



Rwanda Electricity Distribution Master Plan



June 2021 revision

APPROVALS

	Names	Title	Signature
Prepared by	Lameck NIYOMUGABO	Quality Assurance and Standards Specialist, REG	
	Florien NTEZIRYAYO	Manager of GIS Services, EDCL	
Checked by	Innocent NIYONSHUTI	Ag. Chief Engineer Power System Design, EDCL	
	Esdras RUGIRA	Ag. Director Energy Planning, EDCL	
	Claver GAKWAVU	Planning Director, EUCL	
	Clementine UMUGWANEZA	Strategic Planning Director, REG	
Approved by	Ron WEISS	Chief Executive Officer, REG	

TABLE OF CONTENTS

TABLE OF CONTENTS.....	iii
I. INTRODUCTION	1
I.1. Overview and Structure of REG.....	1
I.2.Objective.....	4
I.3. Expected Key Outputs of the development Plan	4
I.4. Major Updates made in the Distribution Plan (June 2021 version)	4
II. BACKGROUND	6
II.1. Rwanda Electricity Sector overview	6
II.2. Current Distribution Network Configuration.....	6
II.3. On-going Projects.....	8
II.4. Network Planning Issues	9
II.5. Very long feeders	9
II.6. Lack of (N-1) solution.....	10
II.7. Network instability;.....	10
III. DISTRIBUTION MASTER PLAN APPROACH.....	10
III.1. Overview	10
III.2. Data Gathering	11
IV. MODELLING OF MV/LV DISTRIBUTION NETWORK.....	12
IV.1. Validation of attributes:	12
IV.2. MV/LV transformers:	13
IV.3. Validation of topology	13
IV.4. Network Modelling and Assessment of Existing Networks	13
IV.4.1. Demand Forecasting	20
IV.4.2. Short-medium term planning.....	20

IV.4.3. Updating the Distribution Master Plan	20
V. DEMAND FORECAST.....	21
V.1. Introduction.....	21
V.2. Electricity Demand as defined in ESSP (Energy Sector Strategic Plan) report.....	21
V.3. Generation vs Demand from LCPDP.....	22
V.4. Country statistics.....	23
VI. PLANNING APPROACH.....	25
VI.1. Assessment of Existing Networks	25
VI.1.1. General overview of existing network.....	25
VI.1.2. Rwanda Distribution network structure.....	25
VI.1.3. Assessment existing network.....	29
VI.1.3. 1. Loss Reduction Programmes	29
VI.1.4. Understanding the Problem	29
VI.1.5. Correcting or Optimizing Designs.....	30
VI.1.6. Implementing Network Standards	30
VI.1.7. Planning challenges and Recommendations.....	30
VI.2. Short-Medium Term Plan	31
VI.2.1. General basis for Expansion Plan.....	31
VII. SHORT-MEDIUM TERM PROJECTS IN THE SOUTH.....	57
VIII. SHORT- MEDIUM TERM PROJECTS FROM MODEL RESULTSIN THE NORTH	
68	
IX. SHORT-MEDIUM TERM PROJECTS FROM MODEL RESULTS IN EAST	84
X. SHORT -MEDIUM TERM PROJECTS FROM MODEL RESULTS IN WEST	97
XI. UPGRADE OF SWITCHING CABINS IN SECONDARY CITIES	114
XII. CONCLUSION AND RECOMMENDATIONS	135

Assessment of existing network.....	135
Recommendations.....	136

I. INTRODUCTION

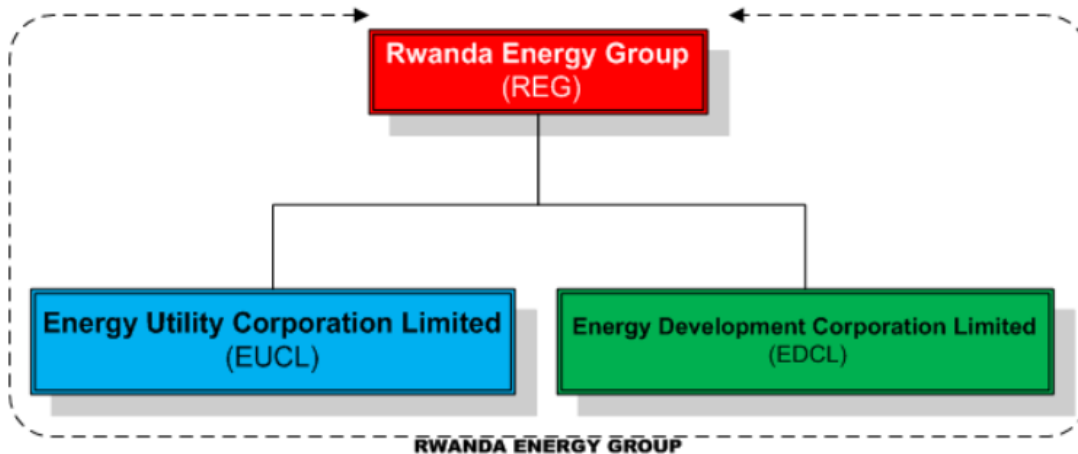
I.1. Overview and Structure of REG

The Government of Rwanda has undertaken reforms in the energy and water sector which have been concretized by the separation of energy from water operations. The main objectives being; to have sector focused and efficient operations; attract more investment; improve planning and accountability; and increase access to services by the population to drive sector performance towards the targets envisaged in the EDPRS II and other national goals.

To this end, Government adopted the corporatization model as a vehicle to implement the required reforms. The law repealing EWSA Law of 97/2013 of January 31, 2014 paved the way for the creation of two corporate entities which were subsequently incorporated in July 2014 with 100% government shareholding.

The Rwanda Energy Group Limited (REG) and its two subsidiaries; The Energy Utility Corporation Limited (EUCL) and The Energy Development Corporation Limited (EDCL) entrusted with energy development and utility service delivery while the Water and Sanitation Corporation (WASAC) has the mandate to develop and operate water and sanitation infrastructure and deliver related services in the country.

The Rwanda Energy Group (REG) was incorporated to expand, maintain and operate the energy infrastructure in the Country through its two subsidiaries the Energy Utility Corporation Limited (EUCL) and the Energy Development Corporation Limited (EDCL). The object of creating these subsidiaries amongst others was to ensure focused attention to enhancing efficiency in utility operations on one hand and ensure timelier and cost efficient implementation of development projects on the other. Moreover, the REG holding structure provides the overall coordination and ensures effective development of energy and investment plans



Overall the group structure is aimed to ensure the autonomy and efficiency of the EDCL and EUCL.

REG, the group is supervised by one Board of Directors and therefore by design, the subsidiaries while being independent corporate entities are under REG Holding. The Board sets the strategic agenda and the CEO of REG ensures that this is achieved by the subsidiaries through the development and implementation of appropriate Business Plans. The organization structure of REG Holding has been designed with a philosophy that the holding is a coordination and monitoring organ of the group.

The Holding ensures the effective implementation of Government policies, monitoring the execution of strategic plans; improvement of service delivery and effective project execution by the subsidiaries. It also plays a coordination role to ensure the smooth interrelationships of the two subsidiaries.

The Holding will also play strategic external stakeholder relationships with the Ministry of Infrastructure on policy and sector matters, Ministry of Finance with respect to the financing arrangements for investments and subsidies, the Rwanda Utility Regulatory Authority (RURA) on wider and compliance issues of the EUCL and EDCL.

The Energy Utility Corporation Limited (EUCL) was incorporated to have devoted attention in providing energy utility services in the Country through operations and maintenance of existing generation plants, transmission and distribution network and retail of electricity to end-users. In executing its mandate, the Company will strive to achieve;

- a) Optimized generation capacity and economic plant dispatch to meet short and long-term energy supply requirements,
- b) Enhanced operational efficiency (progressive system loss reduction, billing and collection efficiency, network reliability and high quality of service),
- c) Improved customer service, and
- d) Network growth and increased connections within the footprint of electrified areas thereby making an effective contribution to the EDPRS targets.

The Company has four main processes feeding into the core business; Policies planning, Marketing planning and development, Distribution planning and development within already electrified areas and Operation & Maintenance of Power Plants and Transmission & Distribution Networks owned by the Utility. The utility will also play a key role in the execution of Power Purchase/Power Sales Agreements with IPPs and other regional utilities for import and export.

The Energy Development Corporation Limited (EDCL) was incorporated to have devoted attention to;

- a) Increasing investment in development of new energy generation projects in a timely and cost-efficient manner to expand supply in line with EDPRS and other national targets,
 - b) Develop appropriate transmission infrastructure to evacuate new plants and deliver energy to relevant distribution nodes; and
 - c) Plan and execute energy access projects to meet the national access targets.
- This ring-fenced approach to development is designed to enhance accountability of development

resources with the various stakeholders while at the same time opening space for increased private sector participation.

I.2.Objective

The main objective of the development plan is to formulate a blueprint for the Power System Development Master Plan up to 2030 which shall be practical and comprehensive. The master plan will coordinate transmission, and distribution expansion to ensure with confidence that all proposed capital investments are not ad hoc and are instead part of a long-term structured plan. It will ensure that network expansion is economically efficient and will provide a realistic framework for loss reduction and reliable network. The study shall use the least cost analysis to compare various options available for the development of transmission and distribution systems.

I.3. Expected Key Outputs of the development Plan

The expected key outputs of the development plan shall include but not limited to the following:

- (i) A detailed long-term demand forecast for Rwanda
- (ii) An estimate of distribution investment costs to meet demand growth;
- (iii) A program of distribution loss reduction initiatives;

The above outputs shall be achieved by using the least-cost analysis to compare various options of distribution, through the following key activities to include;

- (i) Assessing existing electricity demand and prepare a demand forecast,
- (ii) Undertaking computer modeling of the country's current existing power system down to the power substation level, and analyze constraints;
- (iii) Prepare a detailed distribution capital works program for the 5 years of the master plan.

I.4. Major Updates made in the Distribution Plan (June 2021 version)

Key updates made during the revision of June 2021 are listed below:

1. The entire Medium Voltage network was modelled using DigSilent Power Factory Software
 - a. A total of 4743 Distribution transformers have been modelled for the entire MV Network
 - b. Distribution transformers were considered as Load scaled at 40%
 - c. Load flow analysis was performed
2. The Purpose was:
 - a. To assess the loading profile of the feeders vis à vis to their power carrying capacities
 - b. To assess the Voltage profile at the end of the lines
 - c. To determine power dissipated or lost in the lines (Technical losses)
 - d. To take initiatives to address the network constraints
3. The simulation results have shown that all feeders were loaded to their acceptable loading capacity except:
 - a. Butare feeder is highly-loaded at 80% of its capacity
 - b. Rukarara II is loaded at 66.7% and is going to be highly loaded in the near future due to fast development which is in Huye as a secondary city
 - c. Goma feeder is loaded at 69.7% and is going to be highly loaded in the near future due to fast development in Rubavu as a secondary city
 - d. Kigali North feeder is loaded 64.1% and is going to be highly loaded in the near future due to many development projects being realised in Kigali
4. Simulation results also showed that all medium voltage feeders were found to have acceptable standard voltage profile
5. Eastern and Southern networks have high losses due to single phase network in those regions that need to be upgraded.
6. **Key actions to address identified network issues above are:**

- Construction of 12km MV line from GISAGARA Substation to make a link with KIGOMA Substation will reduce the length of Butare and Rukarara II feeders.
- Construction of 4 switching substations in Gisagara and Huye will increase load transfer capacities and shorten MV line length.
- Rubavu and Goma feeders' loads will be reduced by Construction of 9.6km Double Circuit MV Line from Rubavu Substation to Rutsiro and associated links
- Construction of 2.4km ring line of Rubavu (Poids Lourds)
- Construction of 1.2km Double circuit MV Line Linking Camp Belge Substation to Nyabihu Substation
- Construction of the 3km Double circuit MV Line linking Nyabihu Substation and Gisenyi Feeder towards Ngororero
- Kigali North feeder loading will be reduced once Kigali 8 switching cabins project will be completed (This project is on-going)
- Upgrade of 395.5km of MV lines and replacement of 922 single phase transformers countrywide will reduce losses on the network especially in East and Southern regions.

II. BACKGROUND

II.1. Rwanda Electricity Sector overview

The Government of Rwanda envisions transitioning from a developing country to a middle-income country (NST1). To achieve this goal, the government is targeting universal electricity access (52% on-grid, 48% off-grid) by 2024. In Rwanda the known natural energy resources include but not limited to hydro, solar, and methane gas. The current installed generation capacity is 235.61MW. The current electricity access plan (as of End June 2021) reveals that Rwanda's national electrification rate reached 65% (47.2% on grid connections, 17.8% off-grid connections).

II.2. Current Distribution Network Configuration

Electrical distribution is the final stage in the delivery of electricity to end users. The distribution system's network carries electricity from the transmission system and delivers it to consumers. Since the transmission system for Rwanda is typically rated from 220kV up to 110kV, substation

step-down transformers are used to bring the voltage levels down to under 30kV and 15 kV levels for distribution to consumers. As the distribution system is rated up to the voltage levels mentioned above, many large industrial end users will be fed at these voltage levels and will supply their own on-site substation that will step-down the voltage to more useful voltage levels for their facility.

For consumer consumption various step-down transformers and pole mounted transformers will be in the geographical region that will supply electricity for consumer use.

The Rwandan Distribution network is composed of 30 sub-stations (high and medium voltage) that include: Gikondo, Jabana, Mt Kigali, Birembo, Gasogi, Kigoma, Karongi, Rulindo, Musha, Mururu 1, Kilinda, Kabarondo, Rwinkwavu, Ntaruka, Mukungwa, Camp Belge, Kibogora, Mashyuza, Bugarama, Gatuna, Ntendezi, Rukarara, Gifurwe, Gabiro, Ndera, Nyabarongo I, Gahanga And Nzove, Bugesera, Shango. These substations have been found insufficient to cope with the existing and future electricity demand across the country. Therefore, investments have been allocated to putting in place required infrastructures into critically growing areas such as secondary cities, Bugesera and Kigali City with main purpose to stimulate demand, achieve a stable and reliable power supply in the country and interconnect the electrical network with neighboring countries. The distribution voltage is 30 kV country wide except Kigali and Rwamagana operating at 15 kV but this level of voltage is no longer developed as the GoR has an intention to phase it out and move to a single 30 kV distribution level.

Distribution networks are typically of two types, radial or networked. A radial feeder leaves the station and passes through the service area with no normal connection to any other supply. This is typical of long rural lines with isolated load areas.

A networked system, having multiple connections to other points of supply, is generally found in more urban areas. These points of connection are normally open but allow various configurations by the operating utility by closing and opening switches. Operation of these switches may be by remote control from a control center or by a lineman. The benefit of the networked model is that in the event of a fault or required maintenance a small area of network can be isolated, and the remainder kept on supply.

REG serves both residential, non-residential, business consumers and productive users.

Reports show remarkable strides that have been made by the Energy Development Corporation limited (EDCL), under which access to the grid has increased as follow:

INDICATOR	UNIT	JUNE 2018	JUNE 2019	JUNE 2020
On- grid Customer base growth	Connections	826,617	957,697	1,092,081
Off- grid Customer base growth	Connections	260,749	382,814	404,982
Productive users Cust. base growth	Connections	3,498	6,320	6,791

The government has committed to ensure universal access of all households to electricity by the year 2024. To realize that, significant investments have been made in extension of the existing network, closer to the end users. From the High Voltage transmission network, power is transported to end users through a string of Medium-to-Low-Voltage distribution infrastructure across the country. By end of the last fiscal year (2020-2021), a total of 27,217.81 km of distribution network had been laid across the country that comprises 9883.56 km of Medium voltage lines and 17334.25 km of Low voltage lines to enable end-user connections. The table below indicates the projections to 2024 and the required budget.

Description	As of June 2020	As of June 2021	By 2024	Required Budget (USD)
On-Grid	41% (1,092,081)	47.2% (1,278,604)	52% (1,734,485)	705.6 Million
Off-grid (SHS)	14.4% (404,982)	17.8% (482,049)	38.2% (1,274,180)	271.3 Million
Off-grid (MG)			9.8% (326,884)	97.9 Million
Total	55.41%	65%	100%	1.0 Billion

II.3. On-going Projects

Many projects are currently underway including new substations and feeders and reinforcement of existing substations, feeders and switching cabins. These are aimed at extending the distribution network to new areas to increase coverage and reinforcement of the existing network to

accommodate demand growth and improve power quality and reliability. This will also allow the smooth implementation of the National Electrification Plan (NEP).

II.4. Network Planning Issues

The distribution network suffers from poor reliability and quality of supply, which is generally due to underinvestment resulted to the lack of clear plans in the distribution part of the network. Some of the key issues identified during the development of this master plan are briefly described below.

II.5. Very long feeders

Many parts of the distribution network are supplied over extremely long, radial 30 kV and 15 kV feeders, with no alternative source of supply. In some cases, 30 kV feeders may be hundreds of km long, with many spurs, resulting in a total length (in extreme cases) in excess of 300 km supplied from a single source. A fault on such a long feeder will have wide-spread impact, be difficult to locate and therefore will result in a long restoration time.

These parts of the network are not surprisingly subjected to frequent and prolonged outages.

Due to excessive feeder lengths and use of undersized conductors, voltage levels on feeders, particularly outside of the urban areas (like Gisenyi, KKK, Butare and Kanazi feeders) are typically poor and significantly under the required standard.

Excessively long, undersized feeders also result in high losses. Furthermore, distribution infrastructure must be sized for both the delivered power and reduce power losses. For these two reasons, there is a financial incentive to reduce losses.

Economically, losses represent part of the generated energy and generation and transmission infrastructure must be sized for both the delivered power and losses. Losses therefore have both energy and capacity cost components and loss reduction measures on distribution networks should be considered as other component of generation investment.

Generally, however, provided distribution plant and feeders are not overloaded and voltage levels are within normal limits, the level of losses will be acceptable. The Distribution Master Plan includes studies to identify excessive feeder loading and poor voltage regulation and includes measures to address these issues.

II.6. Lack of (N-1) solution

This issue of course has a direct bearing on the 30 kV and 15 kV feeder lengths and the associated reliability and power quality issues.

REG is currently investing in new transmission lines and associated substations, both in Kigali and in other parts of the country. These new substations will relieve loading on existing overloaded feeders and will allow for shorter feeder lengths and greater levels of interconnection. These measures will therefore improve voltage levels and reliability. In some cases, the new feeders will result in extension of the grid to create opportunities of new customers to be connected to the grid and improve reliability of supply to those areas under construction or committed.

II.7. Network instability;

Distribution network is an important part of power system, as well as a giant system of complex uncertainty, which is a line of transmitting power from the distribution transformer to the power point, in order to supply power for each distribution substation of cities and various power loads.

A need to upgrade and reinforce the distribution network as per current demand and network operation situation is very recommended in order to have a stable network.

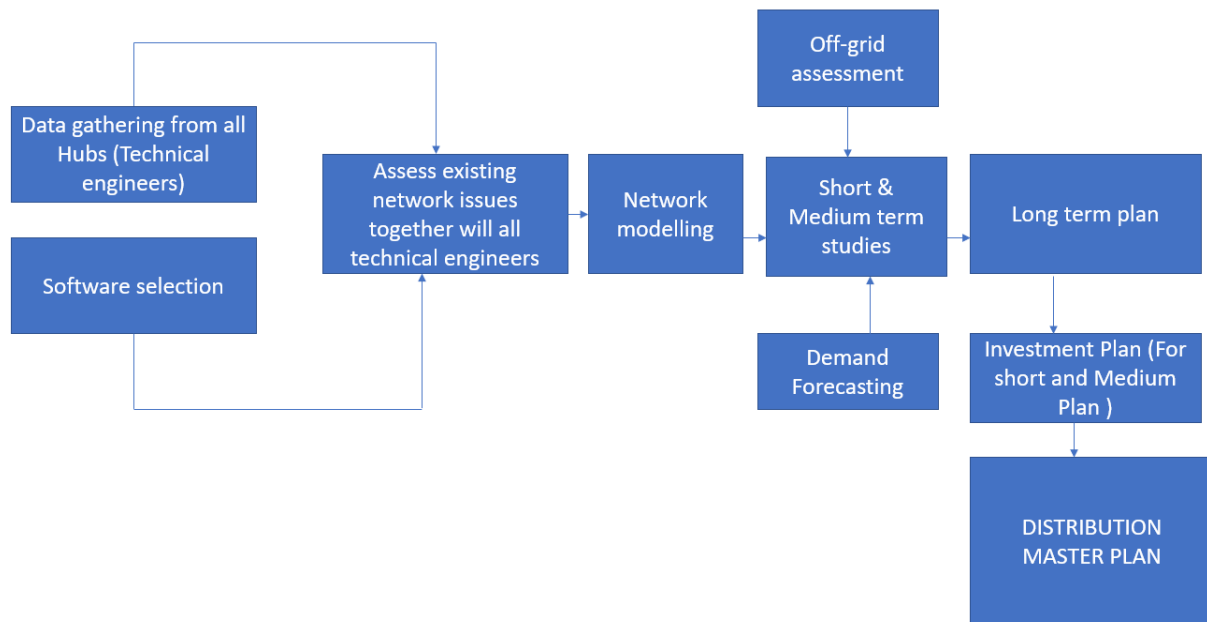
III. DISTRIBUTION MASTER PLAN APPROACH

III.1. Overview

Distribution master plan provide solution to the existing challenges mentioned in the network planning issues by:

- Reducing feeder length
- Reducing feeder load
- Upgrading existing lines
- Constructing new lines to share the load
- Planning for contingency supply
- Planning for future network
- Monitoring Distribution transformer loading status

The process by which the Distribution Master Plan was completed is shown in Figure:



Apart from the network data and models, key inputs to the planning studies were; the demand forecast and the standards guidelines.

Long term planning was based on the development of ‘generic networks’ to represent the different typical network Topologies and off-grid configurations as per NEP. These were used along with the county level demand forecast to determine the long-term investment requirements.

III.2. Data Gathering

Data gathering was conducted at feeder by feeder in the organized workshop together with all technical engineers operating the network in all hubs in order to consider all network issues in the plans. This was conducted in five teams from five hubs, each comprising all technical engineers of each hub.

The teams covered five hubs as follows:

- I. Kigali Hub.
- II. North Hub
- III. South Hub
- IV. East Hub

V. West Hub

The data obtained in the hubs were used to complete many gaps in the data obtained initially from the central offices and GIS information, this was with the purpose of minimizing the number of assumptions that needed to be made with respect to the network models.

Alternatively, data about the ongoing revisions of urban development master plans, irrigation and mineral processing areas were also collected from relevant institutions such as MINICOM, MINAGRI, Rwanda Mines Petroleum and Gas Board, Rwanda Housing Authority, and Local administration entities. During this update a projected electricity demand for the productive use areas, were estimated in this document upon acquisition of relevant data from projects owners.

IV. MODELLING OF MV/LV DISTRIBUTION NETWORK

The distribution network modelling is essential in the planning of the distribution network developments. This involves modelling of a wide range of cable sizes and types, substations locations, and transformer types and sizes, settlement of LV consumers and optimum feeder routing from LV consumers connected to distribution transformers.

Using the available software tools i.e. GIS database and the Power Factory/ Dig. SILENT, Validation of the available GIS database of the electrical network is required to transfer GIS data to an electrical model in power factory/ Dig. SILENT via DGS interface.

The following checks must be performed in order to efficiently transfer data from GIS to a power factory/Dig. SILENT electrical model. Further checks must be performed to validate the general structure of a database.

IV.1. Validation of attributes:

MV lines:

- Identify for each MV line whether substation/Feeder Name are correctly parametered to create the general architecture of the network
- Make sure that attributes of voltage and phase are correct
- Make sure that the conductor cross section and type are confirmed on site
- Identify mismatch of conductors (for example number of phases and conductor-type)

- Recalculate length for every MV lines

IV.2. MV/LV transformers:

- Identify for each MV/LV transformer that Substation / Feeder Name are correctly parameter to create the general architecture of the network
- Ensure that Capacity Nominal Power is entered as integer for every transformer
- Ensure that connection is correct (1ph or 3ph)
- Create a unique identifier for each MV/LV transformer

IV.3. Validation of topology

Connectivity of every element in the GIS must be ensured with a tolerance of 0.1m. This connectivity can be checked by using topology checkers and the following rules can be applied:

Items	Type	Topology rules
MV lines	Line	Must not have angles
MV/LV Transformers	Point	Must be covered by endpoint of lines
Switches	Point	Must be covered by endpoint of lines
Opening points	Point	Must be covered by endpoint of lines

IV.4. Network Modelling and Assessment of Existing Networks

The construction of the distribution network (30 kV and 15 kV) were preceding and these were initially used to assess the performance of the existing networks in each of the Five REG hubs and to identify specific network constraints and propose specific measures together with the branches technical engineers and hub managers and later to test the proposed solution by analyzing the load flow.

1. Modelling Methodology

- Distribution transformers are considered as Load
- A total of 4743 Distribution transformers have been modelled for the entire MV Network
- A total of 961 Distribution transformers have been modelled for the Northern Hub Network, 1077 for South, 1305 for East, 592 for West and 808 for Kigali
- Micro power plants Feeding into the MV Network have also been considered.

