UGANDA ELECTRICITY TRANSMISSION COMPANY LTD

GRID DEVELOPMENT PLAN 2018- 2040

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Message from Management of UETCL

I am pleased to introduce to you this latest edition of our Grid development Plan (GDevP) 2018 – 2040. The GDevP is a strategic document in UETCL's overall planning, which is in line with the Company's Corporate Business Plan (CBP). It details the future grid requirements in terms of projects and investment costs to meet the national load growth, generation developments and regional interconnection requirements.

The 2018 edition of the Grid Development Plan provides a 23 year outlook of the Uganda transmission system.

The Electricity Sector is one of the major enablers of economic transformation and with this in mind, the GDevP will aid UETCL and the sector at large to make the right investments to the grid to enable industrialization which is line with Vision 2040. The GDevP is therefore a necessary guide to Government of Uganda on the required investments to the transmission grid and will aid in sourcing funding and prioritizing investments. As such, this document is important in fast tracking the Implementation of Uganda's Development Agenda.

Finally, I would like to thank and appreciate the efforts of all our stakeholders whom we have worked with over the course of the year formulating various plans and in particular, Ministry of Energy and Mineral Development, Electricity Regulatory Authority, Uganda Electricity Distribution Company Limited, Uganda Electricity Generation Company Limited, UMEME, Rural Electrification Agency amongst others. Your contribution is much appreciated.

Willy K. Kiryahika
Managing Director/CEO

Foreword

The Grid Development Plan (GDevP) is a strategic document in UETCL's overall planning, which is in line with the company's Corporate Business Plan (CBP).

The GDevP is updated annually. It details the future grid requirements in terms of projects and investment costs to meet the national load growth, generation developments and regional interconnection requirements. The 2018 edition of the Grid Development Plan provides a 23 year outlook of the Uganda transmission system. The GDevP presents the latest demand forecast, generation expansion plan, Demand – Supply Balance for the current and subsequent years, power system analysis result, the Grid Investment Requirements and Implementation Schedule.

The 2018 edition presents an outlook of three scenarios showing their planned implementation strategy and recommendations.

- The base case scenario looks at the business as usual case.
- The National Development Plan II (NDP 2015-2020) scenario that aims at strengthening Uganda's competitiveness for sustainable wealth creation, employment and inclusive growth with set targets to be implemented within 5years.
- The Uganda's VISION 2040 scenario that aims at transforming Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 years.

The 2018 GDP edition is our planning reference guide for the year 2018-2040.

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Abbreviations and Acronyms

AAAC	All Aluminim Alloy Conductor
ACSR	Aluminium Conductor Steel Reinforced
AFD	French Development Bank
AfDB	African Development Bank
BID	Better Investment Decisions
CBP	Corporate Business Plan
CCTV	Closed Circuit Television
DCST	Double Circuit
EAC	East African Community
EAPMP	East African Power Master Plan
EAPP	Eastern Africa Power Pool
EIA	Environmental Impact Assessment
EPC	Engineering Procurement and Construction
ERA	Electricity Regulatory Authority
ERP	Enterprise Resource Planning
ESIA	Environmental and Social Impact Assessment
EXIM	Export and Import
FS	Feasibility Study
GDevP	Grid Development Plan
GDP	Gross Domestic Product
GIP	Grid Investment Plan
GIS	Geographical Information System
GoU	Government of Uganda
GWh	Giga Watt Hour
HFO	Heavy Fuel Oil
HPP	Hydro Power Plant
HTLS	High Temperature Low Sag
HVTG	High Voltage Transmission Grid
Hz	Hertz
IEC	International Electromechanical Commission
IP	Internet Protocol
IPP	Independent Power Producer
ISDB	Islamic Development Bank
JICA	Japan International Cooperation Agency
kA	Kilo Amperes
KCCL	Kasese Cobalt Company Limited
KFW	German Development Bank

km	Kilo meter
KML	Kilembe Mines Limited
kV	Kilo Volt (1kV=1000 Volts)
kW	Kilo Watt (1kW=1000 Watts)
kWh	Kilo Watt Hour
MDMS	Meter Data Management System
MEMD	Ministry of Energy and Mineral Development
MoFPED	Ministry of Finance, Planning and Economic Developement
MVA	Mega volt Ampere
MVAr	Mega Volt Ampere- reactive
MW	Mega Watt
NBI	Nile Basin Initiative
NDP	National Development Plan
NELSAP	Nile Equatorial Lakes Subsidiary Action Programme
NEMA	National Environment Management Authority
NFA	National Forestry Authority
OPGW	Optical Ground Wire
OTDR	Optical time Domain Reflectometer
PDH	Plesiochronous Digital Hierarchy
PMA	Power Market Analyzer
PSA	Power Sales Agreement
PSS/E	Power System Simulation for Engineers
RAP	Resettlement Action Plan
REA	Rural Electrification Agency
RPT	Regional Power Trade
SCADA	Supervisory, Control, and Data Acquisition
SDH	Synchronous Digital Hierarchy
SVC	Static var Compensator
SWECO	SWECO AB of Sweden
TCP	Transfer Control Protocol
SIA	Social Impact Assessment
UBOS	Uganda Bureau of Statistics
UETCL	Uganda Electricity Transmission Company Limited
USD	United States Dollar
UWA	Uganda Wildlife Authority
var	Volt Ampere Reactive
WA	Wheeling Agreements
WIS	Wayleaves Information System
WB	World Bank

Executive Summary

Uganda Electricity Transmission Company Limited (UETCL) has a leading role in developing, Operating and maintaining an efficient High Voltage Transmission Grid (HVTG) to meet the national load demand, power evacuation from new generation plants and regional power exchange requirement through regional interconnections within the national and International technical, social-economic and environmental standards.

A key responsibility in this respect is to constantly plan and develop the HVTG. The purpose is to establish a rationale for building a robust network, improve reliability and quality of supply, which will in turn contribute towards the economic development of Uganda.

In line with company objectives, the Grid Development Plan (GDevP) is a strategic document in UETCL's overall planning process and thus must be communicated to all major stakeholders. The plan, which covers a period of 23 years, identifies and justifies new grid investments. It is reviewed and updated annually to reflect latest information on Government policy and strategies. It is also an input to the company's financial projections and annual budget. The GDevP presents results of technical analyses for various investments to meet the national demand and power exchange obligations.

The technical analysis derived from power system studies form a basis for determining technical feasibility of the proposed projects. The results from the technical analysis are used to determine the Grid Investment plan and the associated cost estimates which culminate into financial projections. The Environmental and Social Impact Assessment are carried out before implementation of each individual project as required by the National Environment Management Authority (NEMA).

The results from the above analyses indicate high capital investment requirements over a period of 2018-2025. This is mainly attributed to the many generation plants that are to be commissioned during this period and the corresponding power evacuation transmission lines and Substations. In order to absorb the new generation capacity, several grid and substations extensions and reinforcements are to be implemented in the same period.

Background

Uganda Electricity Transmission Company Limited (UETCL) has a major role in contributing to the development of an efficient electricity sub sector in Uganda through planning, developing and maintaining an efficient transmission grid to meet the national electric power requirements within the allowable national, regional and international standards.

UETCL owns, operates, develops and maintains the high voltage transmission grid. The grid connects power generation plants to load centers throughout the country as well as interconnection with neighboring countries. UETCL also owns a National Control Center which coordinates and monitors grid operations and maintenance activities.

Presently, the transmission grid comprises 150km of 220kV (initially operated at 132kV), 1443km of 132kV, 300m of 132kV underground cable, 35.2km of 66kV high voltage transmission lines and 20 substations (includes Kabulasoke and Nalubaale switching stations).

The Grid Development Plan (GDevP) is a planning document that is written in line with UETCL's strategic Corporate Business Plan. It details present and future transmission grid infrastructure that will support National demand growth, generation requirements and regional power trade obligations.

The GDP is updated annually to review the System Demand forecast, Generation Planning, Demand – Supply Balance for the current and subsequent years, Power evacuation transmission lines and Substations, Grid expansion requirements in line with National Development Plan II (NDP), Vision 2040, sustainable energy for all, rural electrification strategy and plan, renewable energy policy among others, Power System Modeling Analysis Results, the 2018-2040 Grid Investment Plan, Financial Implications and Proposed implementation schedule as well as expectations from Stakeholders to provide a harmonized energy sector planning process.
The 2018 edition GDP is UETCL's planning reference guide for the years 2018-2040.

2 THE GRID DEVELOPMENT PLAN PROCESS

2.1 OBJECTIVE FOR THE GRID DEVELOPMENT PLAN

The main objectives of the Grid Development Plan are:

- To give an outlook of the future power system of Uganda.
- To present the High Voltage Transmission Grid's (HVTG) investment requirements to meet forecasted demand.
- To detail the new generation development projects over the planning horizon and their associated evacuation infrastructure.
- Identify power transmission investment requirements to mitigate anticipated system constraints.
- To form a basis for the company's financial projections, multi -year tariff and multi-year budget.

2.2 METHODOLOGY

A scenario based approach has been adopted for the 2018 Grid Development Plan Update. Three scenarios have been considered as follows:

- **Base Case Scenario**
  The main assumptions for this scenario include: observed historical demand growth trends, Growth projections of the Gross Domestic Product (GDP), distribution connection strategies and regional power trade projections, implementation of loss reduction strategies and the need to address constraints that have created suppressed demand in the past.
- **NDPII Scenario**
  This scenario is designed to implement the second National Development Plan (NDPII) launched in March 2015. The planning horizon of this scenario is five years from 2015 to 2020.
- **Vision 2040**
  Uganda Vision 2040 provides development paths and strategies to operationalize Uganda's Vision statement which is "A Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 years". It aims at transforming Uganda from a predominantly peasant and low income country to a competitive upper middle income country.

It builds on the progress that has been made in addressing the strategic bottle-necks that have constrained Uganda's socio-economic development since independence, including; ideological disorientation, weak private sector, underdeveloped human resources, inadequate infrastructure, small market, lack of industrialization, underdeveloped services sector, underdevelopment of agriculture, and poor democracy, among others.

The Vision 2040 is conceptualized around strengthening the fundamentals of the economy to harness the abundant opportunities around the country. The identified opportunities include: oil and gas, tourism, minerals, ICT business, abundant labour force, geographical location and trade, water resources, industrialization and agriculture among others that are to date considerably under-exploited. Achieving the transformational goal will thus depend on the country's capacity to strengthen the fundamentals including: infrastructure (energy, transport, water, oil and gas, and ICT); Science, Technology, Engineering and Innovation (STEI); land use and management; urbanization; human resource; and peace, security and defense and that's where UETCL comes in to expand the transmission network and offer a strong backbone that delivers bulk, quality and reliable power.

2.2.1 THE GRID DEVELOPMENT PLAN PROCESS

The process used for formulating the GDevP is illustrated in Figure 1 below.

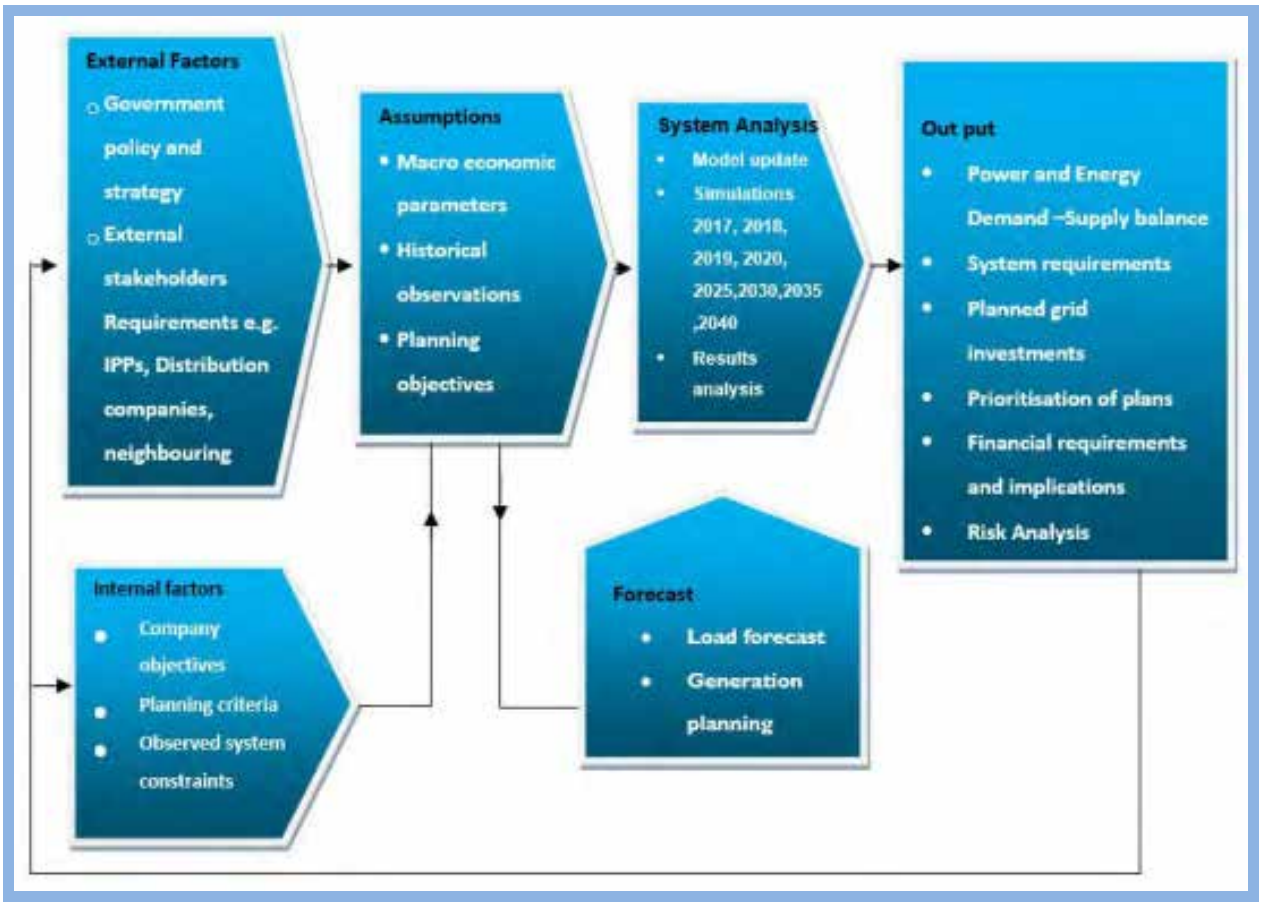

Figure 1: GDevP process

From Figure 1, it can be observed that the inputs to the GDevP process include both external and internal factors, which are then used in the analyses (load forecast and power system analysis) to yield results which are further analyzed to come-up with the outputs.

The load forecast conducted for the Base, NDPII, and Vision 2040 scenarios for the period 2018 - 2040 was based on the respective assumptions for each scenario as detailed in sections below respectively. Power system constraints as observed in the day to day operation of the network were considered in the power system analysis. These include quality of supply, equipment loading, system reliability and availability.

Generation expansion planning was based on the implementation timelines for power plants under construction and those planned (Licensed, with or without executed Power Purchase Agreements). The demand-supply balance analysis for each respective scenario recommended the timing of additional required generation capacities.
Power system studies and analysis were carried out on eight system models. The results formed the basis for determining the Grid Investment Plan that details the technically feasible projects with their respective cost estimates and timing.

3 PLANNING CRITERIA

3.1 TRANSMISSION PLANNING CRITERIA

The transmission planning criteria provides a framework for system design in order to operate the power grid in a manner that satisfies the grid code requirements and the regional interconnection requirements as well. This section describes the criteria utilized when analyzing Uganda's transmission system and serves as a guide for determining future transmission infrastructure investments.

The Planning criteria are utilized to ensure the following objectives are met:

- Provide a transmission system that can adequately serve the system loads.
- Provide a robust transmission system that can withstand reasonable system disturbances on the bulk power system.
- Provide a transmission system that contributes to overall bulk system integrity and supports effective competition in a power pool.
- Provide a transmission system whose revenue requirements, capital and operating costs are minimized while being consistent with the above goals.

3.1.1 SYSTEM VOLTAGE

Under steady state and post contingency conditions, all system voltages from 66kV and above (i.e. 132kV, 220kV, and 400kV) should be within the limits set in Table 1: Voltage Limits

	Normal condition		Contingency condition	
Location	**Minimum Value/ %**	**Maximum Value/ %**	**Minimum Value/ %**	**Maximum Value/ %**
400 kV Transmission Substation Bus Voltage	380 (95%)	420 (105%)	360 (90%)	440 (110%)
220 kV Transmission Substation Bus Voltage	209 (95%)	231 (105%)	198 (90%)	242 (110%)
132 kV Transmission Substation Bus Voltage	125.4 (95%)	138.6 (105%)	118.8 (90%)	145 (110%)
66 kV Transmission Substation Bus Voltage	62.7 (95%)	69.3 (105%)	59.4 (90%)	72.6 (110%)

Table 1: Voltage limits

The above limits may be exceeded only during outages of 400kV lines and in such cases it is necessary to supply dynamic VAr resources at sensitive nodes. Such nodes should be identified by conducting power system analyses. Under normal operations when all the system elements are healthy and tap positions of the power transformers at the sending end at the nominal tap, the system voltages at various levels at the tail end of the lines shall be as close to the nominal voltage as possible. The tap positions may be increased or decreased at peak load or off load conditions as need arises.

The system should withstand outage of any two circuits of 220kV lines or any one circuit of 400 kV line with voltage and frequency levels remaining within prescribed limits.

3.1.2 SYNCHRONISM

The system shall remain in synchronism even in case of a single line to ground fault or three phase fault, assuming successful clearance of fault by the protective devices.

Adequate margin shall be available, in terms of voltage and steady state oscillating stability. The voltage angles between consecutive substations should be in the region of 30 degrees.

3.1.3 EQUIPMENT LOADING

Under normal conditions all transmission equipment can be loaded up to 100% of the continuous rating. Under contingency conditions, this will be allowed to increase to 120% of continuous rating depending on the age and physical conditions of the equipment.

3.1.4 REACTIVE POWER COMPENSATION

Reactive resources should be planned and designed such that adequate reactive power reserves are available in the form of dynamic reserves at synchronous generators and Static var Compensators (SVCs) in anticipation of system disturbances. Reactive loads should be served by fixed and mechanically switched shunt compensation to the extent practical. Reactive power dynamic reserves at generators and SVC should help minimize the impact of system disturbances and unusual operating conditions.

3.1.5 VOLTAGE SELECTION

Voltage selection shall consider cases where existing voltages are found inadequate and will also consider new power transmission lines, catering for all power plants to be developed and power to be evacuated from that particular region. This aims at optimizing transmission capacity, optimizing way-leaves, reducing technical losses and operation & maintenance costs.

3.1.6 RELIABILITY CRITERIA

The future transmission system is planned to operate satisfactorily under the condition of a single element contingency, N-1. Modifications and enhancements shall be made to the system to improve reliability when needed. Criteria such as contingency, load growth, load density was used in the analysis of reliability.

3.1.7 OPERATING RESERVE

Operating reserves consist of spinning reserves and non-spinning reserves.

Spinning reserves constitute the additional output from generating plant that must be realisable in real time in order to arrest a drop of system frequency due to a loss of generation or a loss of external inter-connector or mismatch between generation and demand.

Non-spinning reserves constitute the output available from standby generating units that can be synchronized and loaded up within 5 minutes for a hydro and 30 minutes for a thermal plant to respond to abnormal demand increase or further generating units breakdown.

3.1.8 GENERATION

For peak load conditions, optimal generation mix comprising of various energy resources taking into consideration the marginal cost of production for the different plants is recommended to be used. For the minimum load conditions, the must run power plants shall be used in conjunction with the most economical generation.

3.1.9 FAULT CURRENT CRITERIA

Three phase and single phase to ground fault current values associated with transmission system buses are reviewed to check equipment rating adequacy. Transmission facilities are rechecked as needed to determine that all equipment can withstand available fault duty. These checks include fault interrupting capacities, fault withstand capacities both electrical and mechanical, and grounding checks. Maximum fault levels should not exceed 80% of

the rated fault interrupting capacity of the circuit breaker.

Rated Voltage (kV)	Switchgear Rating (kA)
400	63
220	40
132	31.5
66	31.5
33	25*
11	25*

Table 2: Switchgear rated fault current interrupting capacity

*Due to the distribution grid configuration adopted and the proximity of generation sources to the medium voltage buses, it has necessitated the installation of higher rated circuit breakers. This is considered on a case by case basis.

3.1.10 SYSTEM FREQUENCY

The operating frequency of the system should be maintained within ±1% of 50Hz. This is a Uganda grid code requirement. Sufficient means to carry out active load balancing with active power generation shall be put in place to ensure that the frequency is within the set limits.

Under frequency load shedding is carried out in the stages below:-

Stage 1 – at 49.2Hz

Stage 2 – at 49Hz

Stage 3 – at 48.9Hz

Stage 4/ decoupling – at 48Hz

3.1.11 INFORMATION AND COMMUNICATION TECHNOLOGY

As new transmission infrastructure is planned, consideration shall be made of the fact that sufficient communication facilities shall be incorporated to cater for present and future needs of the company and other potential external users.

BASE CASE SCENARIO

4 LOAD AND GENERATION PROGNOSIS

The load forecast is based on projected growth of Gross Domestic Product (GDP), population and new electricity connection, regional power trade obligations and power transmission and distribution losses. The tool used for load forecasting is an excel based econometrics model. The assumptions and results for the load forecast and demand-supply balance are discussed below.

4.1 ASSUMPTIONS FOR DEMAND - SUPPLY PROGNOSIS

4.1.1 HISTORICAL DEMAND TRENDS

Year	Total Energy Sales including Export (GWh)	Growth	System Peak Demand (MW)	Growth	Domestic Sales (GWh)	Growth	Domestic Peak Demand (MW)	Growth
2007	1,825	17%	394.9		1,759	17%	379.7	
2008	2,017	11%	389.5	-1.4%	1,950	11%	380.0	0.7%
2009	2,233	11%	400.7	2.8%	2,151	10%	393.9	3.6%
2010	2,413	8%	434.7	8.5%	2,336	9%	423.9	7.6%
2011	2,544	5%	454.6	4.6%	2,450	5%	445.9	5.2%
2012	2,739	8%	545.1	16.6%	2,640	8%	498.2	10.5%
2013	2,933	7%	516.6	5.2%	2,826	7%	492.3	-1.2%
2014	3,098	6%	549.8	6.4%	2,931	4%	508.3	3.15%
2015	3,219	4%	560.1	1.9%	3,097	6%	520.7	2.4%
2016	3,400	6%	579.3	3.4%	3,235	4%	534.1	2.6%
2017	3,716	9%	625.3	7.9%	3,399	5%	562.5	5.3%

Table 3: Trend of Growth in Energy sales and Power peak demand
Source: UETCL Statistics Reports

The average growth for the past ten years for system peak demand, domestic demand, system energy and domestic energy is shown the table below.

	Average growth (2008 – 2017)
System peak demand (MW)	5.59%
Domestic demand (MW)	3.99%
System Energy (GWh)	7.5%
Domestic Energy (GWh)	6.9%

TABLE 4: Average demand and energy growth for years 2008- 2017

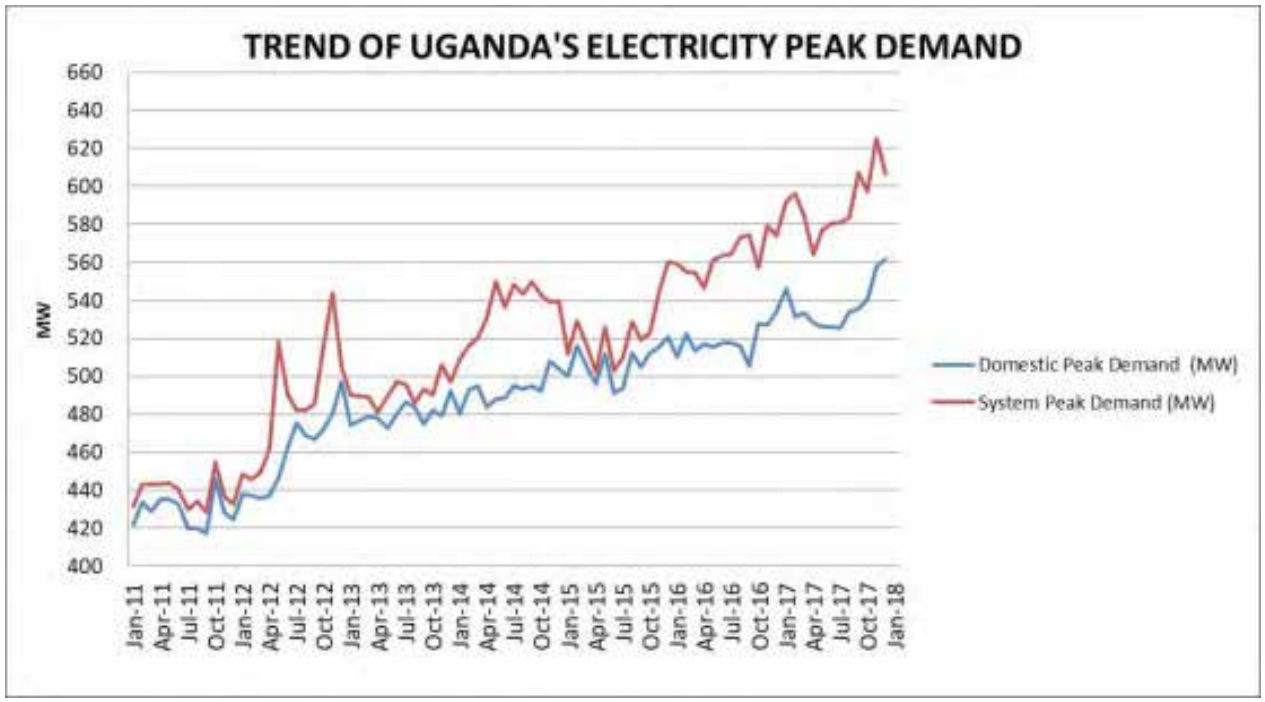

Figure 2: Trend of Uganda's electricity peak demand (Jan 2011 - Jan 2018).

* Domestic Demand excludes Tanzania load.

- The total peak demand for Uganda including exports significantly increased from 440MW in 2011 to as high as 540MW in December 2012 as shown in figure 2. The significant growth in 2012 was as a result of the commissioning of the Bujagali Hydro Power Plant which unlocked some of the unserved demand due to load shedding that was experienced up to 2011.
- A significant spike is observed in 2012, 2014, 2016 and 2017 for the total peak demand due to an increase in exports. This increase in exports for 2012 and 2014 was attributed to the shutdown of the transmission line in western Kenya whereas for 2016 and 2017 was attributed to the draught in the western region of Kenya and constraints in their transmission line capacity between western and eastern side of Kenya leading to an increase in purchases of power by Kenya.
- The rate of growth in domestic peak demand is however noted to have been on average increasing slowly at the rate of 5.6% starting from 2011 to 2017. In particular, domestic demand has been fluctuating between 420MW and 562 MW from 2011 to 2017 with the highest domestic demand registered in December 2017.
- Trend of energy sales compared to peak demand, it can be observed that the average growth in energy sales has been 6% since 2011 to date. Despite the lower growth in peak demand which was less by 2%, the growth in sales was significantly higher. The growth of total energy sales in 2017 was 9% compared to 6% in 2016 due to increased exports to Kenya.

4.1.2 GROSS DOMESTIC PRODUCT

Historical of GDP Growth Rate

Recorded GDP growth rate	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
	4.4%	3.3%	4.8%	%	4.7%	4.0%

Source: UBOS

Table 5: Historical GDP values

Forecast of GDP Growth Rate

Forecast	2017/18	2018/19	2019/20	2021/25	2026/30	2031/35	2036/40
	6.0%	6.1%	6.3%	8.35%	8.22%	8.07%	7.83%

Table 6: GDP projections

Source: NDPII & Vision 2040

4.1.3 POPULATION GROWTH

- The 2014 national census results indicated that Uganda's population is estimated at 34.9million[1] showing that the country's population has grown by 10.7 million from 24.2 million since the last census in 2002. At an average annual growth rate of 3.03%, Uganda's population is projected to increase to 39.3 million in 2018 and to 61.3 million in 2040.

4.1.4 SYSTEM LOSSES

- It was assumed that, given the aggressive program that is in place to reduce the distribution non-technical and technical losses, non-technical losses will reduce to 3% and the technical losses will reduce to 11% to make a total of 14% by 2020. Thereafter distribution losses are assumed to reduce farther to 12.8 by 2024 and remain at the same levels to 2040 while transmission losses will be at 2.5% by 2040.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total Energy Losses (%)	38	39	33.9	31.3	29.6	28.1	25	23.1	20.3	19.2
Transmission Losses (%)	4.3	3.8	4.2	3.35	3.98	3.6	3.27	3.37	3.9	3.86
Distribution Losses (%)	34	35	30	27.3	26.1	24.3	21.3	19.5	19	16

Table 7 :System losses

Source for transmission losses: UETCL System Annual Operations Reports

	2018	2019	2020	2022	2024-2040
Total Energy Losses (%)	18.1	17.5	16.7	15.5	15.3
Transmission Losses (%)	3.1	3	2.7	2.5	2.5
Distribution Losses (%)	15	14.5	14	13	12.8

Table 8 : System loss projections

4.1.5 EXPORT POTENTIAL

Uganda has exported up to about 17 MW to Tanzania. The general exchange of power between Uganda and Kenya has been on the basis of the tie line agreement of only 4 MW, however, Uganda has been the net exporter over the last couple of years with an exchange up to about 50MW in year 2017 as observed from the national control centre system report. Table 10 shows the trend of export by Uganda to its neighboring countries.

