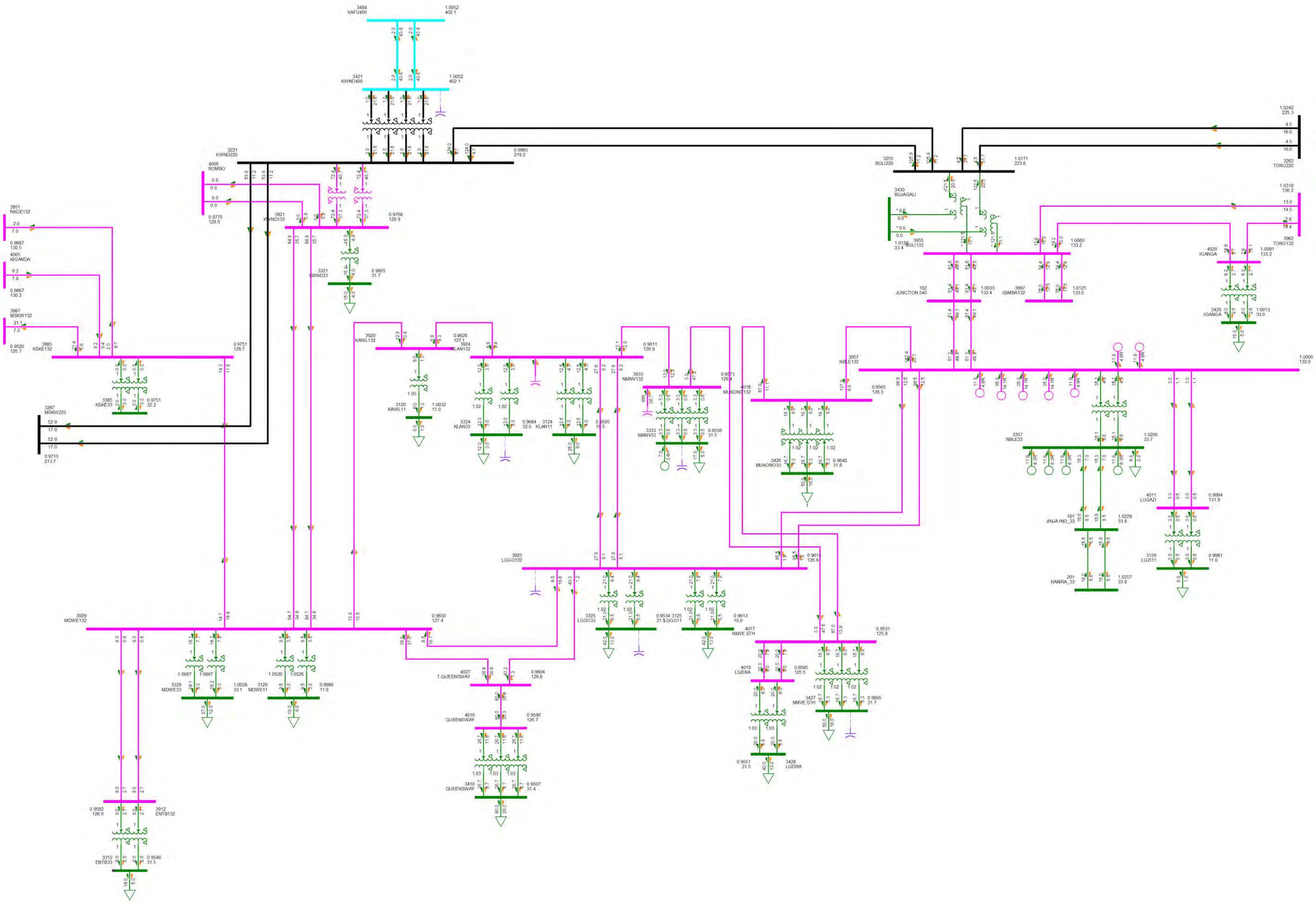


Figure 4.11 Power Flow in the Section of 2018 : Normal Condition