- Load scaling percentages have been set at 40%

2. Distribution Network Simulation results: Load scaling set at 40%

A. Simulation results for Kigali Hub MV Network

REG\ EUCL	Medium Voltage Network/Distribution Transformer are considered as a load and Scaled at 40%. Rigali Hub MV network			DIGSILENT PowerFactory 2018 SP1	Project: Modelling Date: 5/21/2021
Load Flow Calculation					Total System Summary
AC Load Flow, balanced, positive sequence Automatic tap adjustment of transformers Consider reactive power limits			No No	Automatic Model Adaptation for Convergence Max. Acceptable Load Flow Error for Nodes Model Equations	Yes 1.00 kVA 0.10 %
Total System Summary			Study Case: High and Medium Voltage Ne		Annex: / 1
No. of Substations	5	No. of Busbars	104	No. of Terminals	1025
No. of 2-w Trfs.	14	No. of 3-w Trfs.	0	No. of syn. Machines	0
No. of Loads	808	No. of Shunts/Filters	3	No. of SVS	0
Generation	=	0.00 MW	0.00 Mvar	0.00 MVA	
External Infeed	=	54.34 MW	33.21 Mvar	63.68 MVA	
Load P(U)	=	53.07 MW	39.80 Mvar	66.34 MVA	
Load P(Un)	=	53.07 MW	39.80 Mvar	66.34 MVA	
Load P(Un-U)	=	-0.00 MW	-0.00 Mvar		
Motor Load	=	0.00 MW	0.00 Mvar	0.00 MVA	
Grid Losses	=	1.27 MW	-2.09 Mvar		
Line Charging	=		-3.63 Mvar		
Compensation ind.	=		0.00 Mvar		
Compensation cap.	=		-4.50 Mvar		
Installed Capacity	=	0.00 MW			
Spinning Reserve	=	0.00 MW			
Total Power Factor:					
Generation	=	0.00 [-]			
Load/Motor	=	0.80 / 0.00 [-]			

Load Flow Result For Medium Voltage Network (considering 40% load scaling factor for all Transformers)				
Substation	Feeders	Load(MW)	Losses(MW)	Minimum Voltage(p.u)
KIGALI HUB(808 Transformer Considered)				
Birembo	Gikomero	1.152	0.009	0.988
Birembo	Kibagabaga/Nyarutarama	1.414	0.022	0.978
Birembo	Kibagabaga/Remera	1.077	0.009	0.987
Birembo	Kinyinya	2.405	0.073	0.96
Gahanga	Master Steel	0.685	0.004	0.993
Gahanga	Pylon 20	0.448	0.002	0.994
Gasogi	Inyange	1.971	0.058	0.951
Gasogi	kabuga	1.954	0.062	0.951
Gasogi	Kanombe	5.062	0.159	0.936
Gikondo	Gasogi	3.388	0.094	0.948
Gikondo	Gikondo Haut	1.542	0.005	0.993
Gikondo	Kimihurura	0.819	0.038	0.999
Gikondo	Nyarurama	0.49	0.001	0.998
Gikondo	Industrial	0.96	0.004	0.994
Gikondo	Kigali North	5.461	0.197	0.944
Gikondo	Kigali south	3.705	0.064	0.974
Jabana	Rutongo	2.742	0.217	0.892
Jabana	Deutch welle	0.919	0.013	0.983
Jabana	Kigali	4.358	0.095	0.957
Jabana	Sucrerie	0.613	0	0.999
Jabana	Utexirwa	2.867	0.063	0.97
Mt Kigali	Kanazi	0.224	0	0.999
Mt Kigali	Kiyumba	0.21	0	1
Mt Kigali	Nyamirambo	1.686	0.01	0.989
Mt Kigali	MNyarurama	0.714	0.007	0.988
Ndera	KSEZ1	3.13	0.034	0.979
Nzove	Abattoir	0.088	0	0.999
Nzove	Skol	2.92	0.034	0.975
Total for Kigali Substations		53.004	1.274	

B. Simulation results for Northern Hub MV Network

REG\ EUCL	Medium Voltage Network/Distribution Transformer are considered as a load and Scaled at 40%. Northern Network			DIGSILENT PowerFactory 2018 SP1	Project: Modelling Date: 5/21/2021		
Load Flow Calculation					Total System Summary		
AC Load Flow, balanced, positive sequence			No	Automatic Model Adaptation for Convergence		Yes	
Automatic tap adjustment of transformers			No	Max. Acceptable Load Flow Error for		1.00 kVA	
Consider reactive power limits			No	Nodes		0.10 %	
				Model Equations			
Total System Summary				Study Case: High and Medium Voltage Ne	Annex:	/ 1	
No. of Substations	8	No. of Busbars	43	No. of Terminals	1490	No. of Lines	1367
No. of 2-w Trfs.	19	No. of 3-w Trfs.	0	No. of syn. Machines	16	No. of asyn.Machines	0
No. of Loads	961	No. of Shunts/Filters	0	No. of SVS	0		
Generation	=	20.73 MW	1.86 Mvar	20.82 MVA			
External Infeed	=	8.32 MW	15.98 Mvar	18.01 MVA			
Load P(U)	=	27.46 MW	20.59 Mvar	34.32 MVA			
Load P(Un)	=	27.46 MW	20.59 Mvar	34.32 MVA			
Load P(Un-U)	=	0.00 MW	-0.00 Mvar				
Motor Load	=	0.00 MW	0.00 Mvar	0.00 MVA			
Grid Losses	=	1.60 MW	-2.76 Mvar				
Line Charging	=		-5.93 Mvar				
Compensation ind.	=		0.00 Mvar				
Compensation cap.	=		0.00 Mvar				
Installed Capacity	=	28.88 MW					
Spinning Reserve	=	8.15 MW					
Total Power Factor:							
Generation	=	1.00 [-]					
Load/Motor	=	0.80 / 0.00 [-]					

Load Flow Result For Medium Voltage Network (considering 40% load scaling factor for all Transformers)				
Substation	Feeders	Load(MW)	Losses(MW)	Minimum Voltage(p.u)
NORTHERN HUB(961 Transformer Considered)				
Camp belge	Gisenyi	9.403	1.086	0.999
Camp belge	Kinigi	1.064	0.004	1
Camp belge	Prime cement	1.44	0.004	1.002
Gifurwe	Gakenke	0.589	0.002	0.996
Gifurwe	Kirambo	0.525	0.001	0.997
Gifurwe	Ntaruka	0.064	0.1135	1
Mukungwa	Remera	0.333	0.1135	1.019
Mukungwa	Janja	0.362	0.004	1.019
Mukungwa	campbelge/Ruhengeri	0.882	0.11	1.01
Ntaruka	Ruhengeri	0.486	0.001	0.996
Ntaruka	Cyanika	0.528	0.001	0.997
Rulindo	Base	0.738	0.003	0.995
Rulindo	Byumba	4.373	0.149	0.952
Rulindo	Gasiza	0.595	0.001	0.997
Rulindo	Musasa	0.936	0.007	0.99
Total for Northern Substations		22.318	1.6	

C. Simulation results for Southern Hub MV Network

REG\ EUCL	Medium Voltage Network/Distribution Transformer are considered as a load and Scaled at 40%. Southern Hub MV network			DigSILENT PowerFactory 2018 SP1	Project: Modelling		
					Date: 5/21/2021		
Load Flow Calculation					Total System Summary		
AC Load Flow, balanced, positive sequence			No	Automatic Model Adaptation for Convergence		Yes	
Automatic tap adjustment of transformers			No	Max. Acceptable Load Flow Error for			
Consider reactive power limits			No	Nodes		1.00 kVA	
				Model Equations		0.10 %	
Total System Summary				Study Case: High and Medium Voltage Ne		Annex: / 1	
No. of Substations	16	No. of Busbars	19	No. of Terminals	1744	No. of Lines	1526
No. of 2-w Trfs.	9	No. of 3-w Trfs.	0	No. of syn. Machines	0	No. of asyn.Machines	0
No. of Loads	1077	No. of Shunts/Filters	0	No. of SVS	0		
Generation	= 0.00 MW	0.00 Mvar		0.00 MVA			
External Infeed	= 38.05 MW	23.26 Mvar		44.60 MVA			
Load P(U)	= 35.58 MW	26.68 Mvar		44.47 MVA			
Load P(Un)	= 35.58 MW	26.68 Mvar		44.47 MVA			
Load P(Un-U)	= 0.00 MW	0.00 Mvar					
Motor Load	= 0.00 MW	0.00 Mvar		0.00 MVA			
Grid Losses	= 2.47 MW	-3.43 Mvar					
Line Charging	=	-6.55 Mvar					
Compensation ind.	=	0.00 Mvar					
Compensation cap.	=	0.00 Mvar					
Installed Capacity	= 0.00 MW						
Spinning Reserve	= 0.00 MW						
Total Power Factor:							
Generation	= 0.00 [-]						
Load/Motor	= 0.80 / 0.00 [-]						

Load Flow Result For Medium Voltage Network (considering 40% load scaling factor for all Transformers)				
Substation	Feeders	Load(MW)	Losses(MW)	Minimum Voltage(p.u)
SOUTHERN HUB(1077 Transformer Considered)				
Mt Kigali	Kiyumba	3.72	0.037	0.967
Kigoma	Butare	13.632	1.578	0.801
Kigoma	Gatumba	4.911	0.184	0.938
Kigoma	Ntongwe	5.246	0.318	0.908
Rukararall	Rukararall	8.038	0.357	0.921
Total for southern Substations		35.547	2.474	

D. Simulation results for Eastern Hub MV Network

REG\ EUCL	Medium Voltage Network/Distribution Transformer are considered as load and scaled 40% Eastern Hub MV network			DigSILENT PowerFactory 2018 SP1	Project: Modelling		
					Date: 5/21/2021		
Load Flow Calculation					Total System Summary		
AC Load Flow, balanced, positive sequence			No	Automatic Model Adaptation for Convergence		Yes	
Automatic tap adjustment of transformers			No	Max. Acceptable Load Flow Error for		1.00 kVA	
Consider reactive power limits				Nodes Model Equations		0.10 %	
Total System Summary				Study Case: High and Medium Voltage Ne		Annex: / 1	
No. of Substations	8	No. of Busbars	14	No. of Terminals	1936	No. of Lines	1844
No. of 2-w Trfs.	0	No. of 3-w Trfs.	0	No. of syn. Machines	0	No. of asyn.Machines	0
No. of Loads	1305	No. of Shunts/Filters	0	No. of SVS	0		
Generation	= 0.00 MW	0.00 Mvar	0.00 MVA				
External Infeed	= 38.87 MW	25.53 Mvar	46.51 MVA				
Load P(U)	= 35.97 MW	26.97 Mvar	44.96 MVA				
Load P(Un)	= 35.97 MW	26.97 Mvar	44.96 MVA				
Load P(Un-U)	= 0.00 MW	-0.00 Mvar					
Motor Load	= 0.00 MW	0.00 Mvar	0.00 MVA				
Grid Losses	= 2.91 MW	-1.45 Mvar					
Line Charging	=	-4.29 Mvar					
Compensation ind.	=	0.00 Mvar					
Compensation cap.	=	0.00 Mvar					
Installed Capacity	= 0.00 MW						
Spinning Reserve	= 0.00 MW						
Total Power Factor:							
Generation	= 0.00 [-]						
Load/Motor	= 0.80 / 0.00 [-]						

Load Flow Result For Medium Voltage Network (considering 40% load scaling factor for all Transformers)				
Substation	Feeders	Load(MW)	Losses(MW)	Minimum Voltage(p.u)
EASTERN HUB(1305 Transformer Considered)				
Mt Kigali	Kanazi	7.064	0.5	0.86
Gabiro	Kiziguro	2.645	0.034	0.973
Gabiro	Ngarama	0.92	0.003	0.993
Gabiro	Nyagatare	5.807	0.326	0.904
Kabarondo	KKK	2.438	0.055	0.968
Kabarondo	Zaza	5.213	0.27	
Musha	Karenge	2.394	0.202	0.86
Musha	Redmi	0.288	0.001	0.994
Musha	Rwamagana	2.893	0.143	0.918
Musha	Steelrwa	3.811	0.071	0.975
Rwinkwavu	Akagera	2.491	1.301	0.567
Total for Eastern Substations		35.964	2.906	

E. Simulation results for Western Hub MV Network

REG\ EUCL	Medium Voltage Network/Distribution Transformer are considered as a load and Scaled at 40%. Western Hub			DigSILENT PowerFactory 2018 SP1	Project: Modelling Date: 5/21/2021		
Load Flow Calculation					Total System Summary		
AC Load Flow, balanced, positive sequence Automatic tap adjustment of transformers Consider reactive power limits			No No	Automatic Model Adaptation for Convergence Max. Acceptable Load Flow Error for Nodes Model Equations		Yes 1.00 kVA 0.10 %	
Total System Summary				Study Case: High and Medium Voltage Ne		Annex: / 1	
No. of Substations	18	No. of Busbars	45	No. of Terminals	1089	No. of Lines	845
No. of 2-w Trfs.	24	No. of 3-w Trfs.	0	No. of syn. Machines	7	No. of asyn.Machines	0
No. of Loads	592	No. of Shunts/Filters	0	No. of SVS	0		
Generation	=	4.57 MW	0.05 Mvar	4.57 MVA			
External Infeed	=	19.75 MW	11.92 Mvar	23.07 MVA			
Load P(U)	=	23.93 MW	17.92 Mvar	29.90 MVA			
Load P(Un)	=	23.93 MW	17.92 Mvar	29.90 MVA			
Load P(Un-U)	=	0.00 MW	0.00 Mvar				
Motor Load	=	0.00 MW	0.00 Mvar	0.00 MVA			
Grid Losses	=	0.39 MW	-5.95 Mvar				
Line Charging	=		-6.62 Mvar				
Compensation ind.	=		0.00 Mvar				
Compensation cap.	=		0.00 Mvar				
Installed Capacity	=	7.23 MW					
Spinning Reserve	=	2.66 MW					
Total Power Factor:							
Generation	=	1.00 [-]					
Load/Motor	=	0.80 / 0.00 [-]					

Load Flow Result For Medium Voltage Network (considering 40% load scaling factor for all Transformers)				
Substation	Feeders	Load(MW)	Losses(MW)	Minimum Voltage(p.u)
WESTERN HUB(592 Transformer considered)				
Gihira	Goma	6.071	0.059	0.996
Karongi	Gisovu	0.272	0.001	1.017
Karongi	Kibuye	3.574	0.1	0.968
Karongi	Mugonero	0.437	0.001	1.016
Kibogora	Nyamashyeke	0.541	0.001	0.997
Kibogora	Rwakina	0.669	0.002	0.996
Kilinda	Birambo	0.443	0.001	0.998
Kilinda	Hospital	0.032	0	1
Mururu1	Mashyuza	2.741	0.061	0.969
Mururu2	Shyagasha	2.469	0.01	0.993
Ntendezi	Kibogora	0.554	0.001	0.999
Ntendezi	Mururu1	0.638	0.002	0.998
Nyabarongo	Nyabarongo Auxiliary	0.12	0	1
Rubavu	Rubavu	5.234	0.215	0.996
Total for Western Substations		23.795	0.454	

E. Summary of simulation results

LOSSES IN THE MEDIUM VOLTAGE NETWORK PER REGION

Region(Hub)	Losses in (MW)	% Contribution to Total
Kigali	1.274	14.63%
North	1.6	18.37%
South	2.474	28.41%
East	2.906	33.37%
West	0.454	5.21%
Total	8.708	

F. Segregation of Distribution Network losses

Energy entering MV distribution system	840,634,065	kWh		
Energy lost in MV lines	26,947,500	kWh	3.09%	4.92%
Energy lost in MV/LV transformers	16,018,562	kWh	1.84%	
No-load losses	11,314,211	kWh		
Load losses	4,704,351	kWh		
Energy entering LV distribution system	797,668,003	kWh		
LV network losses	34,846,249	kWh	3.99%	5.09%
Street lights	8,238,214	kWh	0.94%	
Connection losses	403,505	kWh	0.05%	
Metering system losses	956,663	kWh	0.11%	

Over 19.1% total losses, distribution Networks contribute 10.01%

IV.4.1. Demand Forecasting

The demand forecast contained within the Least Cost Power Development Plan (LCPDP) extracted from IHS mark report was used for the study. Country demand growth rates were applied to the respective substations to determine substation demands for the network studies. Country growth rates were also used to determine investment requirements at a county level.

IV.4.2. Short-medium term planning

The existing network models were used as the basis for the short-medium term planning studies. Ongoing and committed projects were also considered during this study. The outcome of these studies was a list of projects that would be required beyond the ongoing and committed projects, in order to meet the forecast demand whilst satisfying the planning criteria.

The short-medium term investment requirements at 30 kV and 15 kV were determined directly from these lists of projects by applying estimated project costs.

IV.4.3. Updating the Distribution Master Plan

The Master Plan is based on many assumptions, not least the demand forecast. It is reviewed every six months and modified as necessary to reflect changes in the underlying assumptions. The network planning software (Digsilent) provides the flexibility to readily incorporate changes and assess new requirements.

V. DEMAND FORECAST

V.1. Introduction

This section highlights the information on electricity demand countrywide. This focus on projection of customer up to 2024 (100% connection) and electricity demand to 2030. Electricity demand forecast was made as Peak demand (average) excluding electricity losses and reserve margin.

V.2. Electricity Demand as defined in ESSP (Energy Sector Strategic Plan) report

The Energy Sector Strategic Plan (ESSP) for 2018/19-2023/24 presents the current status of, and plans for, the energy sector, covering its three subsectors: electricity, biomass and petroleum. In this report we focus on electricity side only.

Table: Projection of household's connection

Indicators	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
New On-Grid Connections	163,914	148,201	160,466	173,624	187,472	202,734
On-Grid Connection Rate	34.5%	38%	41.5%	45%	48.5%	52%
New Off-Grid Connections	283,507	220,262	271,266	255,706	274,286	293,938
Off-Grid Connection Rate	17%	23%	30%	36%	42%	48%
Households Connected (Million)	1.5	1.8	2.3	2.7	3.2	3.7
Households Connection Rate	51.5%	61%	71.5%	81%	90.5%	100%
Households Projection (Million)	3.1	3.2	3.3	3.5	3.6	3.7

Source: ESSP 2018/19-2023/24 and NISR 4th PHC report 2012.

As stated in table 1, forecast of electricity demand include household's electricity demand as the main consumer of electricity produced in Rwanda. Thus, after 2024 will be a new plan for connecting off-grid connected households to grid electricity.

V.3. Generation vs Demand from LCPDP

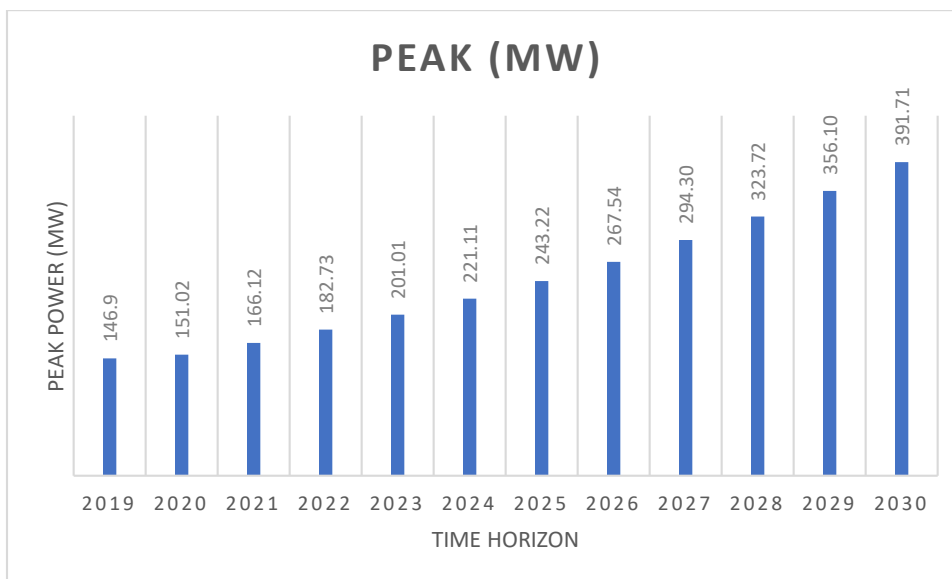
Table: National Installed Capacity throughout the planning horizon

Year	2020	2025	2030
Hydro (MW)	209.602	232.74	273.84
Solar (MW)	11.95	11.95	11.95
Biomass (MW)	0	0	11.98
Methane (MW)	25.9	81.8	81.8
Peat (MW)	86.9	86.9	86.9
Thermal (Diesel) (MW)	27.8	27.8	27.8
HydroPS (MW)	0	0	33.59
TOTAL (MW)	362.152	441.19	527.86

Source: LCPDP, 2020

Table 2 show that, national demand will be satisfied by the available resources such as: hydro, solar, biomass, methane, peat, thermal and hydro pumping station. The installed capacity is enough to satisfy demand maximum peak, reserve margin (15% constant all the year) and losses (planned to be reduced from 20% by 2018/19 to 15% 2023/24).

Peak Demand projection 2019 to 2030 with reference to LCPDP



Source: LCPD, 2020

LCPDP has considered 10% of growth from 2019 to 2030. Thus, by 2030 there a requirement of 392 peak demand while from the same report, there is a plan of reaching 527.86 MW of installed capacity.

V.4. Country statistics

Here main statistics related to the energy sector are population characteristics (as resulted by EICV5) and projection of National GDP (because household's projection was presented in table "Projection of household's connection").

Table: National economy main indicators

No	Area	Indicator Name	2005/06	2010/11	2013/14	2016/17
			EICV2	EICV3	EICV4	EICV5
1	Poverty	Poverty	56.7	44.9	39.1	38.2
2		Extreme Poverty	35.8	24.1	16.3	16.0
3		GINI index	0.5	0.5	0.4	0.429
4	Demography	Average household size	5.0	4.8	4.6	4.4
5		Mean dependence ratio	87.0	85.7	82.7	80.0
6		Number of males per 100 females	90.3	90.2	91.6	92.4
7	Education	Percentage of individuals (6+ years) that have ever attended school	78.7	83.2	86.1	87.2
8		Net Attendance Rate in Primary School	86.6	89.6	87.9	87.6
9		Net Attendance Rate in Secondary School	10.4	17.8	23.0	23.2
10		Literacy rate among people aged 15-24	76.9	83.1	86.2	86.5
11	Housing	Percentage of households living in Umudugudu	17.6	37.5	49.2	58.9
12		Percentage of households with thatch or leaves roof	9.8	2.2	0.4	0.0
13		Percentage of households with metal sheet roof	43.7	54.4	61.1	67.3
14		Percentage of households with cement floor	13.3	17.1	21.1	25.8
15		Percentage of households with electricity as main source of lighting	4.3	10.8	19.8	27.1
16		Percentage of households with oil lamp as main source of lighting	12.7	9.7	5.0	1.4
17		Percentage of households with candle as main source of lighting	1.6	5.9	7.4	6.1
18		Percentage of households with firewood as main cooking fuel	88.2	86.3	83.3	79.9
19		Percentage of households with charcoal as main cooking fuel	7.9	10.6	15.2	17.4
20		Percentage of households with crop waste as main cooking fuel	2.7	2.3	0.8	0.6
21		Percentage of households with improved drinking water source	70.3	74.2	84.8	87.4
22		Percentage of households with improved sanitation	58.5	74.5	83.4	86.2

No	Area	Indicator Name	2005/06	2010/11	2013/14	2016/17
			EICV2	EICV3	EICV4	EICV5
23		Percentage of households owning radio set	46.7	60.2	59.8	73.8
24		Percentage of households owning TV set	2.4	6.4	9.9	10.4
25		Percentage of households owning computer	0.3	1.7	2.5	3.3
26		Percentage of households with access to internet	-	3.7	9.3	17.2
27		Percentage of households owning mobile phone	6.2	45.2	63.6	66.9
28		Percentage of households owning bicycle	12.9	13.4	15.8	13.3
29	Health	Average time (in minutes) to reach a health center	95.1	61.4	56.5	49.9
30		Prevalence of health insurance	43.3	68.8	70.0	73.9
31	Economic Activities	Percentage of workers in wage farm	8.2	9.8	11.7	15.9
32		Percentage of workers in wage non-farm	10.9	16.8	18.5	21.0
33		Percentage of independent/small-scale farmer	71.3	61.2	59.7	53.2
34		Percentage of Independent non-farm	8.1	9.6	9.2	8.9
35	Saving	Percentage of households with at least one savings account	18.9	36.1	54.1	54.7

Source: EICV5 (NISR, 2018)

Table: Gross Domestic product by Kind of Activity at current prices (in billion Rwfs) 2018/19

Activity description (basic prices)	2018-19	2018-19
Gross domestic product (GDP)	8,596	100%
Agriculture, forestry & fishing	2,380	28%
Industry	1,456	17%
Total Manufacturing	510	6%
Electricity	100	1%
Water & waste management	47	1%
Construction	586	7%
Services	4,150	48%
Trade & Transport	1,050	12%
Other Services	3,101	36%
Taxes less subsidies on products	609	7%

Source: National Institute of Statistics of Rwanda 9/16/2019

VI. PLANNING APPROACH

VI.1. Assessment of Existing Networks

VI.1.1. General overview of existing network

It is important to consider that the laws of physics ultimately dictate the physical operation of the electric system and that the foundation for system planning starts with rigorous power flow analysis of the current system to fulfill obligations to provide safe, reliable service to customers at a reasonable cost.

More specifically, this engineering analysis assesses the maximum electricity demand for each distribution feeder. The demand forecast used in this analysis is typically based on deterministic methods using historical peak loading. The purpose is to ensure that the feeders can supply customer demands and maintain the feeder voltages within established standards. Some reserve capacity on each feeder is also desirable to allow for new loads to be added on the feeder and enable operational flexibility to switch sections of one feeder onto an adjacent feeder for outage restoration and maintenance. Additionally, an assessment of current feeder and substation reliability, condition of grid assets, asset loading, and operations is performed along with a comparative assessment of current operating conditions against prior forecasts.

VI.1.2. Rwanda Distribution network structure

Substation	Feeder	Length(km)	Number of Transformers
Gikondo	Nyarurama	2.1	5
	Kimuhurura	11	19
	Kigali nord	17	38
	Gikondo haut	9	19
	Kigali sud	20	40
	Parc indust.	18	41
	Gasogi	34.9	42
	Gikondo-ministere	3.7	
	2 spares		
Jabana	Kigali	88	82
	Rutongo	90	74
	D. Welle	38.5	35
	Utexrwa	22	42
	Sucrierie	0.5	3
	2 spares		
Mt kigali	Kiyumba	152	87
	Kanazi	265	155

Substation	Feeder	Length(km)	Number of Transformers
	Nyamirambo	30	42
	Nyarurama	2	5
	2 spares (30kv)		
	2 spares (15kv)		
Birembo	Gikomero	24	45
	Kinyinya	20	32
	Kibagabaga/remera	8	13
	Kbgbg/nyarutarama	15	29
	Kimironko	7.5	
	No spare		
Gahanga	Master steel	16	
	Pylon20	6	
Gasogi	Kanombe	122.5	120
	Inyange	8.5	3
	Kabuga	99	55
	No spare		
Kigoma	Butare	552	230
	Gatumba	266	163
	Ntongwe	286	183
	1 spare		
Karongi	Kibuye	281	146
	Gisovu	36	5
	Mugonero	34	12
	No spare		
Rulindo	Byumba	482	150
	Base	76	51
	Musasa	95	51
	Gasiza		
	1 spare		
Musha	Rwamagana	109	81
	Karenge	67	33
	Redemi	11.5	9
	Steel rwa		
	Rubona solar	9	Evacuation solar
	Rwamagana industrial park		
Mururu 1	Shagasha	84	58
	Mashyuza	85	57
	No spare		
Kilinda	Birambo	74	48
	Hopital	1.5	2
	No spare		
Kabarondo	Kiziguro(kkk)	224	146
	Zaza	561	386
	No spare		
	Akagera	140.5	69
	Redemi	11.5	9
	4 spares		

Substation	Feeder	Length(km)	Number of Transformers
Ntaruka	Ruhengeri		
	Cyanika	42	26
	No spare		
Gisenyi	Poids lourds	24.6	
	Gihira	15.5	
	Serena.cpgl	0.8	1
Mukungwa	Ruhengeri		
	Remera	33	26
	Janja	49	33
	No spare		
Camp belge	Mukungwa (input)	4	4
	Ntaruka (input)	27	14
	Gisenyi (input)	43.5	255
	Mukungwa (output)		
	Ntaruka (output)		
	Gisenyi (output)	427	
	Kinigi	34	25
	No spare		
Kibogora	Nyamasheke	7	10
	Rwakina	66	46
	2 spares		
Mashyuza	Cimerwa 1	0.2	2
	Cimerwa 2		
	Bugarama	18	11
	2 spare(defected)		
Bugarama	Cimerwa export		
	No spare		
Gatuna/import from ug	Byumba	2.4	2
	No spare		
Ntendezi	Kibogora	32	19
	Mururu 1	33	27
	2 spares		
Rukarara	Rukarara 2 from ss	527	244
	Rukarara 2 from hpp		
	2 spares		
Gifurwe	Gakenke	36	
	Ntaruka	9	
	Kirambo		
	1 spare		
Gabiro	Nyagatare	362	226
	Ngarama	105	30
	2 spares		
Ndera	Free zone i	0.6	
	Free zone ii		
	Birembo		
	Gikomero	60	62
	2 spares		

Substation	Feeder	Length(km)	Number of Transformers
Gahanga	Master steal	16	19
	Pylone 20	6	5
	2 spares		
Rwinkwavu	Akagera	102	
	Redemi2		
Nzove	Skol/nzove	8	
	Nyabugogo/abbatoir	11.5	
	1 spares		
Nyabarongo I			
	Nyabarongo auxiliary	3	
Total		9673.40	5071

New substations are being proposed in new areas with feeders to reduce the length and the load on existing feeders as per the table below:

S/N	Substation	Expected commissioning date	District
1	Musanze	2021	Musanze
2	Nyabihu	2021	Nyabihu
3	Rubavu	2022	Rubavu
4	Muhanga	2026	Muhanga
5	Huye	2022	Huye
6	Gisagara	2021	Gisagara
7	Kirehe	2023	Kirehe
8	Gicumbi	2025	Gicumbi
9	Nyagatare	2023	Nyagatare
10	Nyabarongo 2	2022	Muhanga
11	Bugesera ss	2021	Bugesera
12	Bugesera Industrial Park ss	2022	Bugesera
13	Two Bugesera airport SS	2021	Bugesera
14	Shango	2021	Kigali

The above Distribution assets are serving bellow entire network divided in five hubs comprising utility branches structured to the Country administrative boundaries:

- i. Kigali Hub (Nyarugenge Branch, Kanombe Branch, Kacyiru Branch, Kicukiro Branch, Rulindo Branch, Bugesera Branch, Gicumbi Branch and Jabana Branch).
- ii. Northern Hub (Gakenke, Musanze, Rubavu, Burera, Nyabihu and Ngororero)
- iii. Southern Hub (Muhanga, Nyanza, Huye, Gisagara, Nyamagabe and Nyaruguru)

- iv. Eastern Hub (Rwamagana, Kayonza, Ngoma, Kirehe, Gatsibo and Nyagatare) and
- v. Western Hub (Karongi, Rutsiro, Nyamasheke and Rusizi)

VI.1.3. Assessment existing network

VI.1.3. 1. Loss Reduction Programmes

The economic justification means that a loss reduction programme is usually cost effective and can be implemented within relatively short timescales. A loss reduction programme normally follows these steps:

- Understanding the problem
- Correcting or optimizing designs
- Implementing network standards
- Maintenance and construction procedures

VI.1.4. Understanding the Problem

It is possible to estimate typical losses based on models (generally only technical losses) but to be able to quantify the actual losses and where best to target loss reduction efforts, physical measurements will need to be taken. Therefore, the first steps in a loss reduction programme would be to initiate changes to allow for better data collection, metering, and energy auditing.