1 MoFPED – 2014 Uganda Population Report

	Energy Sales (GWh)							
	2010	2011	2012	2013	2014	2015	2016	2017
KPLC	29.24	38.2	37.9	47.41	107.06	56.03	83.21	225.88
TANESCO	45.36	50.94	57.1	54.44	55.65	61.23	77.18	79.17
EWSA	1.97	3.13	1.8	1.4	2.59	1.94	2.42	9.28
SNEL	0.14	1.6	2.4	2.11	2.44	2.25	2.19	2.3
Total Export	76.71	93.87	99.20	105.36	167.74	121.45	165	316.63
% Growth Rate	-6.5%	22.4%	5.7%	6.2%	59.2%	-27.6%	35.9%	91.9%

TABLE 9: Energy exports
Source: UETCL Annual Report

Uganda has not concluded any new export contract with her neighbouring countries however a Wheeling Agreement was signed between Kenya, Uganda and Rwanda for the export power from Kenya to Rwanda over UETCL's network until 2019.

In this analysis it is assumed that no additional export above 50 MW (export to Kenya and Tanzania) will be made by end of 2020. This assumption is mainly based on the fact that Uganda does not have any new Power Sale Agreements. It is assumed that with the commissioning of various interconnectors with neighbouring countries the export capacity shall increase to more than 50MW during the planning horizon. This is subject to UETCL entering into Power Sales Agreements with the neighbouring countries refer to Annex-A.1: Demand-Supply Balance prognosis.

4.1.6 LOAD FACTOR

Current Load factor is 74% based on the 2016 System Annual Operations report. The load factor is assumed to increase to maximum 79% by the end of the planning period.

Year	2002-2005	2006-2009	2010-2011	2012-2013	2014-2015	2016-2017
Load factor	65%	68%	69%	70%	71%	74%

Table 10: Historical load factor

Year	2018-2022	2023-2028	2029-2031	2032-2035	2036-2038	2039-2040
Load factor	74%	75%	76%	77%	78%	79%

Table 11: Load factor projection

The assumed increase in the load factor is due to growth in the base load due to increased industrialization.

4.2 ASSUMPTIONS FOR GENERATION PLAN

1. For the River Nile based generation plants, the average flow considered is 800 cumecs which is equivalent to P50[2].
2. Spinning Reserve –the additional output from generating plant that must be realisable in real time in order to arrest a drop of system frequency due to a loss of generation or a loss of external inter-connector or mismatch between generation and demand. The spinning reserve should be equal to the largest unit on the grid.

2 Probability of getting 50%

3. Plant factor for large hydros is :
    - Nalubaale & Kira – 0.38
    - Bujagali – 0.6

4. Eskom dispatch is optimised in accordance with the allowable discharge as follows:
    - Peak: 190-220MW
    - Shoulder: 150-176MW
    - Off peak: 80-138MW –The Exact dispatch will depend on the coincident demand requirements for the different periods

5. Dispatch of Bujagali HPP will follow the discharge from Kiira and Nalubaale thus limiting its capacity to 1.237 times the combined dispatch of Nalubaale and Kiira and is estimated as below;
    - Peak: 235 -250MW
    - Shoulder : 185 - 217MW
    - Off peak: 100 -169MW -The exact dispatch will depend on the coincident maximum demand requirements for the different periods.

6. Mini hydros have been dispatched with a plant factor between 40% and 80%. All the mini-hydro Power Plants are dispatched as base plants. The following plant factors have been observed and are assumed to hold for the future:-
    - Mobuku 1(KML) 0.52
    - TPL(Bugoye) 0.77
    - EMS (Mpanga) 0.52
    - EPUL (Ishasha) 0.4
    - Hydromaxx (Buseruka) 0.48
    - Mobuku 3(KCCL) 0.78
    - Muvumbe (0.55)
    - Siti 1 (0.57)
    - Rwimi (0.56)

7. Thermal Power Plants:
    - Namanve 50MW HFO Thermal Plant: The thermal power plant shall be dispatched according to merit order dispatch of up to 50MW but with a minimum dispatch of 7MW. It has an availability factor of 85%.
    - Electromaxx (50MW) thermal power plants: The power plant shall be dispatched according to merit order dispatch of up to 33.7 MW but with a minimum dispatch of 7MW. It has an availability factor of 85%.
    - A 50MW Thermal Plant in the Albertine Region:

8. Cogeneration Plants
    - 51MW Kakira dispatching up to 32MW
    - 14.5MW Kinyara dispatching 2-5MW
    - 11.9MW SAIL dispatching up to 6.9MW

9. Solar Power Plants
    - Access Solar 10MWp dispatched during the shoulder band
    - Tororo Solar North 10MWp dispatched during the shoulder band

4.3 GENERATION EXPANSION PLAN

The objective of generation expansion planning is to determine the generation capacity and energy requirements to meet forecasted demand during the planning period.

Table 10 shows the generation plan with evacuation line projects

No.	Power Plant	Capacity (MW)	Estimate Commission Year	Evacuation Line Project Name
1	Isimba HPP	183	2018	42km, 132kV Isimba Bujagali double Circuit transmission line, 2x132kV Isimba bays at Bujagali and 2x132kV Bujagali bays at Isimba
2	Mahoma HPP	2.7	2018	Embedded generation: (connecting to the 33kV grid)
3	Nkusi HPP	9	2018	Embedded generation: (connecting to the 33kV grid)
4	Sindila HPP	5.25	2018	Embedded generation: (connecting to the 33kV grid)
5	Mayuge Solar plant	10	2018	Embedded generation: (connecting to the 33kV grid)
6	Nyamwamba HPP	9.2	2018	Embedded generation, To be evacuated at Nkenda Substation: new 2x60MVA, 33/132kV additional transformers are proposed at Nkenda Substation
7	Agago-Achwa HPP II (ARPE)	42	2018	132kV - Gulu Agago double Circuit transmission line Project
8	Karuma HPP	600	2018	Karuma Interconnection Project: 248.2km, 400kV, 1423MVA Double Circuit Karuma Kawanda Transmission line, 2x650MVA, 400/220kV Kawanda Substation 54.25km, 400kV 1423MVA Double Circuit Karuma Olwiyo Transmission line, 2x125MVA, 400/132/33kV Olwiyo Substation 75.5km, 132kV, 135MVA Karuma Lira Double Circuit Transmission line
9	Siti 2 HPP	16.5	2018	80km, 132kV Mbale Bulambuli transmission line, 132/33kV 2X32/40MVA Mbale substation, 132/33kV, 2X32/40MVA Bulambuli substation
10	Mayuge Sugar plant	23	2020	Embedded generation: (connecting to the 33kV grid)
11	Waki Hydro HPP	4.8	2019	Embedded generation: (connecting to the 33kV grid)
12	Kakaka HPP	5	2019	Embedded generation: (connecting to the 33kV grid)
13	Nyagak III HPP	5.5	2019	Embedded generation and operating off grid but shall eventually be evacuated via 132kV Lira Gulu Nebbi Arua Project
14	Kyambura HPP	7.6	2019	Embedded generation: (connecting to the 33kV grid)
15	Nyamagasani 1 HPP	15	2019	To be evacuated at Nkenda Substation: new 2x60MVA, 33/132kV additional transformers are proposed at Nkenda Substation)
16	Nyamagasani 2 HPP	5	2019	To be evacuated at Nkenda Substation: A new 2x60MVA, 33/132kV Substation is proposed adjacent to Nkenda Substation
17	Ndugutu HPP	5.1	2019	Embedded generation: (connecting to the 33kV grid)
18	Kanyampara	4.8	2019	Embedded generation: (connecting to the 33kV grid)
19	Nyamabuye	7	2019	Embedded generation: (connecting to the 33kV grid)
20	Nyabuhuka-Mujunju HPP	3.2	2019	Embedded generation: (connecting to the 33kV grid)
21	SCOUL	25	2020	Embedded generation: (connecting to the 33kV grid)

No.	Power Plant	Capacity (MW)	Estimate Commission Year	Evacuation Line Project Name
22	Xsabo Solar	20	2019	132kV Kabulasoke Substation
23	Nengo Bridge HPP	6.7	2020	Embedded generation: (connecting to the 33kV grid)
24	Bukinda HPP	6.5	2020	Embedded generation: (connecting to the 33kV grid)
25	Kikagati HPP Project	14 (7)	2020	Embedded generation: (connecting to the 33kV grid)
26	Senok Wind Project	20	2020	Embedded generation: (connecting to the 33kV grid)
27	Agago-Achwa HPP I (ARPE)	42	2020	132/33kV Agago Substation
28	Keere Small HPP	6.3	2021	Embedded generation: (connecting to the 33kV grid)
29	Kinyara Cogen plant	35	2021	45km, 220kV double circuit Hoima Kinyara transmission line
30	Albatros Thermal Power	50	2021	220kV Hoima Nkenda Project
31	Sironko HPP	7	2021	Embedded generation: (connecting to the 33kV grid)
32	Gas to Power	58	2021	220kV Hoima Nkenda Project
33	Kabeywa HPP	12	2021	Embedded generation: (connecting to the 33kV grid)
34	Nshongezi HPP Project	35 (17.5)	2021	38km, 132 kV double circuit Mirama-Nsongezi Transmission line, Mirama 220/132kV Substation extension Nshongezi 33/132kV Substation: 2x32/40MVA power transformer 2 x line feeder bay for 33kV lines from Kikagati
35	Ngoromwo HPP	8	2021	Embedded generation: (connecting to the 33kV grid)
36	Maziba	1	2021	Embedded generation: (connecting to the 33kV grid)
37	Nyagak 1	3.5	2021	Embedded generation: (connecting to the 33kV grid)
38	Cresta	5	2021	Embedded generation: (connecting to the 33kV grid)
39	Muyembe-Sirimityo HPP	7	2021	Embedded generation: (connecting to the 33kV grid)
40	Jinke solar	500	2021	Unknown
41	CP- EM solar	1000	2021	Unknown
42	Sky power Solar	500	2021	Unknown
43	Bukwa HPP	9	2021	Embedded generation: (connecting to the 33kV grid)
44	Ngoromwo HPP	8	2021	Embedded generation: (connecting to the 33kV grid)
45	Muzizi HPP	44.7	2022	To be interconnected and evacuated via 132 (220kV) double circuit Nkenda Fort Portal Hoima transmission line (Evacuation line is 6km)
46	Agago-Achwa HPP III (ARPE)	13	2022	132/33kV Agago Substation
47	Agago-Achwa HPP IV (ARPE)	10.5	2022	132/33kV Agago Substation
48	Kigwabya	4.2	2022	Embedded generation: (connecting to the 33kV grid)
49	Sisi	7.1	2022	80km 132kV Mbale Bulambuli transmission line, 132/33kV 2X32/40MVA Mbale substation, 132/33kV, 2X32/40MVA Bulambuli substation
50	Simu	9.9	2022	80km 132kV Mbale Bulambuli transmission line, 132/33kV 2X32/40MVA Mbale substation, 132/33kV, 2X32/40MVA Bulambuli substation
51	Lwakhaka	6	2024	Embedded generation: (connecting to the 33kV grid)
52	Agbinika	2	2024	Embedded generation: (connecting to the 33kV grid)
53	Okulacere	6.5	2024	Embedded generation: (connecting to the 33kV grid)

No.	Power Plant	Capacity (MW)	Estimate Commission Year	Evacuation Line Project Name
54	Oriang HPP	392	2025	To be evacuated at Olwiyo Substation
55	Ayago HPP	840	2025	12.57km, 400kV underground cable double circuit Ayago Olwiyo transmission line
56	Kiba	330	2025	12km, 400kV underground cable double circuit to Ayago switchyard
57	Kabale Peat	30	2027	Embedded generation, 132kV Mirama Kabale Double Circuit Transmission Line Project
58	Uhuru	600	2035	40km, 400kV underground cables double circuit to Ayago switchyard.
Total		5,614.05		

TABLE 12: Generation expansion plan

4.4 PRESENT DEMAND- SUPPLY STATUS

The graph below shows the energy demand[3] and supply as recorded for the period December 2016 – December 2017. An analysis shows an annual growth in energy supply and demand of 5% (Refer to Table 4). This shows that the electricity supply needs to be maintained at this rate or higher in order to avoid running into a deficit situation

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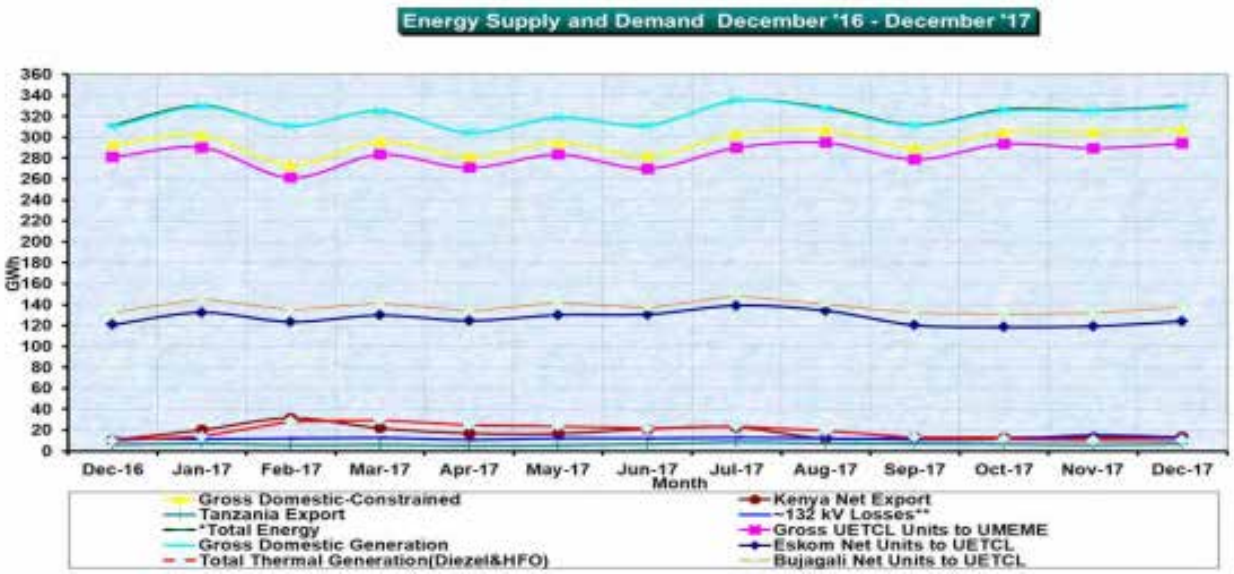


FIGURE 3: Energy supply and demand Dec 2016 - Dec 2017

The graph below shows the load duration curve for December 2017. It illustrates the relationship between generating capacity requirements and capacity utilization.

The maximum system peak demand registered in 2017 was about 562.45MW and 534MW in 2016. The peak demand period is experienced for about 15% of the time. There is need to improve Demand Side Management measures to reduce the peak demand to avoid investment in expensive peak generation facilities.

The future outlook of the Demand –Supply is presented in Annex A.1.

3 Source: UETCL Control Centre Monthly Reports

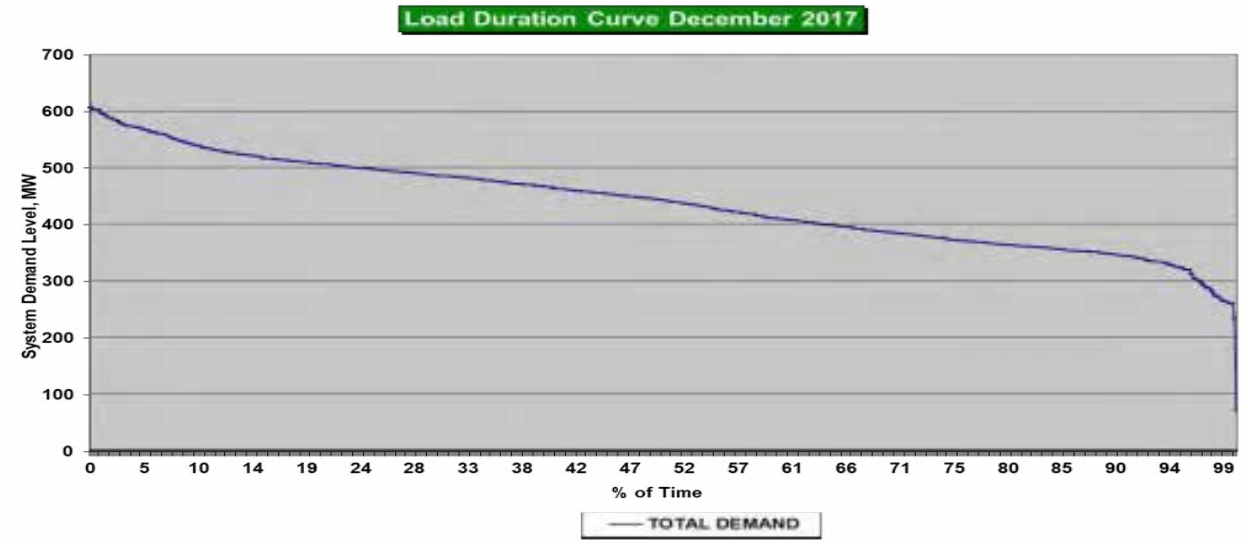


FIGURE 4: Load duration curve Dec'17

The Load Duration curve shows that the base load of the Ugandan grid is about 250MW and the maximum power peak load of the Ugandan grid is about 590 MW that is observed to occur for approximately a period of less than 5% of the time. Therefore since UETCL is the system operator should ensure that the generators are well scheduled to serve the different load requirements.

In order to meet the power and energy requirements, the generation plants in Table 14 are utilized.

CATEGORY/SUPPLIER	INSTALLED CAPACITY (MW)
LARGE HYDROS	
ESKOM UGANDA LIMITED	380MW
BUJAGALI	250MW
MINI HYDROS	
MPANGA	18MW
BUGOYE	13MW
KILEMBE MINES	5MW
KASESE COBALT	10.5MW
ISHASHA	6.4MW
BUSERUKA	9MW
RWIMI	5.54MW
MUVUMBE	6.5MW
SITI 1	5MW
LUBILIA	5.4MW
NYAMWAMBA	9.2MW
NKUSI	9.6MW
CO-GENERATION	
KAKIRA SUGAR WORKS	51MW

CATEGORY/SUPPLIER	INSTALLED CAPACITY (MW)
KINYARA SUGAR WORKS	14.5MW
SAIL SUGAR WORKS	11.9MW
THERMAL	
JACOBSEN UGANDA LIMITED (NAMANVE HFO)	50MW
ELECTROMAXX (TORORO HFO)	50MW
SOLAR	
ACCESS UGANDA SOLAR (OPUYO)	10MW
TORORO SOLAR NORTH LIMITED	10MW
AVAILABLE TOTAL GENERATION	930.54

Table 13: Existing generation plants

Source: Executed Power Purchase Agreements

4.5 DEMAND FORECAST

The demand prognosis was prepared using 2017 as the base year. For the Base case scenario demand forecast, the assumptions in section 4.1 above were used. A correlation factor between electricity consumption and the Gross Domestic Product was determined using historical values. The average annual growth rates obtained for the planning period is 4.1% for both peak demand and energy. A summary of the load forecast results is shown in the Tables below:-

Year	Domestic Demand (MW)	Export Demand (MW)	Industrial Loads (MW)	Total Demand (MW)
2018	590	47	100	737
2019	615	21	410	1046
2020	641	21	659	1320
2021	667	51	692	1410
2022	695	114	726	1535
2023	723	114	763	1600
2024	753	164	801	1718
2025	784	164	841	1789
2026	816	164	981	1961
2027	849	164	1030	2044
2028	884	164	1082	2130
2029	920	164	1136	2220
2030	958	164	1192	2314
2031	997	164	1252	2413
2032	1,037	164	1315	2516
2033	1,079	164	1380	2624
2034	1,123	164	1449	2736
2035	1,169	164	1521	2854
2036	1,216	164	1597	2977

Year	Domestic Demand (MW)	Export Demand (MW)	Industrial Loads (MW)	Total Demand (MW)
2037	1,265	164	1677	3106
2038	1,317	164	1761	3242
2039	1,370	164	1849	3383
2040	1,426	164	1941	3536

TABLE 14: Demand forecast (MW) 2018-2040
Source for Industrial loads : Umeme LTD

Year	Domestic Demand (GWh)	Export Demand (GWh)	Proposed Industrial Loads (GWh)	Total Demand (GWh)
2018	3,827	82	876	4,785
2019	3,987	37	3,592	7,615
2020	4,208	37	5,771	10,017
2021	4,383	89	6,060	10,532
2022	4,625	200	6,363	11,187
2023	4,815	200	6,681	11,696
2024	5,013	287	7,015	12,316
2025	5,357	287	7,367	13,011
2026	5,576	287	8,594	14,457
2027	5,953	287	9,024	15,264
2028	6,196	287	9,475	15,958
2029	6,448	287	9,948	16,684
2030	6,711	287	10,446	17,444
2031	7,421	287	10,968	18,676
2032	7,722	287	11,517	19,526
2033	8,036	287	12,092	20,416
2034	8,362	287	12,697	21,347
2035	8,702	287	13,324	22,313
2036	9,055	287	13,990	23,333
2037	9,423	287	14,690	24,400
2038	9,805	287	15,424	25,517
2039	10,204	287	16,196	26,687
2040	10,619	296	17,005	27,920

TABLE 15: Energy forecast (GWh) 2018-2040

	Average growth (2018 – 2040)
System peak demand (MW)	13.84%
Domestic demand (MW)	3.95%
System Energy (GWh)	11.66%
Domestic Energy (GWh)	12.07%