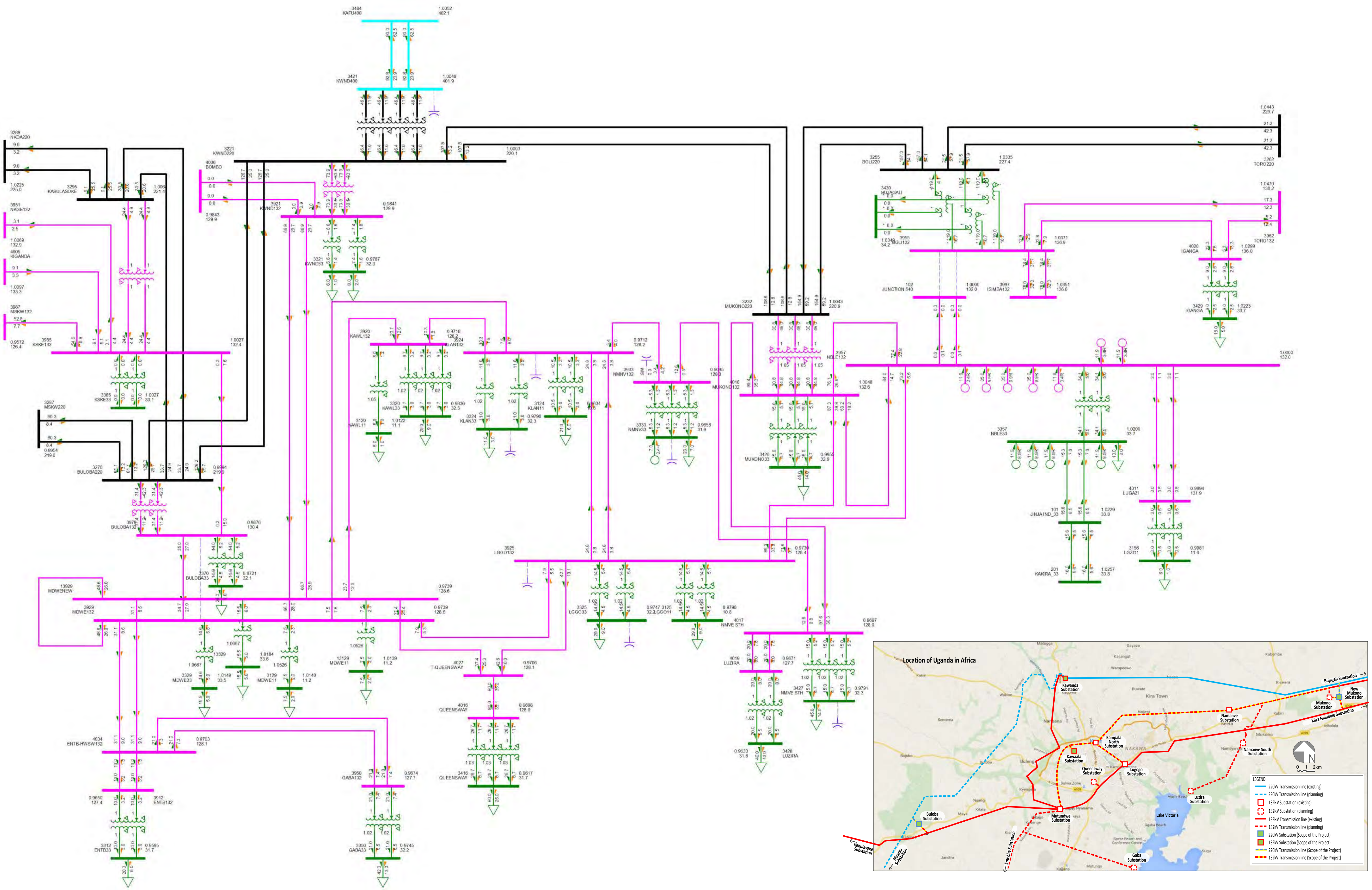


Figure 4.12 Power Flow in the Section of 2020 : Normal Condition