This will include:

- Acquiring field data i.e. feeder routes and sizes
- Building network models
- Meter installation and meter reading programme
- Systems and procedures developed and implemented to allow future energy auditing

After the energy auditing, an impact of each project on the contribution of energy losses reduction can be calculated and reported.

VI.1.5. Correcting or Optimizing Designs

Designs associated with construction or rehabilitation work should consider the economic impact of losses. This economic consideration when sizing conductors and transformers should ensure that REG not only minimizes losses to an economic level, but also implements not the lowest construction cost solution, but the lowest lifetime cost solution. The lowest construction cost solution result in early upgrade and rehabilitation which cost all most the same as construction of new facilities, an example of single-phase upgrade which require REG more than 20 billion USD for the entire network.

VI.1.6. Implementing Network Standards

Generally, losses will be maintained at acceptable levels if reticulation standards are followed, and network parameters are maintained within the planning limits identified REG standards. This means keeping:

- Voltage within required range;
- Equipment loaded to standard levels; and
- Power factor will be optimized by maintaining it at the level of 80%. To achieve this, we need to impose to the productive user clients, to install power factor correction devices if they do not meet the minimum PF network requirement.
- Maintenance and Construction Procedures
- Another way to reduce losses at the distribution level is to ensure that maintenance is done regularly; and if this is done regularly, additional costs should be minimal.

VI.1.7. Planning challenges and Recommendations

During the data collection when developing this distribution master plan, it was observed that essential network planning data is not always readily available such as the loading capacity of distribution transformers, the productive use sectors such as mining and other bulk loads which are going to be established in many areas are not able to approximate the exact load in their business plans. For a better planning of electricity distribution network, REG has taken initiatives such as installation of smart meters on distribution transformers while approximation of load

capacity for productive use sectors will be done gradually based on best practices from existing similar projects.

In order to improve the efficiency and effectiveness of the network planning process, it is essential that as built network of the whole country is conducted and being updated regularly in order to have the updated database which will guide future plans and increase the quality of results.

VI.2. Short-Medium Term Plan

VI.2.1. General basis for Expansion Plan

This section of the plan describes the short-medium term distribution network expansion plans that have been developed for each of the hub (feeder by feeder) to cover the period up to 2024.

The plans take account of the many ongoing and committed distribution reinforcement and expansion projects that have received funding and are due for completion over the next few years. Ongoing and committed transmission projects are also considered to the extent that they will impact on the distribution network. These are essentially extensions of the transmission network to create new substations, which provide more feeders to the distribution network.

Detailed network analysis has been conducted for each of the regions covering each year from 2019 – 2024 and further distribution projects have been proposed over the short-medium term period, beyond the ongoing and committed projects mentioned above. The need for additional substations and reinforcement of existing substations has also been identified across the network as detailed below on the list of proposed new projects.

VII. Planning of Electricity supply in Kigali City

1. Introduction

Kigali City is rapidly urbanizing, and with the changing dynamics of population, demand, lifestyles and socio-economic conditions of its residents, an integrated and inclusive urban planning to achieve sustainable economic growth and social well-being. The economy of the City of Kigali has experienced positive GDP growth in the last decade averaging **6.5%**. The city is

projected to continue growing between **6.5% and 10%** for the next three decades pertaining to enormous investments taking place especially in the service, trade and manufacturing sectors.

Given the migration trend to Kigali, the pressure of urbanization and development on the City and after cross-referencing with other ongoing studies (IGC), the resident population of Kigali City will reach about **3.8 million by 2050** according to the high population growth scenario from IPAR studies.

Electricity infrastructures among others underpin the economic, social, and environmental performance of life in cities. They are the basic spatial infrastructure grids, which, quite literally, provide the fundamental conduits through which modern cities operate.

With the current electricity access averaging at 66.3% in Kigali City with Kicukiro at 89%, Gasabo at 57%, Nyarugenge at 53%, Rwanda Energy Group (REG) through its subsidiary companies (EUCL & EDCL) is targeting to achieve **100% electricity access in Kigali City by 2021**, increase the productive use of electricity through demand simulation incentives.

With the above mentioned ambitious targets, the electrical load is expected to grow in the following trend:

2. Anticipated Major load on Kigali Hub Network (2021-2023)

Load Category	Total Load (MW) (2021-2023)	Additional Loads in each year			Planned Connection Feeder	Substation
		2021	2022	2023		
Big Industries	3.3	1.5	1.3	0.5		
Rwanda Engineering and Manufacturing Corporation (REMCO)	1.3	0.9	0.4		Freezone 1/Freezone 2	Ndera
Extension of Aldango Ltd Refineries	0.3	0.2	0.1		Freezone 1/Freezone 2	Ndera
Extension of SKOL Brewery Industry	0.5	0.1	0.3	0.1	Nzove	Nzove
Extension of Inyange Industries	0.3	0	0.3		Inyange	Gasogi
Others	0.9	0.3	0.2	0.4		
Commercial complexes + Big Offices	7.1	2.7	1.7	2.7		
African Leadership University	0.1	0.1			Freezone 1 or Freezone 2	Ndera
Adventist University of Central Africa-Masoro	0.1	0.1			Kimironko	Birembo
I & M Bank Building	0.3	0.3			Kigali South	Gikondo
Albert Supply Building	0.7	0.7			Kibagabaga-Nyarutarama	Birembo
National Archive Building	0.2	0.2			Kinyinya	Birembo
NSIT Office Building	0.2	0	0.2		Kigali South/North	Gikondo
Nobelia Business Center	0.3	0.1	0.2		Kigali South/North	Gikondo
Defense Research & Development (DRD)	0.7	0.7	0		Nyarurama	Mt.Kigali/Gikondo
University of Rwanda Offices & Hostels	0.3	0.1	0.2		Kigali South/North	Gikondo
Nzovu Mall (Former MINJUST)	0.7	0.1	0.1	0.5	Kimihurura/KBC	Gikondo
Mall du Plateau	0.5	0.1	0.2	0.2	Kigali South/North	Gikondo
West Gate Commercial Complex	0.3			0.3	Abbatoir	Jabana
Equity Bank Building	0.3			0.3	Kigali South/North	Gikondo
CATCHUP Commercial Building (opposite U)	0.3			0.3	Kigali South/North	Gikondo
Kigali International Finance and Business Ce	0.7		0.3	0.4	Kigali South/North	Gikondo
Extension of KBC (Jade Water Group)	0.4		0.2	0.2	Kimihurura/KBC	Gikondo
Others	1	0.2	0.3	0.5		
Hotels & Apartments	1.8	0.9	0.6	0.3		
Sheraton Hotel	0.3	0.3			Kigali South/North	Gikondo
Torch Africa	0.2	0.1	0.1		Kigali North	Gikondo
Pacific Hotel	0.1	0.1			Gasogi	Gikondo
New Century Hotels	0.2	0.1	0.1		Kibagabaga-Nyarutarama	Birembo
Golf Course Developments	0.2	0.1	0.1		Kibagabaga-Nyarutarama	Birembo
Kiyovu Hotels & Apartments	0.4	0	0.2	0.2	Kigali South/Ministerie	Birembo
Others	0.4	0.2	0.1	0.1		
Small Industries (SMEs) & Modern Market	4.1	1.3	1.3	1.5		
Extension of King Faisal Hospital	0.4	0.3	0.1		Kinyinya	Birembo
Extension of Kanombe Military Hospital	0.3	0.1	0.1	0.1	Kanombe	Gasogi
Extension of Masaka Hospital	0.7		0.4	0.3	New Masaka	Gasogi
Kimironko Market Expansion	0.3			0.3	Kimironko	Birembo
Gako beef project	1	0.5	0.3	0.2	Kanazi	Mont Kigali
NAEB Storage facility	0.2	0	0	0.2	Parc Industriel	Gikondo
Extension of Dubai Ports World	0.4	0.2	0.1	0.1	New Masaka	Gasogi
Rebero Cultural Village	0.4	0	0.2	0.2	Nyarurama	Mt.Kigali/Gikondo
Others	0.4	0.2	0.1	0.1		
Airport & Stadium Expansion	2.4	0.7	0.9	0.8		
Expansion of Kanombe International Airport	0.6	0.2	0.2	0.2	Kanombe/Gasogi	Gasogi/Gikondo
Gahanga Intertainment City	1.2	0.5	0.4	0.3	Pylon20	Gahanga
Extension of Amahoro Stadium	0.6		0.3	0.3	Nyarutarama/Remera	Birembo
Water Treatment plants	1.7	0.7	0.6	0.4		
Kanzenze Water plants	0.7	0.4	0.3		Kanazi	Mt.Kigali
Others	1	0.3	0.3	0.4		
Real Estate Projects	5.3	1.1	2.1	2.1		
Remote Group Estate (Nyamirambo)	0.2	0.1	0.1		Nyamirambo	Mt.Kigali
Remote Group Estate (Masaka)	0.2		0.2		Kanombe	Gasogi
Expansion of Vision City	0.4		0.2	0.2	Kinyinya	Birembo
Opulent Park Nearby Century Park	0.3			0.3	Kibagabaga-Nyarutarama	Birembo
Norrskén Kigali House Project	0.4		0.1	0.3	Kibagabaga-Nyarutarama	Birembo
Gahanga Model Village	0.1	0.1			Master steel	Gahanga
Busanza Re-settlement Area	0.1		0.1		Gasogi	Gikondo
Batsinda Real Estate Project	0.2		0.1	0.1	Deutsche Welle	Jabana
Next Generation Housing Estate-Bumbogo	0.3		0.2	0.1	Gikomero	Ndera
Kigali Green City-Kinyinya	1	0.2	0.4	0.4	Deutschwelle	Birembo
Kigali Innovation City (KIC) Masoro	1.5	0.5	0.5	0.5	Free zone 1/2	Ndera
Others	0.6	0.2	0.2	0.2		
Street lights+ CCTV Cameras	0.5	0.2	0.2	0.1		
Street lights on newly constructed roads	0.3	0.1	0.1	0.1	All kigali feeders	All Kigali SS
Security Cameras on all Roads	0.2	0.1	0.1		All kigali feeders	All Kigali SS
Industrial Parks	9.8	0.9	4.4	4.5		
Bugesera Gashora Industrial Park(20 to 25M	3.3		3.5	3.5	Bugesera IP	Bugesera IP
Gahanga Industrial Park(6.6 to 10MW)	1.6	0.5	0.5	0.6	Mastersteel	Gahanga
Bugesera tanery Park(3MW)	1.2	0.4	0.4	0.4	Tanery Park	Bugesera IP
Total Projected load Growth	36.0					
Maximum available Load (as of June 2020)	151.0					
Yearly Total Load Increment (MW)		22.6	27.5	29.2		

Status of Existing Electricity Infrastructure after anticipated Major loads (2021-2023)

The major electricity infrastructures in Kigali is composed of the High voltage (HV), medium voltage (MV) and low voltage networks (LV). The major substations and MV feeders supplying the load in Kigali area is illustrated in the table below:

SUBSTATION	Existing Transfo MVA	Feeder	Length (km)	Conductor Size	Maximum Current (A)	Max Power Capacity (MW)	Peak Power [MW]	% Loading at Peak (Calculated)	Load Increment on Feeders(MV) as per the anticipated major loads	% Feeder Loading increment (2021-2023)
BIREMBO	1*20	Kibgbg/Nyarutarama	15	ACSR 120/20 mm²	410	8.52	3.7	43.43%	1.8	64.55%
		Kibagabaga /Remera	7.4	ACSR 120/20 mm²	410	8.52	4.7	55.16%	0.9	65.72%
		Kimironko	7.5	ACSR 70/12 mm²	290	6.03	5	82.92%	0.9	97.84%
		Kinyinya	19.3	ACSR 120/20 mm²	410	8.52	4.4	51.64%	1	63.38%
Total						17.8		4.6		
GAHANGA	1*20	Master Steel	16	ACSR 70/12 mm²	290	6.03	1.3	21.56%	2	54.72%
		Pylon 20	6	ACSR 70/12 mm²	290	6.03	1.64	27.20%	1.8	57.05%
Total						2.94		3.1		
GASOGI	1*20	Inyanga	8.5	ACSR 70/12 mm²	290	6.03	1.319	21.87%	0.5	30.16%
		Kabusa	99	ACSR 120/20 mm²	410	8.52	1.047	12.29%	1.2	26.37%
		Kanombe	136	ACSR 120/20 mm²	410	8.52	5.84	68.54%	1.1	81.45%
Total						8.206		2.8		
GIKONDO	3*15	Gasogi	34.93	ACSR 120/20 mm²	410	8.52	6.77	79.46%	0.2	81.80%
		Gikondo Haut	9	ACSR 70/12 mm²	290	6.03	1.52	25.21%		
		Kigali North	16	ACSR 120/20 mm²	410	8.52	7.25	85.09%		
		Kigali South	20	ACSR 120/20 mm²	410	8.52	6.3	73.94%	3.1	110.32%
		Kimihurura	11	ACSR 150/25 mm²	410	8.52	2.95	34.62%	1.5	52.23%
		Nyarurama	2.1	ACSR 70/12 mm²	290	6.03	0.58	9.62%	1.1	27.86%
		Ministerie	3.72	CU/XLPE/PVC 1+ 240 mm²	596	12.39	3.5	28.25%	0.7	33.89%
		Parc Industriale	18	CU/XLPE/PVC 1+ 95 mm²	323	6.71	2.78	41.43%	0.4	47.39%
Total						31.65		7		
JABANA 1	2*10	D.Welle	39	ACSR 120/20 mm²	410	8.52	1.57	18.43%	1.2	32.51%
		Kigali	90	ACSR 120/20 mm²	410	8.52	4.02	47.18%	0.2	49.53%
		Rutorongo	90	ACSR 70/12 mm²	290	6.03	1.61	26.70%	0.1	28.35%
		Sucrerie	0.5	CU/XLPE/PVC 1*50 mm²	210	4.36	0.31	7.11%	0.1	9.40%
		Utexerwa	22	ACSR 70/12 mm²	290	6.03	4.13	68.49%	0.2	71.8
Total						11.64		1.8		
MONT KIGALI	1*20	Kanazi	265	ACSR 120/20 mm²	410	17.04	8.49	49.82%	2	61.56%
		Karumba	184	ACSR 120/20 mm²	410	17.04	2.3	13.50%	0.6	17.01%
		Nyamirambo	29.25	ACSR 120/20 mm²	410	17.04	3.6	21.13%	0.6	24.64%
		Nyarurama	2.5	ACSR 70/12 mm²	290	12.05	1.9	15.77%		29.04%
Total						16.29		3.2		
NDERA	2*20	Birembo	15	ACSR 120/20 mm²	410	8.52	3.12	36.62%		
		Free zone 1	1.5	ACSR 120/20 mm²	410	8.52	5.68	66.67%	3.2	104.22%
		Gikomero	28	ACSR 120/20 mm²	410	8.52	1.9	22.30%	0.6	29.34%
Total						10.7		3.8		
NZOVE	1*20	Abattoir	11.5	ACSR 120/20 mm²	410	8.52	2.6	30.52%	0.7	38.73%
		Nzove	8	ACSR 120/20 mm²	410	8.52	5.21	61.15%	0.8	70.54%
Total							7.81		1.5	
Bugesera IP(Planned)		IP							7	
		Imana Steel								
		Gakoo beef							1.2	
		Buffet solar								
Total									8.2	
Grand Total									36	

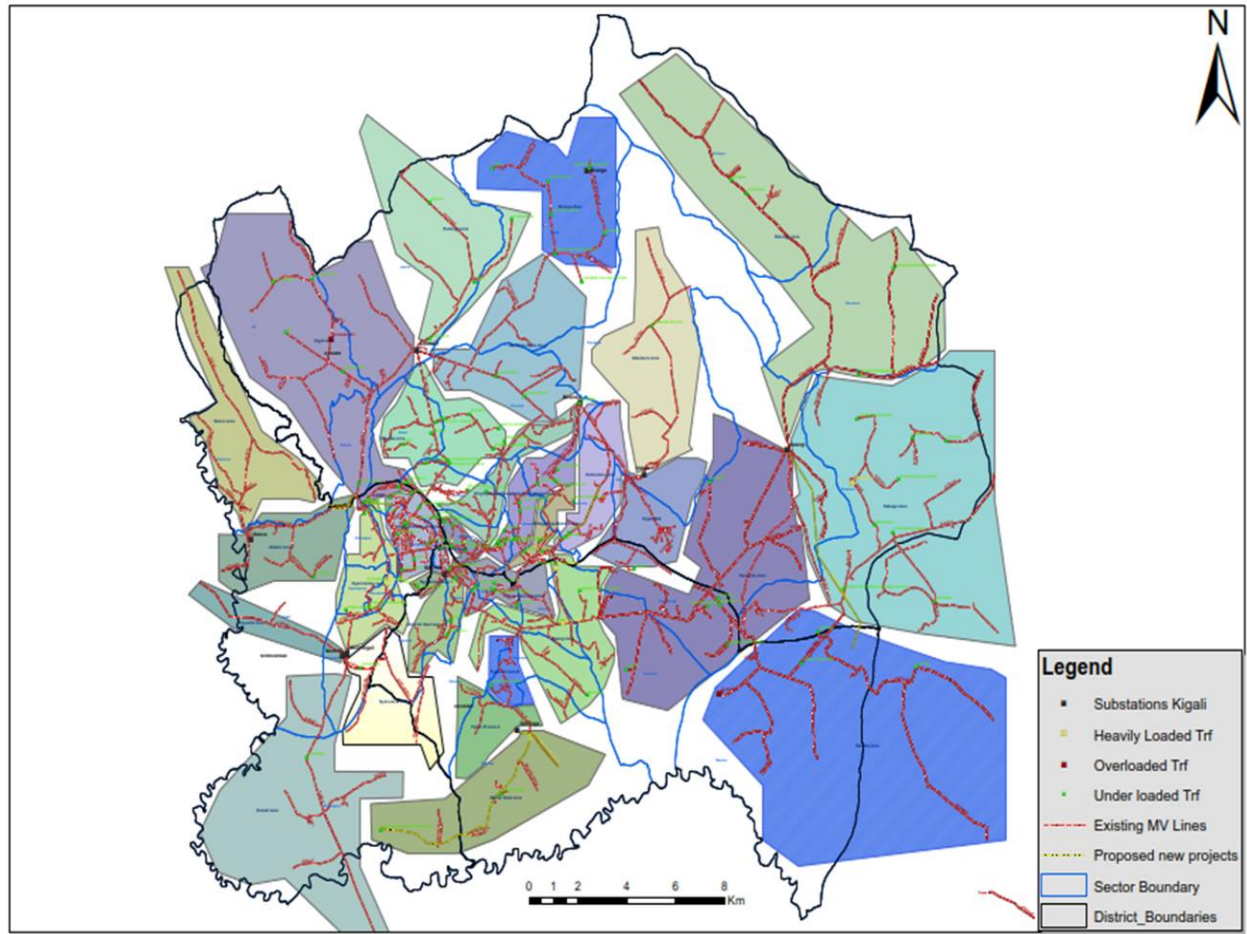
Currently the distribution network in Kigali is composed of **1207.1km** of medium voltage and **1884.453km** of low voltage. The distribution network is growing significantly to accommodate the increasing load and reinforcements to improve on the quality of power supply. The figure

below illustrates the zone supplied by each MV feeder from main substations, areas with voltage drop issues, some of the major sections of the lines that need to be reinforced.

Zoning of Main Feeders from Substations, areas with voltage drop issues & Distribution transformer status

In Kigali, 22 zones were identified following the existing feeders, substations as well as cabins. Details are on the table 3 below:

S/N	Name	Feeders	Substation
1	Kigali zone	Kigali	Jabana 1
2	Nzove zone	Skol	Nzove
3	Abatoir zone	Abatoir	Nzove
4	Kiyumba zone	Kiyumba	Mont Kigali
5	Nyamirambo zone	Nyamirambo	Mont Kigali
6	Mageragere zone	Kanazi	Mont Kigali
7	Gahanga zone	Master Steel	Gahanga
8	Gatenga zone	Pylon 20	Gahanga, Gikondo
9	Kigali SEZ	Gikomero	Ndera
10	Kanombe zone	Kanombe, Kabuga	Gasogi
11	Kimironko zone	Kimironko	Birembo
12	Rutongo zone	Rutongo	Jabana
13	Utexrwa zone	Utexrwa	Jabana 1
14	Deutsche Welle	Deutsche	Shango
15	Kinyinya zone	Kinyinya	Birembo
16	Nyarutarama zone	Kibagabaga-Nyarutarama	Birembo
17	Kigali North-South Zone	Kigali North, Kigali South	Gikondo dispatch
18	Kabuga zone	Kanombe	Gasogi
19	Gikondo Haut zone	Gikondo Haut	Gikondo
20	Pylon 20 zone	Gasogi	Gikondo
21	Former Park Industriel	Parc Industriel	Gikondo
22	Kimihurura zone	Kimihurura	Gikondo



1. Key Network challenges in the Kigali distribution network

- Overloading or nearly over load of some transformers at substations.
- Lack of a fast switching mechanisms to allow load transfer in times of contingencies.
- The existing low voltage electrical network in parts of Nyarugenge i.e. Kiyovu and the CBD is old, poorly designed and laid thus subjecting them to frequent faults that require frequent interventions.
- Voltage drops in some parts of Kigali are below acceptable limits with very low voltage at the end of the feeder.
- Single phase network in some fast growing areas in the out skirts of Kigali.

2. Initiatives to reinforce power supply in Kigali area (Each to be described separately)

- Replacement of Power transformers at Gikondo Substation, 3*15MVA with new big ones (3*30MVA)
- Extension of Birembo Substation with a new 20MVA transformer
- Extension of Nzove substation with a new 20MVA transformer

- Extension of Gahanga substation with a new 20MVA, with an upgrade of Master steel feeder
- Upgrade of Gasogi Substation from 10MVA to 30MVA, construction of MV line from Gasogi SS to Masaka Center
- Link of new Shango Substation to distribution Network
- Rehabilitation of Low Voltage U.G Network in Nyarugenge (Kiyovu and the CBD)
- Renovation of existing Electro-Mechanical MV/LV Cabins in Kigali
- Construction of switching MV/LV Cabins
- Reconductoring and Construction of MV links to facilitate configuration (Load transfer between feeders)
- Network strengthening projects that include construction of Switching cabins with remote control via SCADA and associated distribution lines (11 cabins, 8 cabins and 25 cabins under the new multi donor project)
- Rehabilitation of LV network and renovation of cabins in in Nyarugenge
- Upgrade and extension of MV lines to solve voltage drop issues
- Upgrade of existing LV lines
- Upgrade of single phase network

3. Major projects to improve the loading on some feeders:

Kimironko Feeder:

1. Upgrade of the conductor size of main feeder Kimironko to 120sqmm from 70sqmm
2. Transfer of Load to Gasogi feeder from Gikondo at Christus cabin.
3. Extension of Birembo Substation with a new 20MVA transformer

Gasogi Feeder:

1. Transfer of current load on Gasogi to pylon 20 from Gahanga substation
2. Extension of pylon 20 cabin with a double bus-bar to facilitate load transfer between pylon 20 feeder and Gasogi feeder (Long term project)
3. Upgrade of power transformers at Gikondo Substation
4. Extension of Gahanga substation to reduce load on both Gikondo, Gasogi and Mont. Kigali S/S

Kigali North & South Feeders:

1. Construction of MV link from Abattoir cabin in Nyabugogo to Minplan Cabin to allow power flow from Jabana or Nzove substations into cabins feeding the city center
2. Construction of new double circuit MV line from Nzove S/S to Abattoir Cabin
3. Upgrade of power transformers at Gikondo Substation
4. Extension of Nzove substation

Kanombe Feeder:

1. Upgrade of Gasogi substation with a new transformer
2. Construction of new feeder dedicated to serve Masaka area i.e. a new zone shall be created reducing the area served by Kanombe feeder

Kanazi Feeder:

1. Extension of Gahanga Substation
2. Construction of switching cabin at Kanzenze to facilitate load transfer
3. Upgrade of Master Steel feeder and its extension to serve parts currently served by Kanazi feeder

Utexrwa Feeder:

1. Rehabilitation of MV line from Gacuriro Cabin-Fawe-ULK-Urubwitso, this will facilitate switching of power from Kinyinya feeder from Birembo Substation
2. Construction of Switching cabin at Fawe to facilitate fast load transfer

Nzove Feeder:

1. Extension of Nzove substation with a new 20MVA transformer
2. Construction of new switching cabin at Nzove (near SKOL and WASAC) to allow fast load transfer with power from Kigali feeder from Jabana Substation

4. Distribution Network strengthening projects

Kigali has experienced a rapid increase of electricity demand for the last 26 years due to development of different income generating activities. REG has planned to refurbish some of existing electricity infrastructures not only to be able to satisfy the increasing demand, but also to have a reliable power with flexibility of operations. Several projects to refurbish the existing MV/LV distribution cabins and associated MV Lines have been completed and many more in pipeline. This shall provide a comprehensive switching mechanism to allow a reliable power supply with a minimum contingency of N-1 and remotely monitor load via SCADA.