TABLE 16: Demand and energy average growth for period 2018-2040

4.6 FORECASTED GENERATION MIX

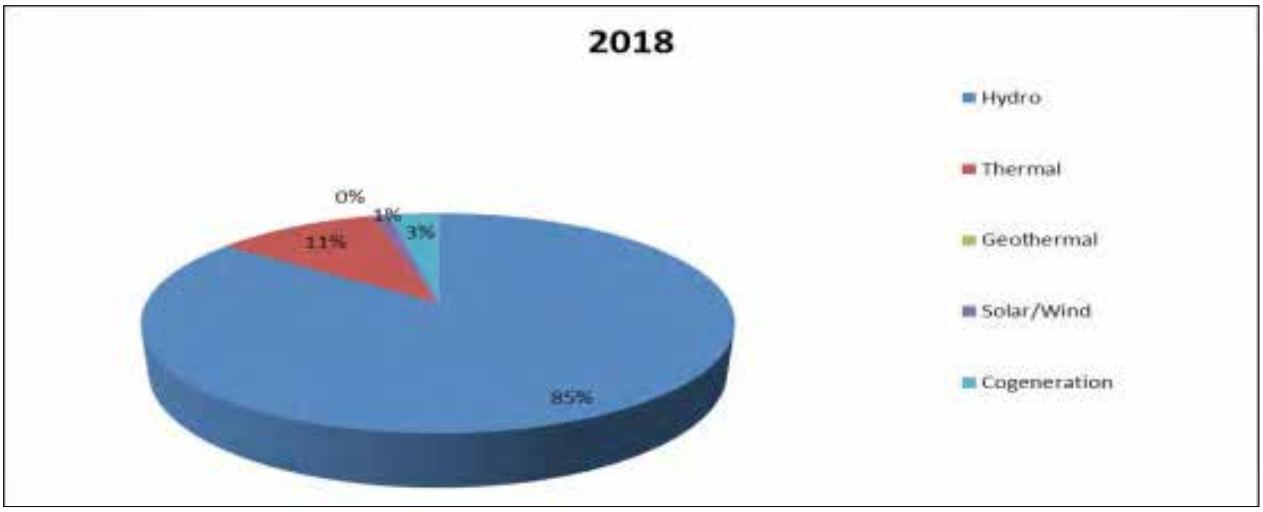


FIGURE 5: Forecasted generation mix for 2018

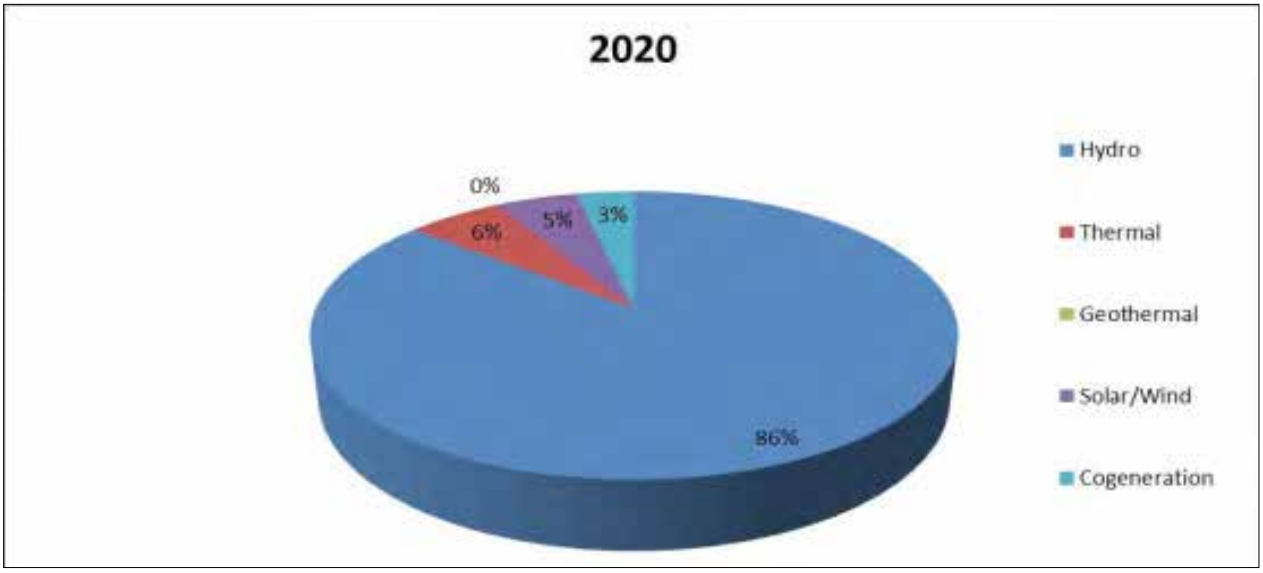


FIGURE 6: Forecasted generation mix for 2020

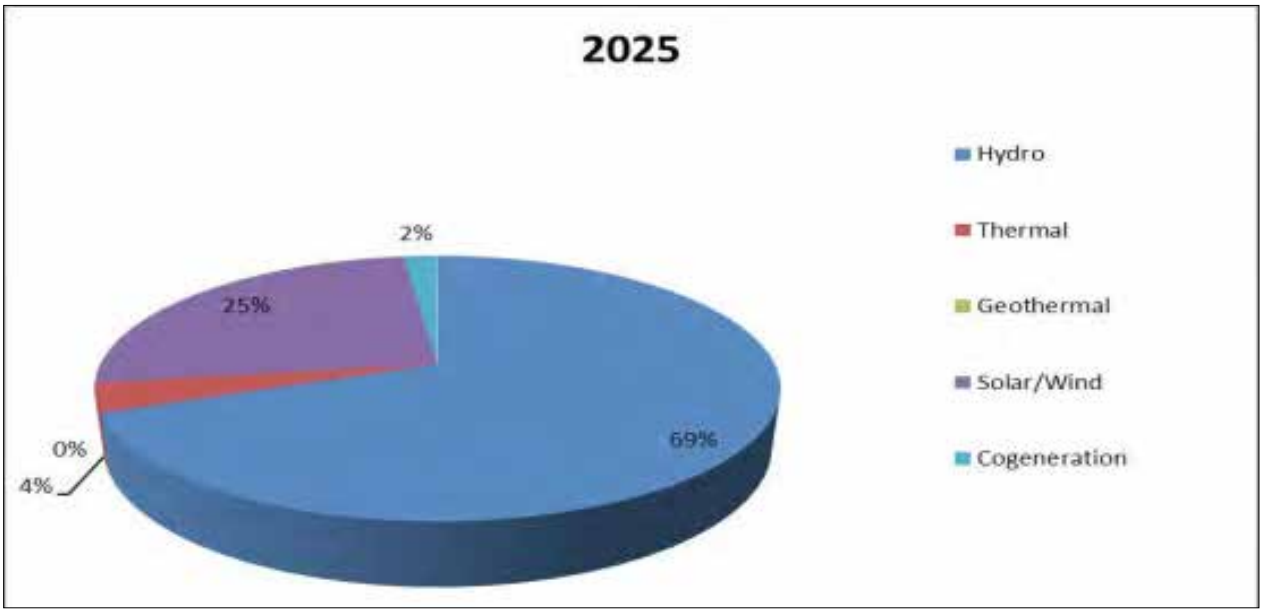


FIGURE 7: Forecasted generation mix 2025

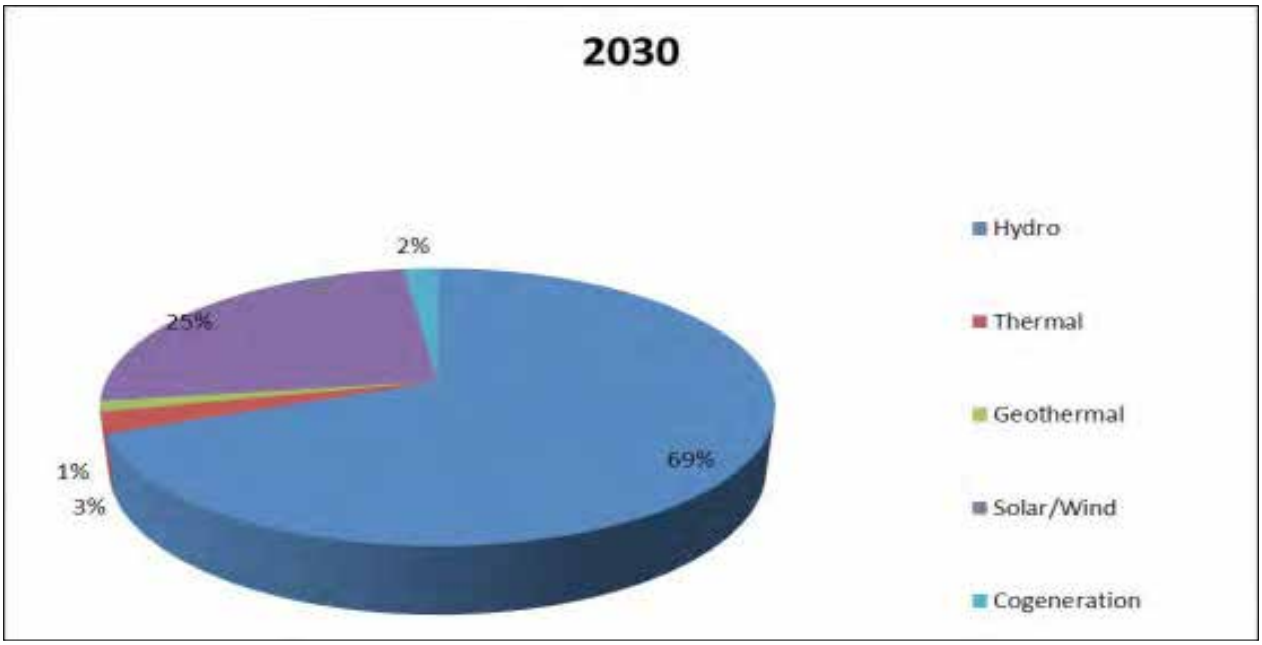


FIGURE 8: Forecasted generation mix 2030

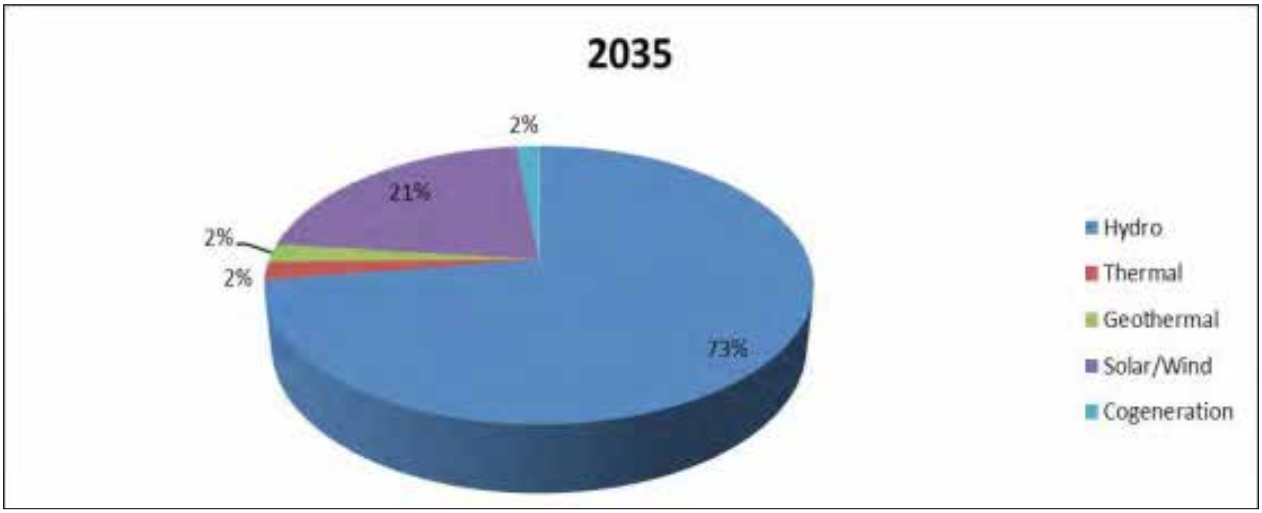


FIGURE 9: Forecasted generation mix 2035

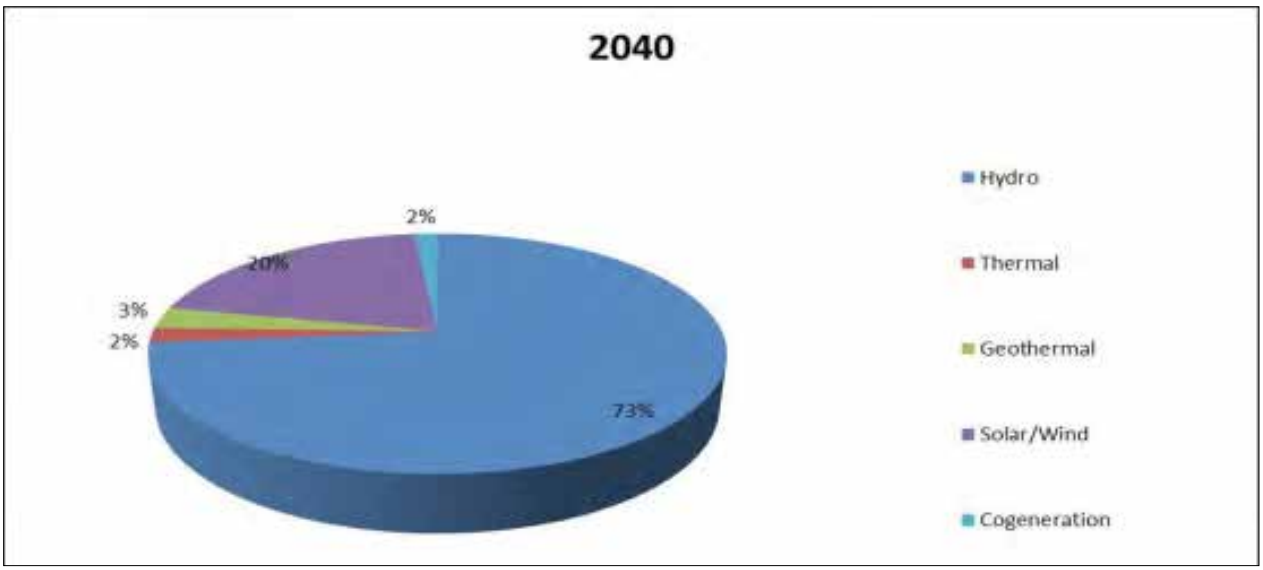


FIGURE 10: Forecasted generation mix 2040

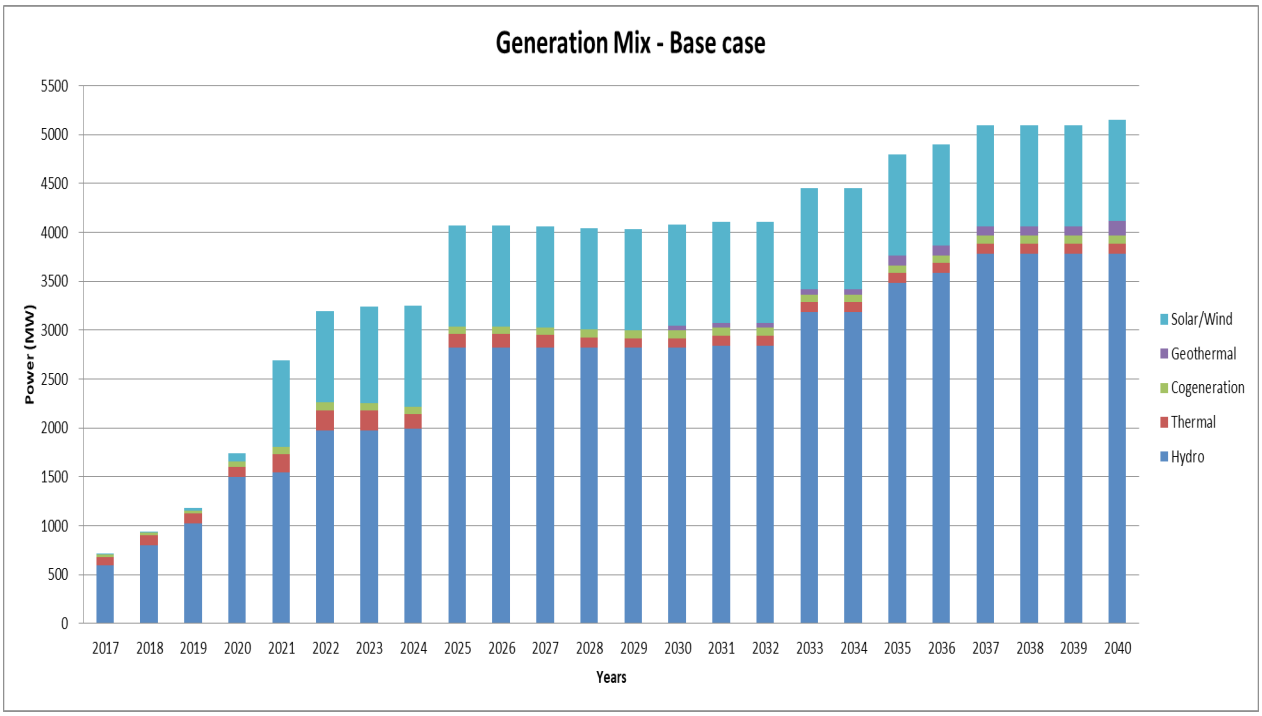


Figure 11: Forecasted generation mix for planning period

4.7 DEMAND-SUPPLY BALANCE FINDINGS

The Load forecast, Power and Energy balance are presented in appendix A.1. The charts below illustrate the demand-supply balance prognosis 2017-2040.

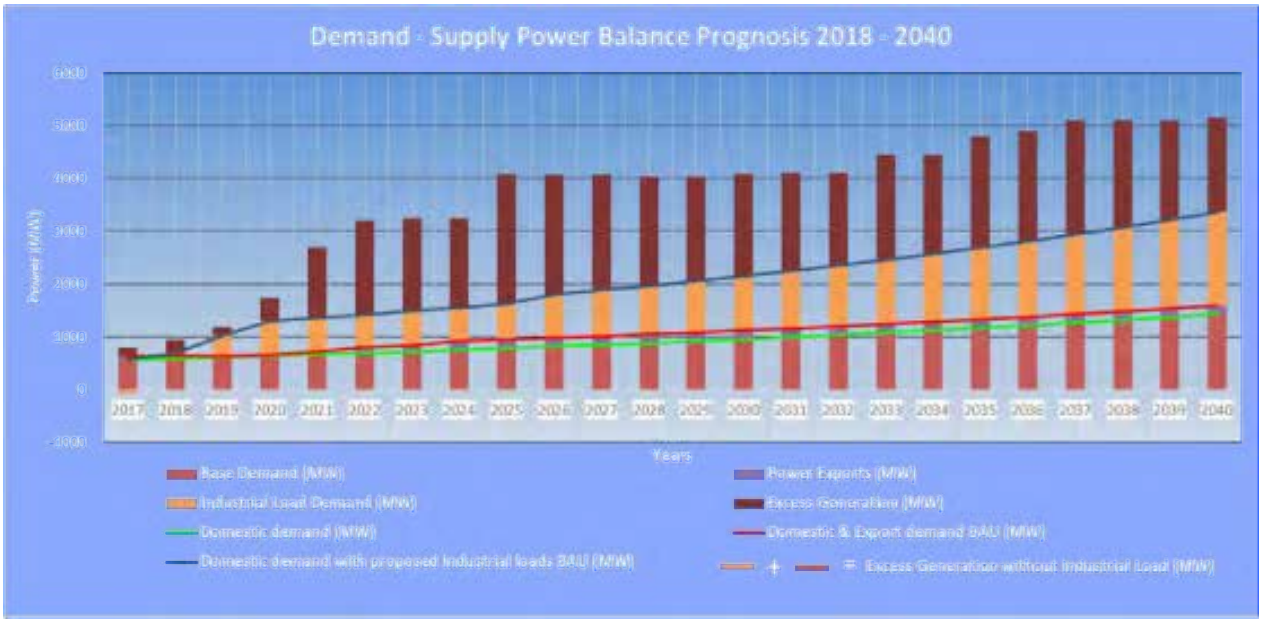


Figure 12: Power projection 2017 – 2040

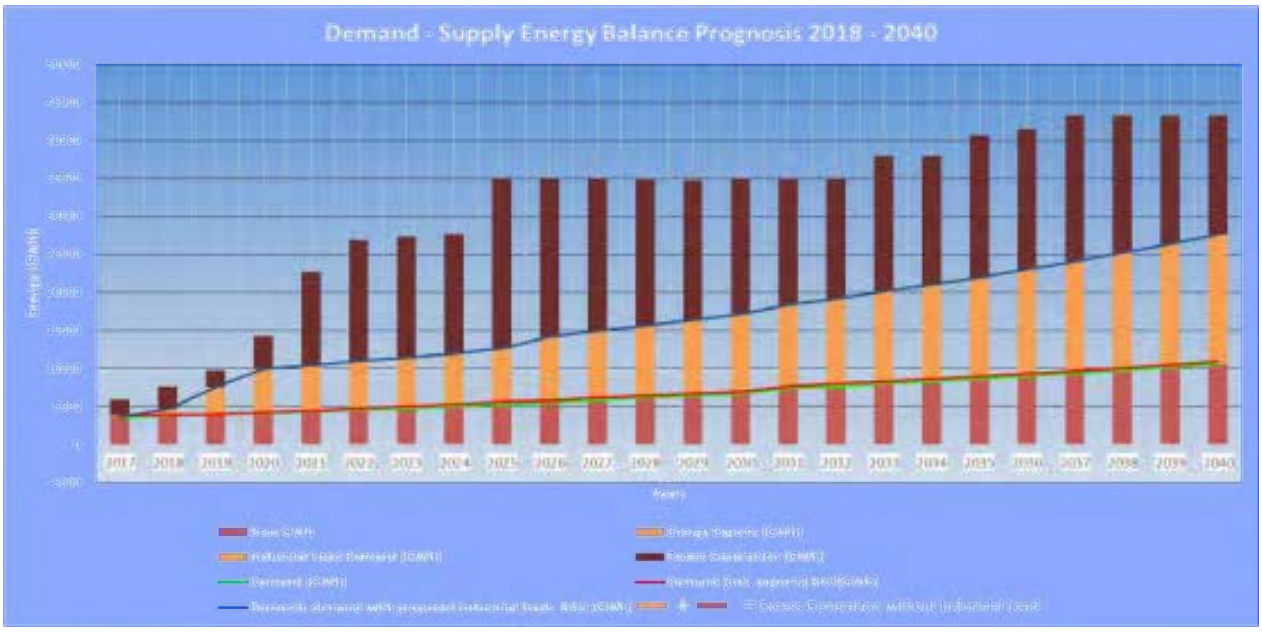


Figure 13: Energy projection 2017-2040

4.7.1 OBSERVATIONS AND FINDINGS FROM DEMAND SUPPLY BALANCE

Observation and Mitigation measures

- A deficit is observed in 2019 because of the anticipated industrial load however there is a surplus in case the industries are not realized as depicted in table 17 below.
- Excess generation is envisaged throughout the planning horizon from 2020 to 2040 and can be utilized through:
    - Development of heavy Industrial loads.
    - Exportation to neighbouring countries e.g. Rwanda , DR Congo, South Sudan and Tanzania

Recommendations

- Demand growth opportunities need to be explored in order to realise demand that matches the generation capacity development.
- Hydro power generation plant development should be matched with demand growth outlook..

Year	Power Excess/ Deficit (Domestic) (MW)	Power Excess/ Deficit (Domestic with proposed industrial loads) (MW)	Power Excess/ Deficit (Domestic with industrial loads + Export) (MW)
2018	167	114	67
2019	359	-30	-51
2020	899	261	240
2021	1,792	1,151	1,100
2022	2,204	1,592	1,478
2023	2,220	1,571	1,457
2024	2,191	1,554	1,390
2025	2,984	2,307	2,143
2026	2,949	2,132	1,968
2027	2,906	2,039	1,875
2028	2,849	1,932	1,768

Year	Power Excess/ Deficit (Domestic) (MW)	Power Excess/ Deficit (Domestic with proposed industrial loads) (MW)	Power Excess/ Deficit (Domestic with industrial loads + Export) (MW)
2029	2,806	1,834	1,670
2030	1,648	619	455
2031	2,805	1,717	1,553
2032	2,764	1,614	1,450
2033	3,063	1,847	1,683
2034	3,019	1,734	1,570
2035	3,324	1,967	1,803
2036	3,376	1,943	1,779
2037	3,527	2,014	1,850
2038	3,475	1,879	1,715
2039	3,422	1,737	1,573
2040	3,411	1,639	1,470

TABLE 17: Deficit/Excess supply 2018-2040

Note: Excess generation is envisaged throughout the planning horizon from 2020 to 2040, however in the event that the industrial loads do not materialize as envisaged, the quantity of surplus power will significantly increase and this will bear a financial burden on UETCL due to payment of deemed energy fees.

5 POWER SYSTEM ANALYSIS

5.1 PRESENT POWER SYSTEM

The current transmission lines and substations are presented in appendix A.3 and A.4 detailing the capacities of the components. The present 2017 power system network is illustrated in appendix A.5.1. This grid consists of:

- The hydro power plants: Owen-Falls complex (Nalubaale and Kiira HPPs) whose installed capacity is 380MW, Bujagali (250MW),Tibet hima mining Co Ltd formerly kilembe mines (5MW), Bugoye (13MW),Kasese Cobalt company Ltd (9.5MW), Mpanga (18MW), Ishasha (6.5MW), Buseruka (9MW), Siti I 5MW, Muvumbe 6.5MW, Rwimi 5.5MW.
- The thermal power plants: Namanve 50MW and Electromaxx 50MW plants
- Co-generation, Bagasse plants: Kakira Sugar works 51MW plant , Kinyara sugar works 7.5MW plant and Sail plant 12MW
- Solar plants: Access solar TSK 10MW, Tororo solar north 10MW.
- The transmission grid: Presently, the transmission grid comprises 150km of 220kV (initially operated at 132kV), 1443km of 132kV, 300m of 132kV underground cable and 35.2km of 66kV high voltage transmission lines and 19 substations (Including Kabulasoke switching station).

5.2 POWER SYSTEM MODELS

Power system models were developed to enable analysis of present and future power systems. An Engineering software, PSS/E (Power System Simulation for Engineers), was used to develop the models. Six models were developed to analyze the present and future grids. The eight models included 2017 models (as at September base models), 2018 model, 2019 model, 2020 model, 2025 model and 2030 model.

The above grid models were established and analyzed to determine whether the grid shall behave within agreed voltage and thermal limits. The power system studies included: load flow and fault analysis. The results were analyzed to pre-determine the following:

- Network reliability
- Power supply quality
- Technical losses and Optimum utilization of transmission lines and substations

5.2.1 MODEL INPUTS AND OUTPUTS

Input Data

The input data for power system modeling is:

- Plant and Generator data
- Exciter Data
- Governor Data
- Transformer data
- Substation loads
- Line parameters for Existing transmission lines
- Line parameters for planned transmission lines

Output Results

The output results for power system modeling are:

a) Power flow result in terms of:

- Voltage profile to guard against insulation failure and maintain quality of supply
- Line and transformer loading

- Power flow and
- Losses

b) Fault calculation results in terms of:

- Fault levels to confirm switchgear safe breaking capability and protection settings

c) Contingency Analysis

d) Economic Dispatch/ Optimal power flow

e) Dynamic System Analysis:

- Power system stability to avoid black outs and maintain quality of supply

The technical analysis derived from power system studies formed a basis for determining technical viability and timing of the projects. The results of the studies are presented below.

5.2.2 2017 MODEL – BASELINE

➢ The demand and generation capacity modelled are:-

- Peak Demand : 666.3 MW
- Required generation : 630.8MW
- Total losses : 35.45MW
- Transmission power losses : 28.84MW (4.33%)
- Transmission energy losses : 3.54%

Key Events

- Queensway substation 132/33kV substation commissioned
- The following generation plants were commissioned;
  - ➢ Mini hydro power plants ; Siti I(5MW), Muvumbe (6.5MW), Rwimi (5.5MW).
  - ➢ Solar ; Tororo north solar (10MW).

Findings

- No buses violate the voltage limits of +/- 10%
- Violations of loading above 100% of MVA rating:
  - ➢ Kawanda 132/33kV– 100.4%
  - ➢ N-1 criterion is violated at the following:
    - Substation ;Lugogo 132/33/11kV,Kawanda 132/33kV,Mutundwe 132/33/11kV,Lugazi 66/11kV ,Nkonge 132/33kV,Opuyo 132/33kV,Mbarara 132/33kV,Lira 132/33kV,Tororo 132/33kV,Kampala North 132/33/11kV,Kawaala 132/11kV,Masaka West 132/33kV,Owenfalls 33/66kV.
  - ➢ Transmission line ; Kabulasoke – Masaka west 132kV , Nalubaale - Namanve 132kV.

Mitigation Measures

- Expedite the upgrade of Opuyo, Kawanda, Kampala North and Tororo substations.
- Upgrade transformation capacities where N-1 criterion is violated.
- UMEME should consider 33kV interconnectors between the primary substations to allow for flexible transfer of loads.

5.2.3 2018 MODEL

Scenario without envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 637MW
- Required generation : 660.3MW
- Total losses : 23.35MW
- Trans. power losses : 19.86MW (3%)
- Transmission energy losses : 2.4%

Scenario envisaged with Industries

The demand and generation capacity modeled are:-

- Peak Demand : 737MW
- Required generation : 769.5MW
- Total losses : 32.54MW
- Trans. power losses : 29.03MW (3.77%)
- Transmission energy losses : 3.08%

Key Events

- Commissioning of large hydro:
  - Isimba -183MW and Agago/Achwa – 42MW
- Commissioning of the following mini-hydros;
  - Siti II (16.5MW), Sindila (5.5MW), Nkusi (9.6MW), Nyamwamba (9.2MW), Mahoma (2.7MW), and Lubilia (5.4MW).
- The following projects commissioned:
  - Kawanda-Masaka 220kV, Nkenda-Fortportal-Hoima 220kV, Bujagali-Isimba 132kV, Mbarara-Mirama 220kV, Mbarara-Nkenda 132kV, Kawanda-Kapeeka 132kV and supply to phosphate Sukulu factory (with 25MVAr Capacitor Bank) commissioned.
- Additional Industrial Load – 100MW

Findings- without industries

- No high Voltage violations are observed at + 10%
- Low Voltage violations of -10% are observed at;
  - Lugazi 66kV (0.84pu)
- Loading violations are observed at;
  - Kawanda 132/33kV, 32/40MVA Transformers (111.2%)
- Additional N-1 violations at;
  - Substation; Namanve 132/33kV (55.2%), Queensway 132/33kV (54.9%)
  - Transmission line; Nalubaale – Lugazi 66kV (70.7%), Mutundwe – Queensway 132kV (53.6%), Lugogo-Mutundwe (T-Queensway) – 60.3%.

Findings- with Industries

- No high Voltage violations are observed at + 10%
- Low Voltage violations of -10% are observed at;
  - Lugazi 66kV (0.832pu), Lugazi 11kV (0.899), Opuyo 132kV (0.895), Lira 132kV (0.881), Tororo 132kV.
- Loading violations are observed at;
  - Kawanda 132/33kV, 32/40MVA Transformers (111.4%)
- Additional N-1 violations at;
  - Substation ; Kawanda 132/33kV 20MVA (70.1%), Nalubaale 132/33kV (55.9%), Kapeeka 132/33kV

20MVA (54.1%).

- Transmission line; Bujagali – Iganga – Tororo 132kV (77%), Bujagali – Isimba 132kV (55.7.5), Tororo-Sukulu 132kV (90.8%).