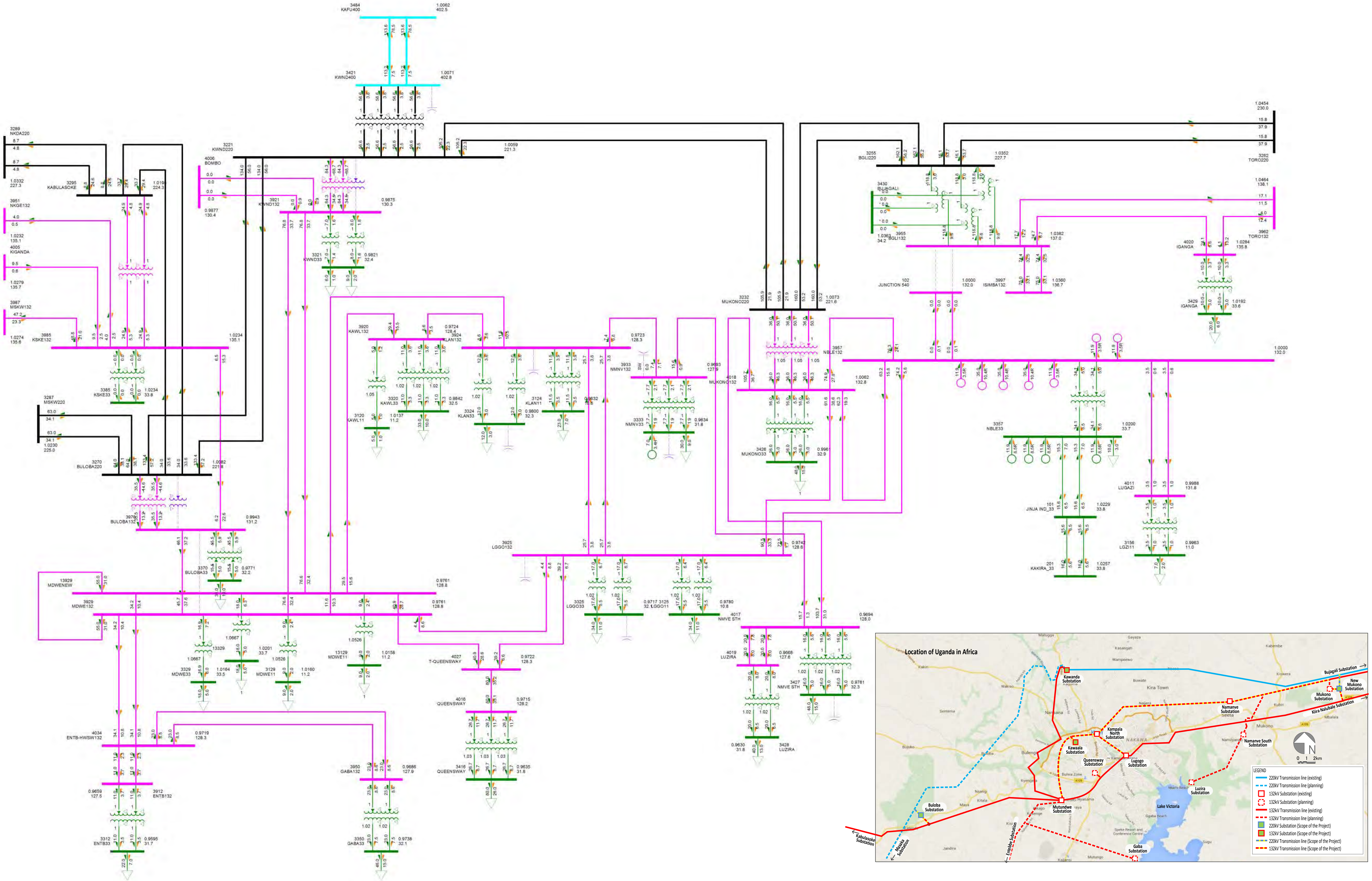


Figure 4.13 Power Flow in the Section of 2022 : Normal Condition