4.1. On-going 8 Cabins

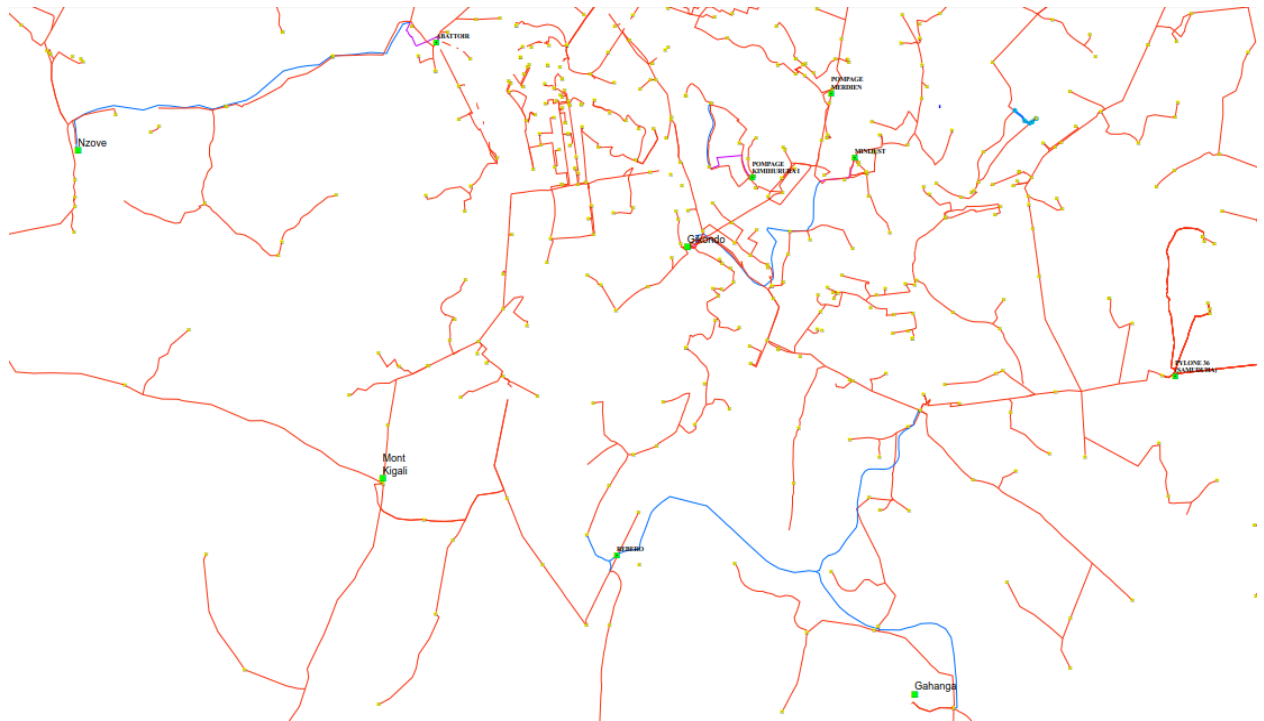
Projects being implemented consist of construction of 8 switching substations and their associated MV lines located in different parts of Kigali:

No	List of Cabins	Specific Area	District
1	Abattoir	Nyabugogo	Nyarugenge
2	Amba Zaire	Kiyovu	Nyarugenge
3	Portofino	Gacuriro	Gasabo
4	Pompage Merdien	Kacyiru	Gasabo
5	Pompage Kimihurura	Kimihurura	Gasabo
6	Rebero	Rebero	Kicukiro
7	Samuduha	Samuduha	Kicukiro
8	MINJUST	Kimihurura	Gasabo

Section of MV lines to be constructed in the 8 cabins project

No	Section		New or Upgrade	Length (km)	
	From :	To:		O.H	U.G
1	Nzove	Abattoir Nyabugogo	Upgrade	7	0.15
2	Kabuga ka Nyarutarama		New	0.6	
3	Pylon 20-Nyanza-Gahanga	Nyanza-Rebero-Gikondo	New	11	
4	Samuduha	Kanombe Airport	Upgrade	0.9	6.35
5	Remera Control Technique		New	0.6	
6	Kimihurura Water Pump	ATS Ruhamanya	Upgrade	1.1	1.1
7	Ugandan Embassy	CSR Kacyiru cabin	New	1	0.2
8	Saint Andre	Pylon 8	Upgrade		0.6
9	Gikondo-Rwandex-	MINJUST	Upgrade	6	0.23
	Total			28.2	8.63

A map showing the cabins to be rehabilitated (Green spots) and the MV lines (Blue) to be constructed



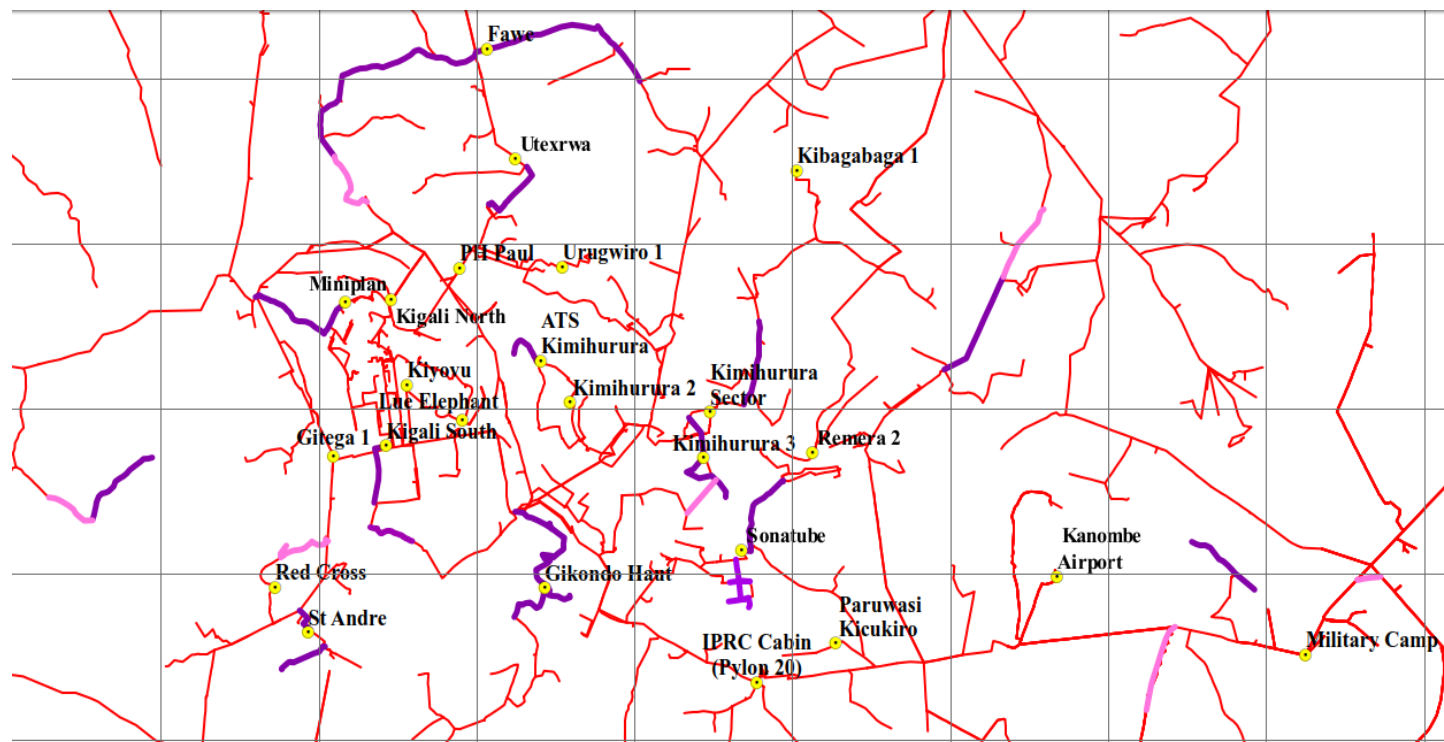
4.2. Scope for upgrade of Nyarugenge network

Rehabilitation of existing LV Underground cables in parts of Nyarugenge City

Section	Area in Nyarugenge	Total Length (km)	No of Distribution Panels
Ambassade Zaire	Kiyovu	4.636	27
Belle vie gakinjira	City Center	1.785	24
Belle vie karamira	City Center	1.506	22
Boulevard Central	City Center	1.334	18
Bureau Pedagogique	City Center	2.513	15
Cercle sportif	Kiyovu	0.766	18
Chat Sauvage	Kiyovu	3.858	43
Cooperation	Kiyovu	3.005	14
Eto Muhima	City Center	2.679	34
Simba	City Center	1.719	13
Ewsa magasin central	City Center	1.565	12
Jeunesse	Kiyovu	2.892	17
Kigali Sud	City Center	0.521	1
La galette	City Center	1.616	15
Lyce francais	Kiyovu	1.629	9
Maternite	City Center	0.661	16
Ministere	City Center	1.426	14
NAHV	City Center	0.496	4
Onatracom	City Center	1.673	41
Pompage Rugunga	Kiyovu	0.641	12
Rue Elephant	Kiyovu	3.879	20
Soras Ville	City Center	1.298	20
TZF	City Center	1.979	16
Total (LV upgrade)		44.075	425

4.3. Proposed switching MV/LV cabins and MV lines

A map showing the switching cabins and MV lines to be constructed in Kigali City



	Name of MV/LV Cabin in Kigali	District
1	Kiyovu	Nyarugenge
2	Utexrwa	Gasabo
3	Miniplan	Nyarugenge
4	Remera 2	Gasabo
5	Sonatube	Kicukiro
6	Kanombe Airport	Kicukiro
7	Gikondo Haut	Kicukiro
8	Kigali North	Nyarugenge
9	Kigali South	Nyarugenge
10	IPRC Cabin (Pylon 20)	Kicukiro
11	PH Paul	Gasabo
12	Urugwiro 1	Gasabo
13	Kibagabaga 1	Gasabo

14	Gitega 1	Nyarugenge
15	Lue Elephant	Nyarugenge
16	Military Camp	Kicukiro
17	Nzove (Near SKOL)	Nyarugenge
18	ATS Kimihurura	Gasabo
19	Kimihurura 2	Gasabo
20	St Andre	Nyarugenge
21	Fawe	Gasabo
22	Paruwasi Kicukiro	Kicukiro
23	Red Cross	Nyarugenge
24	Kimihurura 3	Gasabo
25	Kimihurura Sector	Gasabo

Construction and rehabilitation of MV Lines in Kigali

No	Section		District	Length (km)		Requirement
	From :	To:		O.H	U.G	
1	Gikondo SS	PH APAPE	Kicukiro	3.5		Upgrade
2	Fawe	Gacuriro	Gasabo	2.5		Upgrade
3	Mt-Kigali	Rebero-Nyarurama	Kicukiro	4		New
4	T-OFF SCAF	Rubangura	Kicukiro	1.5		Upgrade
5	Kabuga 2 Cabin	Kabuga	Gasabo	0.5		Upgrade
6	Utexrwa Cabin	Caisse Hypotaicare	Gasabo	1.5		Upgrade
7	Miniplan	Abatoir	Nyarugenge		1.5	New
8	Kigali sud	Onatracom Cabin	Nyarugenge		1	New
9	Kimironko Prison	Le printemps	Gasabo	2		Upgrade
10	Chez Rasta	ATS Cabin	Gasabo		1.5	New
11	Ministere	Kiyovu	Nyarugenge		1.2	New
12	Nyarutarama 1	Nyarutarama 2	Gasabo	1		Upgrade
13	Busanza Cementry	Busanza AirForce	Kicukiro		1	Upgrade
14	Busanza AirForce	Rubirizi Hatchery	Kicukiro	3		New
15	Murindi Cabin	T-OFF Masaka	Kicukiro		0.5	New
16	Karama-Norvege	Mt-Kigali	Nyarugenge	5		New
19	Remera 1	Sonatube	Gasabo		1	Upgrade
20	Pompage Nyirnuma	Agatare	Nyarugenge	2.2		New
21	Mumena	Kivugiza	Nyarugenge		0.5	Upgrade

22	St Andre	Pylon 8	Nyarugenge		0.5	Upgrade
23	Fawe	ULK-Urwibutso	Gasabo	5		New
24	Munanira	Nyakabanda	Nyarugenge		0.5	Upgrade
25	MINJUST-Lemigo	Kimihurura 3-Rukiri	Gasabo		3	New
26	Rukiri	INILAK	Gasabo	1		New
	Total			32.7	12.2	

4.4. Details of Areas with Voltage drop issues in Kigali HUB and proposed Actions to be taken

Below are the areas identified with voltage drop. However, 52 areas were identified to have a critical voltage drop. Criticality is based on voltage level below 200V

BRANCH	LOCATION	Voltage Level (V)	PROBLEM (YES or NO)			RECOMMENDED ACTION			
			Overloaded Transformers	Undersized cables	Over-extended LV network	Extend MV and Insert new Tx		LV NETWORK (reconduct and reconfigure)	
						Length of MV (km)	Transformer size (kVA)	LV length (km)	Poles
JABANA	Nyagasozi(kabuye - jabana)	185	No	Yes	Yes	0	0	1.5	30
	Gashyushya-jali	190	Yes	No	No	0	0	1.5	30
	Nyacyonga centre	200	Yes	No	No	0	0	0.8	16
	Kanyinya- nyamweru	195	Yes	No	No	1	160	1.2	24
	Nzove	180	Yes	No	Yes	0.7	400	0.5	10
	Rwinyana -gatsata	155 v	Yes	Yes	Yes	1	200	0.5	10
	Nyagasozi -gatsata	180	Yes	Yes	Yes	2	160	1.5	30
	Mont julu	170	Yes	No	Yes	1	160	0.5	10
						5.7	5	8	160
KICUKIRO	Rwabutenge	169v	Yes	No	Yes	1.85	200	1	20
	Rukatsa	180v	Yes	No	Yes	1.2	250	1	20
	Kagasa	165	Yes	Yes	Yes	2.6	100,100,100	2	40
						5.85	5	12.5	250
KACYIRU	Rwintare	155 v	Yes	No	Yes	1.35	200	0	0
	Rukingu	160v	No	Yes	Yes	1	200	4	80
	Byimana	170v	No	Yes	Yes	0.003	200	3	60
	Gasharu	170	No	Yes	No	1	200	10	200
	Kabuhunde	190	No	Yes	No	0	0	3	60

	Kamutwa	200	No	No	No	0	0	4	80
	Ntora	190	No	Yes	No	0	0	7	140
	Murama	170	No	Yes	No	0	0	8	160
						3.353	4	39	780
GICUMBI	Gisuna	160	Yes	Yes	Yes	1	200	3	60
	Byumba/kinihira	145	No		Yes	0	0	2	40
	Kamitsinga	160	No	Yes	Yes	0	0	1.5	30
	Gasharu	180	No	Yes	Yes	0	0	1	20
	Kabuga	180	Yes	Yes	Yes	0.5	100	2	40
	Kibali/bureshi	150	Yes	Yes	Yes	1.5	100	2	40
	Murama/kivugiza	150	Yes	Yes	Yes	2	100	2	40
	Karago	160	Yes	Yes	Yes	0	0	2	40
	Kinishya	140	Yes	Yes	Yes	2	100	4	70
	Gatuna	160	Yes	Yes	Yes	0.2	100	1	20
	Miyove/kacyiru	170	Yes	Yes	Yes			1	20
	Miyove/banda	180	Yes	Yes	Yes	0.5	100	1	20
	Bushara	170	Yes	Yes	Yes	1	100	3	60
	Nyabubare	170	Yes	Yes	Yes	1	100	2.5	50
	Total					9.7	9	27.5	550
NYARUGENGE	Agatare	168 v	Yes	No	Yes	3	200	1.5	30
	Munanira	165				0.6	250	1	20
	Rugarama-rwarutabura	145-165				1.5	250	1	20
	Rugarama-gasharu	170				2	160	1	20
	Gasiza	160				3	200		0
	Bonjour- akarekare	180				2	315	3	60
	Mumena- irembo	185				0.5	250	1	20
	Musave	175				2.5	160		0
	Mataba	170				2	160	1	20
	Kigali-norvege	170				0	200		0
	Total					17.1	10	22.5	190
KAMONYI	Ruyenzi - tambwe	170	Yes	No	Yes	0	100	0	0
	Ruyenzi - kimoteri	180	No	No	Yes	0	0	1.5	30
	Muganza - adepr	175	No	No	Yes	0.5	100	0	0
	Rugarika - sheli	180	Yes	No	Yes	0	100	1.5	30
	Runda - muganza	188	Yes	No	Yes	0.5	50	2	40
	Runda - bimba	178	Yes	No	Yes	0	0	0	0
	Runda - musebeya	179	Yes	No	Yes	0	0	0	0
	Mugina - mbati	180	Yes	No	Yes	0	0	0.5	10
						1	4	5.5	110

REMERA	Musave	180	No	Yes	Yes	1	200	2	40
	Mukuyu	158	Yes	Yes	Yes	2.5	100	3	60
	Masizi p h	179	No	Yes	Yes	0.1	100	2	40
	Ngara	182	Yes	Yes	Yes	1.5	100	2	40
	Uwaruraza	175	Yes	No	Yes	1	100	2	40
	Kiriza ii	176	Yes	Yes	Yes	0	0	3	60
	Nyirabwana	182	No	Yes	Yes	2	400	3	60
	Total					8.1	7	17	340
RULINDO	Rutonde	195v	No	-	No	-	-	0.0	0
	Kagwa	185v	No	-	No	-	-	0.0	0
	Shyorongi market	190v	No	-	Yes	1.5	50	2.0	40
	Shyorongi parish	185v	No	-	No	-	-	0.0	0
	Kijabagwe g.s	189v	No	-	Yes	2.0	50	1.5	30
	Centre de santé rwahi	192v	No	-	No	-	-	0.0	0
	Nyabyondo	195v	No	-	Yes	1.5	50	2.0	40
	Centre de santé rutonde	188v	No	-	No	-	-	0.0	0
	Ngarama	198v	No	-	Yes	2.0	25	2.0	40
	Nyirangarama	198v	No	-	Yes	2.0	50	2.0	40
	Kiruri/ kidomo	185v	No	-	Yes	2.0	50	1.5	30
	Base/ gitovu village	185v	No	-	Yes	0.0	25	2.2	44
	Total					11.0	7	13.2	264
KANOMBE	Masaka(cyimo)rui ikinamba	161	No	Yes	No	0.5	250		
	Busanza(nyarugugu)	160		Yes	No	1.5	160		
	Nyarugunga (bpr)	180		Yes	No	0.5	200		
	Busanza(gashyushya)	175		Yes	No	1	100		
	Nyagahinga (gisharara)	160		Yes	No	0.5	100		
	Muyumbu (redemuta)	162		Yes	No				
	Nyarugunga(gasaraba)	175		Yes	No	0.5	315		
	Kanombe (itunda(mosque))	186		Yes	No	0.5	200		
	Rusheshe 2	170		Yes	No	0	200		
	Masaka(ayabaraya)	180		Yes	No	0.5	160		
	Total					5.5	9	18.5	370
BUGESERA	Bidudu(gashora- biryogo)	184	No	Yes	Yes	0		1.5	30
	Karusine (gashora- ramiro)	187	Yes	Yes	Yes	0		1	20
	Kingaju(juru-musovu)	184	No	Yes	Yes	0		1	20
	Pamba i (kamabuye- kampeka)	184	No	Yes	Yes	0		0.5	10

	Gakindo (mayange-gakindo)	185	No	Yes	Yes	0		1	20
	Komesa(musenyi-musenyi)	186	No	Yes	Yes	0		1	20
	Kagasa(mwogo-rurenge)	184	No	Yes	Yes	0		1.5	30
	Nyarunazi (ntarama-kibungo)	188	Yes	Yes	Yes	1	50	1.5	30
	Kurugenge,karumuna (ntarama-kanzenze)	184	0	Yes	Yes	1	50	1.5	30
	Kabeza (ntarama-kabeza)	184	0	Yes	Yes	0		1	20
	Cyeru (ntarama-kanzenze)	184	Yes	Yes	Yes	0		1.5	30
	Kabaha (ntarama-kanzenze)	185	0	Yes	Yes	1	25	1	20
	Rwanza (nyamata-kayumba)	188	No	Yes	Yes	0.05	15	1.5	30
	Gatare (nyamata-kayumba)	184	No	Yes	Yes	0		1	20
	Kibari (nyamata-nyamata v)	185	No	Yes	Yes	0.05	25	1.5	30
	Maranyundo (nyamata-muyange)	186	No	Yes	Yes	0.05	15	1.5	30
	Gasenga (nyamata-maranyundo)	184	Yes	Yes	Yes	0.1	25	1.5	30
	Nyabagendwa (rilima-nyabagendwa)	188	No	Yes	Yes	0.1	160	1.5	30
	Rizieri (rilima-kabeza)	184	Yes	Yes	Yes	0		1.5	30
	Mubano (ruhuha-ruhuha)	189	No	Yes	Yes	0		0.8	16
	Nyiragiseke(rweru)	189	No	Yes	Yes	0		1.2	24
	Gasenyi(rweru)	189	No	Yes	Yes	0		1	20
	Muyoboro(rweru,nemba)	189	No	Yes	Yes	0		1	20
	Total						3.35	8	28
TOTAL FOR KIGALI HUB						62.6	68	174.7	3,574

	<i>Scope of Works</i>	UoM	Qty	Cost estimate for Supply & Installation	
				U.price	T.price
KIGALI HUB (10 branches)	Extension of MV lines	km	62.6	29,916,550	1,872,776,030
	Insertion of New Transformers (with protective devices & LVDB)	pc	68	12,500,000	850,000,000
	LV Network Reconductoring and Reconfiguration	km	174.7	9,625,000	1,681,487,500
	Total 1				4,404,263,530

4.5. Single Phase Network Upgrade

MV & LV lines to be upgraded (km)	89.4
Transformers to be upgraded	23
Total Budget Required (USD)	1,364,553,215

4.6. On-Grid Access Plan in Kigali (2021)

4.6.1. Kicukiro and Bugesera

Name	Type	HHS	KVA	Sector	Cell	Village
Kabeza	Proposed	44	25	Gahanga	Karembure	Kabeza
Kanyetabi	Proposed	43	25	Masaka	Rusheshe	Kanyetabi
kAMASHASHI	Proposed	34	25	Masaka	Mbabe	Kamashashi
Rususa2	Proposed	34	25	Masaka	Ayabaraya	Rususa
Nyakarambi	Proposed	45	25	Masaka	Gitaraga	Nyakarambi
Rugasa	Proposed	83	50	Gahanga	Nunga	Rugasa
Nyabigugu 1	Proposed	67	50	Gahanga	Murinja	Nyabigugu
GicacaI	Proposed	66	50	Masaka	Gako	Gicaca
Nyamyijima	Proposed	75	50	Masaka	Ayabaraya	Nyamyijima
Nunga I	Proposed	67	50	Gahanga	Nunga	Nunga I
Mubuga	Proposed	56	50	Gahanga	Karembure	Mubuga
Ngarama	Proposed	65	50	Masaka	Mbabe	Ngarama
Ayabaraya	Proposed	67	50	Masaka	Ayabaraya	Ayabaraya
Ruyaga	Proposed	49	50	Masaka	Gako	Ruyaga
Mbabe2	Proposed	49	50	Masaka	Mbabe	Mbabe
Ruhanga	Proposed	71	50	Masaka	Gitaraga	Ruhanga
Kanyeri	Proposed	90	50	Kanombe	Busanza	Kariyeri
KabezaII	Proposed	60	50	Gatenga	Nyarurama	Kabeza
Nyirakavomo2	Proposed	181	100	Masaka	Ayabaraya	Nyirakavomo
Cyeru	Proposed	122	100	Masaka	Rusheshe	Cyeru I
Nyabigugu 2	Proposed	184	100	Gahanga	Murinja	Nyabigugu
Kababyeyi	Proposed	105	100	Masaka	Ayabaraya	Kababyeyi
Nyamico2	Proposed	172	100	Masaka	Ayabaraya	Nyamico
Nyamico	Proposed	172	100	Masaka	Ayabaraya	Nyamico
Kagasa	Proposed	183	100	Gahanga	Murinja	Kigasa
Gashubi	Proposed	138	100	Gahanga	Rwabutenge	Gashubi
Kagese	Proposed	188	100	Masaka	Rusheshe	Kagese
Rugando I	Proposed	97	100	Gahanga	Rwabutenge	Rugando I
Nyabikenke	Proposed	137	100	Gatenga	Nyarurama	Nyabikenke
NyaruguguI	Proposed	122	100	Kanombe	Busanza	Nyarugugu

Runini	Proposed	112	100	Gahanga	Gahanga	Rinini
Nyabikenke	Proposed	137	100	Gatenga	Nyarurama	Nyabikenke
Bigo	Proposed	103	100	Gatenga	Nyarurama	Bigo
MUGENDO	Existing	69	100	Gahanga	Nunga	Mugendo
GOLDEN FERMER	Existing	139	100	Gahanga	Murinja	Nyabigugu
GAHANGA	Existing	139	100	Gahanga	Murinja	Nyabigugu
MURINJA	Existing	140	100	Gahanga	Murinja	Mashyiga
VILLAGE RUSHESHE	Existing	141	100	Masaka	Rusheshe	Mubano
RWABUTENGE	Existing	142	100	Gahanga	Rwabutenge	Karambo
GAHANGA CENTRE	Existing	143	100	Gahanga	Gahanga	Ubumwe
ISANGANO CENTRE (PARIS)	Existing	144	100	Masaka	Mbabe	Sangano
MBABE2	Existing	145	100	Masaka	Mbabe	Kabeza
MBABE 1	Existing	146	100	Masaka	Mbabe	Mbabe
KAGASA 2	Existing	147	100	Gahanga	Kagasa	Kabidandi
CENTRE RUYAGA	Existing	148	100	Masaka	Mbabe	Sangano
KAREMBURE 2	Existing	149	100	Gahanga	Karembure	Kamuyinga
RUSIRARE	Existing	150	100	Gahanga	Karembure	Kamuyinga
KAGASA 1	Existing	151	100	Gahanga	Kagasa	Kiyanja
KAJEVUBA	Existing	152	100	Masaka	Gitaraga	Kajevuba
MUYANGE	Existing	153	100	Kagarama	Muyange	Muyange
GITARAGA	Existing	154	100	Masaka	Gitaraga	Kabeza
KAYANJA/NYACYONGA	Existing	155	100	Gahanga	Kagasa	Kiyanja
RUGENDE YITAKA 1	Existing	156	100	Masaka	Gako	Rugende
PAROISSE MASAKA	Existing	157	100	Masaka	Cyimo	Cyimo
GIHUBUKE	Existing	158	100	Masaka	Gako	Gihuke
AFRIPRECAST	Existing	159	100	Masaka	Gitaraga	Nyange
COKO	Existing	160	100	Kanombe	Karama	Cyurusagara
NYARURAMA	Existing	161	100	Gatenga	Nyarurama	Bisambu
Cyankongi I	Proposed	196	160	Masaka	Rusheshe	Cyankongi
Nyamuhuza	Proposed	230	160	Gahanga	Murinja	Rukore
Gitagara	Proposed	289	100	Bugesera	-	Gitagara
Kabyo	Proposed	226	100	Bugesera	-	Kabyo

4.6.2. Nyarugenge

Transformer Nam	Type	HHs	Sise (kVA)	Sector	Cell	Village
TRF Amaharo 1	proposed	51	50	Mageregere	Nyarurenzi	Amahoro
TRF Amahoro 2	proposed	53	50	Mageregere	Nyarurenzi	Amahoro
TRF Burema	proposed	62	50	Mageregere	Mataba	Burema
TRF Gakoni	proposed	48	50	Kigali	Nyabugogo	Gakoni I

TRF Gateko	proposed	33	25	Kanyinya	Nzove	Gateko
TRF Gatovu	proposed	69	50	Mageregere	Ntungamo	Gatovu
TRF Rwakivumu	Existing	38	25	Kanyinya	Taba	Taba
TRF Kagasa	proposed	38	25	Kanyinya	Nzove	Kagasa
TRF Kamatamu	proposed	38	25	Mageregere	Kankuba	Kamatamu
TRF Kankurimba I	proposed	86	50	Mageregere	Kavumu	Kankurimba
TRF Kankurimba II	proposed	40	25	Mageregere	Kavumu	Kankurimba
TRF Karukina	proposed	37	25	Mageregere	Kankuba	Karukina
TRF Kavumu	proposed	117	100	Mageregere	Kavumu	Kavumu
TRF Mageregere	proposed	58	50	Mageregere	Mataba	Mageragere
TRF Mataba	Existing	66	50	Mageregere	Mataba	Rushubi
TRF Mubura	Existing	42	25	Mageregere	Kavumu	Mubura
TRF Muganza	proposed	12	25	Kigali	Kigali	Muganza
TRF Murondo 1	proposed	117	100	Mageregere	Kavumu	Murondo
TRF Murondo 2	proposed	44	50	Mageregere	Kavumu	Murondo
TRF Ngendo 1	proposed	55	50	Kanyinya	Taba	Ngendo
TRF Ngendo 2	proposed	52	50	Kanyinya	Taba	Ngendo
TRF Ngendo 3	proposed	42	50	Kanyinya	Taba	Ngendo
TRF Nkomero	proposed	42	50	Mageregere	Runzenze	Nkomero
TRF Nyabirondo	proposed	17	25	Mageregere	Nyarurenzi	Nyabirondo
TRF Nyabitare	proposed	137	100	Kigali	Ruriba	Nyabitare
TRF Nyabitare2	proposed	24	25	Mageregere	Ntungamo	Nyabitare
TRF Nyarubande 1	proposed	91	100	Mageregere	Ntungamo	Nyabitare
TRF Nyarubande 2	proposed	70	50	Mageregere	Ntungamo	Nyarubande
TRF Nyarubande 3	proposed	60	50	Mageregere	Ntungamo	Nyarubande
TRF Nyarubuye 1	proposed	75	50	Mageregere	Kavumu	Nyarubuye
TRF Nyarubuye 2	proposed	88	50	Mageregere	Kavumu	Nyarubuye
TRF Nyarubuye 3	proposed	45	25	Mageregere	Kavumu	Nyarubuye
TRF Nyarumanga	proposed	14	25	Mageregere	Kankuba	Nyarumanga
TRF Nyarurenzi	proposed	80	50	Mageregere	Nyarurenzi	Nyarurenzi
TRF PH Kigali I	Existing	80	50	Kigali	Kigali	Kadobogo
TRF PH Kigali III	Existing	30	25	Kigali	Kigali	Kibisogi
TRF Rubungo	Existing	100	100	Mageregere	Ntungamo	Rubungo
TRF Rugendabari	proposed	35	25	Mageregere	Kankuba	Rugendabari
TRF Runzenze	proposed	99	100	Mageregere	Runzenze	Runzenze
TRF Rwandonyi	proposed	36	25	Mageregere	Ntungamo	Rwindonyi
TRF Ryamakomari 1	proposed	34	25	Kigali	Ruriba	Ruhango
TRF Ryamakomari 2	proposed	40	25	Kigali	Ruriba	Ryamakomari
TRF Taba	Existing	23	25	Kanyinya	Taba	Taba
TRF Uwurugenge	proposed	29	25	Mageregere	Runzenze	Uwurugenge