Mitigation Measures

- Expedite the commissioning of 132kV Tororo – Opuyo – Lira Transmission line
- Install a 10MVar capacitor bank at Lugazi 66kV.
- Install a 25MVar capacitor bank at Sukulu 10.5kV.
- Expedite upgrade of Kapeeka substation

5.2.4 2019 MODEL

Scenario without envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 736MW
- Required generation : 760.4MW
- Total losses :24.36MW
- Transmission power losses : 22.28MW (2.93%)
- Transmission energy losses : 2.4%

Scenario with envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 1044.4MW
- Required generation : 1093.6MW
- Total losses :49.6MW
- Transmission power losses : 44.19MW (4.04%)
- Transmission energy losses : 3.3%

Key Events

- Large hydro commissioned :
  - Karuma is fully commissioned 600MW.
- Mini hydros commissioned:
  - Waki(4.8MW), Kakaka(5MW), Kyambura(7.6MW), Nyamagasani I & II(20MW), and Nyamabuye (7MW),
- Solar plant commissioned ;
  - Xsabo Solar (20MW).
- The following projects commissioned:
  - Bujagali-Tororo-Lessos 220kV,132kV Opuyo – Moroto, Tororo-Lira 132kV Mutundwe-Entebbe 132kV, Bujagali-Kawanda 220kV, Opuyo, Kawanda, Tororo, Lira and Kampala North substation upgrade, Electrification of Industrial Parks (Namanve South,Luzira, Iganga and Mukono) and 54km, 132kV Kawanda-Kasana
- Additional Industrial Load – 310MW

Findings without additional industries

- Voltage Violations were observed at -10%: Lugazi 66kV (0.8241pu), Lugazi 11kV (0.7138)
- No Loading violations are observed
- Additional N-1 criterion violations are observed at
  - Substations: Kawanda 220/132kV (51.4%), Nkenda 132/33kV (55.6%).
  - Transmission Lines: 3km T-Bujagali – Nalubaale132kV (63.8%)

Findings with envisaged additional industries

- Voltage Violations were observed at -10%: Lugazi 66kV (0.7337pu), Lugazi 11kV (0.6239pu), Moroto 132kV (0.8619pu), Nalubaale 66kV (0.8472pu)
- Loading violations are observed at:-
  - Substations: Mutundwe 132/11kV (110.5%), Lira 132/33kV (103.7%)
  - Transmission lines: Nalubaale – T-Bujagali (130.1%)
- Additional N-1 criterion violations are observed at
  - Substations: Moroto 132/33kV (84.2%), Kasana 132/33kV (69.2%)
  - Transmission Lines: 8km Nalubaale – Bujagali 132kV (130.1%), Kampala North – Lugogo 132kV (59.1%), Nalubaale – T-Mukono 132kV (86.2%), Kawanda – Kasana 132kV (52.2%)

Mitigation Measures

- Expedite the upgrade of Nkenda Substation to higher transformation capacity of 2x60MVA

5.2.5 2020 MODEL

Scenario without envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 1071MW
- Required Generation : 1117.8MW
- Total losses : 46.79MW
- Transmission power Losses : 42.47MW (3.8%)
- Transmission energy losses : 3.11%

Scenario with envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 1318.7MW
- Required Generation : 1384.4MW
- Total losses : 65.69MW
- Transmission power Losses : 60.26MW (4.35%)
- Transmission energy losses : 3.56%

Key Events

- Mini hydros commissioned;
  - Nengo Bridge (6.7MW), Bukinda (6.5MW), Kikagati (16MW), Achwa III &IV (42MW),Nyagak I (3.5MW), Nyagak III (5.5MW), Ndugutu (51MW).
- Wind generation commissioned;
  - Senok wind (10MW).
- Cogeneration Plants Commissioned
  - Mayuge Sugar (23MW)
- The following projects commissioned;
  - 313km, 132kV Lira-Gulu-Nebbi-Arua132kV
  - 83km Gulu – Agago 132kV
  - Nkenda Substation Upgrade
- Additional Industrial Load – 249MW

Findings without additional industries

- Voltage Violations were observed at Moroto 132kV (0.8982pu)
- Loading violations are observed at
  - Substations; Mutundwe 132/11kV (112.7%)
  - Transmission Lines; 3km T-Bujagali – Nalubaale132kV (119.9%)
- Additional N-1 criterion violations are observed at
  - Transmission lines: Mukono-Namanve (52%), Lugogo- Nalubaale (50.5%)

Findings with additional industries

- Voltage Violations were observed at Moroto 132kV (0.8983pu), Moroto 33kV (0.8945pu)
- Loading violations are observed at;
  - Substations; Mutundwe 132/11kV (112.4%), Kasana 132/33kV (112.2%)
  - Transmission Lines; 3km T-Bujagali – Nalubaale132kV (140.7%), 5km T-Bujagali – Nalubaale132kV (100.3%), Nalubaale – T-Mukono 132kV (104.3%)
- Additional N-1 criterion violations are observed at
  - Substations; Entebbe 132/33kV (56.7%), Luzira 132/33kV (66.9%)
  - Transmission Lines; Kawanda- Kapeeka (50%), Kampala North-Namanve (51.4%) , Kampala North-Mutundwe 33kV (74.4%)

Mitigation measures

- Expedite commissioning of Kampala Metropolitan Project to relieve the Nalubaale-Mukono leg
- All big customers should ensure local reactive power compensation. (Moroto cement factory)
- Upgrade Mutundwe 132/11kV substation with additional transformation capacity
- Upgrade Kasana 132/33kV substation with additional transformation capacity
- Reconductor the Bujagali-Nalubaale 8km transmission line.
- Expedite the planned projects to feed the industrial areas in the Luwero area i.e. Wobulenzi-Kapeeka 220kV, Kapeeka-Kaweweta-Nakasongola 132kV and associated substations

5.2.6 2025 MODEL

Scenario without envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 1606.8MW
- Required Generation : 1657.MW
- Total losses : 50.19MW
- Transmission power Losses : 44.61MW (2.69%)
- Transmission energy losses : 2.22%

Scenario with envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 1789 MW
- Required Generation : 1856.6MW
- Total losses : 67.49MW
- Transmission power Losses : 61.69MW (3.3%)
- Transmission energy losses : 2.72%

Key Events

- Large hydros commissioned include Ayago (840MW), Oriang (392MW) and Kiba (330MW), Muzizi (44.7MW),

- Mini-hydros commissioned
  - Kabeywa (12MW), Bukwa (9MW), Keere Small HPP (6.3MW),Ngoromwo HPP (8MW), Maziba(1MW),Okulacere(6.5MW),Agbinika(2MW),Lwakhakha(6MW),Nyagak1(3.5MW),Crest (5MW),Nshongezi (35MW), Muyembe-Sirimityo (7MW), Sironko (7MW).
  - Other generation plants commissioned include; Gas to power -Tilenga&Kingfisher (58MW), Kinyara 25MW
- The following transmission projects commissioned;
  - Hoima-Kinyara-Kafu 220kV, Kampala Metropolitan project, Mirama-Nsongezi132kV,Mutundwe-Gaba-Luzira132kV,Bulambuli-Kapeterol 132kV,Nkenda-FortPortal-Lyanda-Kaabale-Hoima 220kV,Nkenda-Mpondwe220kV,Mirama-Kabale132kV,Masaka-Mwanza 220kV, Ayago interconnection project, Oriang interconnection project Kiba interconnection project, Olwiyo-Nimule-Juba 400kV, Masaka–Mbarara220kV, Ishaka132/33kV and associated transmission lines ,Wobulenzi-Kapeka 220kV ,Kapeka-Kaweweta-Nakasongola 132kV, Lugazi 132/33kV and associated transmission line, ,Evacuation of tilenga and kingfisher oil fields,
  - Upgrade Tororo, Mbarara South and Mirama 220/132kV substations, Upgrade of Moroto Tororo, Mbarara North, Masaka West, Nkonge, Lira (kole), Mutundwe and Lugogo 132/33/11kV substations
  - Supply to 5 Standard Gauge Railway traction stations(Iganga, Tororo, Nyenga, Buwoola and Kampala East) at 132kV Eastern Route)
- Additional Industrial Load – 182MW

Findings without additional Industries

- No Voltage Violations are observed at +/-10%
- Loading violations are observed at;
  - Substations; Kasana 132/33kV (112.4%)
  - Transmission Lines; 3km T-Bujagali – Nalubaale132kV (110.2%)
- Additional N-1 criterion violation is observed at
  - Substations; Olwiyo 400/132kV (82.6%)
  - Transmission Lines; Mutundwe-Kabulasoke (T-Buloba) 132kV (66%)

Findings with additional Industries

- Voltage Violations were observed at Moroto 132kV (0.891pu), Entebbe 33kV (0.874pu) Kawanda 33kV (0.896pu), Kasana 33kV (0.891pu), Kampala North 11kV (0.873pu)

- Loading violations are observed at;
  - Substations; Kasana 132/33kV (102.7%)
  - Transmission Lines; 3km T-Bujagali – Nalubaale132kV (106.9%)
- Additional N-1 criterion violations are observed at
  - Substations; Kafu 400/220kV 75MVA (52.5%), Mbale 132/33kV 3x60/80MVA (61.7%)
  - Transmission Lines; Mutundwe-Entebbe 132kV (51.7%), Nalubaale-Mukono (T-Lugazi) 132kV (66.9%)

Mitigation measures

- All big customers should ensure local reactive power compensation. (Entebbe, Kawanda, Kasana)

5.2.7 2030 MODEL

Scenario without envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 1962 MW
- Required Generation : 2041.6MW
- Total losses : 79.51MW
- Transmission power Losses : 71.5MW (3.5%)
- Transmission energy losses : 2.91%

Scenario without envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 2312 MW
- Required Generation : 2408.2MW
- Total losses : 96.09MW
- Transmission power Losses : 88.26MW (3.66%)
- Transmission energy losses : 3.05%

Key Events

- The following projects commissioned:
  - Masaka-Mbarara 400kV, 130.5km
  - Supply to Sukulu at 220kV
  - Northern Corridor (Tororo-Wobulenzi-Masaka, Mbarara-Shango 400kV, 535.8km)
  - Tororo-Karuma 400kV, 345km
  - Supply to Standard Gauge Railway traction stations for the Western Route (15 Traction Stations each at 2X4MVA) and Northern Routes (15 Traction Stations each at 2X4MVA) at 132kV
- Additional Industrial Load – 351MW

Findings without additional industries

- Voltage Violations are observed at Entebbe 33kV (0.7691pu), Kampala North 11kV (0.8585)
- Loading violations are observed at;
  - Substations; Kawanda 132/33kV (113.8%)
  - Transmission Lines; 8km T-Bujagali – Nalubaale132kV (154.2%)
- Additional N-1 criterion violation is observed at
  - Substations; Tororo 400/220kV 1x200MVA (54.6%)
  - Transmission Lines; Namanve-Namanve South 132kV (64.8%)

Findings with additional industries

- Voltage Violations were observed at Lugazi 66kV (0.897pu),Entebbe 33kV (0.8752pu) Kawanda 33kV (0.8968pu), Nkonge 33kV (0.899pu), Kampala North 11kV (0.8527pu), Lugazi 11kV (0.8193pu), SCOUL 11kV (0.8193pu)
- Loading violations are observed at;
  - Substations; Kasana 132/33kV (102.7%), Kawanda 132/33kV (113.9%)
  - Transmission Lines; 8km T-Bujagali – Nalubaale 132kV (150.5%)
- Additional N-1 criterion violations are observed at :
  - Substations; Masaka 400/220kV 1x200MVA (52.9%) Buloba 132/33kV 2x125MVA (50.5%), Kahungye 132/33kV 2x40MVA (60.7%), Kasana 132/33kV 2x15/20MVA (54.1%)
  - Transmission Lines; Tororo-Mbale 132kV (51.2%)

Mitigation measures

- Install an additional 200MVA transformer at Tororo 400/220kV substation

5.2.8 2035 MODEL

Scenario without envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 2523 MW
- Required Generation : 2632.3MW
- Total losses : 109.31MW
- Transmission power Losses : 101.08MW (3.84%)
- Transmission energy losses : 3.22%

Scenario without envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 2853 MW
- Required Generation : 3011.7MW
- Total losses : 158.65MW
- Transmission power Losses : 150.01MW (4.98%)
- Transmission energy losses : 4.18%

Key Events

- The following projects commissioned:
  - Ishaka-Kabale 132kV 94km
  - Kapeka-Kiboga 220kV 67.2km
  - Kiboga-Hoima 220kV 75.7km
  - Kabulasoke-Kiganda-Kiboga 132kV
- Additional Industrial Load – 329MW

Findings without additional loads

- Voltage Violations are observed at Moroto 132kV (0.8691pu), Lugazi 66kV (0.8755)
- Loading violations are observed at;
  - Substations; Kawanda 132/33kV 2x 32/40MVA (133.4%), Lira 132/33kV 2x15/20MVA (116.1%)
  - Transmission Lines; 8km T-Bujagali – Nalubaale132kV (161.3%), Mutundwe-T-Buloba (117.4%)
- Additional N-1 criterion violation is observed at :-
  - Substations; Kawanda 400/220kV 2x 650MVA (53.4%)
  - Transmission Lines; Karuma-Kole 132kV (52.7%), Nkenda-Kahungye (53.4%)

Findings with additional loads

- Voltage Violations were observed at Entebbe 132kV (0.8887pu), Nkonge 132kV (0.8110pu), Kawaala 11kV (0.8897pu), Lugazi 66kV (0.8661pu), Mubende 132kV (0.7913pu), Mubende 33kV (0.8581pu), Opuyo 132kV (0.888pu), Mbale 132kV (0.8760pu), Moroto 132kV (0.8248pu), Moroto 33kV (0.8952).
- Loading violations are observed at;
  - Substations; Tororo 400/220kV (101.5%), Kawanda 2x32/40MVA 132/33kV (133.2%), Nkonge 132/33kV 2x32/40MVA (97.9%), Lira 132/33kV 2x32/40MVA (116.4%), Mbale 132/33kV 3x60/80MVA (109%)
  - Transmission Lines; 8km T-Bujagali – Nalubaale132kV (163.3%), Mutundwe-T-Buloba (109.5%), Nkonge – Kabulasoke (113.4%), Nkenda-Kahungye (107.3%), Jinja Industrial-Nalubaale 33kV (109%)

- Additional N-1 criterion violation is observed at :-
    - Substations; Mubende 132/33kV 2x40MVA (54%), Rakai 132/33kV 2x40MVA (53.8%), Tororo 400/220kV 2x200MVA (101.5%)
    - Transmission Lines; Kole-Lira 132kV (75.2%), Masaka-Rakai 132kV (85.6%), Nkonge-Kabulasoke 132kV (113.4%), Nkonge-Kahungye 132kV (69.3%), Opuyo- Lira 132kV (61.2%), Nile HPPS –Ayago 400kV (57.3%)

Mitigation measures

- Upgrade Lira 132/33kV substation
- Re-conductor Nkenda-Kahungye-Nkonge-Kabulasoke 132kV transmission line

5.2.9 2040 MODEL

Scenario without envisaged additional Industries

The demand and generation capacity modeled are:-

- Peak Demand : 3114.1 MW
- Required Generation : 3301.2 6MW
- Total losses : 187.15MW
- Transmission power Losses : 176.88MW (5.4%)
- Transmission energy losses : 4.61%

Key Events

- The following projects commissioned:
    - Bulambuli-Moroto 132kV 15km
    - Moroto-Kitgum 132kV 250km
    - kitgum-Agago 132kV 50km
    - Agago-Adjumani 132kV 86km
    - Adjumani-Arua 132kV 110km
    - Arua-Aru 132kV 5.4km
- Additional Industrial Load – 420MW

Findings without additional loads

- Voltage Violations were observed at Entebbe 132kV (0.8818pu), Kampala North 132kV (0.8889pu), Nkonge 132kV (0.7899pu), Kawaala 132kV (0.8925pu), Mubende 132kV (0.7695pu), Mubende 33kV (0.8331pu), Lugogo 132kV (0.8868pu), Mutundwe 132kV (0.8995pu), Mbale 132kV (0.8936pu), Lugogo – Mutundwe (t-Queensway) 132kV (0.8910pu), Queensway 132kV (0.8907pu), Nkonge 33kV (0.8869pu), Kawaala 11kV (0.8780pu)
- Loading violations are observed at;
    - Substations; Tororo 400/220kV (108.7%), Kawanda 220/132kV (120.8%), Nalubaale 132/33kV 2 x 60MVA (107.4%), Nkonge 132/33kV 2x32/40MVA (107.7%), Lira 132/33kV 2x32/40MVA (115.5%), Mbale 132/33kV 3x60/80MVA (109.1%)
    - Transmission Lines; 8km T-Bujagali – Nalubaale132kV (183%), Mutundwe-T-Buloba (136.1%), Nkonge – Kabulasoke (117.7%), Nkenda-Kahungye (114.2%), Jinja Industrial-Nalubaale 33kV (144.9%)
- Additional N-1 criterion violation is observed at
    - Substations; Mukono 220/132kV 2x125MVA (51.4%)
    - Transmission Lines; Karuma-Ayago 400kV (76.3%), Kawaala-Mutundwe 132kV (69%), Kawanda-Mutundwe (53.7%), Kampala North-Mutundwe 132kV (57.1%)

		2018	2019	2020	2025	2030	2035	2040
Power losses (%)	Without new industries	3	2.93	3.8	2.69	3.5	3.84	5.4
	With industries	3.77	4.04	4.35	3.3	3.66	4.98	
	Load factor	0.74	0.74	0.74	0.75	0.76	0.77	0.79
	Conversion Factor	0.82	0.82	0.82	0.83	0.83	0.84	0.85
Energy losses	Without new industries	2.45	2.40	3.11	2.22	2.91	3.22	4.61
	With industries	3.08	3.30	3.56	2.72	3.05	4.18	

Table 18: Transmission loss trajectory

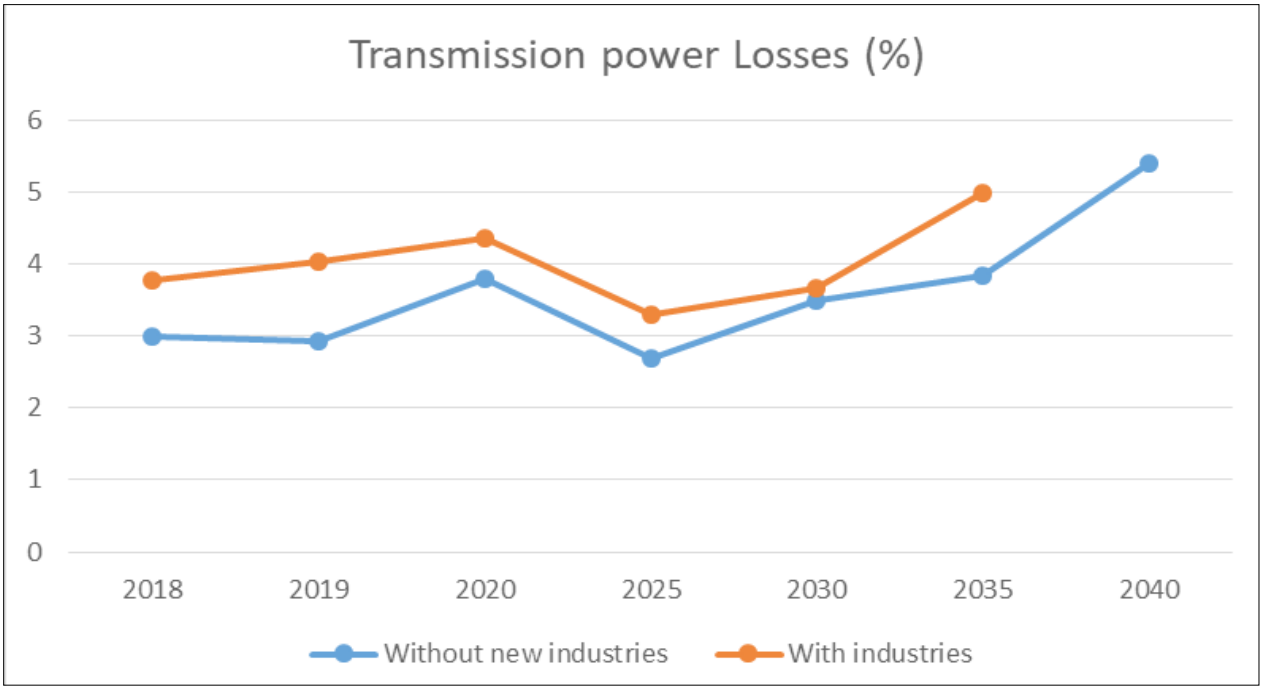


FIGURE 14: Transmission power losses (%)

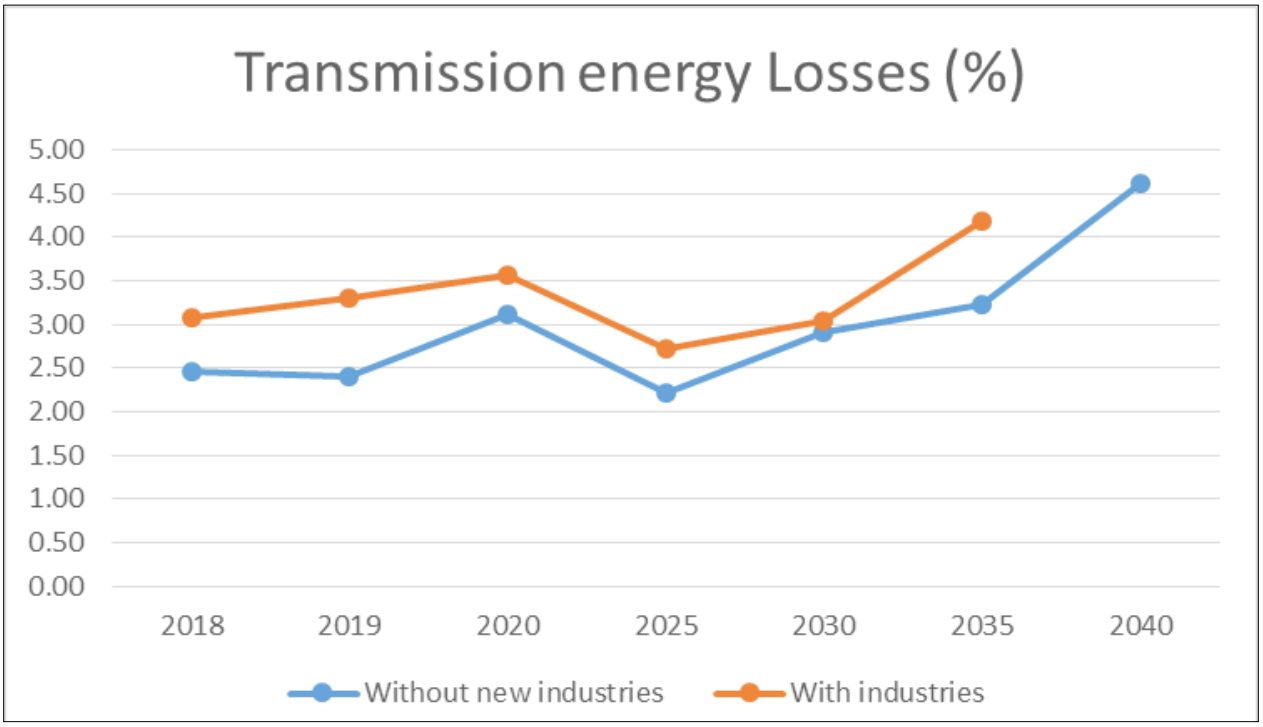


FIGURE 15: Transmission energy losses (%)

6 GRID INVESTMENT PLAN (2018-2040)

To ensure that the future electricity needs of the nation are satisfied, there is need to have major capital investments in the power sector. Such investments comprise of generation plants, transmission lines and expansion of the distribution network.

It is against this background that the Grid Investment Plan was developed to establish a rationale for building a robust network, contribute to Government of Uganda's strategic objective to provide adequate and reliable energy supply to meet national and regional, socio-economic development.
The Grid Investment Plan Projects have been classified into the following categories:

- Power evacuation projects
- Grid re-investment projects
- System Expansion Projects
- Regional Projects

6.1 GRID INVESTMENT PLAN SUMMARY

The Grid Investments, objectives, cost estimates and implementation period are presented in the Table 16 below. The detailed Grid Investment Plan is presented in Appendix A.2. 1USD=UGX 3,655.25; Source BOU 31/10/2017.

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
A	POWER EVACUATION PROJECTS						
1	Bujagali 220kV Switchyard Project (2X250MVA 220/132/33kV Power Transformers)	Evacuation of Power from Bujagali HPP	32.90	9,001.80	2012 – 2017	In Defects Liability Period	AfDB at EPC
2	Karuma Hydro Power & Interconnection Project (2X650MVA 400/132kV Karuma SS, 2X20MVA 132/33kV Karuma SS, 2X650MVA 400/132kV Kawanda SS, 2X20MVA 132/33kV Olwiyo SS; 248km 400kV Karuma - Kawanda Transmission Line, 54.2km 400kV Karuma - Olwiyo Transmission Line, 75.5km 132kV Karuma - Lira Transmission Line)	Evacuation of power from Karuma HPP and Supporting Rural electrification program	1,171.26	320,432.78	2013 – 2019	Under Construction	China EXIM Bank at EPC
3	220kV Nkenda - FortPortal - Hoima (2X40MVA 132/33kV Hoima SS, 2X40MVA 132/33kV FortPortal SS; 54km 220kV Nkenda - FortPortal Transmission Line, 172km 220kV FortPortal - Hoima SS)	Improvement of reliability and quality of supply in the western region of Uganda. Provision of transmission capacity to evacuate power from Kabaale 53MW Testcrude	299.03	81,807.85	2015 – 2018	Under Construction	Government of the Royal Kingdom of Norway and French Development Agency (AFD) at EPC
4	132kV 42km Isimba Interconnection Project	Provision of transmission capacity to evacuate power from Isimba HPP	2,114.25	578,414.20	2015 – 2018	Under Construction	China EXIM Bank at EPC
5	220kV Bujagali – Kawanda Line Bays	Provision of transmission capacity to evacuate power from Bujagali Substation	11.63	3,182.81	2017 - 2019	Under Construction	World Bank
6	Muzizi Interconnection: (2x90 MVA 220/132/33 kV Muzizi Substation)	Provision of transmission capacity to evacuate power from Muzizi SHPP	106.05	29,014.00	2018 – 2023	Sourcing for Financing for Implementation	Under Consideration for Funding Using EPC+F
7	Ayago Interconnection Project (2km 400kV Ayago - Nile HPPs Switching Station Underground Cable; 10km 400kV Nile HPPs Switching Station - T-Ayago Underground Cable)	Provision of transmission capacity to evacuate power from Ayago HPP	123.51	33,789.20	2018 – 2023	At Feasibility Study/ Project Proposal Stage.	Under Consideration using EPC + F
8	37.3km 132kV Mirama-Kikagati-Nsongezi (2X32/40MVA 132/33kV Nsongezi SS)	Provision of transmission capacity to evacuate power	122.14	33,414.12	2016 – 2022	Feasibility Study Complete Sourcing for Funding for EPC	Under Consideration using EPC + F

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
9	183km, 132kV single circuit Agago - Lira Transmission Line on wooden structures and related substations	Provision of transmission capacity to evacuate power from Agago 42 MW HPP	79.42	21,728.42	2018	Sourcing for Funding from GOU for Implementation	GOU
10	83km 132kV Gulu-Agago TL Project (2X32/40MVA 132/33kV Agago SS)	Provision of transmission capacity to evacuate power from Agago 83MW HPP	144.14	39,432.65	2016 – 2020	Feasibility Study Complete Procurement of EPC Contractor stage	GOU at FS and kfW at EPC
11	45km 220kV Hoima-Kinyara (2X90/40MVA 220/132/33kV Kinyara SS)	Provision of transmission capacity to evacuate power	169.10	46,261.08	2016 – 2021	Update of Tender Documents. Sourcing for Financing for EPC	Government of the Royal Kingdom of Norway at FS EPC Funding to be determined
12	74km 132kV Mbale – Bulambuli - Kapterol Transmission Line; 2X 60/80MVA 132/33kV Mbale SS, 2X45/60MVA 132/33kV Kapterol SS	Provision of transmission capacity to evacuate power from IPPs in Bulambuli area	208.58	57,063.71	2017-2022	Feasibility Study Ongoing	KFW at FS
13	Extension of Transmission Grid to Evacuate excess electricity generated from Tilenga and Kingfisher oil fields (Substations: 2x32/40MVA 132/33KV King Fisher SS, 3x32/40MVA 132/33KV Tilenga SS & 2x250/250/50MVA 220/132/33 kV Kabaale SS; Transmission Lines: 135km, 132kV transmission line from Tilenga SS to Kabaale SS & 50km, 132kV transmission line from Kingfisher SS to Kabaale SS)	Provision of transmission capacity to evacuate power from Tilenga and King Fisher Oil Fields	386.90	105,847.73	2018 – 2021	Sourcing for Financing for Feasibility Study and Implementation	Under Consideration using EPC + F
14	400kV Oriang Interconnection project (10km 400kV Oriang - Nile HPPs Switching Station Underground cable)	Provision of transmission capacity to evacuate power from Oriang HPP	206.11	56,388.45	2019 – 2023	Sourcing for Financing for Feasibility Study and Implementation	To be determined
15	400kV Kiba Interconnection Project (10km 400kV Kiba - Nile HPPs Switching Station Underground cable)	Provision of transmission capacity to evacuate power from Kiba HPP	202.49	55,398.30	2021 – 2025	Sourcing for Financing for Feasibility Study and Implementation	To be determined
16	400kV Uhuru Falls Interconnection Project (145km 400kV Uhuru - Tilenga - Kabaale Transmission Line)	Provision of transmission capacity to evacuate power from Uhuru Falls	479.30	131,126.35	2025 - 2031	Sourcing for Financing for Feasibility Study and Implementation	To be determined

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
B	GRID RE-INVESTMENT PROJECTS						
	High Voltage Transmission Line Works						
1	Kabulasoke-Nkonge-Nkenda 132kV 216.5 km (Re-stringing)	Improvement of reliability and power supply quality	10.97	3,000.00	2019	Sourcing for Financing	To be determined
2	Kabulasoke-Masaka West 132kV 60km (Re-stringing)	Improvement of reliability and power supply quality	5.48	1,500.00	2019	Sourcing for Financing	To be determined
3	Reconductoring 3km of Bujagali - Nalubaale line with HTLS Conductor	Improvement of reliability and power supply quality	1.83	500.00	2019	Sourcing for Financing	To be determined
4	Reconductoring 113km of Bujagali - Tororo line with HTLS Conductor	Improvement of reliability and power supply quality	69.02	18,883	2019	Sourcing for Financing	To be determined
	Substation Works						
5	50MVA 33/33kV Bujagali Phase Shifting Transformers	Enable power supply to the distribution network	17.54	4,798.00	2020	Sourcing for Financing	To be determined
6	Mirama Substation Upgrade (2X50/63MVA, 132/33kV Transformers)	Enable power supply to the distribution network	22.83	6,244.69	2019 - 2021	Sourcing for Financing for Feasibility Study and Implementation	Under Consideration using EPC + F
7	Tororo 2x250MVA 220/132kV Interbus Transformers	Connection of 132kV grid to the 220kV grid at the substation	40.94	11201.53	2021	Sourcing for Financing for Feasibility Study and Implementation	Under Consideration using EPC + F
8	2X250MVA 220/132kV Mbarara South Interbus Transformers	Connection of 132kV grid to the 220kV grid at the substation	40.94	11201.53	2021	Sourcing for Financing for Feasibility Study and Implementation	Under Consideration using EPC + F
9	Reallocation of 1X60MVA 220/132/33kV Transformer from Mbarara to Mirama Substation	Provision of additional Transformation capacity	0.37	100	2019	Sourcing for Financing from GOU	GOU
10	Refurbishment of transformer bay and shift of 20MVA Transformer to Lira Substation from Tororo	Improvement of reliability and power supply quality	0.29	80.00	2019	Sourcing for Financing from GOU	GOU