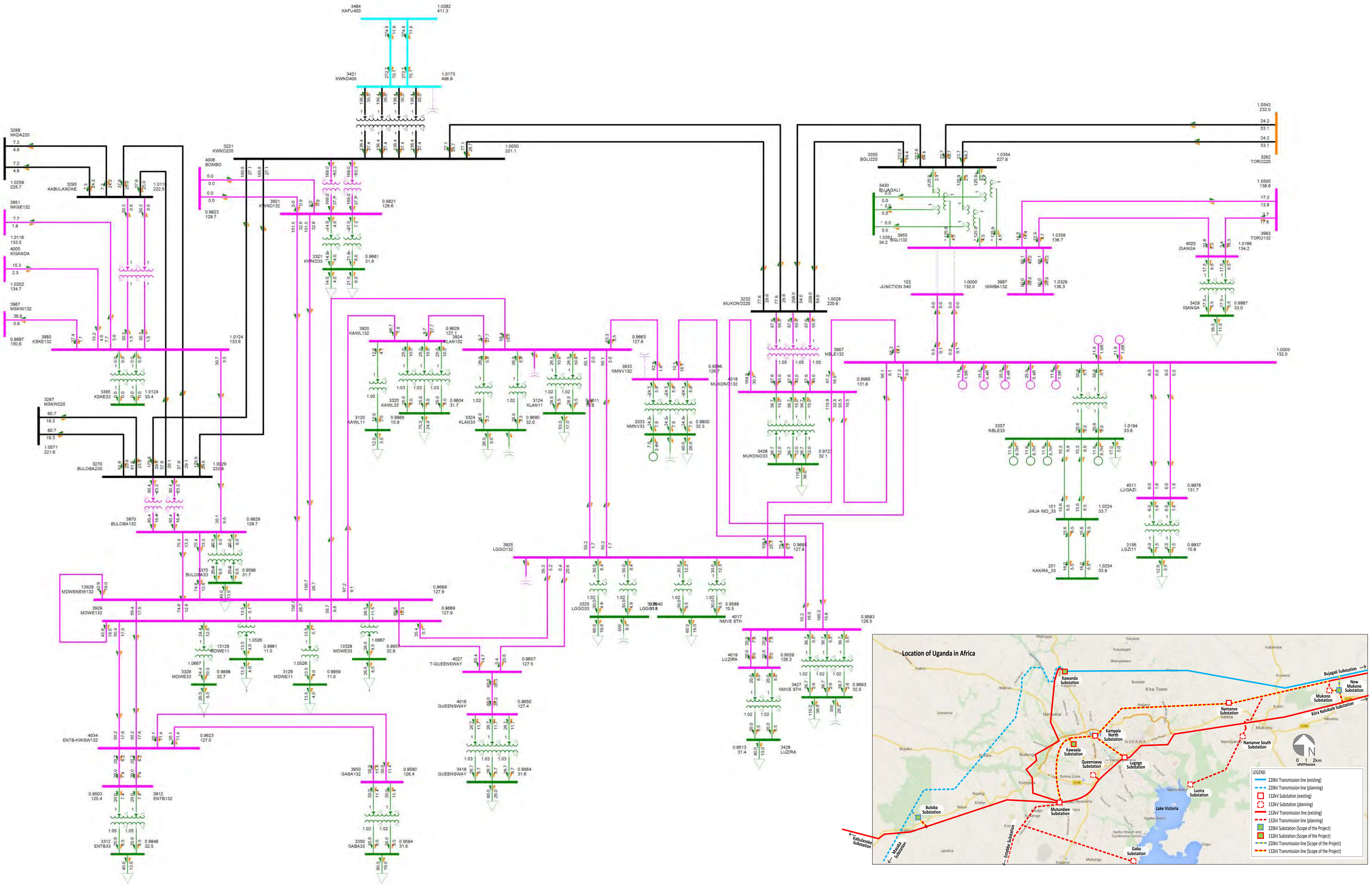


Figure 4.14 Power Flow in the Section of 2030 : Normal Condition