4.6.3. Gasabo

No	Sector	MV line Surveyed (Km)	LV line Surveyed (Km)	No of Transfo Surveyed	No Of Customers Surveyed
1	Jali	8.705	53.224	8	1,260
2	Jabana	13.369	77.826	15	2,148
3	Nduba	10.977	103.189	11	2,915
4	Kinyinya	0.668	6.881	3	194
5	Gisozi	0.715	0.000	3	N/A
6	Gatsata	1.103	0.000	2	N/A
7	Kacyiru	0.689	0.000	2	N/A
8	Kimihurura	2.429	0.000	3	N/A
9	Remera	0.352	0.000	1	N/A
10	Kimironko	2.909	0.000	7	N/A
11	Bumbogo	27.844	84.881	27	2,267
12	Ndera	12.249	60.823	19	1,477
13	Rusororo	9.054	58.750	16	1,254
14	Rutunga	10.958	25.381	11	581
15	Gikomero	9.559	78.061	12	2,005
Total		111.580	549.016	140	14,101

Summary of Kigali Total Electrification Plan (2021)

District	MV (km)	LV (km)	Transformers	Customers
Nyarugenge	28	111	36	2,758
Kicukiro	36	196	38	5,349
Bugesera	5	9	2	515
Gasabo	111.58	549.016	140	14101
Total	180.58	865.016	216	22,723
Required Budget (USD)	27,103,323.04			

4.7. Source of Funds for the projects in Kigali City

Project	Needed Year	Status of Funding	Source of Funds
Transmission			
Replacement of Power transformers at Gikondo Substation, 2*15MVA with new big ones (2*30MVA)	2021	Secured	AFDB
Extension of Nzove substation with a new 20MVA transformer	2022	Secured	AFDB
Extension of Gahanga substation with a new 20MVA, with an upgrade of Master steel feeder	2022	Secured	AFDB
Upgrade of Gasogi Substation from 10MVA to 30MVA, construction of MV line from Gasogi SS to Masaka Center	2021	Secured	JICA
Link of new Shango Substation to distribution Network	2021		
Electricity Access			
Electricity Access in all parts of Kigali	2021	Ongoing	World Bank
Reinforcement of the Distribution Network			
Construction of 8 Switching MV/LV Cabins in Kigali: Ongoing	2021	Ongoing	World Bank
Construction and Rehabilitation of MV lines (28.2km Overhead & 8.63km Underground): Ongoing	2021	Ongoing	World Bank

Rehabilitation of Low voltage U.G Network in Nyarugenge (Kiyovu and the CBD) i.e. 44.1km of LV Underground	2022	Secured	AFDB/EIB
Renovation of existing MV/LV Cabins	2021	Secured	AFDB/EIB
Construction of Switching MV/LV Cabins	2022	Secured	EIB
Construction and Rehabilitation of MV lines in Kigali (32.7km Overhead & 12.2km Underground)	2021	Secured	EIB
Construction and upgrade of MV & LV lines in areas with voltage drops (45.603km of MV and 117.5km of LV)	2020	Secured	AFDB/EIB
Upgrade of single phase network (89.4km of MV and LV)	2022	Secured	AFDB/EIB

Required investment in Kigali HUB

Quantity	MV length (km)	LV length (km)	Number of Transformers	Rehabilitation of cabins
	415	1084	307	25
Investment Required (USD)	18,675,000	21,680,000	2,383,376.08	17,500,000
Total Investment (USD)	25,966,678			

Note: The cost of one km of MV line is 45,000 USD and the cost of 100 kVA is 7,763.44 USD, while the cost of rehabilitation of cabins is 700,000USD.

All transformers are assumed to be 100 kVA in Kigali while modelling the size of each transformer depending on demand forecast in each area.

VII. BUGESERA ELECTRICITY DISTRIBUTION PLAN

Kigali Hub network also comprises of Bugesera, Rulindo and Gicumbi. However, Bugesera area has been one of the fastest growing load centers in the power network of Rwanda due to its fastest urban expansion for the last few years, industrial park and other key infrastructures that are planned there including the New Bugesera International Airport while the power supply to Bugesera did not immediately catch up with this fast-growing demand until in the recent years.

1. Key network challenges for supplying Bugesera area

- No high voltage transmission line in place supplying Bugesera area
- Kanazi feeder (30kV) was very long (303km) and highly loaded (7.8 MVA)
- There was no alternative supply to Bugesera apart from Kanazi Feeder
- Voltage drops in Bugesera network are below acceptable limits with very low voltage at the end of the feeder especially at Nemba Border and other areas in Bugesera.
- There is high load in the south of Kanazi feeder, due to heavy industries towards the feeder's end.
- The load in the area is increasing fast due to the Bugesera Industrial Park development and the New Bugesera International Airport under construction in addition to the current increasing urban expansion of Bugesera District which in turns increases demand in power supply

2. Initiatives to improve power supply in Bugesera Area

A. New Substations:

- i. Two important substations to be constructed in Bugesera. These are **Bugesera Substation**, and the **Bugesera Industrial Park Substation**, each with 220kV/110kV and 110kV/30kV transformers.
- ii. The two substations will be supplied by key high voltage 220kV transmission lines from Rwabusoro, Shango and Rusumo in order to increase the redundancy supply for Bugesera Industrial Park SS and strengthening the network in general.
- iii. Additional two substations will be constructed, dedicated only for New Bugesera International Airport (NBIA) supplied from both Bugesera Substation, and the Industrial Park Substation on 110kV transmission lines.

B. New Feeders:

- iv. In addition, Bugesera Industrial Park substation will be interconnected with Bugesera SS. The different key feeders of Kanazi, Imana Steel, Gako Beef and the Bugesera Industrial Park will be adequately supplied from this substation.

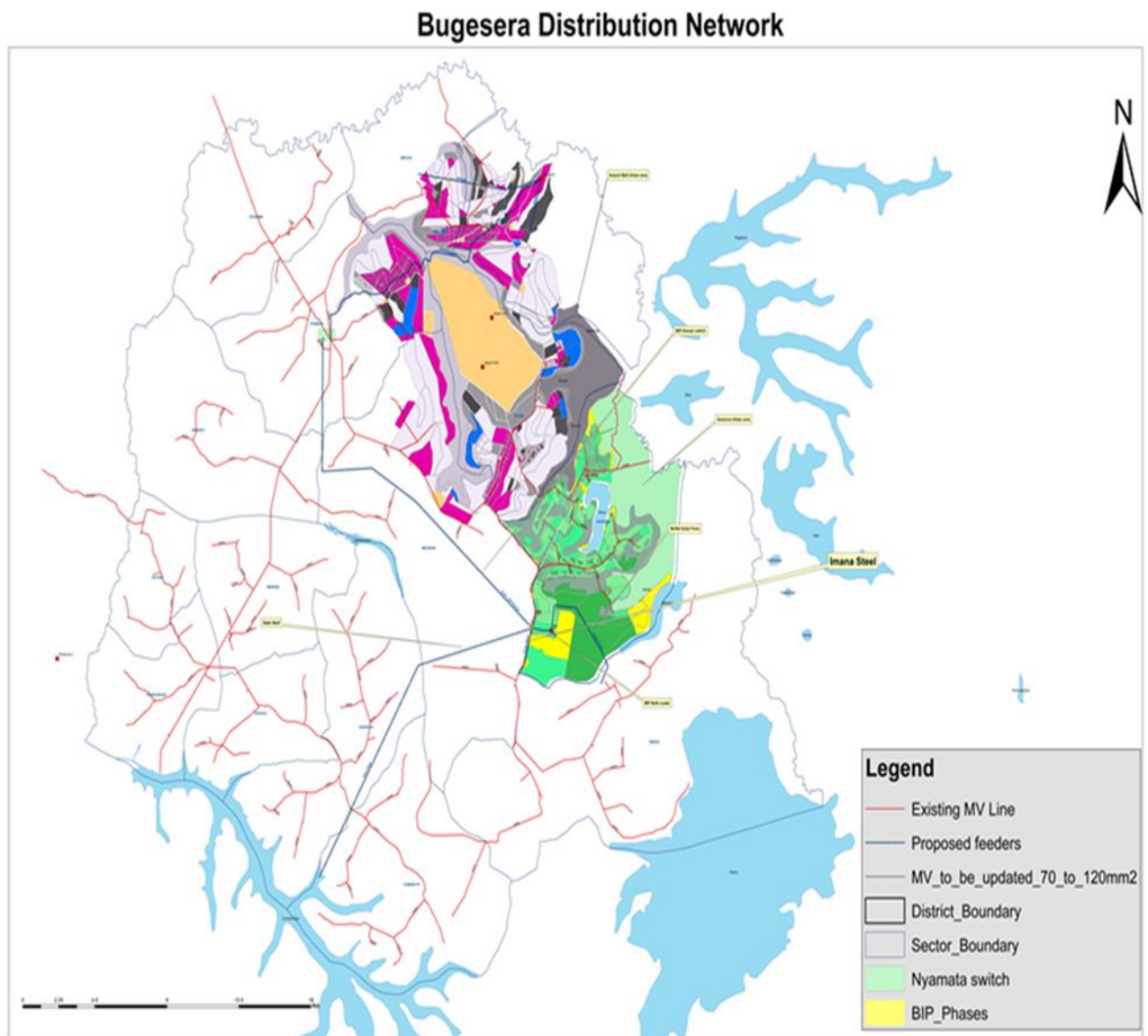
- v. A Double Circuit MV Line from Bugesera SS to Kanazi feeder was proposed to serve as contingency on Kanazi feeder
- vi. An evacuation MV Line from Buffet Solar farm to Bugesera Industrial Park was also proposed to increase the reliability of electricity at the Industrial Park SS
- vii. In April 2018, part of the load of Kanazi feeder (1.5MW) was transferred to Ntongwe feeder through the construction of a 30kV interconnection from Ntongwe feeder to Kanazi feeder and in the process, N-1 option was obtained. This improved power supply to the key customer Imana Steel and the town of Nyamata. However, the part that was transferred to Ntongwe, which has other important customers such as WASAC's water pumping station of Ngenda and the Border Post of Nemba, is now more undersupplied. To completely address the issue, the substation in the Industrial Park is needed.
- viii. There are projects underway from WASAC to build the Kanzenze Water Treatment Plant that requires also reliable power supply in addition to addressing the voltage drop issue faced by Karumuna residents. The portion of the line will be upgraded to accommodate the new load from Kanzenze Water treatment plant.
- ix. A switch cabin was proposed at former ETO Nyamata to reduce load on Kanazi feeder and also to monitor and control power from different sources in Bugesera.

3. Network reinforcement projects in Bugesera area

Table below shows Network reinforcement projects in Bugesera and the required Investment

Project	New MV length (km)	Nyamata Switching Cabin + its MV Line
Conductor size upgrade: Karumuna and Nyamata-Nemba	39.65	1
Construction of DCKT Line Bugesera BIP-Kanazi	20	
Bugesera SS-Kanazi	3.4	
Bugesera IP SS-Imana Steel	1.7	
Bugesera IP SS-Gako Beef	20	
Bugesera IP SS-Industrial Park Loads	2	
Buffet Solar Farm-BIP SS	7	
Interconnection Zaza-Kanazi	5	
Total Length	98.75	
Investment Required (USD)	4,443,750	1,628,612
Total Investment (USD)	6,072,362	

The Map below shows Proposed Electricity distribution network in Bugesera area



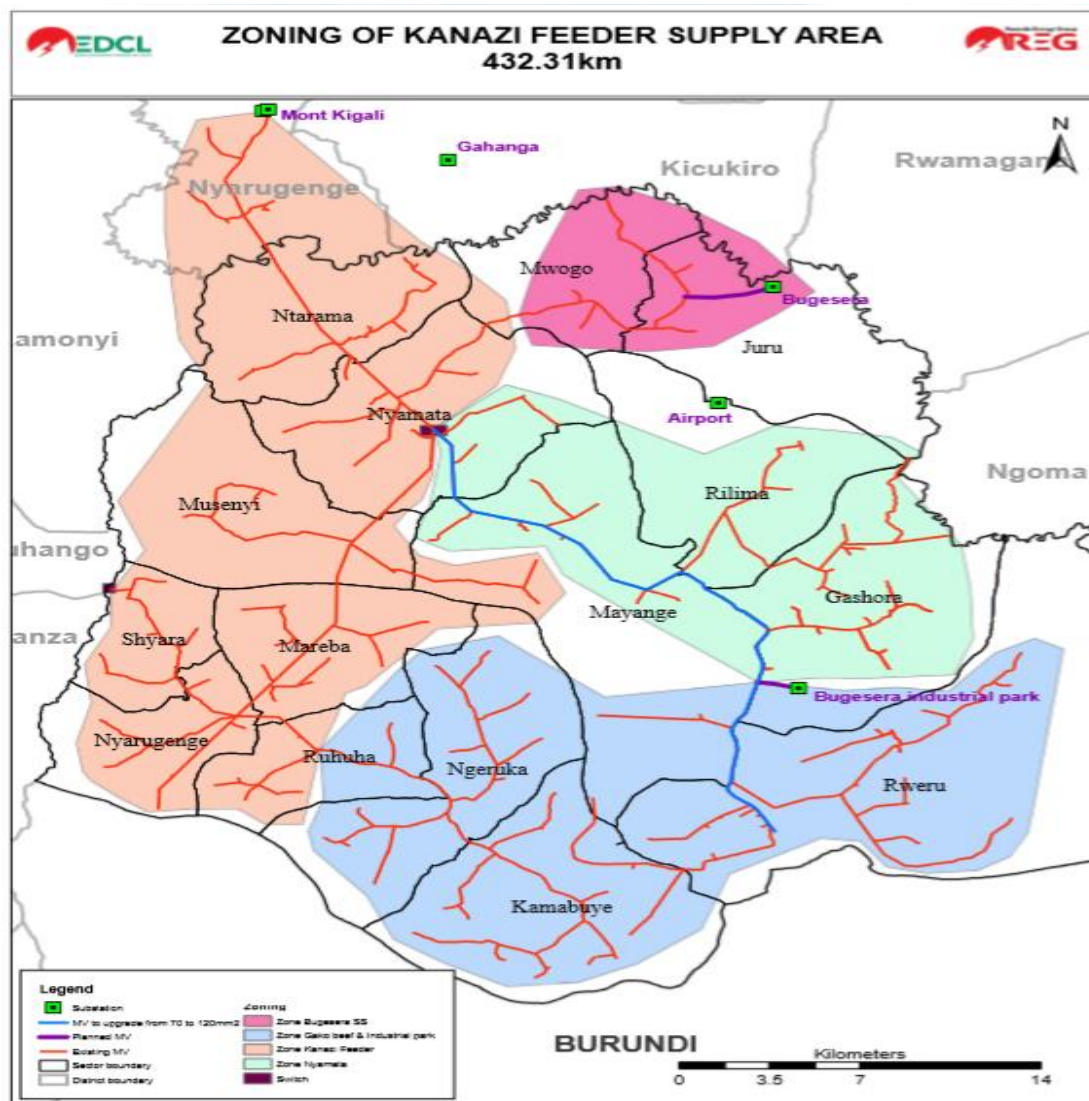
4. Bugesera Area Distribution Network and Zoning

Bugesera area was zoned into 4 main parts as shown on the table below with their key pulling factors as found on the table below:

Table 7: Bugesera zoning

S/N	Zone Name	Feeder	Key factors
1	Zone Nyamata	Kanazi	New Bugesera International Airport, Nyamata town
2	Zone Kanazi Feeder	Kanazi	Kanezne Water Treatment Plant, Residential
3	Zone Gako beef & Industrial park	Kanazi	Bugesera Special Economic Zone (SEZ), Gako beef, Imana Steel, Tanary Park, and other bulk loads
4	Zone Bugesera SS	Kanazi	Airport belt master plan (urban)

Map 3: Zoning Map for Bugesera area



VII. SHORT-MEDIUM TERM PROJECTS IN THE SOUTH

1. Introduction

The Southern Hub network is composed of Muhanga, Nyanza, Huye, Gisagara, Nyamagabe and Nyaruguru. Main feeders supplying the southern area are Gatumba, Butare, Rukarara II, Ntongwe and Kiyumba. Butare and Rukarara II are very long and overloaded due to the fastest urban expansion in South encompassing Muhanga and Huye as secondary Cities.

Many projects to reinforce the network in South area are underway including establishment of necessary infrastructures such as Muhanga SS, Huye SS and Gisagara SS.

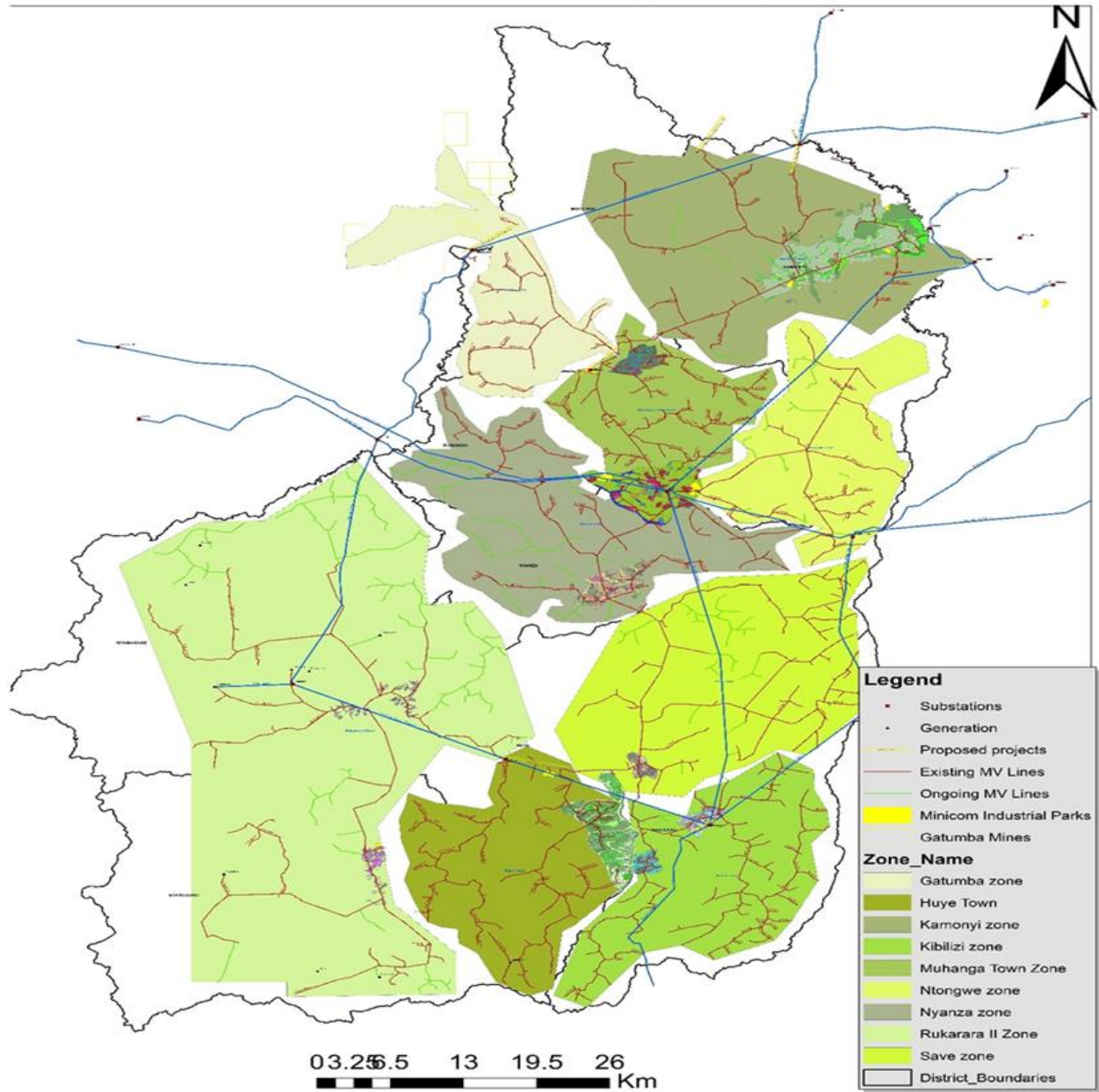
In addition to the mentioned substations, New lines and interconnection projects have been planned to be implemented including Kiyumba- Musasa, Huye SS-Rukarara 2, Nyabarongo 1 SS-Gatumba, Double Circuit Muhanga SS-Gatumba, Double Circuit Huye SS-Rukarara 2-Butare and Gisagara SS-Butare.

2. Zones in Southern Hub and zoning factors

Nine (9) Zones have been identified following the location of feeders in Southern Hub and considering key pulling factors as highlighted in the table below:

S/N	Zone Name	Source	District	Feeders	Pulling Factors
1	Kamonyi zone	Mont Kigali SS, Muhanga SS	Kamonyi	Kiyumba	District town, beverages processing
2	Huye Town	Huye SS	Huye	Butare	Secondary city, SEZ
3	Nyanza zone	Kigoma SS	Nyanza	Butare	District town, Milk processing industry
4	Gatumba zone	Muhanga SS, Kigoma SS	Muhanga	Gatumba	Mining area, Ngororero Town
5	Muhanga Town Zone	Muhanga SS, Nyabarongo 1 SS	Muhanga	Gatumba	SEZ, Muhanga Town
6	Ntongwe zone	Kigoma SS	Ruhango	Ntongwe	Cassave processing, residential
7	Rukarara II Zone	Rukarara	Nyaruguru	Rukarara 2	District town, Tea factories
8	Save zone	Huye SS	Gisagara	Butare	Urban Centre
9	Kibilizi zone	Gisagara	Gisagara	Butare	Urban Centre

Southern Hub zoning and projects



3. Anticipated Major load in Southern Hub

Anticipated major load in SOUTHERN HUB						
Gisagara Branch						
SUBSTATION	FEEDER	Load Category	Total Load (MW) (2021-2023)			
KIGOMA	BUTARE			2021	2022	2023
		Youth Center	0.1	0.1		
		Head Craft Center	0.1	0.1		
		Maternity	0.1	0.1		
		Banana Processing Plant	0.1	0.1		
		Meat processing Plant	0.1			
		Maize Milling Plant	0.1			
		Markets	0.1			
		Water Pump Stations	0.2	0.1	0.1	
		Street lights	0.2	0.1	0.1	
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	1.1	0.7	0.3	0.1
Ruhango Branch						
KIGOMA	BUTARE					
		Extension of Industrial at Bweramana	0.3	0.1	0.1	0.1
		New Hotel under construction	0.1	0.1		
		Extension Agakiro	0.3	0.1	0.1	0.1
		Water Treatment plants	0.2		0.1	0.1
		Street lights	0.1	0.1		
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	1.3	0.5	0.4	0.4
Huye Branch						
Rukarara	RukararaII	six food processing Factories	0.3	0.1	0.1	0.1
		Upgraded Street lights on the main road Kigali-Kanyaru (huye part)	0.1	0.1		
		Four big Commercial Buildings in HUYE city	0.3	0.1	0.1	0.1
		New Hotel 5star	0.1	0.1		
Huye SS(Planned)	Huye IP	Huye Industrial Park(9 to15MW)	3	1	1	1
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	4.1	1.5	1.3	1.3
Muhanga Branch						
KIGOMA	GATUMBA	Commercial Buildings in Muhanga city	0.4	0.1	0.1	0.2
		New Hotels under construction	0.2	0.1	0.1	
		New Modern Markets	0.3	0.1	0.1	0.1
		Industrial Park(4.4 to 8MW)	2	0.6	0.7	0.7
		Water Treatment plants	0.3	0.1	0.1	0.1
Mont kigali	KIYUMBA	Kiyumba and Kabgayi hospitals	0.1	0.1		
		New street lights	0.3	0.1	0.1	0.1
		TVT Kiyumba under consrtuction	0.1	0.1		

		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	4	1.4	1.3	1.3
Nyamagabe Branch						
RUKARARA	RUKARARA II	Tea factories	0.3	0.1	0.1	0.1
		Coffee Washing stations	0.1	0.1		
		Commercial Banks	0.1	0.1		
		Street lights	0.1	0.1		
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	0.9	0.5	0.2	0.2
Nyanza Branch						
KIGOMA	NTONGWE	Mark cable industry	1	0.5	0.3	0.2
		New Hotel	0.1	0.1		
		Nyanza Modern Market and car parking	0.1	0.1		
		Busogwe Water Treatment Plant	0.1	0.1		
		Street lights	0.3	0.1	0.1	0.1
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	1.9	1	0.5	0.4
Nyaruguru Branch						
RUKARARA	RUKARARA II	Big Commercial Buildings in Nyaruguru	0.1			0.1
		New Hotel under construction	0.1			
		Tea factories	0.3	0.1	0.1	0.1
		Water Treatment plants	0.3	0.1	0.1	0.1
		Street lights	0.1			0.1
		Others loads	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	1.2	0.3	0.3	0.5
		SOUTHERN TOTAL LOAD	14.5			

4. Feeder loading after anticipated Major load growth (2021-2023) in Southern Hub

SUBSTATION	Existing Transfo MVA	SOUTHERN NETWORK SUBSTATIONS					Peak Power [MW]	% Loading at Peak (Calculated)	Load Increment on Feeders(MV) as per the anticipated major loads	% Feeder Loading (2021-2023)
		Feeder	Length (km)	Conductor Size	Maximum Current (A)	Max Power Capacity (MW)				
KIGOMA	1 *10	Butare	552	ACSR 70/12 mm ²	290	12.05	4.0	33.20%	2.8	56.43 %
		Gatumba	266	ACSR 70/12 mm ²	290	12.05	2.8	23.23%	3.2	26.55 %

		Ntongwe	286	ACSR 70/12 mm ²	290	12.05	1.6	13.27%	1.9	15.76 %
Total							8.4	69.70%	7.9	
KILINDA	1*1.6	Birambo	74	ACSR 120/20 mm ²	410	17.04	0.243	1.42%		
		kilinda mission	1.5	ACSR 120/20 mm ²	410	17.04				
Total							0.243	1.42%		
RUKARARA	2*10	Rukarara II from substation	527	ACSR 120/12 mm ²	410	17.04	3.48	22.53%	5.3	31.10 %
		RUKARARA 2 HPP		ACSR 120/20 mm ²	410	17.04	2.2	13.00%	1.3	20.53 %
		MAZIMERU		ACSR 35/6 mm ²						
		NSHILI MHPP								
Total							5.68		6.6	
Total								35.53%	14.5	