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
11	20MVAr Capacitor Banks at Sukulu 10.5kV Bus	Improvement of reliability and power supply quality	2.56	700.00	2018	To be pitched to the Sukulu Phosphate Developer for implementation	Developer of Sukulu Phosphate Factory
12	10MVAr 11kV Capacitor Banks at Lugazi	Improvement of reliability and power supply quality	1.86	510.00	2019	Sourcing for Financing from GOU	GOU
13	Tororo 80MVA, 132/33kV	Improvement of reliability and power supply quality	8.11	2,219.18	2019	Under Procurement	GOU
14	Mbarara North Substation Upgrade (2x50/63MVA, 132/33kV Power Transformers)	Improvement of reliability and power supply quality	26.61	7,279.69	2022	Sourcing for Financing for Feasibility Study and Implementation	Under Consideration for Funding Using EPC+F
15	Kampala North substation upgrade (1X32/40MVA 132/33kV Transformer)	Provision of adequate capacity	7.21	1,972.60	2019	Under Procurement	GOU
16	Kawanda substation upgrade (1X32/40MVA 132/33kV Transformer)	Provision of adequate capacity	7.21	1,972.60	2019	Under Procurement	GOU
17	Opuyo Substation 132/33kV Upgrade (2X32/40MVA 132/33kV Transformers)	Provision of adequate capacity	21.20	5,800.00	2017 – 2019	Under Construction	KFW
18	Nkenda Substation 132/33kV Upgrade (2X60MVA 132/33kV Transformers)	Increase Substation Capacity	43.83	11,992.20	2018 – 2020	Preparation of Tender Documents by World Bank. Sourcing of Financing for Implementation	World Bank for Tender Document Preparation. EPC - To Be Determined
19	2km 132kV Mukono - Nalubaale Toff - Lugazi SS (2X32/40MVA 132/33kV Lugazi SS)	Provision of adequate capacity, improvement of reliability	89.73	24,548.95	2020 - 2025	Sourcing for Financing for Feasibility Study and Implementation	To be determined

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
20	Kampala Metropolitan Area Improvement Project ((Transmission Lines; 25.4km 132kV 1 cct Mukono branch point (Northern trunk line) – Kampala North Substation, 10.2km 2cct Kampala North Substation – Mutundwe Substation, 5.3km 132kV 2 cct Kampala North Substation – Lugogo Substation, 0.1km 132kV 2 cct Kawaala branch point – Kawaala Substation, 0.3km 132kV 2 cct (New Mukono Substation – Mukono Substation), 4.2km 220kV 4 cct New Mukono branch point – New Mukono Substation, 0.4km 132km 2 cct New Mukono Substation – New Mukono branch point (Southern trunk line), 0.8km 132kV 2 cct Buloba branch point – Buloba Substation, 0.9km 220kV 4 cct Buloba branch point – Buloba Substation; Substations (2X 125MVA 220/132kV Buloba SS, 2X40MVA 132/33kV Buloba SS, 3X125MVA 220/132/33kV Mukono SS, 3X40MVA 132/33kV Kawaala SS, 1X20MVA 132/11kV Kawaala SS, 1X250MVA 220/132/33kV Bujagali SS, 1X20MVA 132/33kV Mobile SS))	Provision of adequate capacity, improvement of reliability	506.98	138,700.00	2015 - 2021	Feasibility Study Complete. EPC Loan approved. Procurement of Supervision Consultant ongoing	JICA at EPC
21	Power Transformers Project 1 (Reinforced Substations: 2X32/40MVA 132/33kV Nkonge SS, 2X50/60MVA 132/33kV Mutundwe SS, 2X50/60MVA 132/11kV Mutundwe SS, 2X50/60MVA 132/33kV Lugogo SS, 2X50/60MVA 132/11kV Lugogo SS, 2X50/60MVA 132/33kV Masaka West SS; New Substations: 3X50/60MVA 132/33kV Jinja SS, 2X40MVA 132/33kV Mubende SS, 2X40MVA 132/33kV Ishaka SS & 2X40MVA 132/33kV Rakai SS; Transmission Lines: 5km 132kV Bujagali Tororo T-Off to Jinja SS, 30km 132kV Nkonge - Mubende, 10km 132kV Mbarara - Nkenda T-off to Ishaka & 10km 132kV Masaka - Kyaka T-Off to Rakai)	Provision of adequate capacity, improvement of reliability	449.77	123,047.32	2019 - 2022	Sourcing for Financing for Feasibility Study and EPC	Under Consideration using EPC + F
22	Substation Reinforcement Project (Upgrade 132/33kV Power Transformers), Upgrade of Tororo Substation (2x125MVA, 132/33kV Power Transformers), Upgrade of Kole Substation (2x32/40MVA, 132/33kV Power Transformers)	Provision of adequate capacity, improvement of reliability	114.67	31,371.78	2019 - 2022	Sourcing for Financing for Feasibility Study and EPC	Under Consideration using EPC + F

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
23	Upgrade of Nkenda - Hoima to 220kV (Nkenda 2X250MVA 220/132/33kV Substation, 2X90MVA Fort Portal 220/132/33kV Substation, 2X250MVA Hoima 220/132/33kV Substation)	Provision of adequate capacity, improvement of reliability	431.70	118,103.75	2019 - 2021	Sourcing for Financing for Feasibility Study and EPC	Under Consideration using EPC + F
C	System Expansion Projects						
1	160km 132kV Mbarara-Nkenda & 260km 132kV Tororo - Opuyo - Lira TL Project & 2X32/40MVA 132/33kV Fortportal SS	Improvement of reliability and quality of supply in the western region of Uganda & Provision of transmission capacity to evacuate power from other generation plants in the West.	114.93	31,442.21	2014 - 2018	Under Construction	AfDB at EPC
2	137km 220kV Kawanda-Masaka Project: Substations; 2X125MVA 220/132kV Masaka SS; 2X250MVA 220/132kV Kawanda SS; 15MVAr 220kV Shunt Reactor at Masaka SS; 2X15MVAr 220kV Shunt Reactor at Mbarara SS	Improvement of reliability, availability and quality of power supply	244.61	66,921.53	2014 - 2018	Under Construction	WB at EPC
3	23.5km 132kV Mutundwe-Entebbe Transmission Line Project: Substation; 2X60/80MVA 132/33kV Entebbe SS	Improvement of reliability and quality of power supply	209.41	57,291.03	2015 - 2019	Under Construction	KFW at FS and EPC
4	Queensway SS Project (2X32/40MVA 132/33kV SS)	Improvement of reliability, availability and quality of power supply	23.14	6,330.26	2015 - 2017	In Defects Liability Period	JICA at EPC
5	Industrial Parks SS Project: Substations; 3X32/40MVA 132/33kV Luzira SS, 3X40/63 MVA 132/33kV Mukono SS, 2X32/40MVA 132/33kV Iganga SS, 3X40/63MVA 132/33kV; Transmission Lines; 15km 132kV 2cct Namanve South SS - Luzira SS, 8km 132kV 2cct 132kV Nalubaale-Namanve Transmission Line to Mukono SS, 15km 132kV 2cct from the Existing 132kV Bujagali-Tororo Transmission Line to Iganga SS & 6km 132kV 2cct from the Existing 132/33kV Namanve Substation and 132kV Nalubaale-Namanve Transmission Line to the proposed Namanve South SS.	Improvement of availability, reliability, and quality of power supply	467.49	127,895.12	2016 - 2019	Under Construction	China EXIM Bank at EPC

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
6	160km 132kV Opuyo-Moroto Transmission Line Project (2X32/40MVA 132/33kV Moroto SS)	Grid expansion to serve new load centers and supporting rural electrification programme	234.48	64,147.60	2015 - 2019	Under Construction	ISDB at EPC
7	130km 132kV Bulambuli - Moroto Transmission Line (60/80MVA 132/33kV Bulambuli SS)	Improvement in availability of power supply	283.35	77,517.44	2036 - 2040	Sourcing for Financing for Feasibility Study and EPC	To be determined
8	90km 132kV Kabale - Ishaka Transmission Line Project	Improvement in availability of power supply	194.09	53,099.05	2029 - 2033	Sourcing for Financing for Feasibility Study and EPC	To be determined
9	65km 132kV Kitgum - Agago Transmission Line (2X15/20MVA 132/33kV Kitgum SS)	Improvement in availability of power supply	189.97	51,972.77	2036 - 2040	Sourcing for Financing for Feasibility Study and EPC	To be determined
10	220km 132kV Kitgum - Moroto Transmission Line	Improvement in availability of power supply	419.71	114,823.25	2036 - 2040	Sourcing for Financing for Feasibility Study and EPC	To be determined
11	110km 132kV Agago - Adjumani Transmission Line Project (2X15/20MVA 132/33kV Adjumani SS)	Improvement in availability of power supply	274.04	74,972.39	2036 - 2040	Sourcing for Financing for Feasibility Study and EPC	To be determined
12	105km 132kV Adjumani - Arua Transmission Line	Improvement in availability of power supply	207.04	56,642.13	2036 - 2040	Sourcing for Financing for Feasibility Study and EPC	To be determined
13	85km 132kV Mirama - Kabale Transmission Line (2X32/40MVA 132/33kV Kabale SS)	Improvement of availability, reliability, and quality of power supply	179.35	49,067.07	2016 - 2020	Procurement of EPC Contractor On-going	ISDB at EPC
14	130.5km 400kV Masaka - Mbarara Transmission Line	Improvement of availability, reliability, and quality of power supply	390.49	106,829.86	2016 - 2021	Procurement for EPC	AFD at FS AFD and KFW at EPC

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
15	132kV Mutundwe-Gaba-Luzira (32/40MVA 132/33kV Gaba SS; 25km 132kV Mutundwe - Gaba Transmission Line, 25km 132kV Gaba - Luzira Transmission Line)	Improvement of availability, reliability, and quality of power supply	165.44	45,262.15	2020 - 2025	Sourcing for Financing for Feasibility Study and EPC	To be determined
16	132kV Lira-Gulu-Nebbi-Arua Project (Substations: 2X32/40MVA 132/33kV Gulu SS, 2X32/40MVA 132/33kV Nebbi SS & 2X32/40MVA 132/33kV Arua SS; Transmission Lines: 90km 132kV Lira SS - Gulu SS, 160km 132kV Gulu SS - Nebbi SS & 63km 132kV Nebbi SS - Arua SS)	Improvement of availability, reliability, and quality of power supply	354.35	96,941.73	2016 - 2020	Procurement for EPC	World Bank at FS & EPC
17	65 km 132kV Mubende - Kiboga Transmission Line (2X15/20MVA 132/33kV Kiboga SS)	Improvement of availability, reliability, and quality of power supply	302.22	82,681.52	2030 - 2035	Sourcing for Financing for Feasibility Study and EPC	To be determined
18	47km 220kV Kinyara-Kafu Transmission Line (2x250/250MVA, 400/220/33kV Kafu SS)	Improvement of availability, reliability, and quality of power supply	154.04	42,142.54	2016 - 2021	Sourcing for Financing for EPC	Under Consideration using EPC + F
19	54km 132kV Kawanda - Kasana (1X20MVA 132/33kV Kawanda SS, 1X20MVA 132/33kV Kasana SS & 132kV Matugga Switching Station)	Improvement of availability, reliability, and quality of power supply	26.77	7,322.49	2017 - 2019	Sourcing for Financing for Feasibility Study and EPC	GOU
20	50km 220kV Buloba - Gaba Transmission Line (2X60MVA 220/132/33kV Gaba SS)	Improvement of availability, reliability, and quality of power supply	185.20	50,665.90	2023 - 2028	Sourcing for Financing for Feasibility Study and EPC	To be determined
21	303km 220kV Nkenda - Buloba Transmission Line (Consideration to be made for 400kV; initially operated at 220kV)	Improvement of availability, reliability, and quality of power supply	545.47	149,228.52	2023 - 2028	Sourcing for Financing for Feasibility Study and EPC	To be determined
22	345km 400kV Karuma - Tororo Transmission Line (2X650MVA 400/220kV Tororo SS)	Improvement of availability, reliability, and quality of power supply	635.08	173,745.12	2026 -2031	Sourcing for Financing for Feasibility Study and EPC	To be determined
23	Sukulu Phosphate Transmission Line Project 2X50/63MVA 132/10.5Kv Power Transformers – Phase 1; 2x125MVA, 220/10.5kV Power Transformers – Phase 2)	Improvement of availability, reliability, and quality of power supply	83.05	22,720.62	Phase 1: 2018 Phase 2: 2018 - 2026	Sourcing for Financing for Feasibility Study and EPC	To be determined

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
24	T-Matugga - Kapeeka (Substations: 1X20MVA 132/33kV Kapeeka; Transmission Lines: 45km 132kV T-Matugga - Kasana)	Improvement of availability, reliability, and quality of power supply	25.42	6,953.11	2018	Under Implementation	GOU
25	Nakasongola - Kaweweeta - Kapeeka (2X32/40MVA 132/33kV Nakasongola SS; 2X32/40MVA 132/33kV Kaweweeta SS 160km, 132kV double circuit Nakasongola, Kaweweta Kapeeka transmission line)	Improvement of availability, reliability, and quality of power supply	299.43	81,917.27	2018 - 2022	Sourcing for Financing for Feasibility Study and EPC	Under Consideration using EPC + F
26	37km 220kV Wobulenzi - Kapeeka Transmission Line (2x250/250/50MVA 400/220/33kV Wobulenzi Substation, 2x125MVA 220/132/33kV Kapeeka Substation, 3X50/63MVA 132/33kV Kapeeka SS)	Improvement of availability, reliability, and quality of power supply	248.56	68,000.32	2018 - 2021	Sourcing for Financing for Feasibility Study and EPC	Under Consideration using EPC + F
27	142.9km 220kV Kapeeka – Kiboga - Hoima Transmission Line	Improvement of availability, reliability, and quality of power supply	267.46	73,172.06	2018 - 2021	Sourcing for Financing for Feasibility Study and EPC	To be determined
28	Mbale Industrial and Business Park Substation (3X60/80MVA 132/33kV Transformers)	Improvement of availability, reliability, and quality of power supply to several industrial parks in Mbale	76.43	20,909.21	2019 - 2020	Sourcing for Financing for Feasibility Study and EPC	Under Consideration using EPC + F
29	Standard Gauge Railway Transmission Line Project (Substations: 2X10MVA 132/27.5kV Tororo, Buwoola, Iganga, Nyenga and Kampala East Traction Stations; Transmission Lines: 11km 132kV 2cct from UETCL Tororo to the SGR Tororo SS, 64km 132kV 2cct double pi-branch off from Bujagali – Tororo 132kV to the SGR Buwoola SS, 3.5km 132kV 2cct from UETCL Iganga Industrial Park SS to SGR Iganga SS, 5km 132kV cct double pi-branch off from Nalubaale – Lugogo 132kV to the SGR Nyenga Traction SS & 3.7km 132kV 2cct from UETCL Namanve south Industrial Park SS to SGR Kampala East Traction SS)	Improvement of availability, reliability, and quality of power supply	174.21	47,660.00	2019 - 2021	Sourcing for Financing for Feasibility Study and EPC	Under Consideration using EPC + F

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
	Olwiyo 400kV Line Bays	Improvement of availability, reliability, and quality of power supply	13.92	3,809.17	2022 - 2024	Sourcing for Financing	To be determined
D	Other System Expansion Projects						
1	SCADA and Communication upgrade and Emergency Control Centre	Improvement of availability, reliability, and quality of power supply	27.74	7,590.00	2017 – 2020	Under Implementation	World Bank
E	Regional Interconnection Projects						
1	220kV NELSAP (Bujagali - Tororo & Mbarara - Mirama): Substations: 1X60MVA 220/132 Mirama SS, 1X60MVA 220/132kV Mbarara SS, 20MVAr 220kV Shunt Reactors at Mbarara, Mirama and Tororo SSs; Transmission Lines: 127km 220kV Bujagali – Tororo- UG/KY Border & 66km 220kV Mbarara – Mirama-UG/RW Border)	Regional Power Trade	95.70	26,182.20	2013 – 2019	Under Construction	AfDB and JICA at EPC
2	Nkenda-Mpondwe (D.R.Congo) 220kV, 72.5km Uganda's side (Consideration to be made for 400kV; initially operated at 220kV)	Regional Power Trade	154.19	42,181.89	2017 – 2022	Sourcing for Financing	Under Consideration Using EPC + F

UETCL GRID INVESTMENT PLAN (2018-2040) : IMPLEMENTATION SCHEDULE SUMMARY							
No.	**PROJECT**	**OBJECTIVE**	**COST(BILLION UGX)**	**COST(X1000 USD)**	**IMPLEMENTATION PERIOD**	**CURRENT STATUS**	**FINANCIER**
3	400kV Northern Corridor (Substations:2X200MVA, 400/220kV transformers at , New Masaka, New Mbarara and Shango SSs; Transmission Lines: 5.76km 220kV Double Circuit Transmission Line from 220/132kV Tororo SS to 400/220kV Tororo SS, 41.4km 220kV Double Circuit Transmission Line from 220/132kV Kawanda SS to 400/220kV Wobulenzi SS, 2.16km 220kV Double Circuit Transmission Line from 220/132kV Mbarara SS to 400/220kV Mbarara SS, 198km 400kV Double Circuit Transmission Line from 400/220kV Tororo SS - 400/220kV Wobulenzi SS, 152km 400kV Double Circuit Transmission Line from 400/220kV Wobulenzi SS - 400/220kV New Masaka SS, 130km 400kV Double Circuit Transmission Line from 400/220kV New Masaka - 400/220kV New Mbarara SS & 160km 400kV Double Circuit Transmission Line from 400/220kV New Mbarara - 400/220kV Shango SS)	Improvement of availability, reliability, and quality of power supply	1,808.10	494,657.56	2016 - 2030	Feasibility Study Complete. Sourcing for Financing for EPC	To be determined
4	82km 220kV Masaka - Mutukula - Mwanza Transmission Line (Consideration to be made for 400kV; initially operated at 220kV)	Regional Power Trade	147.63	40,387.72	2016 – 2022	Update of Feasibility Study through KfW financing On going	Update of FS by KFW EPC- Sourcing funds from KFW/AFD
5	400kV Olwiyo-Nimule-Juba(Sudan) 400kV Line (Substation: 2X150MVA 400/220kV Olwiyo SS; 190km Olwiyo - Nimule - Juba Transmission Line- Uganda's part)	Regional Power Trade	477.33	130,587.50	2019 – 2026	Sourcing for Financing for Feasibility Study from AfDB through NELSAP	To be determined
6	15km 132kV Arua - Aru TL Project (2X15/20MVA 132/33kV Aru SS)	Regional Power Trade	133.57	36,541.82	2036 – 2040	Sourcing for Financing for Feasibility Study and EPC	To be determined

TABLE 19: The grid investment plan-Base case

By the end of the planning period and upon successful implementation of this plan, the grid shall have a total additional length of about 13,029.43km, 55 additional substations and 17,229MVA additional transformation capacity. Tables 19 and 20 below illustrate the incremental transmission line length, number of substations and transformational capacity during the period.

Line Voltage (kV)	Line Length 2017 (km)	Line Length 2040 (km)	Additional Grid (km)
66	35.20	35.20	0
132	1,406.99	6,688.99	5282.00
220	260.00	2,939.84	2679.84
400	0	3,365.40	3365.40
TOTAL	1,702.19	13,029.43	11,327.24

TABLE 20: Transmission line length growth

	2017	2040	Additional Grid
No. of Stations (Substations and Switching Stations)	18	73	55
Transformation Capacity (MVA)	1,640.5	18,870	17,229

TABLE 21: Additional substations and transformation capacity

6.2 SUMMARY OF FINANCIAL REQUIREMENTS BY THE YEAR 2040

Project Category	Estimated Cost (Billion UGX)	Estimated Cost (x1000USD)
Power Evacuation Projects	5,856.82	1,602,303
Re-investment Projects	1,921.66	525,727
System Expansion Projects	7,106.62	1,944,222
Regional Interconnection Projects	2,816.51	770,539
Total Grid Re-investment Requirement	17,701.61	4,842,791

TABLE 22: Summary of financial requirements by 2040

COMMITTED FUNDING AND ADDITIONAL FUNDING REQUIREMENT 2018 – 2040

Project Category	EPC		COUNTERPART FUNDS	
	COMMITTED FUNDS (x1000USD)	ADDITIONAL REQUIREMENT (x1000USD)	*COMMITTED FUNDS (x1000USD)	ADDITIONAL REQUIREMENT (x1000USD)
Power Evacuation Projects	977,963	485,752	49,899	88,690
Re-investment Projects	129,100	372,555	87	23,984
System Expansion Projects	464,996	1,057,576	82,032	339,619
Regional Interconnection Projects	20,993	666,806	13,683	69,057
Total Grid Re-investment Requirement	1,593,051	2,582,689	145,701	521,350

*Committed counterpart funds represents funds released since inception of project up to Q4 2017/2018

TABLE 23: COMMITED FUNDING AND ADDITIONAL FUNDING REQUIREMENT 2018-2040

TABLE 24:5 YEAR PLAN GDP 2018 – 2040 INVESTMENT REQUIREMENT SUMMARY

Project Category	Estimated Cost (x1000USD)				
	2018-2020	2021-2025	2026-2030	2031-2035	2036-2040
Power Evacuation Projects	1,243,748	172,031	169,874	16,651	0
Re-investment Projects	279,217	246,510	0	0	0
System Expansion Projects	818,711	270,224	313,160	166,199	375,928
Regional Interconnection Projects	73,156	129,347	531,494	0	36,542
Total Grid Re-investment Requirement	2,414,832	818,112	1,014,528	182,850	412,470

TABLE 25: 5 YEAR PLAN GDP 2018 – 2040 DONOR FUNDING AND COUNTERPART FUNDING REQUIREMENTS INVESTMENT REQUIREMENT SUMMARY

Project Category	Estimated Cost (x1000USD)										
	2018-2020		2021-2025		2026-2030		2031-2035		2036-2040		
	EPC	RAP	EPC	RAP	EPC	RAP	EPC	RAP	EPC	RAP	TOTAL
Power Evacuation Projects	1,137,737	106,012	156,206	15,825	153,121	16,752	16,651	0	0	0	1,602,303
Re-investment Projects	258,012	21,205	243,644	2,867	0	0	0	0	0	0	525,727
System Expansion Projects	650,386	168,325	227,251	42,973	256,414	56,746	144,973	21,226	243,548	132,380	1,944,222
Regional Interconnection Projects	49,639	23,517	123,800	5,548	481,234	50,260	0	0	33,127	3,415	770,539
Total Grid Re-investment Requirement	2,095,773	319,059	750,900	67,213	890,769	123,758	161,624	21,226	276,675	135,795	4,842,791

A GRAPH SHOWING GDP 2018 – 2040 INVESTMENT REQUIREMENTS

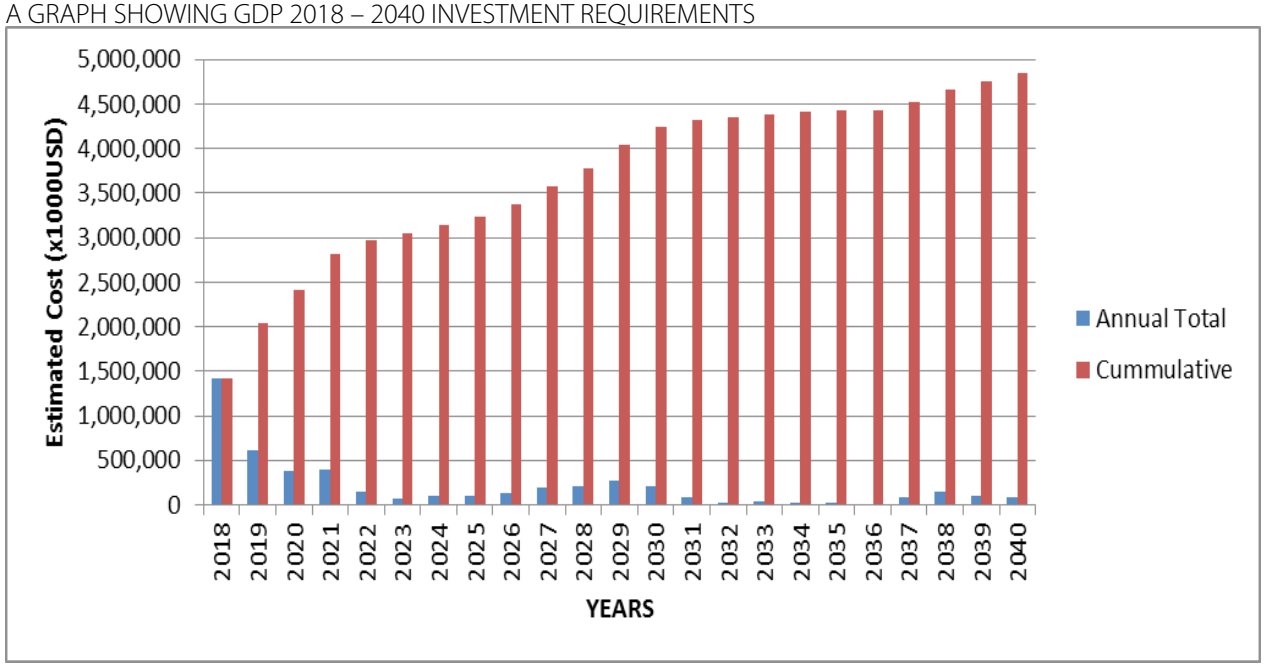


Figure 16: UETCL grid investment requirements 2018-2040

6.3 REGIONAL INTERCONNECTION POWER LINES

Regional interconnection power lines are based on the recommendations from the interconnection studies carried out by the regional bodies (NBI and EAC) including EAPMP, the Comprehensive Basin Wide Study undertaken by the Nile Basin Initiative (NBI) and the Eastern Africa Power Pool Master Plan by EAPP.

Within the Nile Basin Initiative framework, the NELSAP has engaged in solidarity actions to promote poverty reduction, economic growth and reverse the environmental degradation process in member countries. Regarding the energy sector, the NBI focused on optimization and development of hydroelectric power generation and interconnection among member states.

The Interconnections projects, involving Uganda under the NELSAP project are currently under construction with expected commissioning year as 2018. These include:

- Uganda (Bujagali) – Kenya (Lessos) 220 kV line
- Uganda (Mbarara) – Rwanda (Birembo) 220 kV line

And studies have been concluded for the following interconnectors awaiting implementation :-

- Uganda (Masaka) – Tanzania (Mwanza) 220kV line

The update of the feasibility study is yet to commence under the financing of KFW. Procurement of the consultant is ongoing and the process is being spreaheaded by TANESCO in Tanzania.

- Uganda (Nkenda_ - DRC (Beni/Bunia) 220kV line

No feasibility studies have been carried out on the proposed Uganda (Olwiyo)- Juba (Southern Sudan) 400kV interconnector ; However the Government of Uganda and the Government of South Sudan entered into an MOU on the development of the project and AfDB has expressed interest in funding the study.