5. Projects proposals for Network reinforcement in Southern Hub

1.1.Upgrade projects

Transformer Name	Substation	Feeder	Voltage	Conductor	Length (m)	Province	District	Sector	Cell	Countermeasure
TBD	Mont kigali	Kiyumba-Musasa	30	70mm2_CU	4500	South	Kamonyi			New interconnection line
TBD	Huye	Huye SS-Rukarara 2	30	70mm2_CU	500	South	Huye	Maraba	Shyembe	New line
TBD	Nyabarongo I	Nyabarongo 1 SS-Gatumba	30	70mm2_CU	4000	South	Muhanga			New Line
TBD	Muhanga SS	DCKT Muhanga SS-Gatumba	30	70mm2_CU	3000	South	Muhanga			New Line
TBD	Huye SS	Doble CKT Huye SS-Rukarara 2-Butare	30	70mm2_CU	5000	South	Huye	Maraba	Shyembe	New Line
TBD	Gisagara	Gisagara SS-Butare feeder	30	70mm2_CU	1500	South	Gisagara	Ndora	Gisagara	New Line
TBD	Muhanga	Nyabarongo SS 2-Kiyumba	30	70mm2_CU	3000	South	Muhanga	Kiyumba		New line
TBD	Gisagara	Gisagara SS-Gisagara SEZ	30	70mm2_CU	1000	South	Gisagara	Kibilizi		New Line
Total					22,500					
Investment										
1,012,500										

Province	District	Substation	Feeder name	Voltage	Phase	Upgrade	Length (m)
South	Gisagara	KIGOMA	BUTARE			35mm to 70mm2	10,546.79
South	Gisagara	KIGOMA	BUTARE	30	Three Phase	35mm to 70mm2	6,602.53
South	Gisagara	KIGOMA	BUTARE	30	Three Phase	35mm to 70mm2	7,069.79
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	7,692.52
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	3,726.54
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	1,494.86
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	1,407.22
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	59.84
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	1,027.26
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	7,137.51
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	4,434.60
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	4,326.99
South	Nyaruguru	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	4,070.93
South	Huye	RUKARARA	RUKARARA II	30	Three Phase	35mm to 70mm2	4,883.57
Total							64,480.94

1.2. Rehabilitation of MV & LV network (Voltage Drop reduction)

BRANCH	LOCATION	Voltage Level (V)	PROBLEM (YES or NO)			RECOMMENDED ACTION			
			Overloaded Transformers	Undersized LV cables	Over-extended LV network	Extend MV and Insert new Tx		LV NETWORK (reconduct and reconfigure)	
						Length of MV (km)	Transformer size (kVA)	LV length (km)	LV poles
MUHANGA	NYABISINDU-ADEPR CEFOCA	200	No	Yes	No			1.5	30
	SHYOGWE-KABUNGO-MBARE	198	No	Yes	No			3.8	76
	GIHUMA-KAMAZURU	195	No	Yes	No			2.5	50
	RUVUMERA-NYABISINDU	199	No	Yes	No			1	20
	BURINGA-BERESHI	199	No	Yes	No			4.5	90
	SHYOGWE-AIDEL	195	No	Yes	No			3	60
	NYABISINDU-NETE	190	Yes	yes	Yes	1.2	100	4	80
	MUSHUBATI-MERU-BIGURUBE	190	No	Yes	Yes		50	2.5	50
	MUSHUBATI-MISIZI-NYAMUKURA	190	No	Yes	No			2.5	50
	KABGAYI-GARAGE	199	No	Yes	No			3	60
	SHYOGWE-MUBUGA	195	No	Yes	No			5.5	110
	KIYUMBA-RUHINA-BUSUMBA	200	No	Yes	Yes	1	50	2.5	50
	NYARUSANGE-RUSOVU	200	No	Yes	No			3	60
	MBARE-KAVUMU	199	No	Yes	No			2.5	50
	GIHUMA-MIGURAMO-GASHINGE	190	No	Yes	No			4	80
	GASHARU-BAHIMBA	197	No	Yes	No			2	40
	MBARE-KINYAMI	198	No	Yes	No			2.5	50
	KIVUMU	200	No	Yes	No			5	100
	GIFUMBA-RUGARAMA	192	No	yes	yes	2	100	3.5	70

	NYARUCYAMO	200	No	Yes	No			2.5	50
	GAHOGO MARCHE	200	No	Yes	No			2.5	50
	RULI-RUHINA	200	No	Yes	No			2	40
	MUNYINYA	200	No	Yes	No			2	40
	MUSHISHIRO-MUNAZI	190	No	Yes	No			3	60
	MUSHISHIRO-BERESHI	190	No	Yes	No			2.5	50
	RUGENDABARI-NSANGA-RUPANGO	180	No	Yes	Yes	1	50	2	40
	RUGENDABARI-MPONGO	190	No	Yes	Yes	1	50	2	30
	MISIZI-MUSUMBA	200	No	Yes	No			3	60
	SHYOGWE-RUKAZA	230	Yes	No	No		50	0	0
	KABEZA	220	No	Yes	No			2.5	50
	Total					6.2	11	82.8	1646
RUHANGO	NYAMAGANA-GITISI	205	NO	YES	YES	0.2	100	2	40
	MUNINI	180	NO	NO	YES	0.1	100	0.2	2
	MUKOMA	175	YES	YES	NO	Existing	100	2	Existing
	KIRENGERI-BYIMANA II.	208	No	YES	YES	Existing	Existing	1.5	30
	BYIMANA-MUHORORO	205	No	NO	YES	2	100	0.6	12
	GITWE-MUNINI	195	NO	YES	YES	0.2	100	1.2	24
	NYAGAHAMA-RUHUHA	200	NO	NO	YES	1.5	100	0.5	10
	NYARUSANGE	185	NO	NO	YES	0.2	50	0.3	6
	GATENGEZI	205	NO	YES	NO	Existing	Existing	1	Existing
	MUSAMO	208	YES	NO	NO	Existing	100	0.8	Existing
	SARUHESHYI-MPANDA	205	NO	YES	NO	Existing	Existing	1.5	30
	RUSORORO	210	NO	YES	YES	2.5	100	1.5	30
	TOTAL					6.7	9	13.1	184
NYANZA	Kerezo	195			yes	0.6	50		
	Ntyazo	180	No		No			0.7	9
	Sholi	190	yes		Yes	1.2	50	2	40

	Total					1.8	2	2.7	49
GISAGARA	GISAGARA DISTRICT	180	No	Yes	No			2	
	RUTURO	180	No	Yes	No			2.5	50
	TTC	190	No	Yes	No			2	
	GIKONKO	160	No	Yes	No			3	60
	GAKOMA	190	No	Yes	No			3	60
	MAMBA MARCHE	190	No	Yes	YES	1	100	1	20
	MUSHA	180	No	Yes	No	0.5	250	2	
	KINTEKO	180	No	Yes	No			2	40
	BAZENGA	190	No	Yes	No			2	40
	Total GISAGARA					1.5	2	19.5	270
HUYE	MATYAZO - KAMUCUZI	201	No	Yes				1	20
	CYARWA-CYILI-SUMO	200	Yes	Yes		1	200	4.9	98
	RANGO-KIGARAMA(TUMBA)	204	No	Yes				3.3	66
	TUMBA-REBERO-AGASENYI	198	No	Yes				2.5	50
	KIBABARA-RUGANGO	199	No	Yes				3	60
	KABUREMERA-RUNGA	198	Yes	Yes		0.5	100	3.1	62
	KIZI-CENTER	201	No	Yes				1	20
	GISHAMVU-BUSORO	206	No	Yes				2.1	42
	SOVU-GAKINJIRO-KIGARAMA	198	Yes	Yes		1	100	1.5	30
	MUKURA -NKUBI	200	No	Yes				2	40
	SIMBI-PAROISSE	205	No	Yes				1.5	30
	MBAZI-RWABUYE	207	Yes	Yes		1	100	1	20
	Total					0	3.5	4	26.9
NYAMAGABE	TABA	180	YES	NO	No	1	250		
	SUMBA	160	No	Yes	YES			2.5	50
	KINUETE	180	YES	Yes	NO	1	100		
	KIBUMBWE	160	YES	NO	NO	1	50		

	DUSEGO	160	YES	YES	No	1	160	2	40
	UWINKINGI	160	YES	Yes	No	1	100	2	40
	NYABIVUMU	160	YES	Yes	Yes			2.5	50
	KIZIBA	160	No	Yes	Yes			2.5	50
	GASARENDA	160	No	Yes	yes			3	60
	THE MATA	140	No	Yes	No			2	40
	NZEGA	160	NO	Yes	NO			1.5	30
	KITABI	180	NO	Yes	NO			2	40
	KIGEME	160	No	Yes	YES			2	40
	NYARUSIZA	160	No	Yes	Yes			1	20
	TOTAL						5	5	23
NYARUGURU	MUGANZA-RUKORE	130	No	Yes	Yes	2.5	50	3	60
	NGOMA-NKOMERO	140	No	Yes	Yes		50	5	100
	VILO CENTRE-CYAHINDA	230	Yes	Yes	No		400	1	0
	RWAMIKO	140	No	Yes	Yes	1	50	2.5	50
	VILO-KIBEHO	160	No	NO	Yes	1	50	2	40
	NYAGISOZI-BIRAMBO	180	No	NO	Yes	1	50	2.5	50
	RUHERU-KABERE	230	No	Yes	No			1	
	Total						5.5	6	17
TOTAL FOR SOUTHERN HUB						30.2	39	185	3,447

	<i>Scope of Works for voltage drop reduction in Southern Hub</i>	UoM	Qty	Cost estimate for Supply & Installation	
				U.price	T.price
SOUTHERN HUB (7branches)	Extension of MV lines	km	30.2	29,916,550	903,479,810
	Installation of New transformers (with protective devices & LVDB)	pc	39	12,500,000	487,500,000
	LV Network Reconductoring and Reconfiguration	km	185	9,625,000	1,780,625,000
	Total				3,171,604,810

Required Investment for network reinforcement South

Quantity	MV length (km)	MV length (km)	Number of Transformers
	117.2	185	39
Investment Required (USD)	5,274,000	3,700,000	232,237.59
Total Investment (USD)	9,206,237.59		

Note: The total length of MV lines to be constructed comprises 22.5km for New extension, 64.5km for conductor size upgrade and 30.2km for extending the network for voltage drop reduction

The cost of one km of MV line is 45,000 USD and the cost of 50 kVA is 5,954.81 USD, all transformers are assumed to be 50 kVA out of Kigali while modelling the size of each transformer depending on demand forecast in each area.

VIII. SHORT- MEDIUM TERM PROJECTS FROM MODEL RESULTSIN THE NORTH

I. Introduction

The Northern hub network is composed of Gakenke, Musanze, Rubavu, Burera, Nyabihu and Ngororero.

According to the National Land Use and Development Master Plan 2050, the North-Western Part of the country has been proposed to be one of the Central Growth Poles of Rwanda with designation of Musanze and Rubavu Districts as secondary Cities. Consequently, the urban development master plans for this area have been revised to match the fastest growing urbanization with land requirement. This did not only affect the land and urbanization sectors but also requires adjustments with associated infrastructure development including electricity network.

Major factories and industrial parks are being developed in the north-western part of the country which in turn puts stress on existing electricity infrastructure. Therefore, the plan to extend and strengthen the network in that corridor is of a paramount importance to catch up with the fast-growth demand at present and in a near future.

REG has initiated projects to reinforce the existing electricity network capacity not only to be able to satisfy the increase in power demand, but also to secure reliability of power with flexibility of operations with a plan to export electricity to neighbor countries.

Several projects to strengthen the existing transmission and distribution lines and associated substations have been completed and many more are in pipeline.

Among them, the construction of Rubavu, Nyabihu and Musanze SS will reduce the load on Gisenyi feeder which is mostly supplying the hub. In addition, new MV lines and switching cabins in Musanze and Rubavu will also be constructed.

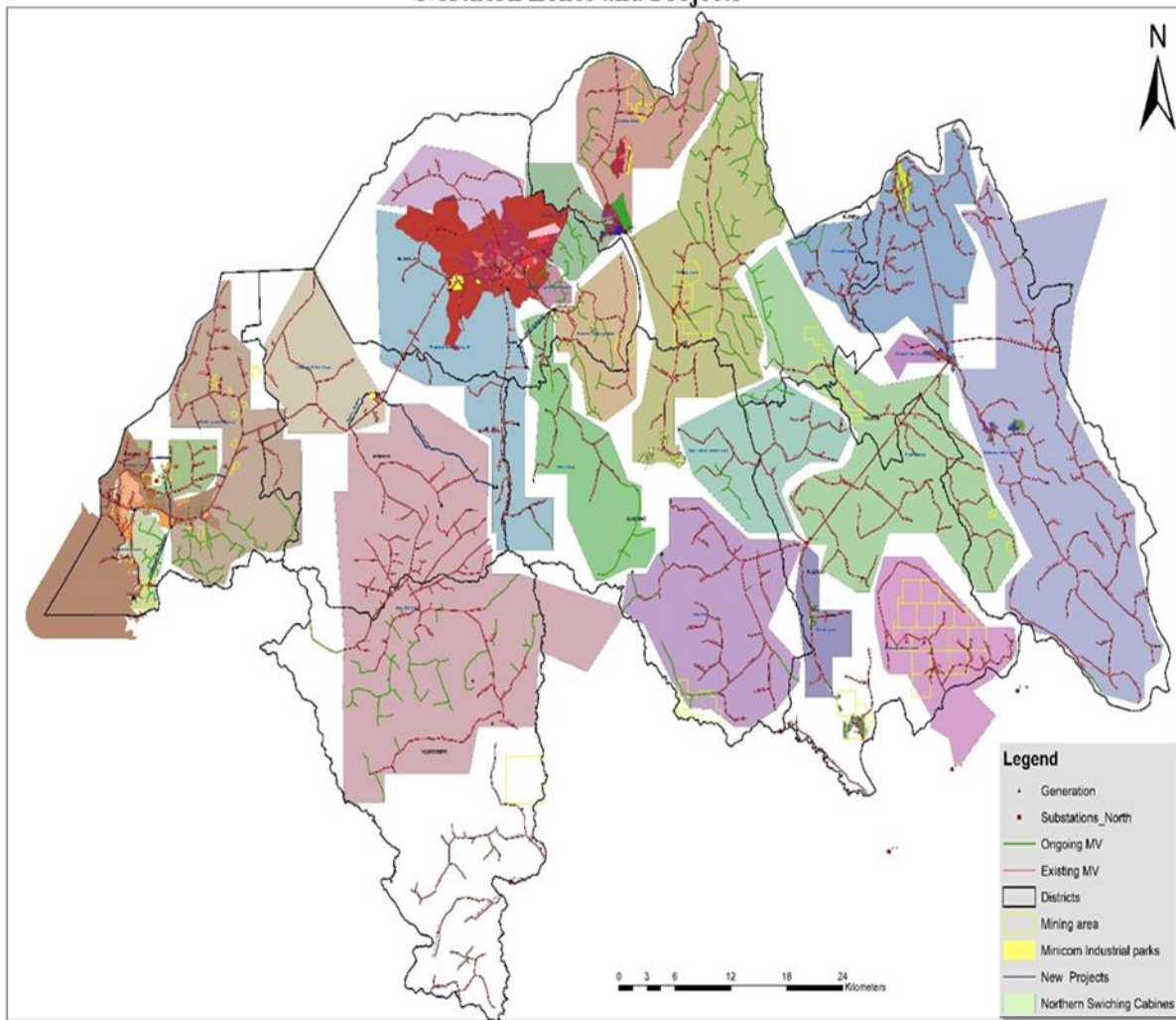
II. Zones in Northern Hub Network and key zoning factors

In this hub, 21 zones have been proposed based on incoming and outgoing feeders of available substations.

S/N	Name	Feeder	District	Key factors for zoning
1	Kinigi zone	Kinigi	Musanze	Touristic hub
2	Musanze Industrial park	Gisenyi	Musanze	SEZ, Urban area
3	Rubavu Town	Poids Lourds	Rubavu	Secondary city, proposed cement factory
4	Rubavu Industrial zone	Gisenyi	Rubavu	Rubavu SEZ, Urban area, crusher plants
5	Nyamyumba zone	Kigufi,Gihira	Rubavu	Brewery, Mining,Hotels, Residential

6	Jenda-Kabatwa Zone	Gisenyi	Nyabihu	Residential, Nyabihu SEZ
7	Nyabihu zone	Gisenyi	Nyabihu	Kabaya urban area, residential, tea factory
8	Ntaruka zone	Ntaruka	Musanze	Residential, Kinoni urban area, Musanze urban
9	Muhoza zone	Cyanika	Musanze	Residential, agriculture
10	Janja Zone	Janja	Gakenke	Residential
11	Remera-Kivuruga zone	Remera	Gakenke	Residential, Mining
12	Cyanika zone	Cyanika	Burera	Cross-border trade, rurembo urban area, mining
13	Gifurwe zone	Gifurwe	Burera	Mineral processing, Butaro UGHE, Hospital
14	Ruli zone	Musasa	Gakenke	Residential, Mining
15	Mbogo zone	Base	Rulindo	urban centre, manufacturing
16	Base urban centre zone	Base	Rulindo	urban centre
17	Tumba zone	Byumba	Gicumbi	Mining area (Miyove), Residential
18	Gicumbi Town	Byumba	Gicumbi	District Town, Kaniga urban centre, Bungwe centre
19	Byumba sector zone	Byumba	Gicumbi	Urban area
20	Rukomo urban zone	Bumba Town	Gicumbi	Rukomo urban area, Kageyo centre
21	Rutongo Mines zone	Rutongo	Rulindo	Mining area, Hospital, residential

Northern Zones and Projects



III. Anticipated Major load in Northern Hub

Anticipated major load in NORTHERN HUB						
Rubavu						
Substation	Feeder	Load Category	Total Load (2021-2023)	Additional Loads in each year		
				2021	2022	2023
Gisenyi	Poids Lourd	Five big Commercial Buildings in Gise	1	0.5	0.3	0.2
	SELENA/CEI	New Hotel under construction	0.1	0.1		
	Poids Lourd	Gisenyi Modern Market	0.1	0.1		
	Gisenyi	Cement Factory	1	0.5	0.3	0.2
	Gisenyi	Water Treatment plants	0.2	0.2		
	Poids Lourd	Extension of Rubavu Air port	0.2		0.1	0.1
	Poids lourde	Street lights	0.3	0.1	0.1	0.1
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	3.2	1.6	0.9	0.7
Musanze						
Camp Belge	Gisenyi	Small Industries (SMEs) & Modern Ma	1	0.2	0.6	0.2
		Musanze Airport Expansion	0.2	0.1	0.1	
		Water Treatment plants under upgrad	0.3	0.1	0.1	0.1
		Real Estate Projects	0.1	0.1		
		Extension Musanze industrial	3	1	1	1
	Kinigi	KINIGI Model village	0.1	0.1	0	
	Kinigi	Street lights on newly constructed roa	0.3	0.1	0.1	0.1
		Others	0.4	0.1	0.1	0.2
		Yearly Total Load Increment (MW)	5.4	1.8	2	1.6
Nyabihu Branch						
Camp Belge	Gisenyi	GITWA Pumping station	0.1	0.1		
		KORA Pumping station	0.1	0.1		
		Other loads	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	0.5	0.3	0.1	0.1
Burera Branch						
Gifurwe	Cyanika	Electrify Cyanika dairy	0.1	0.1		
		Electrify Burera stadium	0.4	0.2	0.1	0.1
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment(MW)	0.8	0.4	0.2	0.2
Gakenke Branch						
Rulindo	Janja	Street lights Ruli, Muhondo, Rushash	0.1	0.1		
	Base	Electrification projects Electrify Ruhar	0.5	0.2	0.2	0.1
		Electrify Buranga,Rwakirari,Rugimbu and Buhuga sites in Kivuruga sector.				
		Electrify Rutabo and Murambi centers in Gashenyi sector.				
		Electrify Gashyamba,Mugandu,Karama,Kivune,Ga				
		tw and Nyagisozi sites in Janja sector.				
		Electrify Murambi,Nyundo,Munanira, and Rure				
		mbo sites in Rusasa and Mugunga sites.				
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment(MW)	0.9	0.4	0.3	0.2
		Northern Hub Total Load(MW)	10.3			

Feeder loading after anticipated Major load growth (2021-2023) in Northern Hub

SUBSTATION	Existing Transfo MVA	NORTHERN NETWORK SUBSTATIONS					Peak Power [MW]	% Loading at Peak (Calculated)	Load Increment on Feeders(MV) as per the anticipated major loads	% Feeder Loading (2021-2023)
		Feeder	Length (km)	Conductor Size	Maximum Current (A)	Max Power Capacity (MW)				
RULINDO	2*10MVA	BASE	76	50/6 mm² Cu	210	8.73	0.47	5.40%	0.6	12.25%
		BYUMBA	469	ACSR 70/12 mm²	290	12.05	1.76	14.60%	0.3	17.09%
		GASIZA		ACSR 70/12 mm²	290	12.05	0.3	5.00%		
		GATUNA		ACSR 70/12 mm²	290	12.05	1.35	11.20%		
		MUSASA	95	50/6 mm² Cu	210	8.73	0.37	4.23%		
Total						53.61	4.25	40.43%		
CAMP BELGE	None	GISENYI	426	ACSR 120/20 mm²	410	17.04	7.6	44.60%	6.3	81.57%
		KINIGI	34	ACSR 70/12 mm²	290	12.05	4.6	38.20%	0.8	44.81%
		MUKUNGWA	4	ACSR 70/12 mm²	290	12.05	6.06	50.30%		
		NTARUKA	27	ACSR 70/12 mm²	290	12.05				
Total						53.19	18.26	133.10%		
GISENYI	None	KITRAKO/Gihira	15.5	50 mm²CU	210	8.73	0.025	0.28%		
		JUDICIAIRE/Poids Lourd	24.6	50 mm²CU	210	8.73	0.839	9.61%	1.3	24.50%
		SELENA/CEP GL	0.8	50 mm²CU	210	8.73	0.145	1.66%	0.2	3.95%
Total						26.19	1.009	11.55%		
GATUNA	1*5MVA	RULINDO	2.4	ACSR 70/12 mm²	290	12.05	1.95	22.30%		
Total						12.05	1.95	22.30%		
GIFURWE	1*10MVA	GAKENKE	36	ACSR 70/12 mm²	290	12.05	0.31	2.57%	0.8	9.21%
		KIRAMBO		ACSR 70/12 mm²	290	12.05	1.85	15.35%		
		NTARUKA	95	ACSR 70/12 mm²	290	12.05	2.08	17.26%		
Total						36.15	4.24	35.18%	10.3	

Key Network reinforcement Projects and Investment Proposal in Northern Hub

Transformer Name	Substation	Feeder	Conductor	Voltsge	Length (m)	District	Sector	Cell	Village/TFR Name	Countermeasure
Rutoyi	Kigoma	Gatumba		30	908.3	Ngororero	BWIRA	Bungwe	Rutoyi	NEW TFR
Ruganda	Camp Belge	Gisenyi	70mm2_12 ACSR	30	1,321.30	Ngororero	KAGEYO	Kageshi	Ruganda	NEW TFR
Butezi	Kigoma	Gatumba	35mm2_6 ACSR	30	906.5	Ngororero	NGORORERO	Kazabe	Butezi	NEW TFR
Butotori	Karongi	Kibuye	50mm2_CU	30	653.1	Rubavu	Nyamyumba	Rubona	Butotori	NEW TFR
Rusongati	Karongi	Kibuye	120mm2_20 ACSR	30	343	Rubavu	Rugerero	Gisa	Rusongati	NEW TFR
Musave	Rulindo	Musasa	35mm2_6 ACSR	30	1,178.00	Gakenke	Gakenke	Kagoma	Musave	NEW TFR
Cyinama	Mukungwa	Janja	35mm2_6 ACSR	30	1,106.60	Gakenke	Mugunga	Gahinga	Cyinama	NEW TFR
Kibonwa	Mukungwa	Janja	35mm2_6 ACSR	30	706.9	Gakenke	Janja	Gakindo	Kibonwa	NEW TFR
Kabaya	Gifurwe	Gakenke	35mm2_6 ACSR	30	789.5	Gakenke	Gakenke	Rusagara	Kabaya	NEW TFR
Sitwe	Gifurwe	Gakenke	35mm2_6 ACSR	30	715	Gakenke	Gakenke	Rusagara	Sitwe	NEW TFR
Gashirwe	Mukungwa	Janja	70mm2_12 ACSR	30	326.9	Gakenke	Busengo	Ruhanga	Gashirwe	NEW TFR
Bukerera	Mukungwa	Janja	35mm2_6 ACSR	30	492.1	Gakenke	Janja	Gakindo	Bukerera	NEW TFR
Ryamukutsi	Camp Belge	Gisenyi	120mm2_20 ACSR	30	367.7	Musanze	Busogo	Sahara	Ryamukutsi	NEW TFR
Nengo	Camp Belge	Gisenyi	35mm2_6 ACSR	30	1,469.40	Musanze	Busogo	Gisesero	Nengo	NEW TFR
Buhoro	Camp Belge	Gisenyi	70mm2_12 ACSR	30	1,004.60	Musanze	Muhoza	Ruhengeri	Buhoro	NEW TFR
Masoro	Camp Belge	Gisenyi	35mm2_6 ACSR	30	1,420.40	Musanze	Kimonyi	Kivumu	Masoro	NEW TFR
Mutungo	Rulindo	Gicumbi	35mm2_6 ACSR	30	850.8	Burera	Bungwe	Tumba	Mutungo	NEW TFR
Nyabagenzi	Ntaruka	Cyanika	120mm2_20 ACSR	30	766.6	Burera	Kinoni	Ntaruka	Nyabagenzi	NEW TFR
Ruginga	Camp Belge	Kinigi	35mm2_6 ACSR	30	820.3	Musanze	Kinigi	Kaguhu	Ruginga	NEW TFR
Bugeyo	Ntaruka	Cyanika	120mm2_20 ACSR	30	1,201.90	Burera	Kinoni	Gafuka	Bugeyo	NEW TFR
Rwinkuba	Ntaruka	Cyanika	120mm2_20 ACSR	30	2,425.00	Burera	Rugarama	Rurembo	Rwinkuba	NEW TFR

Mugera	Gifurwe	Kirambo	70mm2_12 ACSR	30	1,627.30	Burera	Butaro	Rusumo	Mugera	NEW TFR
Gitanda	Gifurwe	Kirambo	70mm2_12 ACSR	30	495.5	Burera	Butaro	Rusumo	Gitanda	NEW TFR
Buyanga	Gifurwe	Kirambo	70mm2_12 ACSR	30	1,627.30	Burera	Butaro	Rusumo	Buyanga	NEW TFR
Total					23,523.80					24
Total Investment					1,057,500					142,915.44

Conductor size Upgrade Projects

Province	District	Length (m)	Comment
Western	Ngororero	2318.25	35mm2 to 70mm2
Western	Ngororero	2181.00	Interconnection Gatumba - Gisenyi
Northern	Gakenke	9686.85	35mm2 to 70mm2
Northern	Gakenke	13272.85	35mm2 to 70mm2
Northern	Gakenke	3341.15	35mm2 to 70mm2
Northern	Musanze	4403.61	35mm2 to 70mm2
Northern	Gakenke	11784.03	35mm2 to 70mm2
Northern	Gakenke	4373.82	35mm2 to 70mm2
Northern	Gakenke	8051.72	35mm2 to 70mm2
Northern	Musanze	6852.18	35mm2 to 70mm2
Northern	Musanze (Kalisimbi)	4500	n/a
Northern	Burera	6054.55	35mm2 to 120mm2

New proposed MV Lines and interconnection (N-1 Solutions)

S/N	Transformer Name	Substation	Feeder	Conductor	Voltage	Length (m)	Countermeasure
1	TBD	Rubavu	Rutsiro	120mm2_20 ACSR		9000	New Line