- 400kV Northern Corridor
- Arua – Aru 132kV line

6.4 PROJECT PRIORITIZATION FOR FINANCING

It is observed, from the Grid Development Plan process, that there are numerous grid projects that have to be implemented in the first five years of the planning horizon. It is therefore necessary to prioritize these projects as a means of allowing special attention to the most critical ones. The projects have been categorized as follows:

- Power Evacuation Projects
- Projects leading to industrial Growth
- Regional Interconnection Projects

Project	Rationale	Current Status	Financing Status
Muzizi Interconnection	Provision of transmission capacity to evacuate power from Muzizi SHPP	Sourcing for Financing	Under Consideration for Funding Using EPC+F
Ayago Interconnection Project	Provision of transmission capacity to evacuate power from Ayago HPP	Sourcing for Financing from China EXIM Bank	Financing for EPC being secured from China EXIM Bank
37.3km 132kV Mirama-Kikagati-Nsongezi Transmission Line and Associated Substations	Evacuation of Kikagati and Nsongezi HPPs	Feasibility Study Complete Sourcing for EPC Financing	Financing for F/S Secured from RNE Sourcing Financing for EPC

Project	Rationale	Current Status	Financing Status
183km, 132kV single circuit Agago - Lira Transmission Line on wooden structures and related substations	Provision of transmission capacity to evacuate power from Agago 42 MW HPP	Sourcing for financing for Interim solution	Sourcing for financing from GOU
45km 220kV Hoima-Kinyara transmission line and associated substations	Evacuation of Committed Co-generation from Kinyara Sugar Works	Feasibility study Complete Procurement of Supervision of works Consultant ongoing	Financing for Review of Tender documents secured from World Bank. Sourcing for financing for EPC
74km 132kV Mbale – Bulambuli - Kapterol Transmission Line and associated substations	Provision of transmission capacity to evacuate power from IPPs in Bulambuli area	Feasibility study ongoing	Financing for Feasibility Study secured from KfW
Extension of Transmission Grid to Evacuate excess electricity generated from Tilenga and Kingfisher oil fields (135km, 132kV transmission line from Tilenga SS to Kabaale SS & 50km, 132kV transmission line from Kingfisher SS to Kabaale SS and associated substations)	Provision of transmission capacity to evacuate power from Tilenga and King Fisher Oil Fields	Sourcing for Financing	Under Consideration using EPC + F
400kV Oriang Interconnection project	Provision of transmission capacity to evacuate power from Oriang HPP	Sourcing for Financing	Sourcing for Financing for Feasibility Study
400kV Kiba Interconnection Project	Provision of transmission capacity to evacuate power from Kiba HPP	Sourcing for Financing	Sourcing for Financing for Feasibility Study
50MVA 33/33kV Bujagali Phase Shifting Transformers	Enable power supply to the distribution network	Sourcing for Financing	Sourcing for Financing
Mirama Substation Upgrade (2X50/63MVA, 132/33kV Transformers)	Enable power supply to the distribution network	Sourcing for Financing	Under Consideration using EPC + F
Tororo 2x250MVA 220/132kV Interbus Transformers	Connection of 132kV grid to the 220kV grid at the substation	Sourcing for Financing	Under Consideration using EPC + F
2X250MVA 220/132kV Mbarara South Interbus Transformers	Connection of 132kV grid to the 220kV grid at the substation	Sourcing for Financing	Under Consideration using EPC + F
10MVAr 11kV Capacitor Banks at Lugazi	Improvement of reliability and power supply quality	Sourcing for Financing	GOU
Mbarara North Substation Upgrade (2x50/63MVA, 132/33kV Power Transformers)	Improvement of reliability and power supply quality	Sourcing for Financing	Under Consideration for Funding Using EPC+F
Nkenda Substation 132/33kV Upgrade (2X60MVA 132/33kV Transformers)	Increase Substation Capacity	Under Implementation	World Bank for Tender Document Preparation. EPC - To Be Determined
2km 132kV Mukono - Nalubaale Toff - Lugazi SS (2X32/40MVA 132/33kV Lugazi SS)	Provision of adequate capacity, improvement of reliability	Tender Documents Prepared Procurement of Supervision of works Consultant ongoing	To be determined
Power Transformers Project 1 (Reinforced Substations: 2X32/40MVA 132/33kV Nkonge SS, 2X50/60MVA 132/33kV Mutundwe SS, 2X50/60MVA 132/11kV Mutundwe SS, 2X50/60MVA 132/33kV Lugogo SS, 2X50/60MVA 132/11kV Lugogo SS, 2X50/60MVA 132/33kV Masaka West SS; New Substations: 3X50/60MVA 132/33kV Jinja SS, 2X40MVA 132/33kV Mubende SS, 2X40MVA 132/33kV Ishaka SS & 2X40MVA 132/33kV Rakai SS; Transmission Lines: 5km 132kV Bujagali Tororo T-Off to Jinja SS, 30km 132kV Nkonge - Mubende, 10km 132kV Mbarara - Nkenda T-off to Ishaka & 10km 132kV Masaka - Kyaka T-Off to Rakai)	Provision of adequate capacity, improvement of reliability	Sourcing for Financing	Under Consideration using EPC+F

Project	Rationale	Current Status	Financing Status
Substation Reinforcement Project (Upgrade 132/33kV Power Transformers), Upgrade of Tororo Substation (2x125MVA, 132/33kV Power Transformers), Upgrade of Kole Substation (2x32/40MVA, 132/33kV Power Transformers)	Provision of adequate capacity, improvement of reliability	Sourcing for Financing	Under Consideration using EPC+F
Upgrade of Nkenda - Hoima to 220kV (Nkenda 2X250MVA 220/132/33kV Substation, 2X90MVA Fort Portal 220/132/33kV Substation, 2X250MVA Hoima 220/132/33kV Substation)	Provision of adequate capacity, improvement of reliability	Sourcing for Financing	Under Consideration using EPC+F
130km 132kV Bulambuli - Moroto Transmission Line (60/80MVA 132/33kV Bulambuli SS)	Improvement in availability of power supply	Sourcing for Financing	Sourcing for Financing
47km 220kV Kinyara-Kafu Transmission Line (2x250/250MVA, 400/220/33kV Kafu SS)	Improvement of availability, reliability, and quality of power supply	Sourcing for Financing	Under Consideration using EPC+F
54km 132kV Kawanda - Kasana (1X20MVA 132/33kV Kawanda SS, 1X20MVA 132/33kV Kasana SS & 132kV Matugga Switching Station)	Improvement of availability, reliability, and quality of power supply	Sourcing for Financing	Sourcing for Financing from GOU
Sukulu Phosphate Transmission Line Project (2X50/63MVA 132/10.5kV Power Transformers – Phase 1; 2x125MVA, 220/10.5kV Power Transformers – Phase 2)	Improvement of availability, reliability, and quality of power supply	Sourcing for Financing	Sourcing for Financing
160km 132kV Nakasongola - Kaweweta – Kapeeka Transmission line and associated substations	Improvement of availability, reliability, and quality of power supply	Sourcing for Financing	To be determined
37km 220kV Wobulenzi - Kapeeka Transmission Line and associated substations	Improvement of availability, reliability, and quality of power supply	Sourcing for Financing	Under Consideration using EPC + F
142.9km 200kV Kapeeka– Kiboga - Hoima Transmission Line and associated substations	Improvement of availability, reliability, and quality of power supply	Sourcing for Financing	Under Consideration using EPC + F
Mbale Industrial and Business Park Substation (3X60/80MVA 132/33kV Transformers)	Improvement of availability, reliability, and quality of power supply to several industrial parks in Mbale	Sourcing for Financing	Sourcing for Financing
Standard Gauge Railway Transmission Line Project (2X10MVA 132/27.5kV Tororo, Buwoola, Iganga, Nyenga and Kampala East Traction Stations and associated transmission lines)	Improvement of availability, reliability, and quality of power supply	Sourcing for Financing	Sourcing for Financing
Nkenda-Mpondwe (D.R.Congo) 220kV, 72.5km Uganda's side	Regional Power Trade	Sourcing for Financing	Under Consideration Using EPC + F
400kV Northern Corridor 2X200MVA, 400/220kV transformers at New Masaka, New Mbarara and Shango SSs and associated transmission lines	Improvement of availability, reliability, and quality of power supply	Sourcing for Financing for EPC	Government of Uganda Government of Rwanda/ Government of Kenya at FS
82km 220kV Masaka - Mutukula - Mwanza Transmission Line	Regional Power Trade	Sourcing for Financing for EPC	Update of FS by KFW EPC- Sourcing funds from KFW/AFD
400kV Olwiyo-Nimule-Juba(Sudan) 400kV Line (Substation: 2X150MVA 400/220kV Olwiyo SS; 190km Olwiyo - Nimule - Juba Transmission Line- Uganda's part)	Regional Power Trade	Sourcing for Financing	To be determined
15km 132kV Arua - Aru TL Project (2X15/20MVA 132/33kV Aru SS)	Regional Power Trade	Sourcing for Financing	To be determined

TABLE 26: Project prioritization for Financing

6.5 INFORMATION AND COMMUNICATION TECHNOLOGY

UETCL's objective is to build and maintain a smart national grid that maintains a flexible and reliable electricity supply. This requires a changed approach to grid investment and a similar change in its telecommunications investment.

UETCL currently implements the Optical Fibre with Ground Earth wire (OPGW) as part of every EPC contract for construction of transmission lines and as such the communication infrastructure is expanding at the same pace as the power transmission grid.

The current UETCL telecommunications network is in most cases up to date but there is need to make certain that it shall continue to be future proof.

The demand for a reliable communication network that ensures optimum management of the power system and its ability to meet other business requirements are increasing.

UETCL's response to the challenges faced includes and shall continue to have the following initiatives:

- Communication infrastructure that enables improved monitoring and control of the power system as well as increased access to detailed power system network information.
- The telecommunications network needs to support UETCL's critical grid services comprising of tele-protection, SCADA, telemetering and voice communication.
- The move towards an IP based environment is leading UETCL into paying more attention to communication networks.
- Evolving real time requirements that shall impact on communication infrastructure development include:
    - SCADA, which is changing to IP based solutions
    - IT security, which requires a robust and reliable network
    - New substation features, such as IP CCTV

In addition, new lines of business in telecommunication are being identified by the company. This shall ensure better utilisation of present and future grid communication infrastructure.

Optical Fibre Leasing: This is a business area that has been identified by UETCL. All new transmission lines shall have sufficient optical fibre installed to cater for other users who wish to lease the fibre. An aggressive marketing campaign shall be used to attract more users. UETCL, however, has a challenge of avoiding service interruptions resulting from vandalising the towers that support the fibre.

7 | NDPII SCENARIO

7.1 LOAD AND GENERATION PROGNOSIS

The current National Development Plan (NDP II) is the second out of the six - five-year NDPs that will be implemented under Vision 2040 and covers the fiscal period 2015/16 to 2019/20. It builds on the achievements attained under NDP I, mitigates the challenges encountered during its implementation, and seeks to take advantage of regional and global development opportunities. Unlike its predecessor, NDP II will serve as the point of reference to inform government planning processes, thereby eliminating parallel planning. The goal of this Plan is to propel the country towards middle income status by 2020 through strengthening the country's competitiveness for sustainable wealth creation, employment and inclusive growth.

7.1.1 ASSUMPTIONS FOR DEMAND SUPPLY PROGNOSIS

- Electricity per Capita Consumption raised from 80kWh (2012) to 578kWh by 2020
- Rural Electrification raised from the current 14% to 30% by 2020
- Generation capacity shall be increased from the current 825MW to 2500MW by 2020.
- System losses shall be reduced to 16% by 2020.
- The forecast growth rate for the country is 3.2% per annum on average between 2014 and 2030. By 2040 the population of Uganda is estimated at 61 million.[4]
- Export potential is assumed to be as presented in Table below.

Market	2011-2016	2016 - 2040
Tanzania	20-40 MW	40MW
Kenya	4-50MW	50-200MW
D.R. Congo	2-30MW	50MW
Rwanda	2	50 MW
Sudan	--	50MW

TABLE 27: Projected export potential (MW)-NDP case

- GDP growth rate[5]

  The average targeted growth rate of about 6.3 percent will be driven by growth in public and private investments and exports up to 2020

Year	2015/16	2016/17	2017/18	2018/19	2	2019/20
Overall GDP growth	5.5	5.7	6.0	6.1	6.3	

TABLE 28: GDP growth projection-NDP case

4 Source: NPA – NPD II 2015-2020
5 Source: NDPII

7.1.2 DEMAND AND GENERATION BALANCE

The charts below illustrate the growth outlook of demand and generation capacity.

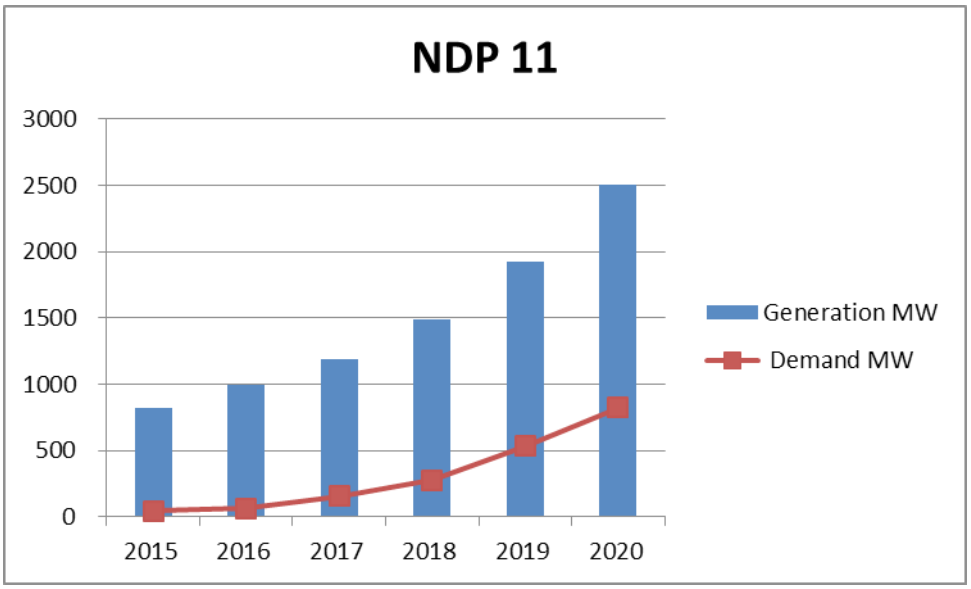


FIGURE 17: Demand-Supply NDPII scenario

Year	Consumption per capita kWh	Population with access to electricity (%)	Population growth rate (%)	Forecasted population	Population accessing electricity	Comp-uted GWh	Demand MW
2015	80	14	3.3	36,058,680	5,048,215	404	46
2016	90	16	3.0	37,151,258	5,944,201	535	61
2017	212	17	3.0	38,265,796	6,505,185	1,379	157
2018	341	18	2.9	39,375,504	7,087,591	2,417	276
2019	463	25	2.8	40,478,018	10,119,504	4,685	535
2020	578	30	2.5	41,489,968	12,446,991	7,194	821

Table 29: Demand forecast for NDPII

Source: Second National Development Plan (NDP II) 2015/16-2019/20

7.1.3 EXISTING AND PROPOSED GENERATION RESOURCES

	Plant	Capacity (MW)
1	Agagol,II,III	88
2	Electromaxx	50
4	Nalubaale	180
5	Kiira	200
6	Albartros	50
7	Jacobsen-Namanve	50
8	Kilembe Mines Limited (KML)	5
9	Kasese Cobalt Co. Ltd. (KCCL)	9.5
10	Kakira Sugar Ltd	12
11	Kikagati Power Company Ltd	16
12	Eco Power (Ishasha)	6.5
13	Buseruka	9
14	Bugoye	13
15	Mpanga	18
16	Kinyara	4.5

	Plant	Capacity (MW)
17	Kabaale & Refinery	53
18	Bujagali	250
19	Isimba	183
20	Karuma	600
21	Mini hydros	203
22	Solar Generation	20
23	Co-generation (Biomass)	100
24	Peat (Kabale)	33
25	Ayago	840
	TOTAL (MW)	**2500**

TABLE 30:Existing and proposed enegy sources-NDPII case

7.2 OBSERVATIONS

In order to meet the NDP II targets, the requirement is to fast track the implementation of the grid investments plan for the planning horizon 2018 –2026 within the next two years.

The table below shows the rationale for the deduction above

	NDP II target- 2020	Base case -2026
Domestic Demand forecast	821	816
Generation forecast	2500	4022

Table 31: Comparison between the base case 2026 and NDP11 targets

Financial requirements for NDP II scenario (Base Case 2018-2026)

Project Category	Estimated Cost (Billion UGX)	Estimated Cost (x1000USD)
Power Evacuation Projects	5,175.03	1,415,779
Re-investment Projects	1,921.66	525,727
System Expansion Projects	4,262.61	1,166,160
Regional Interconnection Projects	948.33	259,443
Total Grid Re-investment Requirement	12,307.63	3,367,109

Table 32: Financial requirements for NDPII

7.3 PROJECTS TO REALIZE NDPII

The following projects should be implemented within the next two years to realize NDPII.

Power evacuation projects

1. Bujagali 220kV Switchyard Project (2X250MVA 220/132/33kV Power Transformers)
2. Karuma Hydro Power & Interconnection Project
3. 220kV Nkenda - FortPortal – Hoima 229 km
4. 132kV 42km Isimba Interconnection Project.
5. 220kV Bujagali – Kawanda Line Bays.
6. Muzizi Interconnection: (2x90 MVA 220/132/33 kV Muzizi Substation)
7. Ayago Interconnection Project (2km 400kV Ayago - Nile HPPs Switching Station Underground Cable; 10km 400kV Nile HPPs Switching Station - T-Ayago Underground Cable)
8. 37.3km 132kV Mirama-Kikagati-Nsongezi (2X32/40MVA 132/33kV Nsongezi SS).
9. 183km, 132kV single circuit Agago - Lira Transmission Line on wooden structures and related substations.
10. 83km 132kV Gulu-Agago TL Project (2X32/40MVA 132/33kV Agago SS.

11. 45km 220kV Hoima-Kinyara (2X90/40MVA 220/132/33kV Kinyara SS).
12. 74km 132kV Mbale – Bulambuli - Kapterol Transmission Line; 2X 60/80MVA 132/33kV Mbale SS, 2X45/60MVA 132/33kV Kapterol SS.
13. Extension of Transmission Grid to evacuate excess electricity generated from Tilenga and Kingfisher oil fields.
14. 400kV Oriang Interconnection project (10km 400kV Oriang - Nile HPPs Switching Station Underground cable)
15. 400kV Kiba Interconnection Project (10km 400kV Kiba - Nile HPPs Switching Station Underground cable)

Grid re-investment projects

1. Kabulasoke-Nkonge-Nkenda 132kV 216.5 km (Re-stringing)
2. Kabulasoke-Masaka West 132kV 60km (Re-stringing)
3. Reconductoring 3km of Bujagali - Nalubaale line with HTLS Conductor
4. Reconductoring 113km of Bujagali - Tororo line with HTLS Conductor.
5. 50MVA 33/33kV Bujagali Phase Shifting Transformers.
6. Mirama Substation Upgrade (2X50/63MVA, 132/33kV Transformers).
7. 2X250MVA 220/132kV Mbarara South Interbus Transformers.
8. Reallocation of 1X60MVA 220/132/33kV Transformer from Mbarara to Mirama Substation.
9. Refurbishment of transformer bay and shift of 20MVA Transformer to Lira Substation from Tororo.
10. 20MVAr Capacitor Banks at Sukulu 10.5kV Bus.
11. 10MVAr 11kV Capacitor Banks at Lugazi.
12. Tororo 80MVA, 132/33kV.
13. Mbarara North Substation Upgrade (2x50/63MVA, 132/33kV Power Transformers).
14. Kampala North substation upgrade (1X32/40MVA 132/33kV Transformer).
15. Kawanda substation upgrade (1X32/40MVA 132/33kV Transformer).
16. Opuyo Substation 132/33kV Upgrade (2X32/40MVA 132/33kV Transformers).
17. Nkenda Substation 132/33kV Upgrade (2X60MVA 132/33kV Transformers).
18. 2km 132kV Mukono - Nalubaale Toff - Lugazi SS (2X32/40MVA 132/33kV Lugazi SS).
19. Kampala Metropolitan Area Improvement Project.
20. Power Transformers Project 1 (Reinforced Substations: 2X32/40MVA 132/33kV Nkonge SS, 2X50/60MVA 132/33kV Mutundwe SS, 2X50/60MVA 132/11kV Mutundwe SS, 2X50/60MVA 132/33kV Lugogo SS, 2X50/60MVA 132/11kV Lugogo SS, 2X50/60MVA 132/33kV Masaka West SS; New Substations: 3X50/60MVA 132/33kV Jinja SS, 2X40MVA 132/33kV Mubende SS, 2X40MVA 132/33kV Ishaka SS & 2X40MVA 132/33kV Rakai SS; Transmission Lines: 5km 132kV Bujagali Tororo T-Off to Jinja SS, 30km 132kV Nkonge - Mubende, 10km 132kV Mbarara - Nkenda T-off to Ishaka & 10km 132kV Masaka - Kyaka T-Off to Rakai).
21. Substation Reinforcement Project (Upgrade 132/33kV Power Transformers), Upgrade of Tororo Substation (2x125MVA, 132/33kV Power Transformers), Upgrade of Kole Substation (2x32/40MVA, 132/33kV Power Transformers).
22. Upgrade of Nkenda - Hoima to 220kV (Nkenda 2X250MVA 220/132/33kV Substation, 2X90MVA Fort Portal 220/132/33kV Substation, 2X250MVA Hoima 220/132/33kV Substation).

System Expansion projects

1. 160km 132kV Mbarara-Nkenda & 260km 132kV Tororo - Opuyo - Lira TL Project & 2X32/40MVA 132/33kV Fortportal SS.
2. 137km 220kV Kawanda-Masaka Project: Substations; 2X125MVA 220/132kV Masaka SS; 2X250MVA 220/132kV Kawanda SS; 15MVAr 220kV Shunt Reactor at Masaka SS; 2X15MVAr 220kV Shunt Reactor at Mbarara SS.

3. 23.5km 132kV Mutundwe-Entebbe Transmission Line Project: Substation; 2X60/80MVA 132/33kV Entebbe SS.
4. Industrial Parks SS Project:
5. 160km 132kV Opuyo-Moroto Transmission Line Project (2X32/40MVA 132/33kV Moroto SS).
6. 85km 132kV Mirama - Kabale Transmission Line (2X32/40MVA 132/33kV Kabale SS).
7. 130.5km 400kV Masaka - Mbarara Transmission Line.
8. 132kV Mutundwe-Gaba-Luzira (32/40MVA 132/33kV Gaba SS; 25km 132kV Mutundwe - Gaba Transmission Line, 25km 132kV Gaba - Luzira Transmission Line.
9. 132kV 313km Lira-Gulu-Nebbi-Arua Project.
10. 47km 220kV Kinyara-Kafu Transmission Line (2x250/250MVA, 400/220/33kV Kafu SS).
11. 54km 132kV Kawanda – Kasana.
12. 50km 220kV Buloba - Gaba Transmission Line (2X60MVA 220/132/33kV Gaba SS).
13. 303km 220kV Nkenda - Buloba Transmission Line.
14. Sukulu Phosphate Transmission Line Project 2X50/63MVA 132/10.5Kv Power Transformers – Phase 1; 2x125MVA, 220/10.5kV Power Transformers – Phase 2).
15. T-Matugga - Kapeeka (Substations: 1X20MVA 132/33kV Kapeeka; Transmission Lines: 45km 132kV T-Matugga - Kasana).
16. Nakasongola - Kaweweeta - Kapeeka (2X32/40MVA 132/33kV Nakasongola SS; 2X32/40MVA 132/33kV Kaweweeta SS 160km, 132kV double circuit Nakasongola, Kaweweta Kapeeka transmission line).
17. 37km 220kV Wobulenzi - Kapeeka Transmission Line (2x250/250/50MVA 400/220/33kV Wobulenzi Substation, 2x125MVA 220/132/33kV Kapeeka Substation, 3X50/63MVA 132/33kV Kapeeka SS).
18. 142.9km 200kV Kapeeka – Kiboga - Hoima Transmission Line.
19. Mbale Industrial and Business Park Substation (3X60/80MVA 132/33kV Transformers).
20. Standard Gauge Railway Transmission Line Project.
21. SCADA and Communication upgrade and Emergency Control Centre.

Regional Interconnection projects

1. 220kV NELSAP (Bujagali - Tororo & Mbarara - Mirama): Transmission Lines: 127km 220kV Bujagali – Tororo-UG/KY Border & 66km 220kV Mbarara – Mirama-UG/RW Border).
2. Nkenda-Mpondwe (D.R.Congo) 220kV, 72.5km Uganda's side.
3. 400kV Northern Corridor.
4. 82km 220kV Masaka - Mutukula - Mwanza Transmission Line.
5. 400kV Olwiyo-Nimule-Juba(Sudan) 400kV Line

8 | VISION 2040

8.1 LOAD AND GENERATION PROGNOSIS

8.1.1 ASSUMPTIONS FOR DEMAND SUPPLY PROGNOSIS

Uganda's Population	• expected to increase from the current 35 million to 60.4 million by 2040
Average Energy Consumption per capita	• 3,668kWh/person/ year by 2040
Access to National Grid	• 80%
Installed Generation Capacity	• 41,738MW by 2040

TABLE 33: Assumptions for demand supply prognosis-vision 2040

SOURCE: NPA –VISION 2040

8.1.2 ASSUMPTIONS ON AVAILABLE ENERGY RESOURCES BY 2040

Energy	Estimated Capacity (MW)
Hydro	4,500
Geothermal	1,500
Solar	5,000
Nuclear	24,000
Biomass	1,700
Peat	800
Thermal	4,300

TABLE 34: Assumptions on available energy resources by Vision 2040

SOURCE: NPA –VISION 2040

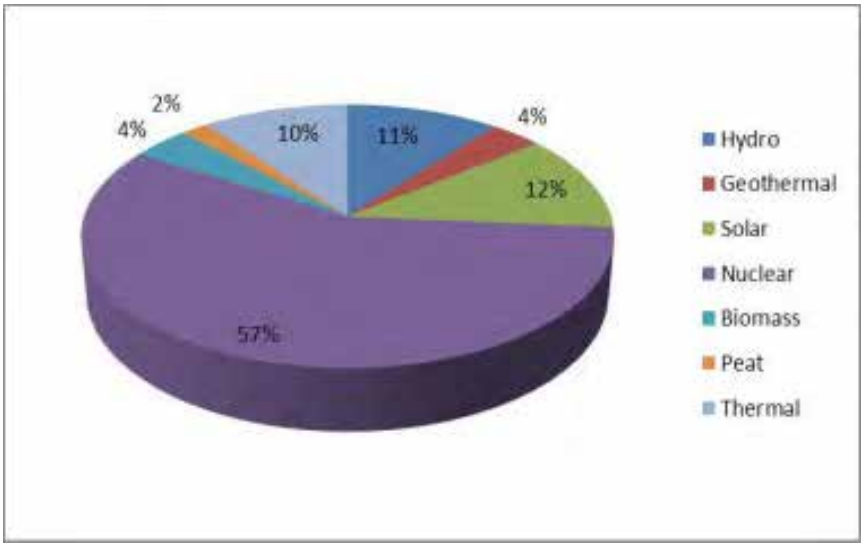


FIGURE 18: Assumptions on available energy resources by Vision 2040

8.1.3 VISION 2040 CASE GDP FORECAST BY 2040

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
GDP	22,838	25,198	27,801	30,672	33,304	36,162	39,264	42,633	46,291	50,156
Growth	2.8%	10.3%	10.3%	10.3%	8.6%	8.6%	8.6%	8.6%	8.6%	8.4%
Year	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
GDP	54,344	58,882	63,799	69,126	74,808	80,957	87,612	94,814	102,607	110,888
Growth	8.4%	8.4%	8.4%	8.4%	8.2%	8.2%	8.2%	8.2%	8.2%	8.1%
Year	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	
GDP	119,837	129,507	139,959	151,253	163,096	175,867	189,637	204,486	220,497	
Growth	8.1%	8.1%	8.1%	8.1%	7.8%	7.8%	7.8%	7.8%	7.8%	

TABLE 35: Vision 2040 case GDP forecast (UGX billion)

8.1.4 DEMAND FORECAST VISION 2040

Year	Maximum Demand(MW)	% Demand Growth
2017	157.4*	-
2018	275.9*	75.3%
2019	534.9	93.9%
2020	821.3	53.54%
2021	964.494	17.435%
2022	1,132.65	17.435%
2023	1,330.13	17.435%
2024	1,562.04	17.435%
2025	1,834.38	17.435%
2026	2,154.21	17.435%
2027	2,529.79	17.435%
2028	2,970.86	17.435%
2029	3,488.83	17.435%
2030	4,097.11	17.435%
2031	4,811.44	17.435%
2032	5,650.31	17.435%
2033	6,635.44	17.435%
2034	7,792.33	17.435%
2035	9,150.93	17.435%
2036	10,746.4	17.435%
2037	12,620	17.435%
2038	14,820.3	17.435%
2039	17,404.3	17.435%
2040	20,438.7	17.435%

TABLE 36: Demand forecast vision 2040

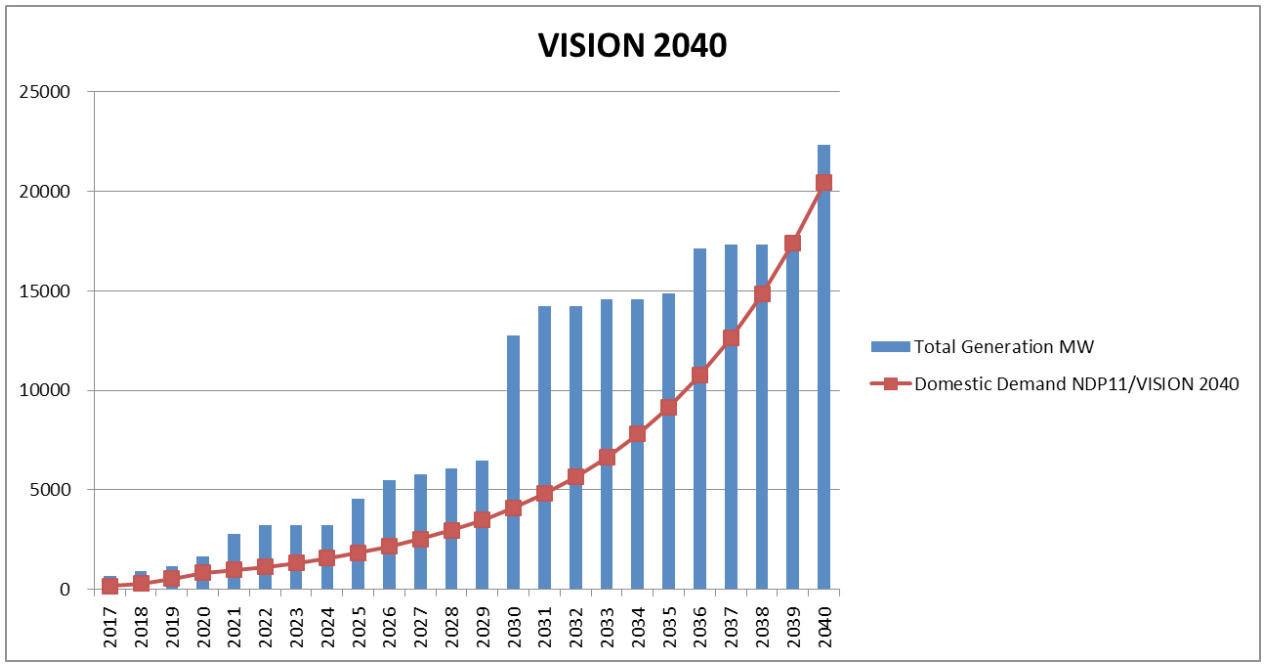


FIGURE 19: Demand supply power balance for VISION 2040

8.2 RECOMMENDATIONS

From the above studies and analysis, the following recommendations are made for consideration.

- The Ugandan 2040 Vision case methodology differs from the other cases in order to be able to match the targeted per capita consumption levels of the reference document. These targets yield very ambitious demand levels and would require a complete transformation of the sector and massive levels of investment in the next 23 years up to 2040.
- The forecasts presented in the above table requires substantial amounts of investments in the power system infrastructure i.e. generation plants, transmission line network and distribution network in order to be realized. Nuclear power plants, given their base load generation profiles, will play a key role in the future investment portfolio allowing for the supply of reliable base load energy that can be complemented with other technologies in order to adapt to the future load profile of the country. These investments will be enormous for the Ugandan 2040 Vision case and will require a complete transformation of the Ugandan electricity system.
- Review other Government Policies e.g. Energy policy, transport, housing, agriculture, industry etc. to align them with the 2040 vision.
- The Ministry of Energy and Mineral Development should give policy guidance to ensure harmonized planning within the energy sector (generation, transmission, distribution and rural electrification.

The demand supply balance prognosis comparing all the three scenarios is shown in the figures below.

FIGURE 20: Demand supply power balance prognosis for all three scenarios

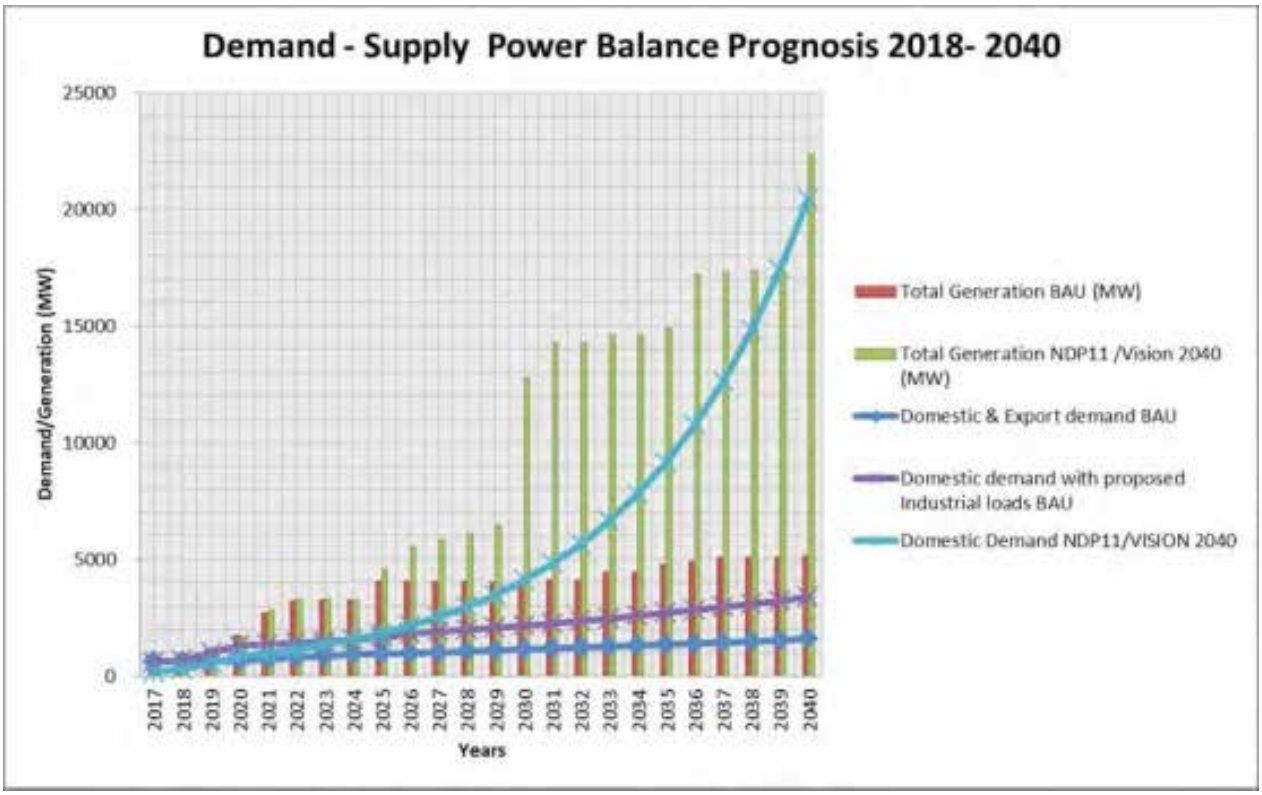
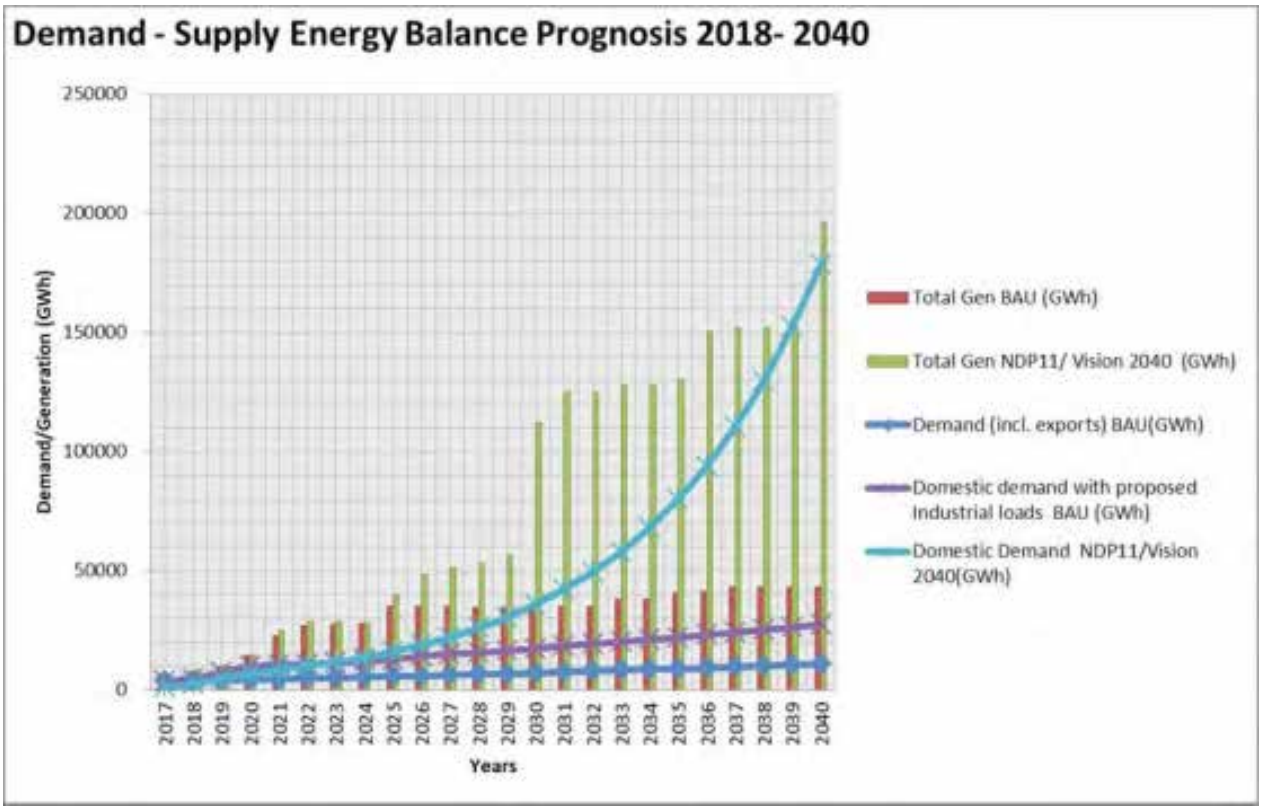


FIGURE 21: Demand supply energy balance for all three scenarios



9 RISK ANALYSIS

Below are the general risks identified, relating to the implementation of the GDevP and the proposed mitigation measures. Mitigation measures will further be discussed in the feasibility studies of the individual projects.

RISK	ASSESSMENT	MITIGATION MEASURES
Strategic and Business a) Failure to adequately commit and invest in the grid due to limitations /budget constraints. b) Failure to obtain alternative financing for capital and grid investment to meet future energy/power demands c) Unfavorable forms of financing could put the company in a poor financial situation d) Uncertainty on currency exchanges e) Possibility of not meeting future demand. f) Inadequate harmonization of plans with other utilities	High	• GoU to attract potential private participation in the projects • Transmission line and substation projects to be in timely presented to GoU for soliciting of financing. • To consider applying Cost recovery tariffs. • Hard currency should be used for settlement of transaction in the Regional Power Trade. • The load growth patterns should constantly be watched and load forecasts adjusted accordingly. • RPT projects should be implemented under the established initiatives i.e. EAPP, NELSAP and NBI. • Constant liaison with the National Planning Authority.

RISK	ASSESSMENT	MITIGATION MEASURES
Environmental and Social Risks Delayed implementation of projects as a result of ; a) Social b) Environmental c) Political d) Legal e) Economic f) Security g) RAP implementation	High	• Feasibility studies should be conducted and detailed EIA and SIA to include mitigation measures in line with NEMA and potential financier's guidelines and all stakeholders should be consulted. • Financial and Economic analysis should be conducted in the Feasibility Studies • Security issues should be addressed in the social Environmental studies
Technical Risks a) Increasing skill gaps due to changing technology b) Likelihood of equipment failure c) Possibility of Equipment under sizing	Low	• Use technologies extensively proven in other parts of the world • UETCL to be trained for proper operation of equipment • Equipment should be covered under the manufactures warranties. • UETCL staff to participate in Factory Acceptance Tests to ensure quality of equipment supplied.
Project Implementation Risks a) Cost overruns b) Engineering c) Design d) Construction e) Commissioning f) Handover	Low-Medium	• Timely procure Consultancy Services for Project Supervision. • Contracts to include penalty clauses to compensate or time delays • Ensure that contractor goes for insurance coverage • Provide for variation order clause to cater for unavoidable risks • Projects intended for evacuation of IPP to be packaged together with the Hydropower Projects. • UETCL counterpart staff to be involved in all aspects from its inception to the commissioning stage.
Operational Risks a) Limitation in Hydrology b) Vandalism	Medium-high	• Hydropower plants should be planned basing on firm capacity. • Steel tubular poles should be used instead of steel lattice towers which are vulnerable to vandalism. • Use of conductors such as AAAC that are less prone to vandalism. • Engage stakeholders to develop more stringent measures / penalties in the laws. • Advocate for the regulation of scrap market. • Local leaders at LCI level are to be engaged to provide security to the lines in their areas where the lines traverse.

TABLE 37: Risk analysis

10 STAKEHOLDERS

Due to the nature of the projects and the environment in which UETCL operates, identification of key stakeholders is a prerequisite for the successful implementation of this Grid Development Plan.
Further still, the key stake holders need to create an environment conducive for the survival of UETCL as a self-sustaining organization without collapsing under the debt burden.
Below are some of the stakeholders and their roles.

STAKEHOLDER	ROLE
Government of Uganda (GoU)	• Sector policy and strategies • Provide counterpart funding for activities like RAP implementation • Power sector contribution to GoU wider objectives • Source for funding from development partners
Distributors (Umeme & others)	• Power sales Agreements (PSA's) • Wheeling Agreements (WA's) • Provide data regarding consumers
Electricity Regulatory Authority	• Issue licenses • Approve budgets • Approve bulk supply tariff
Rural Electrification Agency	• Provide data on future rural electrification projects • Facilitates implementation of rural electrification program
Regional utilities	• Power Exchange Agreements
Independent Power Producers	• Generate and sell power under Power Purchase Agreements
Funding agencies	• Project identification • Project appraisal • Approval of financing • Project supervision
Government Valuer	• Approval of RAP costs and budget • Provision of properties compensation amounts.
Public	• Way leaves acquisition • Land acquisition
NEMA	• Approval of ESIA report • Ensuring compliance with environmental conservation guidelines
NFA	• Approval of ESIA report • Wayleaves acquisition
UWA	• Approval of ESIA report • Wayleaves acquisition
UIA	• Information on upcoming demand
NPA	• Harmonize national planning
Infrastructure Utilities	• UNRA (Uganda National Road Authority). • NWSC (National Water Sewage Corporation) • PAU (Petroleum Authority of Uganda) These provide data on their respective infrastructure plan.

TABLE 38: Stakeholders

APPENDICES

A.1 DEMAND - SUPPLY BALANCE AND PROGNOSIS

A.2 GIP IMPLEMENTATION PLAN AND SCHEDULE

A.3 UETCL TRANSMISSION LINES

Period:	1954 - 2017								
Line	Nominal Voltage (kV)	Route Length (km)	No. of circuits	Circuit Length (km)	No. of structures	Type	In service date	Line Age (yrs)	Line Rating (MVA)
Kampala North - Namungoona	132	5.6	2	11.2	20	Steel tower	1959	59	79.1
Namungoona - Mutundwe	132	5.4	2	10.8	16	Steel tower	1959	59	79.1
Lugogo - Kampala North	132	5.7	2	11.4	25	Steel tower	1997	21	73.2
Lugogo - Mutundwe	132	10.2	2	20.4	46	Steel tower	1997	21	180
Mutundwe - Kabulasoke	132	84.7	1	84.7	476	wooden	1963	55	63.1
Kabulasoke - Masaka West	132	60	1	60	338	wooden	1963	55	63.1
Masaka West - Kyaka	132	84.5	1	84.5	262	Steel tower	1994	24	73.8
Masaka West - Mbarara North	132	130.5	1	130.5	407	tower	1995	23	151.6
Kabulasoke - Nkonge	132	78.5	1	78.5	422	wooden	1963	55	63.1
Nkonge - Rugonjo	132	62.113	1	62.113	529	wooden	1963	55	63.1
Rugonjo - Nkenda	132	40.978	1	40.978	229	wooden	1963	55	63.1
Nalubaale – Namanve	132	56.3	1	56.3	169	Steel tower	1954	64	147
Namanve - Kampala North	132	12.6	1	12.6	37	Steel tower	1954	64	147
Nalubaale - Lugazi	66	35.2	1	35.2	104	Steel tower	1963	55	10.6
Nalubaale- Lugogo	132	70.2	2	140.4	243	Steel tower	1998	20	180.6
Bujagali – Tororo	132	118.8	2	237.6	207	Steel tower	1954	64	78
Tororo - Opuyo	132	119.5	1	119.5	775	wooden	1963	55	63.1
Opuyo – Lira	132	141.2	1	141.2	607	wooden	1963	55	63.1
Tororo - Kenya	132	27	2	54	28	Steel tower	1954	64	78
Bujagali - Nalubaale	132	8	2	16	35	Steel tower	2011	7	205.8
Bujagali - Kawanda	220	75	2	150	212	Steel tower	2012	7	205.8
Kawanda - Mutundwe	132	17	2	34	72	Steel tower	2012	7	457
Queensway – Lugogo Queens way t off	132	0.3	1	0.3		Underground cable	2017		
Nkenda – Fort Portal	220kV	55	2	110		Steel tower	2017		
Total				**1701.19**					

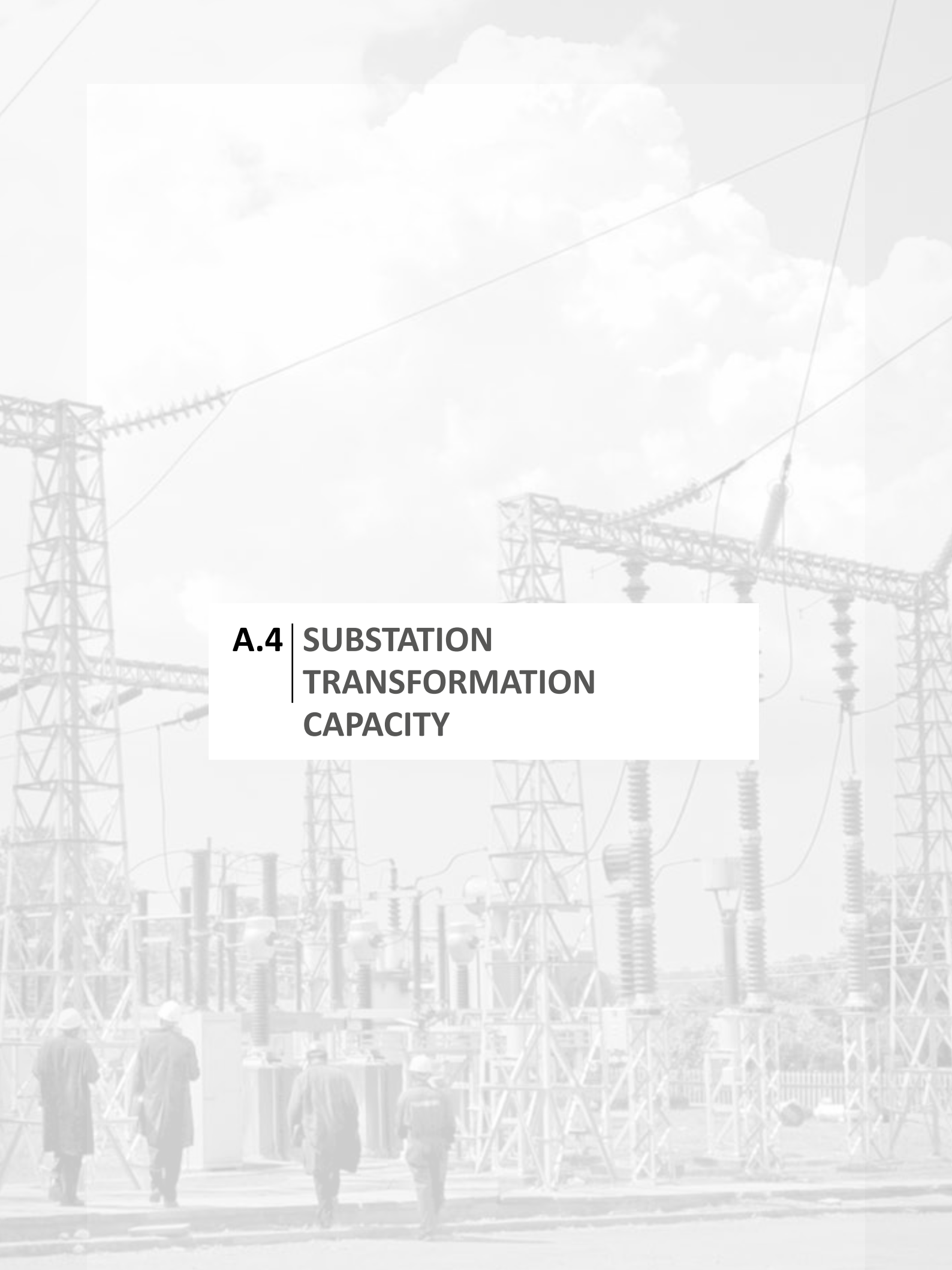
PLANNED TRANSMISSION LINES

Period:	**2018 – 2040**					
Line	Nominal Voltage (kV)	Route Length (km)	No. of circuits	Circuit Length (km)	Type	Expected commissioning year
Mbarara – Nkenda	132	160	2	320	Steel tower	2018
Bujagali – Tororo - UG'KY border	220	127	2	254	Steel tower	2018
Mbarara – Mirama - UG'RW border	220	66	2	132	Steel tower	2018
Kawanda – Masaka	220	137	2	274	Steel tower	2018
Fort Portal – Hoima	220	170	2	340	Steel tower	2018
Isimba – Bujagali	132	42	2	84	Steel tower	2018
Karuma – Olwiyo	400	54.2	2	108.4	Steel tower	2018
Karuma – Lira	132	75.5	2	151	Steel tower	2018
Karuma – Kawanda	400	248	2	496	Steel tower	2018
T Matuga Kapeka	132	45	2	90	Steel tower	2018
Mutundwe – Entebbe	132	23.5	2	47	Steel tower	2019
Namanve South - Luzira	132	15	2	30	Steel tower	2019
T-Mukono from Nalubaale - Namanve Transmission Line	132	8	2	16	Steel tower	2019
T- Iganga from Bujagali - Tororo Transmission Line	132	15	4	60	Steel tower	2019
Namanve - Namanve South	132	6	2	12	Steel tower	2019
Kawanda - Kasana	132	54	2	108	Wooden poles	2019
Opuyo – Moroto	132	160	2	320	Monopoles	2019
Gulu – Agago	132	83	2	166	Steel tower	2020
Lira – Gulu	132	90	2	180	Steel tower	2020
Gulu - Nebbi (Via Olwiyo)	132	160	2	320	Steel tower	2020
Nebbi – Arua	132	63	2	126	Steel tower	2020
Buloba branch point – Buloba Substation	132	0.8	2	1.6	Steel tower	2020

Period:	2018 – 2040					
Line	Nominal Voltage (kV)	Route Length (km)	No. of circuits	Circuit Length (km)	Type	Expected commissioning year
(New Mukono Substation – Mukono Substation)	132	0.3	2	0.6	Steel tower	2020
New Mukono branch point – New Mukono Substation (including modification of 132kV Transmission Line between No. 77 & No.78)	220	4.2	4	16.8	Steel tower	2020
New Mukono Substation – New Mukono branch point (Southern trunk line)	132	0.4	2	0.8	Steel tower	2020
Mukono branch point (Northern trunk line) – Kampala North Substation	132	25.4	1	25.4	Steel tower	2020
Kampala North Substation – Mutundwe Substation	132	10.2	2	20.4	Steel tower	2020
Kawaala branch point – Kawaala Substation	132	0.1	2	0.2	Steel tower	2020
Buloba branch point – Buloba Substation	220	0.9	4	3.6	Steel tower	2020
Mirama – Kabale	132	85	2	170	Steel tower	2020
Masaka - Mbarara	400	130.5	2	261	Steel tower	2021
Tororo SS – SGR Tororo Traction SS	132	11	2	22	Steel tower	2021
Bujagali – Tororo T/L T-off to SGR Buwoola SS	132	64	2	128	Steel tower	2021
Iganga SS – SGR Iganga Traction SS	132	3.5	2	7	Steel tower	2021
Nalubaale – Lugogo T/L to SGR Nyenga SS	132	5	2	10	Steel tower	2021
Namanve South – SGR Kampala East SS	132	3.7	2	7.4	Steel tower	2021
Hoima - Kinyara	220	45	2	90	Steel tower	2021
Kinyara – Kafu	220	47	2	94	Steel tower	2021
Kingfisher – Kabale	132	50	2	100	Steel tower	2021
Tilenga - Kabale	132	135	2	270	Steel tower	2021
Wobulenzi – Kapeka	220	37	2	74	Steel tower	2022

Period:	2018 – 2040					
Line	Nominal Voltage (kV)	Route Length (km)	No. of circuits	Circuit Length (km)	Type	Expected commissioning year
Kapeka - Kiboga - Hoima	220	142.9	2	285.8	Steel tower	2022
Nakasongola – Kaweweta- Kapeka	132	160	2	320	Steel tower	2022
Mbale - Kapetrol - Bulambuli	132	74	2	148	Steel tower	2022
Mirama – Nsongezi	132	37.3	2	74.6	Steel tower	2022
Masaka – Mutukula	220	82	2	164	Steel tower	2022
Bujagali – Tororo T off to Jinja	132	5	2	10	Steel tower	2022
Mbarara Nkenda Toff to Ishaka	132	10	2	20	Steel tower	2022
Masaka Kyaka Toff to Rakai	132	10	2	20	Steel tower	2022
Nkonge – Mubende	132	30	2	60	Steel tower	2022
Nkenda – Mpondwe	220	72.5	2	145	Steel tower	2022
Oriang interconnection	400	10	2	20	Underground cable	2023
Ayago interconnection	400	12	2	24	Underground cable	2023
Mukono Nalubaale T off to Lugazi	132	2	2	4	Steel towers	2025
Mutundwe – Gaba – Luzira	132	50	2	100	Steel towers	2025
Phosphate – Tororo	220	1	2	2	Steel tower	2026
Nkenda – Buloba	220	303	2	606	steel towes	2026
Buloba – Gaba	220	50	2	100	Steel tower	2026
Olwiyo – Nimule	400	190	2	390	Steel tower	2026
Tororo - Wobulenzi	400	198	2	396	Steel tower	2030
New Masaka – Mbarara	400	130	2	260	Steel tower	2030
Wobulenzi – Masaka	400	152	2	304	Steel tower	2030
New Mbarara – Shango	400	160	2	320	Steel tower	2030
Tororo 400 /220 - Tororo 220 /132	220	5.76	2	11.52	steel towers	2030
Kawanda – Wobulenzi	220	41.4	2	82.8	Steel towers	2030

Period:	2018 – 2040					
Line	Nominal Voltage (kV)	Route Length (km)	No. of circuits	Circuit Length (km)	Type	Expected commissioning year
Mbarara 400/220 - Mbarara 220/132	220	2.16	2	4.32	Steel towers	2030
Tororo - Karuma	400	345	2	690	Steel tower	2031
Kiba interconnection project	400	10	2	20	Underground cable	2031
Uhuru – Olwiyo	400	38	2	76	Underground cable	2031
Kabale – Ishaka	132	90	2	180	Steel towers	2033
Kabulasoke – Kiboga	132	131	2	262	Steel towers	2035
Bulambuli – Moroto	132	130	2	260	Steel towers	2040
Kitgum – Agago	132	65	2	130	Steel towers	2040
Kitgum – Moroto	132	220	2	440	Steel towers	2040
Agago – Adjumani	132	110	2	220	Steel towers	2040
Adjumani – Arua	132	105	2	210	Steel towers	2040
Arua – Aru	132	15	2	30	Steel towers	2040
Total				11327.24		
TOTAL CIRCUIT LENGTH BY 2040				13,029.43		



A.4 SUBSTATION TRANSFORMATION CAPACITY

A.4 UETCL SUBSTATION TRANSFORMATION CAPACITY

Period:	1963-2017										
SUBSTATION	**TRANSFORMER**	**MAKE/ TYPE**	**YEAR OF MANUFACTURE**	**MIN MVA**	**MAX MVA**	**VOLTAGE RATIO**	**NOMINAL TAP**	**IMPEDANCE VOLTAGE AT NOMINAL TAP**	**NO. OF TAPS**	**CONNECTION SYMBOL (VECTOR GROUP)**	**EARTHING RESISTANCE**
CENTRAL REGION											
NAMANVE											
	Transformer 1	Crompton Greaves	2007	32	40	132/33kV	5	11.52%	17	YNyn0d1	
	Transformer 2	Crompton Greaves	2007	32	40	132/33kV	5	11.52%	17	YNyn0d1	
	Transformer 3	Crompton Greaves	2008	32/40	40	132/33kV	5	11.52%	17	YNyn0d1	
LUGOGO											
	Transformer 1	ABB Kraft	1997	32	40	132/11kV	7	10.21%	17	YNyn0	21 Ohms
	Transformer 6	ABB	1998	32	40	132/33kV	5	13.60%	17	YNyn0	
	Transformer 3	ABB	1998	32	40	132/33kV	5	13.60%	17	YNyn0	
	Transformer 5	Elektro Putere-Romania	1991	32	40	132/11kV	7	10.78%	17	YNyn0 (d)	21 Ohms
MUTUNDWE											
	Transformer 1	Elektro Putere	1991	32	40	132/33kV	5	13.60%	17	YNyn0(d)	
	Transformer 2	ABB	1995	32	40	132/33kV	5	13.50%	17	YNyn0	
	Transformer 3	ABB Powertech	2003	15	20	132/11kV	5	9.64%	17	YNyn0 (d)	7.94Ohms (25deg Celcius)
	Transformer 4	ABB Powertech	2003	15	20	132/11kV	5	9.54%	17	YNyn0 (d)	7.94Ohms (25deg Celcius)
KAMPALA NORTH											
	Transformer 1	ABB	1995	32	40	132/33kV	5	13.60%	17	YNyn0	
	Transformer 5	EMCO Transformers	2006	32	40	132/11kV	7	9.62%	17	YNyn0 (d)	
	Transformer 6	EMCO Transformers	2006	32	40	132/11kV	7	9.63%	17	YNyn0 (d)	
	Transformer 2	Crompton Greaves	2011	32	40	132/33kV	5	13.43%	17	YNyn0d1	