2	TBD	Rubavu	Ring Rubavu-Nyabihu	70mm2_12 ACSR	30	1000	New Interconnection
3	TBD	Rubavu	Ring Rubavu (Poids Lourds)	70mm2_12 ACSR	30	2400	New Interconnection
4	TBD	Rubavu	Ring Rubavu-Rutsiro	70mm2_12 ACSR	30	300	New Interconnection
5	TBD	Nyabihu	Double CKT Camp Belge-Nyabihu	70mm2_12 ACSR	30	1200	New Interconnection
6	TBD	Nyabihu	Double CKT Nyabihu-Rubavu-Ngororero	70mm2_12 ACSR	30	3000	New Interconnection
7	TBD	Rulindo	Gisenyi-Musasa	70mm2_12 ACSR	30	16000	New Interconnection
8	TBD	Kigoma	Gatumba-Gisenyi	70mm2_12 ACSR	30	2600	New Interconnection to reduce load on Gatumba
9	TBD	Nyabarongo I	Nyabarongo I SS-Gatumba	70mm2_12 ACSR	30	5000	New Interconnection to reduce load on Gatumba
10	TBD	Gicumbi	Gicumbi SS-Rukomo	70mm2_12 ACSR	30	200	New Line

11	TBD	Gicumbi	Gicumbi SS-Mukarange feeder	70mm2_12 ACSR	30	100	New Line
12	TBD	Gicumbi	Gicumbi SS-Byumba town feeder	70mm2_12 ACSR	30	200	New Line
13	TBD	Gicumbi	Gicumbi SS-Tumba feeder	70mm2_12 ACSR	30	200	New Line
14	TBD	Burera	Interconnection Gifurwe-Byumba	70mm2_12 ACSR	30	500	New Interconnection
15	TBD		Interconnection Base-Byumba	70mm2_12 ACSR	30	600	New Interconnection
16	TBD	Mukungwa	Gisenyi-Rwaza	70mm2_12 ACSR	30	1500	New Line
17	TBD	Mukungwa	Rwaza-Mukungwa	70mm2_12 ACSR	30	5000	New Line
18	TBD	Mukungwa	Rwaza-Mukungwa 2	70mm2_12 ACSR	30	3000	New Line
	Total					51,8	

Voltage Drop reduction projects in Northern Hub

BRANCH	LOCATION	Voltage Level (V)	PROBLEM (YES or NO)			RECOMMENDED ACTION			
			Overloaded Transformers	Undersized cables	Over-extended LV network	Extend MV and Insert new Tx		LV NETWORK (reconduct and reconfigure)	
						Length of MV (km)	Transformer size (kVA)	LV length (km)	LV POLES
MUSANZE	BYANGABO-MUGOGO	189	No	Yes	No			2	40
	BYANGABO-SAHARA	191	No	Yes	Yes	0.2	50	2	40
	JABIRO AGGLOMERATION	170	No	Yes	Yes	0.5	50	2	40
	KAGEZI-NYAGISOZI	184	No	Yes	Yes			2	40
	CYAMAHESHI-NYARUBARA	181	No	Yes	No	1.5	50	3	60
	GATOVU-RUNGU	160	No	Yes	No	2	160	3	60
	MURAGO	160	No	Yes	Yes	4	100	3.5	70
	BUTAKANYUNDO	192	No	Yes	Yes			2.5	50
	RWAMBOGO-BUHUNGE	179	No	Yes	yes	3	50	3	60
	KINIGI-CYANTURO-KAMPANGA	170	No	Yes	Yes	2	100	3.5	70
	KABEZA-CYABAGARURA-RUVUMU	110	Yes	Yes	Yes	1.2	100	3	60
	NYARUBARA-RWUNGA-KIREREMA	120	No	Yes	Yes	2	100	3	60
	SUSA BIRIRA KADAHENDA	188	No	Yes	Yes	1.5	50	3	60
	KIMONYI-RUREMBO	190	No	Yes	Yes	1	50	2	40
	KIMONYI-KIVUMU	200	No	Yes	Yes	1.5	50	2.5	50
	KABERE-MUBAGO-NYAGASAMBU	174	Yes	Yes	Yes	2	100	3	60
	KABERE-MUSENYI	185	No	yes	yes	1.5	50	2.5	50

MUKO-RWASIRIZO	181	No	Yes	No	1.1	50	2.5	50
MUKO-CYIVUGIZA	196	No	Yes	Yes	0.5	50	2	40
MUKO-MBURABUTURO-KUMAZI	189	No	Yes	Yes			2.5	50
MWANGANZARA	194	No	Yes	No			1.5	30
KIRUHURA-RUYUMBA	170	No	Yes	No	2	50	2	40
CONCASSEUR NYAKINAMA-GASYATA	192	No	Yes	Yes	1	50	3	60
CONCASSEUR KIRY-BUHAMA	183	No	Yes	Yes	0.9	50	2	40
GICUBA NPD-GICUBA CENTER	175	No	Yes	Yes	1.5	25	1	20
RDB-BUTORWA I-BUTORWA II	199	No	Yes	Yes	0		2	40
NYABIGOMA-KARYASENGE	185	No	Yes	No	0		2	40
KINIGI-CYIVUGIZA	200	No	Yes	Yes	0		2.1	42
CYIVUGIZA-EP KAGANO	178	No	Yes	No	0.7	50	2	40
NYARUBANDE-BURUBA-CYUVE SECTOR	191	No	Yes	Yes	1.3	50	2.5	50
KUNGO-NGANZO-R-MU RUKORO	196	No	Yes	No	0.5	100	2	40
CYANYA-BUTARE	198	No	Yes	Yes			2	40
KABIRIZI-RUNGU	189	No	Yes	No	0.3	50	2	40
CONCASSEUR-GITOVU	192	No	Yes	Yes			2	40
KIZUNGU-BURERA	177	No	Yes	No	0.2	160	3	60
GARE-EP MUBONA	181	No	Yes	Yes			2	40
GREAT LAKES CIMENT-GASANZE	190	No	Yes	No	0.5	50	2	40
BWUZURE	194	No	Yes	Yes			3	60

	MPENGE	201	No	Yes	No			1.5	30
	FOYER-KUMPALA-MATEUS	174	No	Yes	Yes			2	40
	NYANGE	194	Yes	Yes	No			4	80
	NYABIGOMA-KARYASENGE	185	No	Yes	Yes	0		2	40
	Total MUSANZE					34.4	26	100.1	2002
BURERA	KIDAKAMA/GAHUNGA	180	No	Yes	YES	3.5	50	5	100
	KANYIRAREBE/GAHUNGA	165	YES	Yes	YES	3	100	3	60
	KARANGARA/RUGARAMA	170	No	Yes	Yes	2.5	100	6	120
	CYAH/RUGARAMA	170	No	Yes	Yes	3	50	4.5	90
	GASIZA/CYANIKA	175	No	Yes	Yes	1.5	50	4	80
	KABYINIRO/CYANIKA	170	No	Yes	Yes	2	50	4	80
	RYABITEYI/CYANIKA	180	No	Yes	Yes	3	50	4	80
	RUREMBO/RUGARAMA	170	No	Yes	Yes	1.5	50	5	100
	NKENKE/KINONI	170	No	Yes	Yes	3	100	4	80
	NTARUKA/KINONI	170	No	Yes	Yes	2.5	50	5	100
	BUTARE/CYERU	180	No	Yes	Yes	4	50	3	60
	GASHORO/RWERERE	170	No	Yes	Yes	2.5	50	2	40
	KIVUMU/NEMBA	160	YES	Yes	Yes	3	50	4	80
	RUNABA/BUTARO	170	No	Yes	Yes	3	50	4	80
	MUCACA/RUGENGABARI	170	No	YES	YES	2	50	4	80
	SETA/RUGENGABARI	180	No	YES	YES	1.5	50	3.5	70
	KIRIBATA/RUGENGABARI	180	No	Yes	YES	1.5	50	3	60
	TABA/RUGENGABARI	175	No	Yes	YES	3.5	50	5	100
	RUKANDABYUMA	200	No	Yes	No			1	20
	REMYA/RUGENGABARI	200	No	Yes	No			2	40
	MUSASA/GITOVU	220	No	Yes	No			2	40
	MOMA/RWERERE	220	No	YES	No			4	80
	MURAMBO/CYERU	220	NO	Yes	No			2	40

	NDAGO/RWERERE	220	No	Yes	No			3	60
	RYUYANGE/CYERU	220	No	Yes	No			4	80
	KABONA/RUSARABUYE	220	No	Yes	No			6	120
	NYAMUGARI/NEMBA	220	No	Yes	No			2	40
	MATYAZO/RUHUNDE	220	No	Yes	No			4	80
	MUGARI/BUTARO	220	No	Yes	No			5	100
	BUGAMBA/KINYABABA	220	No	Yes	No			3	60
	KIRWA/KINYABABA	220	No	Yes	No			1	20
	MUSASA/KINYABABA	220	No	Yes	No			3	60
	MURAMBO/KINYABABA	220	No	Yes	No			3	60
	MASANGABO/KAGOGO	220	No	Yes	No			1	20
	KARUSIZI/KAGOGO	220	No	Yes	No			2	40
	RWARA/KAGOGO	220	No	Yes	No			4	80
	GISOVU/CYANIKA	220	No	YES	No			4	80
	BUTETE/CYANIKA	220	No	Yes	No			5	100
	NYARWONDO/RUGARAMA	220	No	Yes	No			6	120
	MAYA/RUGARAMA	220	No	Yes	No			4	80
	MAYA/RUGARAMA	220	No	Yes	No			3	60
	GAFUKA/KINONI	220	No	Yes	No			4	80
	NKUMBA/KINONI	220	No	Yes	No			4	80
	MUGU/KAGOGO	220	No	Yes	No			1	20
	KAMONYI/BUTARO	180				2	50	4	80
	NYAMABUYE/KAGOGO	170	No	Yes	Yes	2.5	50	5	100
	Total BURERA					51	20	165	3300
GAKENKE	GAKENKE CENTER	160	YES	NO	YES	1.8	400	2.5	50
	MUHONDO	180	No	Yes	YES	1	100	2	40
	KAMUBUGA	160	No	Yes	Yes	2	50	4	80
	RUSHASHI	180	No	Yes	NO	1	160	1.5	30

	RULI	180	NO	Yes	No	0.6	200	2	40
	MUGUNGA	180	No	Yes	YES	1.1	25	1.5	30
	Total GAKENKE					7.5	6	13.5	270
NGORORERO									
	KAMPALA	180	NO	NO	YES	3	50	0.5	10
	RUHINDAGE	185	NO	NO	YES	4	50	1	20
	MWIHA	190	NO	NO	YES	2.5	50	0.3	6
	Tatal NGORORERO					9.5	3	1.8	36
NYABIHU	REGA - JENDA	140	YES	NO	YES	0.1	50	0.4	8
	BUSORO - KADAHENDA	180	No	NO	YES	1.3	50	0.5	10
	AGASOKO - MUKAMIRA	160	No	Yes	Yes	0.3	100	0.3	6
	KABASHUMBA - KINTOBO	180	No	NO	YES	4	50	1	20
	GAHARAWA - KIRAMIRA	160	YES	NO	No			0.8	16
	MURAMA - NYAKIRIBA - RUGERA	140	No	Yes	YES			15	300
	Total NYABIHU					5.7	4	18	350
RUBAVU	Nyamyumba	160	No	Yes	yes	2	100	2	40
	Rugerero-Hotellerie	170	No	Yes	yes			3	60
	Bugeshi-Kabumba-Buringo	160	No	Yes	Yes	5.5	25(1),50(1) and 100(1)	5	40
	Mbugangali-Karundo	140	Yes	No	No			1	20
	Mahoko-Kanama	140	No	Yes	Yes			3	60
	Nyamyumba-Buraseli	160	No	Yes	Yes			3	60
	Rugerero-Cyanika	160	No	Yes	yes		160	2	40
	Rugerero-Kabirizi	150	No	Yes	No	0.8	100	2	40
	Byahi-Zone	170	No	Yes	Yes	1	400	1	20
	Mahoko-Kayove	165	yes	NO	No		100	0	0
	Gisenyi-G. Boarder-Nyakabungo	170	No	Yes	Yes	1.2	250	1	40

	Nyamyumba/Ruggerero-Rushibi	180	No	Yes	Yes		100	2	40
	Mahoko-Mucyondo	170	Yes	Yes	Yes	2	100	3	60
	Mpfunda-Keya-Kinigi	160	No	yes	yes			1	20
	Nyamyumba-Munanira-Kabiza	160	No	Yes	No	8	250 (2)	10	100
	Nyamyumba-Nyaneja-Buruseri	170	No	Yes	Yes			4	80
	Nyundo-Terimbere	160	No	Yes	No	2	160	2.5	50
	Ruggerero-Muhira	180	No	Yes	Yes	3	160	4	80
	Nyakiriba-Kanyefurwe	140	No	Yes	Yes	1.5	100	1.5	30
	Kanzenze	160	No	Yes	Yes	1	100	2	40
	Total RUBAVU					28	17	53	920
TOTAL FOR NORTHERN HUB						136.1	76	351.4	6,878

Required Investment for network reinforcement in Northern Hub

Quantity	MV length (km)	MV length (km)	Number of Transformers
	223	351.4	100
Investment Required (USD)	10,035,000	7,028,000	595,481
Total Investment (USD)	17,658,481		

Note: The cost of one 1km of MV and LV lines are 45,000 USD and 20,000 USD respectively, and the cost of 50 kVA is 5,954.81 USD, all transformers are assumed to be 50 kVA out of Kigali while modelling the size of each transformer depending on demand forecast in each area.

IX. SHORT-MEDIUM TERM PROJECTS FROM MODEL RESULTS IN EAST

1. Introduction

The Eastern Hub comprises of Rwamagana, Kayonza, Ngoma, Kirehe, Gatsibo and Nyagatare Districts.

The Eastern area is the host of the railway connecting countries of the Northern Corridor.

In addition to that, it is an area where critical projects are being implemented which require enough power to sustain businesses amongst which irrigation, Milk collection Centres, Mining and Special Economic Zones in Nyagatare and Rwamagana Districts.

Important projects are underway in Gatsibo and Nyagatare including but not limited to Gabiro Commercial farm project and East African Granite Industries and there is no doubt that these planned and ongoing projects will put stress on existing electricity infrastructure while the entire area is currently supplied mainly by KKK and Zaza feeders.

Network reinforcement projects are ongoing, and others are planned including the construction of Gicumbi SS, Nyagatare SS and Kirehe SS. Important feeders will be drawn from those Substations to reinforce network in the Eastern area.

2. Zones in Eastern Hub and key factors for zoning

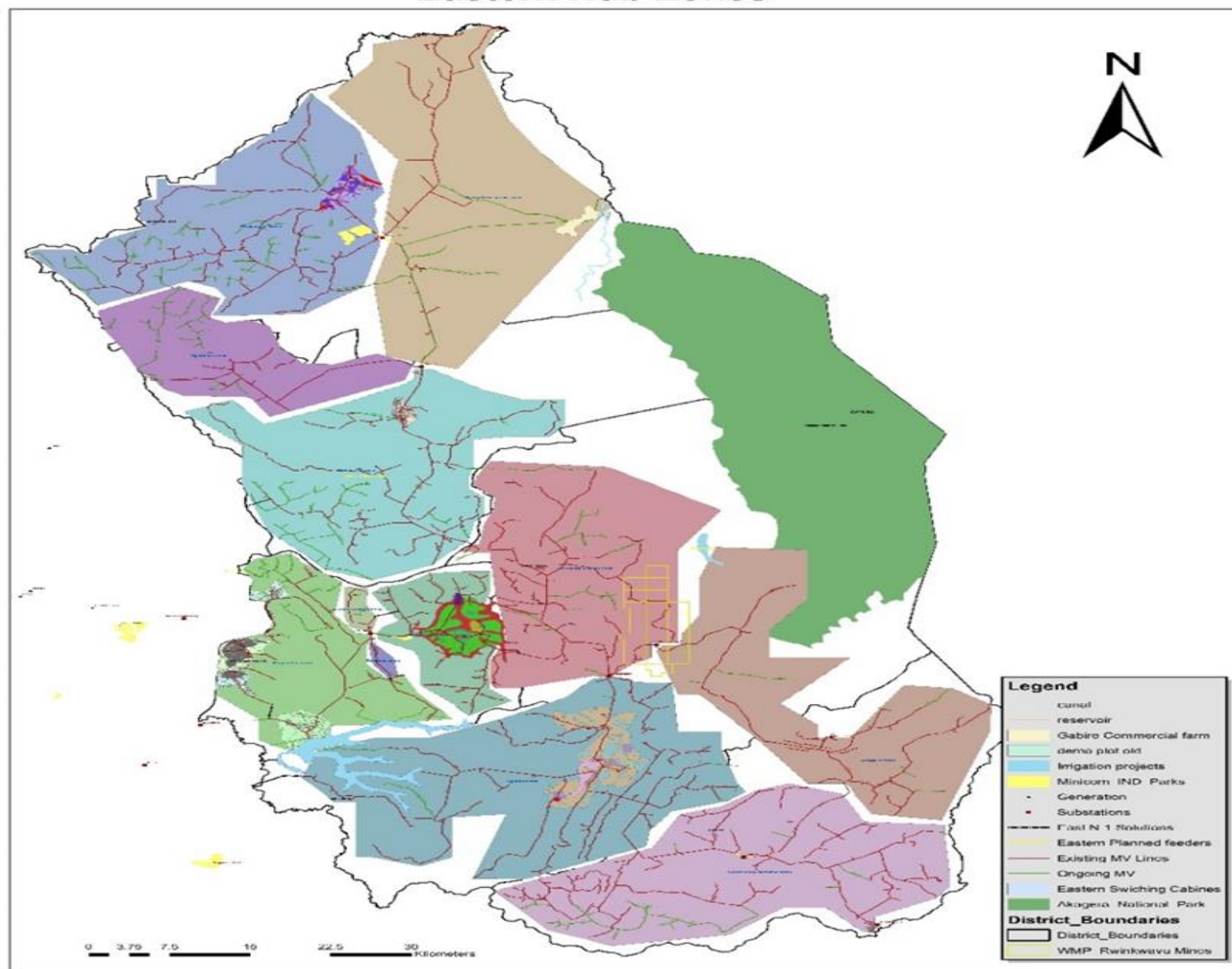
Twelve (12) zones have been proposed in line with available feeders and substations in the Eastern Hub. Key factors for zoning were also mentioned as found on the table below:

S/N	Name	District	Feeder	Keyfactors
1	Nyagatare Town Zone	Nyagatare	KKK	District Town,SEZ, irrigation at Karangazi
2	Nyagatare farms zone	Nyagatare	KKK	Gabiro commercial farm, other farms, cross-border
3	Ngarama zone	Gatsibo	KKK	Irrigation in warufu marsh, urban area
4	Ruramira-Gahini zone	Kayonza	KKK	Rwinkwavu Mines,Urban areas, irrigation

5	Kabarore zone	Gatsibo	KKK	Gatsibo District town, urban centres
6	Akagera zone	Kirehe	Akagera	Nasho irrigation facilities, Akagera Hotel
7	Nyarubuye-Mahama zone	Kirehe	Zaza	Rusumo one Stop Border Residential, refugees' camps
8	Ngoma zone	Ngoma	Zaza	Ngoma District Town, Mugesera Lakeshores MP
9	Rwamagana Town zone	Rwamagana	Rwamagana	District town, SEZ
10	Musha-Ntunga zone	Rwamagana	Rwamagana	Mines, residential
11	Muyumbu zone	Rwamagana	Karenge, Kanombe	Karenge, Muyumbu, Nyakaliro and Nyagasambu urban
12	Rubona zone	Rwamagana	Rubona solar	Mwulire Gigawatt project for residential

The map for zoning is found as follow:

Eastern Hub Zones



3. Major Anticipated loads on Electricity Distribution Network in Eastern Hub

Anticipated major load in EASTERN HUB						
		Load Category	Total Load MW (2021-2023)			
Substation	Feeder			2021	2022	2023
Kabarondo	Zaza	RUSUMO BORDER cross border market	0.1	0.1		
		KIYANZI stone crusher KIREHE	0.1	0.1		
		Street lights KAYONZA- RUSUMO	0.2	0.1	0.1	
		Street lights KIBUNGO- RAMIRO	0.2	0.1	0.1	
	KKK	KAGITUMBA BORDER cross border market	0.1	0.1		
		MIRAMA meat Plant NYAGATARE	0.2		0.1	0.1
		Kayonza Industrial Zone	0.4	0.1	0.1	0.2
		Water treatment plant WASAC Ndego KAYONZA	0.5	0.2	0.2	0.1
Gabiro	Nyagatare	Nyagatare Golf	0.1	0.1		
		NYAGATARE Industrial zone RUTARAKA	3.7	0.9	1.4	1.4
		GABIRO Airport extension	0.2		0.1	0.1
		Water treatment plant WASAC CYONDO NYAGATARE&GIHENGGERI	0.9	0.5	0.2	0.2
		Street lights KAGITUMBA KAYONZA	0.2		0.1	0.1
	Kiziguro	Irrigation BRAMIN	0.4	0.1	0.1	0.2
	Ngarama	GABIRO Agribusiness Hub	1	0.3	0.3	0.4
Gabiro	Ngarama	Karangazi commercial farm	1	0.4	0.3	0.3
Musha		Rwamagana Industrial Park(1.3	0.4	0.4	0.5
	All Eastern Feeders	Others	0.1	0.1		
		Yearly Total Load Increment in EASTERN HUB (MW)	10.7	3.6	3.5	3.6

4. Feeder loading after anticipated Major load growth (2021-2023) in Eastern Hub

SUBSTATION	Existing Transfo MVA	Feeder	Length (km)	EASTERN SUBSTATIONS				% Loading at Peak (Calculated)	Load Increment on Feeders(MV) as per the anticipated major loads	% Feeder Loading (2021-2023)
				Conductor Size	Maximum Current (A)	Max Power Capacity (MW)	Peak Power [MW]			
GABIRO	2 *10	Nyagatare	362	ACSR 120/20 mm ²	410	17.04	2.6	15.00%	5.1	45.18%
		Kiziguro	425	ACSR 120/20 mm ²	410	17.04	0.9	7.50%	0.5	8.21%
		Ngarama	105	ACSR 120/20 mm ²	410	17.04	0.6	3.50%	2	15.25%
		Total					4.1			
RWINKWAVU	1*6	Akagera	102	ACSR 70/12 mm ²	290	12.05	1.47	11.76%		
		Redemi		ACSR 35/6 mm ²	145	6.03	0	0.00%		
Total							1.47			
MUSHA	1*20	Rwamagana	108	ACSR 70/12 mm ²	290	6.03	1.98	32.84%	1.3	54.39%
		Karenge	70.5	ACSR 70/12 mm ²	290	6.03	1.93	32.00%		
		Redemi	11.4	ACSR 70/12 mm ²	290	6.03	0.206	3.41%		
		Rubona	9.2	ACSR 70/12 mm ²	290	6.03	2.96	49.08%		
		Steelrwa		ACSR 120/20 mm ²	410	8.52	3.26	38.26%		
Total							10.336			
KABARONDO	1*10	Kabarondo, Kayonza (KKK)		ACSR 70/12 mm ²	290	12.05	2.04	17.00%	1.2	26.88%
		ZAZA	561	ACSR 70/12 mm ²	290	12.05	2.72	22.60%	0.6	27.55%
Total							4.76			
Grand total									10.7	

5. Network Strengthening Projects and Investment Proposal in Eastern Hub

Transformer Name	Substation	Feeder	Conductor	kV	Length (m)	District	Sector	Cell	Village/TFR Name	Countermeasure
Tetero	KABARONDO	ZAZA	54_6_AAC	30	-	Kirehe	Nyamugari	Kazizi	Tetero	NEW TFR
Bukokozi	KABARONDO	ZAZA	70_12_ACSR	30	160.4	Ngoma	Sake	Nkanga	Bukokoza	NEW TFR
Kagarama	KABARONDO	ZAZA	54_6_AAC	30	2,397.80	Ngoma	Rukumberi	Rubona	Kagarama	NEW TFR
Kigese	KABARONDO	ZAZA	54_6_AAC	30	2,513.20	Ngoma	Rukumberi	Ntovi	Kigese	NEW TFR
Rwamibabi	KABARONDO	ZAZA	54_6_AAC	30	2,809.20	Ngoma	Rukumberi	Ntovi	Rwamibabi	NEW TFR
Nyagakizi	KABARONDO	ZAZA	35_6_ACSR	30	816.9	Ngoma	Kibungo	Gatonde	Nyagakizi	NEW TFR
Rwinyange	RWINKWAVU	AKAGERA	35_6_ACSR	30	-	Kirehe	Nasho	Kagese	Kagese Ii	NEW TFR
Rugazi	KABARONDO	ZAZA	54_6_AAC	30	2,992.80	Ngoma	Mugesera	Nyange	Agatare	NEW TFR
Nunga 2	KABARONDO	ZAZA	54_6_AAC	30	1,851.10	Ngoma	Mugesera	Nyange	Nunga	NEW TFR
Nunga 1	KABARONDO	ZAZA	54_6_AAC	30	2,051.80	Ngoma	Mugesera	Nyange	Nunga	NEW TFR
Rushoka	RWINKWAVU	AKAGERA	70_12_ACSR	30	-	Kirehe	Nasho	Cyambwe	Rushoka	NEW TFR
Rugando	KABARONDO	ZAZA	70_12_ACSR	30	1,379.90	Ngoma	Remera	Ndekwe	Rugando	NEW TFR
Ndengo	MUSHA	KARENGE	35_6_ACSR	30	2,160.70	Rwamagana	Karenge	Nyamatete	Ndengo	NEW TFR
Kiboha	MUSHA	KARENGE	35_6_ACSR	30	1,745.00	Rwamagana	Rubona	Kabatasi	Umurehe	NEW TFR
Rwabudengeri	RWINKWAVU	AKAGERA	70_12_ACSR	30	2,080.00	Kayonza	Murama	Murama	Rwabugengeri	NEW TFR
Bushenyi	GABIRO	KIZIGURO	54_6_AL	17.32	927.8	Gatsibo	Kiramuruzi	Nyabisindu	Bushenyi	NEW TFR
Urubibi	GABIRO	KIZIGURO	70_12_ACSR	30	-	Gatsibo	Muhura	Gakorokombe	Urubibi	NEW TFR
Nyamugali	GABIRO	KIZIGURO	35_6_ACSR	30	1,180.80	Gatsibo	Remera	Rwarenga	Nyamugari	NEW TFR
Rwakabanda	GABIRO	KKK	54_6_AL	17.32	-	Kayonza	Murundi	Ryamanyoni	Rwakabanda	NEW TFR
Cyoga I	GABIRO	KIZIGURO	35_6_ACSR	30	363.3	Gatsibo	Muhura	Taba	Cyoga I	NEW TFR
Kabeza 1	GABIRO	KIZIGURO	54_6_AL	17.32	529.9	Gatsibo	Kabarore	Nyabikiri	Kabeza	NEW TFR
Kabeza 2	GABIRO	KIZIGURO	120_20_ACSR	30	728.7	Gatsibo	Kabarore	Nyabikiri	Kabeza	NEW TFR
Bihinga	GABIRO	NYAGATARE	120_20_ACSR	30	869	Gatsibo	Kabarore	Kabarore	Bihinga	NEW TFR
Nyakagarama	GABIRO	NYAGATARE	35_6_ACSR	30	73.7	Gatsibo	Gatsibo	Gatsibo	Gatare	NEW TFR
Simbwa	GABIRO	NYAGATARE	120_20_ACSR	30	1,290.80	Gatsibo	Kabarore	Simbwa	Simbwa	NEW TFR
Total					28,922.80					25
Investment					1,300,500					148,870.25
Total Investment					1,449,370.25					

Voltage drop Reduction Projects

BRANCH	LOCATION	Voltage Level (V)	PROBLEM (YES or NO)			RECOMMENDED ACTION			
			Overloaded Transformer	Undersized cables	Over-extended LV network	Extend MV and Insert new Tx		LV NETWORK (reconduct and reconfuge)	
						Length of MV (km)	Transformer size (kVA)	LV length (km)	LV POLES
NGOMA	GAHURI	180	YES	Yes	YES	1	100	1.5	30
	GATORO, ASPEC, KARUTANESHA	170	YES	NO	YES	1.5	100	1	20
	SOEUR THERAPEUSTINE	230	No	Yes	NO			1	0
	KINUNGA REMERA	180	No	Yes	YES			1.5	25
	NYAMAGARA REMERA	180	No	Yes	YES			1	20
	ZAZA JYAMBERE	180	No	Yes	NO			1	30
	SAKE RUKOMA	230	No	Yes	NO			0.4	8
	KARENSE SEKODO	230	No	Yes	NO			1	20
	Total RUSIZI					2.5	2	8.4	153
NYAGATARE	KAMAGIRI	230	No	Yes	No			1	20
	BUGARAGARA	220	No	Yes	yes	0.5	100	3	60
	KABEZA	220	yes	Yes	Yes		250	2	40
	RWIMIYAGA	220	yes	Yes	Yes	0.2	250	6	120
	NTOMA	220	No	Yes	No			0.5	10