Period:	1963-2017										
SUBSTATION	**TRANSFORMER**	**MAKE/ TYPE**	**YEAR OF MANUFACTURE**	**MIN MVA**	**MAX MVA**	**VOLTAGE RATIO**	**NOMINAL TAP**	**IMPEDANCE VOLTAGE AT NOMINAL TAP**	**NO. OF TAPS**	**CONNECTION SYMBOL (VECTOR GROUP)**	**EARTHING RESISTANCE**
KAWAALA											
	Tranformer no 5	Hawker Siddeley -Brush	1972	15	20	132/11kV	7	9.80%	17	Yy0d1	
KAWANDA											
	Transformer 1	Crompton Greaves	2009	32	40	132/33kV	5	14.17%	17	YNyn0d11	
QUEENSWAY											
	Transformer 1	Aichi Electric	2016	32	40	132/33kV		13.50%	17	YNyn0d11	
	Transformer 2	Aichi Electric	2016	32	40	132/33kV		13.50%	17	YNyn0d11	
	Transformer 3	Aichi Electric	2016	32	40	132/33kV		13.50%	17	YNyn0d11	
WESTERN REGION											
MASAKA WEST											
	Transformer 1	Elektro Putere	1991	15	20	132/33kV	5	9.44%	17	YNyn (d)	
	Transformer 2	ABB	2007	20	20	132/33kV	5	9.43%	17	YNyn0+d11	
MBARARA NORTH											
	Transformer 1	Crompton Parkinson	1963	15	15	132/33kV	5	10.12%	17	YNynd11	
	Transformer 2	ABB	2007	20	20	132/33kV	5	9.45%	17	YNyn0+d	
NKONGE											
	Transformer 1	Ferranti	1970	7.5	7.5	132/33kV	5	10.13%	17	YNyn0	
NKENDA											
	Transformer 1	Elektro Putere	1991	15	20	132/33kV	5	9.44%	17	YNyn (d)	
	Transformer 2	EMCO India	2003	15	20	132/33kV	5	9.77%	17	YNy0(d)	
KAHUNGYE /RUGONJO											
	Transformer 1	Jiangsu Huapeng	2010	20	20	132/33kV					
	Transformer 2	Jiangsu Huapeng	2010	20	20	132/33kV					

Period:	1963-2017										
SUBSTATION	**TRANSFORMER**	**MAKE/ TYPE**	**YEAR OF MANUFACTURE**	**MIN MVA**	**MAX MVA**	**VOLTAGE RATIO**	**NOMINAL TAP**	**IMPEDANCE VOLTAGE AT NOMINAL TAP**	**NO. OF TAPS**	**CONNECTION SYMBOL (VECTOR GROUP)**	**EARTHING RESISTANCE**
FORT PORTAL											
	Transformer 1			32	40	132/33kV					
	Transformer 2			32	40	132/33kV					
EASTERN REGION											
LUGAZI											
	Transformer 1	ABB	2007	14	14	66/11kV		9.00%	17	Dyn11	
	Transformer 2	ABB	2007	14	14	66/11kV		9.00%	17	Dyn11	
TORORO											
	Transformer 1	Brush	1988	15	20	132/33kV	5	13.34%	17	YNyn0	
	Transformer 2	Hawker Siddeley Brush	1985	15	20	132/33kV	9	13.57%	17	YNyn0	
	Transformer 3	Crompton Greaves	2006	32	40	132/33kV	5	9.44%	17	YNyn0(d11)	
BUJAGALI											
	Transformer 1	EMCO	2016	250	250	220/132/33kV	9	14.49%	17	YNa0d11	
	Transformer 2	EMCO	2016	250	250	220/132/33kV	9	14.49%	17	YNa0d11	
NORTHERN REGION											
OPUYO											
	Transformer 1	Pauwels Trafo	1993	10	10	132/33kV	5	9.05%	17	YNyn0(d11)	
LIRA											
	Transformer 1	Hackbridge Hewittic-Easun	1974	15	20	132/33kV	9	9.82%	17	YNyn0d11	
	Transformer 2	ABB	2007	20	20	132/33kV	5	9.39%	17	YNyn0d11	
TOTAL					1640.5						

PLANNED SUBSTATIONS

Period:	2018-2040				
SUBSTATION	TRANSFORMER	EXPECTED COMMISSIONING YEAR	MIN MVA	MAX MVA	VOLTAGE RATIO
CENTRAL REGION					
NAMANVE SOUTH					
	Transformer 1	2019	40	63	132/33kV
	Transformer 2	2019	40	63	132/33kV
	Transformer 3	2019	40	63	132/33kV
LUZIRA					
	Transformer 1	2019	32	40	132/33kV
	Transformer 2	2019	32	40	132/33kV
	Transformer 3	2019	32	40	132/33kV
MUKONO					
	Transformer 1	2019	40	63	132/33kV
	Transformer 2	2019	40	63	132/33kV
	Transformer 3	2019	40	63	132/33kV
MUTUNDWE					
	Transformer 1	2022	50	60	132/33kV
	Transformer 2	2022	50	60	132/33kV
	Transformer 3	2022	50	60	132/11kV
	Transformer 4	2022	50	60	132/11kV
ENTEBBE					
	Transformer 1	2019	60	80	132/33kV
	Transformer 2	2019	60	80	132/33kV
KASANA					
	Transformer 1	2019	15	20	132/33kV
KAPEEKA					
	Transformer 1	2018	15	20	132/33kV
	Transformer 2	2022	50	63	132/33kV
	Transformer 3	2022	50	63	132/33kV
	Transformer 4	2022	50	63	132/33kV
	Transformer 1	2022	125	125	220/33kV
	Transformer 2	2022	125	125	220/33kV
KAWANDA					
	Transformer 1	2018	20	20	132/33kV
	Transformer 2	2018	250	250	220/132kV
	Transformer 3	2018	250	250	220/132kV
	Transformer 4	2018	650	650	400/220kV
	Transformer 5	2018	650	650	400/220kV
	Transformer 6	2019	32	40	132/33kV
WOBULENZI					
	Transformer 1	2021	250	250	400/220/33kV
	Transformer 2	2021	250	250	400/220/33kV
NAKASONGOLA					
	Transformer 1	2022	32	40	132/33kV
	Transformer 2	2022	32	40	132/33kV

Period:	2018-2040				
SUBSTATION	TRANSFORMER	EXPECTED COMMISSIONING YEAR	MIN MVA	MAX MVA	VOLTAGE RATIO
LUGOGO					
	Transformer 1	2022	50	60	132/33kV
	Transformer 2	2022	50	60	132/33kV
	Transformer 4	2022	50	60	132/11kV
	Transformer 5	2022	50	60	132/11kV
KAMPALA NORTH					
	Transformer 1	2019	32	40	132/33kV
NEW MUKONO					
	Transformer 1	2021	125	125	220/132kV
	Transformer 2	2021	125	125	220/132kV
	Transformer 3	2021	125	125	220/132kV
BULOBA					
	Transformer 1	2021	125	125	220/132kV
	Transformer 2	2021	125	125	220/132kV
	Transformer 3	2021	32	40	132/33kV
	Transformer 4	2021	32	40	132/33kV
KAWAALA UPGRADE					
	Transformer 6	2021	20	20	132/11kV
	Transformer 1	2021	32	40	132/33kV
	Transformer 2	2021	32	40	132/33kV
	Transformer 3	2021	32	40	132/33kV
MOBILE SUBSTATION					
	Transformer 1	2018	50	50	132/33kV
	Transformer 2	2021	20	20	132/33kV
NYENGA TRACTION SS					
	Transformer 1	2021	10	10	132/27.5kV
	Transformer 2	2021	10	10	132/27.5kV
GABA					
	Transformer 1	2025	32	40	132/33kV
	Transformer 2	2026	60	60	220/132/33kV
	Transformer 3	2026	60	60	220/132/33kV
KABULASOKE					
	Transformer 1	2035	15	20	132/33kV
	Transformer 2	2035	15	20	132/33kV
KAMPALA EAST TRACTION SS					
	Transformer 1	2021	10	10	132/27.5kV
	Transformer 2	2021	10	10	132/27.5kV
KAWEWETA					
	Transformer 1	2022	32	40	132/33kV
	Transformer 2	2022	32	40	132/33kV
WESTERN REGION					
MASAKA WEST					
	Transformer 3	2018	125	125	220/132kV
	Transformer 4	2018	125	125	220/132kV

Period:	2018-2040				
SUBSTATION	TRANSFORMER	EXPECTED COMMISSIONING YEAR	MIN MVA	MAX MVA	VOLTAGE RATIO
	Transformer 5	2022	50	60	132/33kV
	Transformer 6	2022	50	60	132/33kV
NEW MASAKA					
	Transformer 1	2030	200	200	400/220kV
	Transformer 2	2030	200	200	400/220kV
MBARARA SOUTH UPGRADE					
	Transformer 1	2018	40	60	132/220kV
	Transformer 1	2021	250	250	132/33kV
	Transformer 2	2021	250	250	132/33kV
MBARARA NORTH UPGRADE					
	Transformer 1	2022	50	63	132/33kV
	Transformer 2	2022	50	63	132/33kV
MBARARA NEW					
	Transformer 1	2030	200	200	400/220kV
	Transformer 2	2030	200	200	400/220kV
FORT PORTAL					
	Transformer 1	2021	40	90	33/132/220kV
	Transformer 2	2021	40	90	33/132/220kV
MIRAMA					
	Transformer 1	2018	60	60	220/132kV
	Transformer 2	2021	60	60	220/132kV
	Transformer 2	2021	50	60	133/33kV
	Transformer 3	2021	50	60	133/33kV
HOIMA					
	Transformer 1	2018	32	40	132/33kV
	Transformer 2	2018	32	40	132/33kV
	Transformer 3	2021	250	250	220/132/33kV
	Transformer 4	2021	250	250	220/132/33kV
NKENDA					
	Transformer 1	2022	60	60	132/33kV
	Transformer 2	2022	60	60	132/33kV
	Transformer 3	2021	250	250	220/132/33kV
	Transformer 4	2021	250	250	220/132/33kV
KABALE					
	Transformer 1	2020	32	40	132/33kV
	Transformer 2	2020	32	40	132/33kV
NSONGEZI					
	Transformer 1	2022	32	40	132/33kV
	Transformer 2	2022	32	40	132/33kV
KAFU					
	Transformer 1	2021	250	250	400/220/33kV
	Transformer 2	2021	250	250	400/220/33kV
KABAALE					

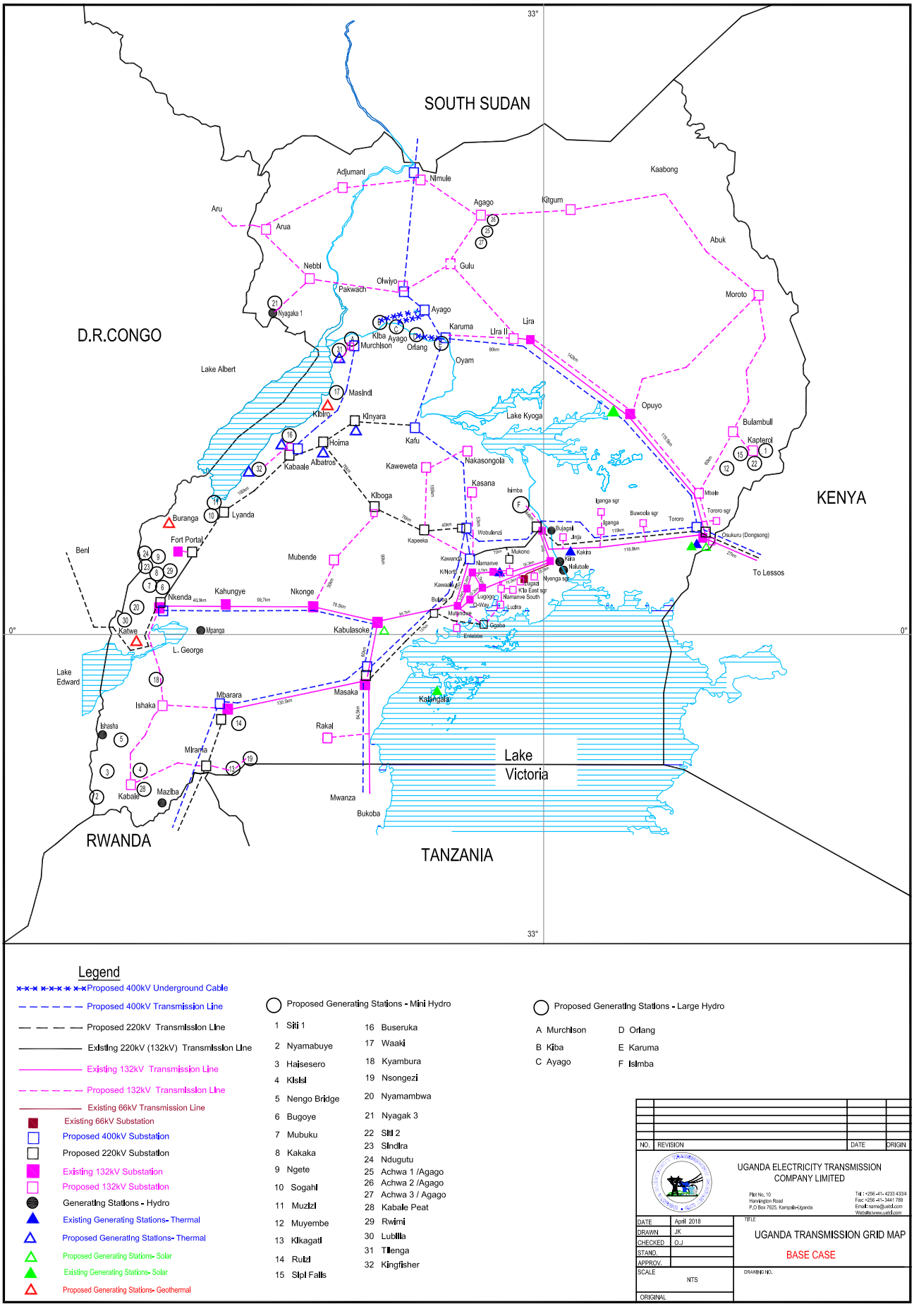
Period:	2018-2040				
SUBSTATION	TRANSFORMER	EXPECTED COMMISSIONING YEAR	MIN MVA	MAX MVA	VOLTAGE RATIO
	Transformer 1	2021	250	250	220/132/33kV
	Transformer 2	2021	250	250	220/132/33kV
KINGFISHER					
	Transformer 1	2021	32	40	132/33kV
	Transformer 2	2021	32	40	132/33kV
TILENGA					
	Transformer 1	2021	32	40	132/33kV
	Transformer 2	2021	32	40	132/33kV
	Transformer	2021	32	40	132/33kV
MUZIZI					
	Transformer 2	2021	250	250	220/132/33kV
	Transformer 3	2021	250	250	220/132/33kV
NKONGE					
	Transformer 1	2022	32	40	132/33kV
	Transformer 2	2022	32	40	132/33kV
MUBENDE					
	Transformer 1	2022	32	40	132/33kV
	Transformer 2	2022	32	40	132/33kV
RAKAI					
	Transformer 1	2022	32	40	132/33kV
	Transformer 2	2022	32	40	132/33kV
ISHAKA					
	Transformer 1	2022	32	40	132/33kV
	Transformer 2	2022	32	40	132/33kV
KIBOGA					
	Transformer 1	2035	15	20	132/33kV
	Transformer 2	2035	15	20	132/33kV
KINYARA					
	Transformer 1	2021	40	90	132/220kV
	Transformer 2	2021	40	90	132/220kV
EASTERN REGION					
BUJAGALI					
	Transformer 3	2021	250	250	220/132kV
JINJA					
	Transformer 1	2022	50	60	132/33kV
	Transformer 2	2022	50	60	132/33kV
	Transformer 3	2022	50	60	132/33kV
TORORO					
	Transformer 3	2019	60	80	132/33kV
	Transformer 1	2021	250	250	220/132kV
	Transformer 2	2021	250	250	220/132kV
	Transformer 4	2022	50	63	132/33kV
	Transformer 5	2022	50	63	132/33kV
	Transformer 6	2022	50	63	132/33kV

Period:	2018-2040				
SUBSTATION	TRANSFORMER	EXPECTED COMMISSIONING YEAR	MIN MVA	MAX MVA	VOLTAGE RATIO
	Transformer 1	2031	650	650	400/220kV
	Transformer 2	2031	650	650	400/220kV
IGANGA					
	Transformer 1	2019	32	40	132/33kV
	Transformer 2	2019	32	40	132/33kV
KAPTEROL					
	Transformer 1	2022	45	60	132/33kV
	Transformer 2	2022	45	60	132/33kV
MBALE					
	Transformer 1	2022	60	80	132/33kV
	Transformer 2	2022	60	80	132/33kV
	Transformer 3	2020	60	80	132/33kV
BULAMBULI					
	Transformer 1	2040	60	80	132/33kV
	Transformer 2	2040	60	80	132/33kV
TORORO TRACTION SS					
	Transformer 1	2021	10	10	132/27.5kV
	Transformer 2	2021	10	10	132/27.5kV
BUWOOLA TRACTION SS					
	Transformer 1	2021	10	10	132/27.5kV
	Transformer 2	2021	10	10	132/27.5kV
IGANGA TRACTION SS					
	Transformer 1	2021	10	10	132/27.5kV
	Transformer 2	2021	10	10	132/27.5kV
SUKULU PHOSPHATE					
	Transformer 1	2018	50	63	132/10.5kV
	Transformer 2	2018	50	63	132/10.5kV
	Transformer 1	2026	125	125	220/10.5kV
	Transformer 2	2026	125	125	220/10.5kV
NEW LUGAZI					
	Transformer 3	2025	32	40	132/33kV
	Transformer 4	2025	32	40	132/33kV
NORTHERN REGION					
OPUYO SUBSTATION UPGRADE					
	Transformer 2	2019	32	40	132/33kV
	Transformer 3	2019	32	40	132/33kV
KARUMA					
	Transformer 1	2018	650	650	400/132kV
	Transformer 2	2018	650	650	400/132kV
	Transformer 3	2018	20	20	132/33kV
	Transformer 4	2018	20	20	132/33kV
OLWIYO					

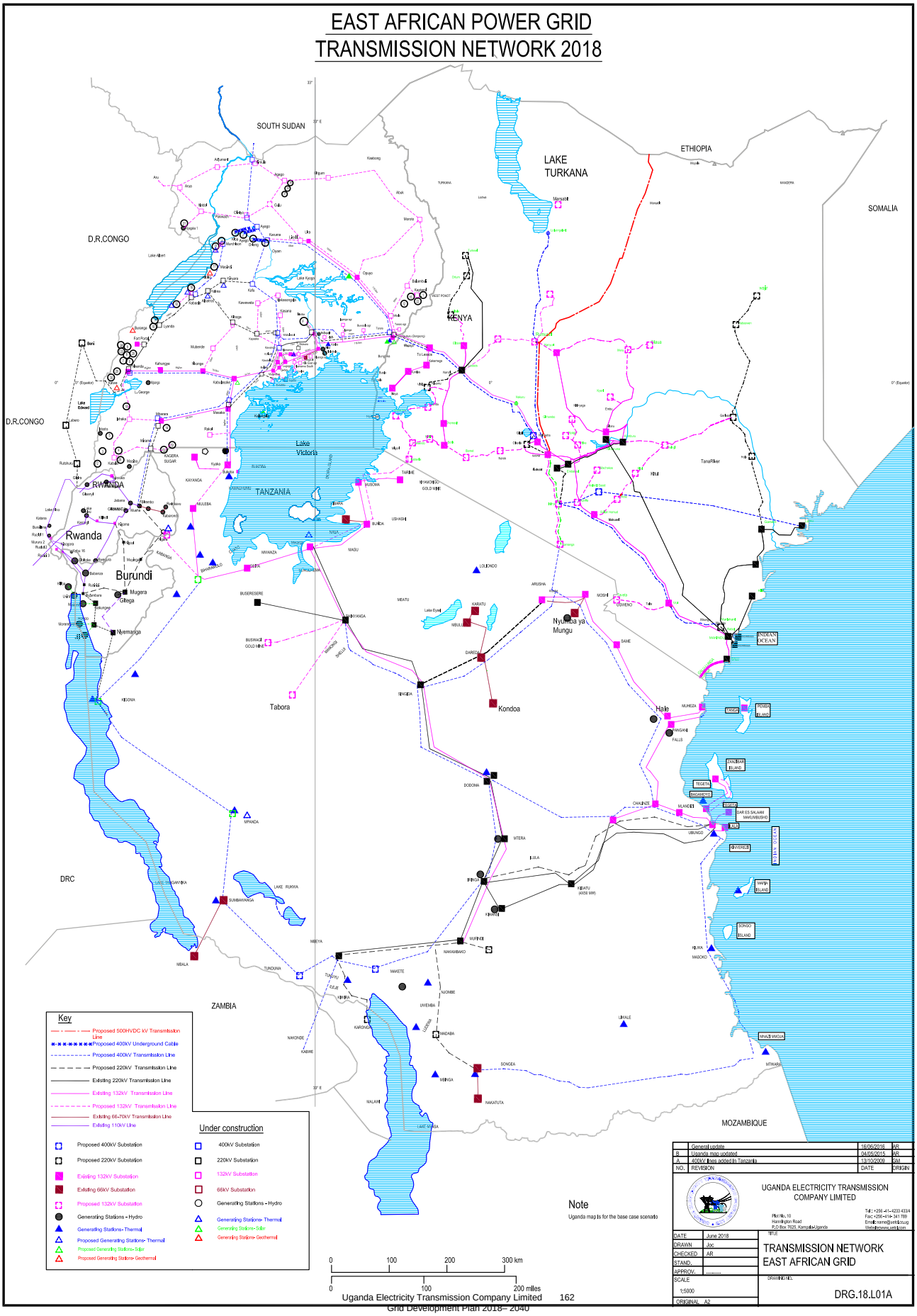
Period:	2018-2040				
SUBSTATION	TRANSFORMER	EXPECTED COMMISSIONING YEAR	MIN MVA	MAX MVA	VOLTAGE RATIO
	Transformer 1	2018	15	20	132/33kV
	Transformer 2	2018	15	20	132/33kV
	Transformer 3	2026	150	150	400/132kV
	Transformer 4	2026	150	150	400/132kV
GULU					
	Transformer 1	2020	32	40	132/33kV
	Transformer 2	2020	32	40	132/33kV
NEBBI					
	Transformer 1	2020	32	40	132/33kV
	Transformer 2	2020	32	40	132/33kV
ARUA					
	Transformer 1	2020	32	40	132/33kV
	Transformer 2	2020	32	40	132/33kV
AGAGO					
	Transformer 1	2020	32	40	132/33kV
	Transformer 2	2020	32	40	132/33kV
MOROTO					
	Transformer 1	2019	32	40	132/33kV
	Transformer 2	2019	32	40	132/33kV
KOLE					
	Transformer 1	2022	50	63	132/33kV
	Transformer 2	2022	50	63	132/33kV
KITGUM					
	Transformer 1	2040	15	20	132/33kV
	Transformer 2	2040	15	20	132/33kV
ADJUMANI					
	Transformer 1	2040	15	20	132/33kV
	Transformer 2	2040	15	20	132/33kV
ARU					
	Transformer 1	2040	15	20	132/33kV
	Transformer 1	2040	15	20	132/33kV
				17,229	
TOTAL MVA				**18,869.50**	

A.5 | MAPS

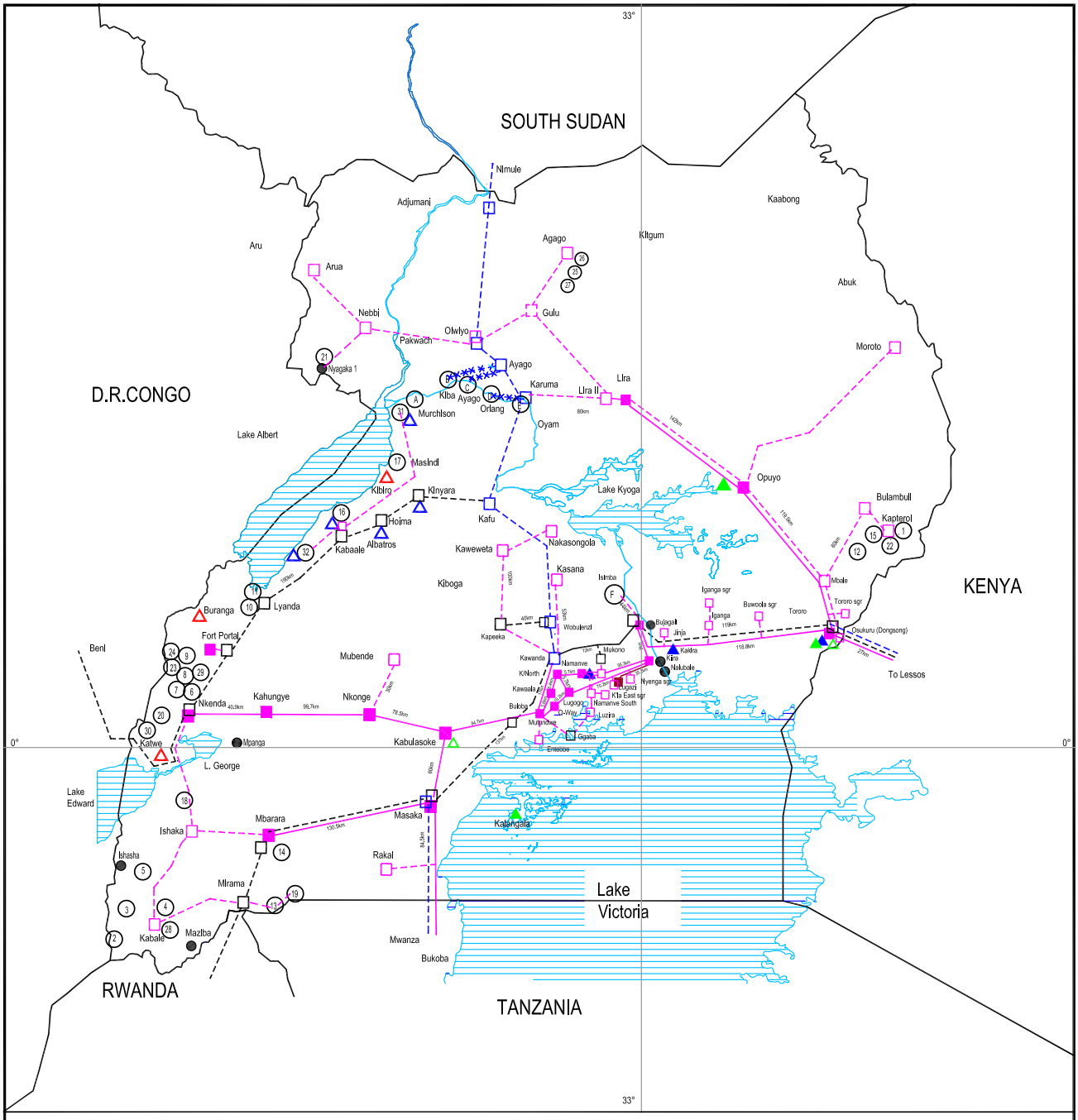
A.5.1 UGANDA POWER SYSTEM PRESENT AND FUTURE NETWORK



A.5.2 EAST AFRICAN POWER SYSTEM



A.5.3 NATIONAL DEVELOPMENT PLAN SCENARIO (NDP)



Legend

- Proposed 400kV Underground Cable
- Proposed 400kV Transmission Line
- Proposed 220kV Transmission Line
- Existing 220kV (132kV) Transmission Line
- Existing 132kV Transmission Line
- Proposed 132kV Transmission Line
- Existing 66kV Transmission Line
- Existing 66kV Substation
- Proposed 400kV Substation
- Proposed 220kV Substation
- Existing 132kV Substation
- Proposed 132kV Substation
- Generating Stations - Hydro
- Existing Generating Stations- Thermal
- Proposed Generating Stations- Thermal
- Proposed Generating Stations- Solar
- Existing Generating Stations- Solar
- Proposed Generating Stations- Geothermal

Proposed Generating Stations - Mini Hydro

1 Siti 1
2 Nyamabuye
3 Halsesero
4 Kisisi
5 Nengo Bridge
6 Bugoye
7 Mubuku
8 Kakaka
9 Ngete
10 Sogahi
11 Muzizi
12 Muyembe
13 Kikagati
14 Ruizi
15 Sipi Falls
16 Buseruka
17 Waaki
18 Kyambura
19 Nsongezi
20 Nyamambwa
21 Nyagak 3
22 Siti 2
23 Sindira
24 Ndugutu
25 Achwa 1 /Agago
26 Achwa 2 /Agago
27 Achwa 3 / Agago
28 Kabale Peat
29 Rwimi
30 Lubilia
31 Tilenga
32 Kingfisher

Proposed Generating Stations - Large Hydro

A Murchison
B Kiba
C Ayago
D Oriang
E Karuma
F Isimba

NO.	REVISION	DATE	ORIGIN

UGANDA ELECTRICITY TRANSMISSION COMPANY LIMITED

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Tel : +256 -41- 4233 433/4 Fax: +256 -41- 3441 789 Email: name@uetcl.com Website:www.uetcl.com

DATE	MAY 2018
DRAWN	JK
CHECKED	O.J
STAND.	
APPROV.	
SCALE	NTS
ORIGINAL	

TITLE

UGANDA TRANSMISSION GRID MAP

NDP II CASE

DRAWING NO.

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