	MUSERI	220	No	Yes	No			3	60
	MATIMBA	220	Yes	Yes	Yes	0.3	100	4	80
	KAGITUMBA	220	No	Yes	No			1	20
	RYABEGA	220	No	Yes	yes	0.5	50	5	100
	KANGUKA(Mbare)	220	No	Yes	No			1.5	30
	RUHUHA 1(Bushoga)	220	No	Yes	No			2	40
	RUHUHA 2(Bushoga)	220	No	Yes	No			2	40
	KANGUKA	220	No	Yes	No			2	40
	GAKIRAGE(Nkonji)	220	No	Yes	No			2	40
	CYABAYAGA	220	No	Yes	Yes			3	60
	MIMURI	220	No	Yes	Yes			2	40
	RURENGE(Nyakagarama)	220	No	yes	No			1.5	30
	RURENGE(MUKOMA)	220	No	Yes	No			5	100
	RUKOMO(Urugwiro+ Bukamba)	220	No	Yes	Yes			3	60
	GATUNDA(Buguma)	220	No	Yes	Yes			6	120
	NYAGATARE Town	220	No	Yes	No			2.5	50
	MUSENYI	220	No	No	No		250		
	Total NYAGATARE					1.5	6	58	1160
GATSIBO	BUGARURA -REMER	140	Yes	NO	Yes	5	100	5	80
	NYABIHEKE - NYABICWAMBA	140	Yes	NO	Yes	0.15	100	2	40
	MUHURA Secteur	100	Yes	NO	Yes	1	25	3	60
	MALIMBA	250	Yes	NO	Yes	3	250	2	40
	KABARORE Secteur	250	Yes	NO	Yes	0	250	3.5	65
	NYAGIHANGA-NGARAMA- GATSIBO	140	Yes	NO	Yes	0	100	2	40
	KIGASHA -KABUGA	50	Yes	NO	Yes	0	25	1.5	30

	MATABA -MURAMBI	80	Yes	NO	Yes	3	50	3.5	65
	Total GATSIBO	1150				12.15	8	22.5	420
KAYONZA	BWIZA	164	yes	yes	yes			3.75	75
	GASOGORORO 1	152	yes	yes	yes			0.6	12
	GAHUSHYI	157	yes	yes	yes			3.25	65
	CYERU	187	yes	yes	yes		160	4	80
	BUHONDI	205	No	yes	yes		100	3	60
	KINYEMERA/PADIRI	184	No	yes	No			3.1	62
	IREBERO	200	yes	yes	Yes			3	60
	MBURABUTURO	172	No	yes	yes			2.5	50
	GIKAYA/KINKORONGO	205	yes	yes	yes		50	3.55	71
	RWINGERI	192	No	yes	yes			1.65	33
	RUVUMU	152	No	yes	yes			4	80
	URUGAGI	153	No	yes	yes			2.15	42
	SHYOGO	198	No	yes	yes			2.8	56
	CYABAJWA	155	Yes	yes	No	1	160	3	
	RUSERA	193	No	No	yes	1	100	0.8	
	KIYENZI/GAHINI	205	No	Yes	yes	0.5	50	2.3	46
	KARUBAMBA/RUKARA	172	No	Yes	yes			2	40
	MUKOYOYO/RWINKWAVU	208	No	Yes	yes			2.5	50
	Total					2.5	6	44.4	807
KAYONZA	EUCL BRANCH NYAGASENYI	190	no	yes	yes	2	200	11.3	226
	POLICE GISHALI	195	no	yes	yes	1	160	4.25	85
	RIZICULTURE	187	no	yes	yes			3.85	77
	MIYANGE	152	yes	yes	yes	1	160	6.4	128
	KIGABIRO	164	No	yes	yes	1	250	4.2	84
	RWAMAGANA IGA -PLAGE	184	YES	yes	yes	1	250	6.2	124

	RWAMAGANA PLAGE	200	yes	yes	yes	1	250	5.3	106
	NYARUSANGE	182	No	yes	yes	1	160	6.6	132
	NSINDA	205	yes	yes	yes	1	160	8	156
	KABARE	192	No	yes	yes			3	60
	GASI	200	No	yes	yes	0	100	2.2	44
	KABASORE	160	No	yes	yes	1	100	8	160
	GAHOKO	195	No	yes	yes	0	100	4.1	82
	NYIRABIGAJI	190	Yes	yes	yes	0	160	1.8	36
	RUBONA	193	No	yes	yes	1	100	10	200
	HAMEAUX DES JEUNES	205	No	yes	yes	1	100	3.9	78
	BIHEMBE A	156	No	yes	yes	3	100	11.8	236
	BIHEMBE B	163	No	yes	yes	3	100	10	200
	KARENGE C.S	175	No	yes	yes	2	100	7.5	150
	SP KARENGE 1	170	No	yes	yes	2	100	7.5	150
	sP KARENGE 2	162	No	yes	yes	2	100	8.55	171
	SANATORIUM	200	No	yes	yes	0		3.5	70
	NZIGE	162	No			4	100	12.3	246
	Total					2.5	20	150.05	2775
KIREHE	RUBIRIZI RWANDARUSHYA KABIGEMBE KAGEYO	140	YES	YES	YES	2	250	7.9	158
	GASHIRU	220	NO	YES	YES			1.25	25
	KABUYE	220	NO	YES	YES			0.4	8
	KAGESE	190	NO	YES	YES			2	40
	CYAMBWE	190	YES	YES	YES			0.25	5
	RUHANGA	190	YES	YES	YES	1	100	7	140
	RWAKARINDA	220	NO	YES	YES			0.25	5
	RWAGASARE	220	NO	YES	YES			0.25	5
	RUBARE	220	NO	YES	YES			0.4	8

RWAMAKARA	220	NO	YES	YES			0.15	3
NYAMUGARI KAZIZI TETERO	220	NO	YES	YES			0.45	9
URUREMBO	220	NO	YES	YES			0.45	9
ISANGANO	220	NO	YES	YES			0.25	5
KABEZA	220	NO	YES	YES			0.3	6
KARAMBI	220	NO	YES	YES			0.9	18
IRAMA	220	NO	YES	YES			1	20
RUSUMO	190	YES	YES	YES			1.33	27
KIREHE CENTRE	220	NO	YES	YES			2.5	50
GATORE IHEMA	220	NO	YES	YES			1	20
GATORE-GAHEZI	190	YES	YES	YES			1.2	24
GATORE-CYUNUZI	220	YES	YES	YES			2	40
GAHARA(DAGAZA , KU MURENGE)	220	YES	YES	YES			1	20
KIREHE-NYABIKOKORA	220	NO	YES	YES			1.25	25
TOTAL					3	2	33.48	670
TOTAL FOR EASTERN HUB					24.15	44	317	5,985

Upgrade Projects

Province	District	Sector	Feeder	Substation	Conductor	Voltage	Length (m)
East	Gatsibo	Gatsibo	NGARAMA	GABIRO	ACSR	30	73.68
East	Gatsibo	Gitoki	NGARAMA	GABIRO	ACSR	30	1548.85
East	Gatsibo	Kabarore	KIZIGURO	GABIRO	AL	17.32	529.91
East	Gatsibo	Kabarore	KIZIGURO	GABIRO	ACSR	30	728.67
East	Gatsibo	Kabarore	KIZIGURO	GABIRO	ACSR	30	1290.82
East	Gatsibo	Kabarore	KIZIGURO	GABIRO	ACSR	30	868.96
East	Gatsibo	Kiramuruzi	KIZIGURO	GABIRO	AL	17.32	927.8
East	Gatsibo	Muhura	KIZIGURO	GABIRO	AL	17.32	252.29
East	Gatsibo	Muhura	KIZIGURO	GABIRO	ACSR	30	363.34
East	Gatsibo	Murambi	KIZIGURO	GABIRO	ACSR	30	217.69
East	Gatsibo	Murambi	KIZIGURO	GABIRO	AL	17.32	1258.24
East	Gatsibo	Remera	KIZIGURO	GABIRO	ACSR	30	963.06
East	Gatsibo	Rugarama	KIZIGURO	GABIRO	ACSR	30	3025.85
East	Gatsibo	Rwimbogo	KIZIGURO	GABIRO	AAAC	17.32	1525.34
East	Gatsibo	Rwimbogo	KIZIGURO	GABIRO	AL	17.32	1508.53
East	Kayonza	Kabare	AKAGERA	RWINKWAVU	ACSR	15	3069.26
East	Kayonza	Kabare	AKAGERA	RWINKWAVU	ACSR	15	341.01
East	Kayonza	Kabarondo	ZAZA	KABARONDO	ACSR	30	7212.25
East	Kayonza	Murama	AKAGERA	RWINKWAVU	ACSR	15	1050.34
East	Kayonza	Murundi	KIZIGURO	GABIRO	ACSR	30	3180.52
East	Kayonza	Ndego	AKAGERA	RWINKWAVU	ACSR	15	11447.71
East	Kirehe	Nasho	AKAGERA	RWINKWAVU	ACSR	15	827.64
East	Kirehe	Nasho	AKAGERA	RWINKWAVU	ACSR	15	71.38
East	Ngoma	Gashanda	ZAZA	KABARONDO	ACSR	30	1365.67
East	Ngoma	Jarama	ZAZA	KABARONDO	AAAC	17.32	2653.34
East	Ngoma	Kibungo	ZAZA	KABARONDO	ACSR	30	392.95
East	Ngoma	Kibungo	ZAZA	KABARONDO	ACSR	30	1760.58
East	Ngoma	Mugesera	ZAZA	KABARONDO	AAAC	17.32	4369.81
East	Ngoma	Mugesera	ZAZA	KABARONDO	AAAC	17.32	5863.48
East	Ngoma	Mugesera	ZAZA	KABARONDO	AAAC	17.32	6895.73
East	Ngoma	Mutenderi	ZAZA	KABARONDO	ACSR	30	379.79
East	Ngoma	Remera	ZAZA	KABARONDO	ACSR	30	1379.93
East	Ngoma	Rukira	ZAZA	KABARONDO	ACSR	30	423.93
East	Ngoma	Rukumberi	ZAZA	KABARONDO	AAAC	17.32	2513.23
East	Ngoma	Rukumberi	ZAZA	KABARONDO	AAAC	17.32	2809.17
East	Ngoma	Rukumberi	ZAZA	KABARONDO	AAAC	17.32	2397.75
East	Ngoma	Sake	ZAZA	KABARONDO	ACSR	30	160.43
East	Ngoma	Sake	ZAZA	KABARONDO	ACSR	30	2718.23
East	Ngoma	Zaza	ZAZA	KABARONDO	ACSR	30	1162.4
East	Ngoma	Zaza	ZAZA	KABARONDO	ACSR	30	434.62
East	Rwamagana	Karenge	KARENGE	MUSHA	ACSR	15	2160.74
East	Rwamagana	Nzige	KARENGE	MUSHA	ACSR	15	2549.85
East	Rwamagana	Rubona	KARENGE	MUSHA	ACSR	15	1981.79
East	Rwamagana	Rubona	KARENGE	MUSHA	ACSR	15	2065.8
East	Rwamagana	Rubona	KARENGE	MUSHA	ACSR	15	1744.99
East	Rwamagana	Rubona	KARENGE	MUSHA	ACSR	15	997.44
Total							91,464.79

New proposed MV Lines and interconnection (N-1 Solutions) in Eastern Hub

	Project	New MV length (km)	Investment
1	MV Line Kirehe SS-Zaza feeder1	1	
2	MV Line Kirehe SS-Zaza feeder2	1	
3	MV Line Kanombe-Karenge (N-1)	2	
4	MV Line Redemi-Rwamagana (N-1)	2.5	
5	MV Line Rwinkwavu SS-KKK (N-1)	0.9	
6	MV Line Rwamagana-KKK (N-1)	0.5	
7	MV Line Byumba Town-KKK (N-1)	2.8	
8	MV Line Rwinkwavu SS-KKK (N-1)	0.8	
9	MV Line Nyagatare SS-KKK Feeder 1	0.5	
10	MV Line Nyagatare SS-KKK Feeder 2	0.5	
11	MV Line Nyagatare SS-KKK Feeder 3	0.5	
	Total Investment	13	585,000

Required Investment for network reinforcement East

Quantity	MV length (km)	MV length (km)	Number of Transformers
	157.65	317	69
Investment Required (USD)	7,094,250	6,340,000	410,881,89
Total Investment (USD)	13,845,131.89		

X. SHORT -MEDIUM TERM PROJECTS FROM MODEL RESULTS IN WEST

1. Introduction

The network in Western Part of the country is not as challenged as for other hubs. This mainly because in the western part there are considerably enough generation and transmission projects including substations and feeders. The feeders are not too long with exception of Kibuye feeder which extends from Karongi to Rutsiro and does not have any other source of power supply.

Following the fact that the western part accommodates important urban nodes with designation of Rusizi District as secondary city, and industries such as tea factories in Shagasha, Gisovu, Gisakura and cement production industries, the western part may be challenged by lack of alternative power supply due to single supply from one feeder.

In addition to that, Rwanda envisages to export power to neighboring countries bordering the western Hub but the current infrastructures in Rubavu and Mururu need to be upgraded

REG has started initiatives to upgrade the existing electricity infrastructure at Mururu and in this master plan, several N-1 Solutions to serve as contingency plan to some of the feeders have been proposed.

2. Zones in Western hub and projects.

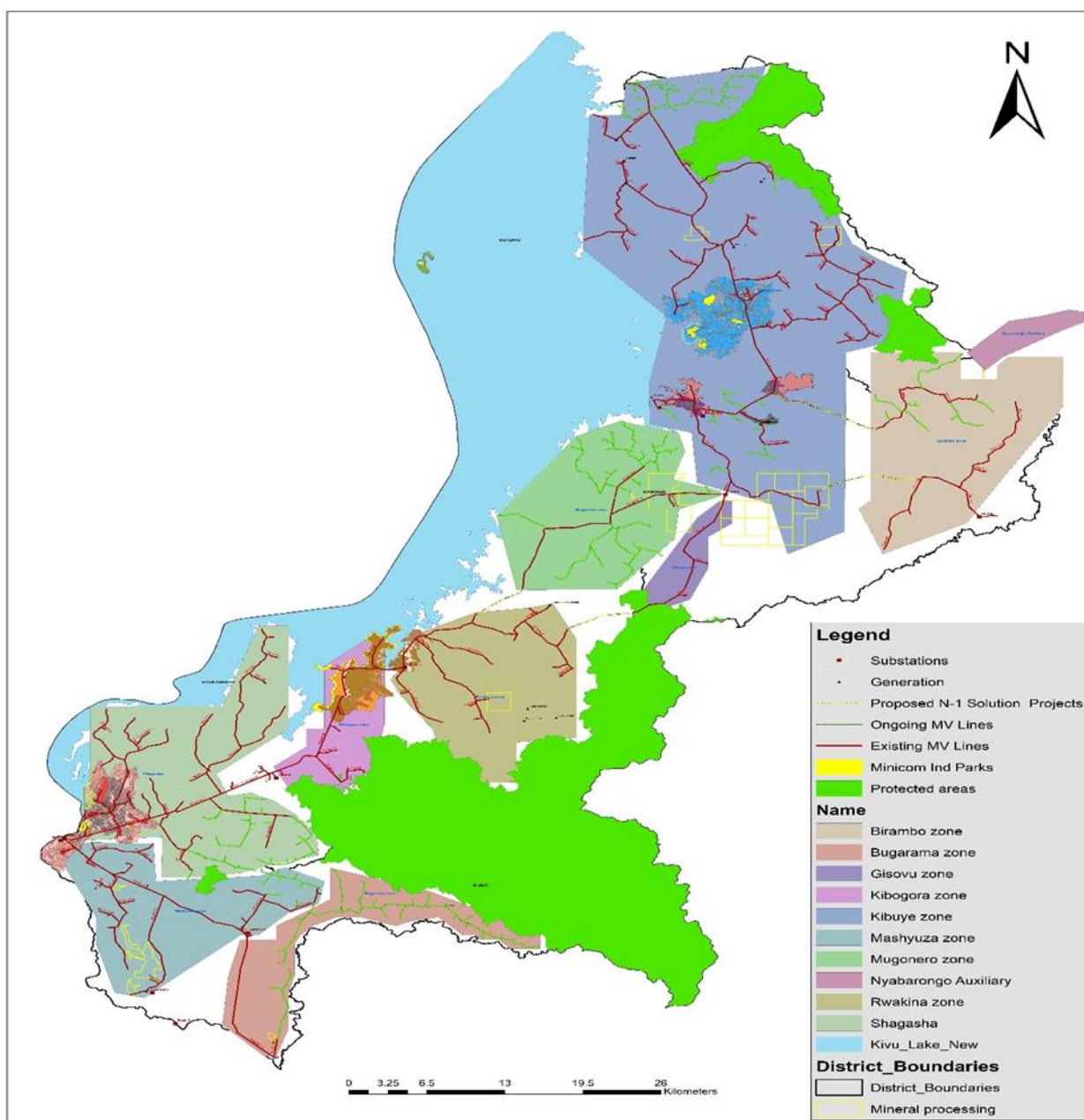
In the western hub, only 10 zones were identified based on the feeders and electricity generation infrastructure available. In addition, key zones were founded based on the pulling factors available and planned to be established in the western hub as per the following table:

S/N	Feeder	District	Name	Keyfactors
1	Kibogora	Nyamasheke	Kibogora zone	Urban centre
2	Shagasha-Mururu	Rusizi	Shagasha zone	Tea Factory, Rusizi District Town, SEZ
3	Kibuye	Rutsiro, Karongi	Kibuye zone	Urban areas, residential, Hotels,Bisesero Mines
4	Birambo	Nyamasheke	Birambo zone	Residential
5	Nyabarongo Auxiliary	Ngororero	Nyabarongo Auxiliary	Mining area
6	Gisovu	Karongi	Gisovu zone	Tea factory,Mineral processing
7	Mugonero	Karongi,Nyamasheke	Mugonero zone	residential, industrial quarry and crushing plant

8	Rwakina	Nyamasheke	Rwakina zone	Residential, factory,pyramide minerals processing
9	Bugarama	Rusizi	Bugarama zone	cross-Border, Residential
10	Mashyuza	Rusizi	Mashyuza zone	Cement factory, residential

Map for zoning in western Hub is as the following:

Western Zoning and projects



3. Anticipated Major Load on Electricity Distribution network in Western Hub

Anticipated major load in WESTERN HUB						
Rusizi Branch						
Substation	Feeder	Load Category	Total Load (2021-2022)	Additional Loads in each year		
				2021	2022	2023
Mururu I	Shagasha	Two big Commercial Buildings in Rusizi	0.2	0.1	0.1	
Mururu I	Shagasha	Two New Hotels under construction	0.2	0.1	0.1	
Mashyuza	Bugarama	Bugarama cross Border Market	0.1	0.1		
Mashyuza	Bugarama	COTCORI Rice Factory Extension	0.1	0.1		
Mashyuza	Cimerwa	CIMERWA Factory Extension	2	0.5	0.5	1
Mashyuza	Mashyuza	Gikundamvura Water Treatment Plant	0.2	0.2		
Mururu I	Shagasha	Banana beer processing factory-Nkungu	0.1	0.1		
Mururu I	Shagasha	Construction Rusizi Port	0.3	0.1	0.1	0.1
Mururu I	Shagasha	Rusizi Airport Extension plus Surround	0.2	0.1	0.1	
Mururu I	Shagasha	Giheke-Ruhwa public road lighting	0.2	0.1	0.1	
Mururu I	Shagasha	Rusizi Industrial Park(8MW)	2.3	0.3	1	1
Mururu I	Shagasha	Street Lights in Rusizi city (kurya 1-kur	0.1	0.1		
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	6.3	2	2.1	2.2
Rutsiro Branch						
Karongi	Kibuye	Two big Commercial Buildings in Rutsir	0.2		0.1	0.1
		New Hotel under construction	0.1	0.1		
		Nkora Modern Market/ lake Port	0.1	0.1		
		Mineral processing plant	0.1	0.1		
		Street lights	0.2	0.1	0.1	
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	1	0.4	0.3	0.2
Karongi Branch						
		4 Hotel under constraction+4 not yet st	0.2		0.1	0.1
		Two New Hotels under construction	0.1	0.1		
		Affrines Factory (ship assembling)	0.1		0.1	
		Stadium and District head office planne	0.4	0.2	0.1	0.1
		Electrification of HHs and Productive Us	0.7	0.2	0.2	0.3
		construction of port in Karongi	0.4	0.2	0.1	0.1
		Increasing the power in Rubengera han	0.1	0.1		
		KOPAKAMA coffee factory	0.1	0.1		
		Others	0.3	0.1	0.1	0.1
		Yearly Total Load Increment (MW)	2.4	1	0.7	0.7
			101			
Nyamasheke Branch						
KIBOGORA	NYAMASHE	World vision Building; Ibigabiro Building	0.1	0.1		
		Street lights(Kabeza-Murwa and roads i	0.3	0.1	0.1	0.1
		Others	0.3	0.1	0.1	0.1

4. Feeder loading after anticipated Major load growth (2021-2023) in Western Hub

SUBSTATION	Existing Transfo MVA	Feeder	Length (km)	Conductor Size	Maximum Current (A)	Max Power Capacity (MW)	Peak Power [MW]	% Loading at Peak (Calculated)	Load Increment on Feeders(MV) as per the anticipated major loads	
KARONGI	1 *10	Kibuye	281	ACSR 70/12 mm ²	290	12.05	3.58	29.70%	9.7	80.50%
		Mugonero	34	ACSR 70/12 mm ²	290	12.05	0.85	7.00%		
		Gisovu	36	ACSR 70/12 mm ²	290	12.05		0.00%		
		Total					4.43			
KIBOGORA	1*6	Rwakina	66	ACSR 120/20 mm ²	410	17.04	1.2	7.04%		
		Nyamasheke	7	ACSR 120/20 mm ²	410	17.04		0.00%	2.3	13.50%
		Total					1.2			
MURURU1	1*10	SHAGASHA	84	ACSR 120/20 mm ²	410	17.04	2.6	15.30%	14	82.16%
		MASHYUZA	85	ACSR 120/20 mm ²	410	17.04	1.8	10.60%	0.7	51.05%
		Total					4.4			
NTENDEZI	1*10	MURURU I	33	ACSR 120/20 mm ²	410	17.04	0.4	2.34%		
		KIBOGORA	32	ACSR 120/20 mm ²	410	17.04	0.6	3.52%		
		Total					1			
MASHYUZA	1*3.5	CIMERWA1	0.2	240 mm ² CU	596	24.77			6	24.22%
		BUGARAMA	18	ACSR 70/12 mm ²	290	12.05			0.6	4.98%
		Total					0			
BUGARAMA	1*15	CIMERWA2		50 mm ² CU	210	8.73				
Total							0		33.3	

Network Strengthening Projects and Investment Proposals in Western Hub

Transformer Name	Substation	Feeder	Conductor	Voltage	length (m)	District	Sector	Cell	Village/TFR Name	Countermeasure
Gombaniro	MURURU 1	MASHYUZA	35mm2_6 ACSR	30	226.18	Rusizi	Bugarama	Ryankana	Gombaniro	NEW TFR
Byangoma	MURURU 1	MASHYUZA	70mm2_12 ACSR	30	552.28	Rusizi	Mururu	Tara	Byangoma	NEW TFR
Kabisheshe	MURURU 1	SHAGASHA	70mm2_12 ACSR	30	626.8	Nyamasheke	Karengera	Miko	Kabisheshe	NEW TFR
Kabisheshe	MURURU 1	SHAGASHA	70mm2_12 ACSR	30	661.45	Nyamasheke	Karengera	Miko	Kabisheshe	NEW TFR
Rugabano	MURURU 1	SHAGASHA	70mm2_12 ACSR	30	862.61	Nyamasheke	Ruharambuga	Wimana	Rugabano	NEW TFR
Shagasha	MURURU 1	SHAGASHA	35mm2_6 ACSR	30	21.02	Rusizi	Gihundwe	Shagasha	Shagasha	NEW TFR
Burembo	MURURU 1	SHAGASHA	35mm2_6 ACSR	30	785.87	Rusizi	Giheke	Cyendajuru	Burembo	NEW TFR
Ruvumbu	KIBOGORA	RWAKINA	120mm2_20 ACSR	30	250.49	Nyamasheke	Bushekeri	Buvungira	Ruvumbu	NEW TFR
Nyanza	KIBOGORA	RWAKINA	120mm2_20 ACSR	30	921.89	Nyamasheke	Bushekeri	Nyarusange	Nyanza	NEW TFR
Musasa	KIBOGORA	RWAKINA	35mm2_6 ACSR	30	1334.36	Nyamasheke	Kanjongo	Raro	Musasa	NEW TFR
Kamuramira	KIBOGORA	RWAKINA	35mm2_6 ACSR	30	1096.53	Nyamasheke	Kanjongo	Susa	Kamuramira	NEW TFR
Ruganda	KIBOGORA	RWAKINA	35mm2_6 ACSR	30	770.31	Nyamasheke	Kanjongo	Susa	Ruganda	NEW TFR
Ruganzu	KIBOGORA	RWAKINA	35mm2_6 ACSR	30	316.87	Nyamasheke	Kanjongo	Kigoya	Ruganzu	NEW TFR
Nyarusiza	KARONGI	GISOVU	70mm2_12 ACSR	30	2686.05	Nyamasheke	Mahembe	Nyakavumu	Nyarusiza	NEW TFR
Gititi	KARONGI	KIBUYE	70mm2_12 ACSR	30	1251.04	Karongi	Mutuntu	Byogo	Gititi	NEW TFR
Gititi	KARONGI	KIBUYE	70mm2_12 ACSR	30	1209.72	Karongi	Mutuntu	Byogo	Gititi	NEW TFR
Rugogo	KARONGI	KIBUYE	70mm2_12 ACSR	30	2206.04	Karongi	Mutuntu	Byogo	Rugogo	NEW TFR
Muhondo	KARONGI	KIBUYE	70mm2_12 ACSR	30	1783.88	Karongi	Mutuntu	Byogo	Muhondo	NEW TFR
Kivumu	KARONGI	KIBUYE	70mm2_12 ACSR	30	1380.62	Karongi	Mutuntu	Byogo	Kivumu	NEW TFR

Transformer Name	Substation	Feeder	Conductor	Voltage	length (m)	District	Sector	Cell	Village/TFR Name	Countermeasure
Rugogo	KARONGI	KIBUYE	70mm2_12 ACSR	30	1303.97	Karongi	Mutuntu	Byogo	Rugogo	NEW TFR
Mahembe	KARONGI	KIBUYE	70mm2_12 ACSR	30	1124.56	Karongi	Rwankuba	Nyakamira	Mahembe	NEW TFR
Nzabuhara	KARONGI	KIBUYE	70mm2_12 ACSR	30	3319.18	Karongi	Gitesi	Kirambo	Nzabuhara	NEW TFR
Nyabikati	KARONGI	KIBUYE	35mm2_6 ACSR	30	1030.6	Karongi	Gitesi	Ruhinga	Nyabikati	NEW TFR
Muramba	KARONGI	KIBUYE	35mm2_6 ACSR	30	603.85	Karongi	Gitesi	Ruhinga	Muramba	NEW TFR
Gasayo	KARONGI	KIBUYE	35mm2_6 ACSR	30	616.35	Karongi	Gitesi	Ruhinga	Gasayo	NEW TFR
Kagano	KILINDA	BIRAMBO	70mm2_12 ACSR	30	2244.46	Rutsiro	Mukura	Kagano	Kagano	NEW TFR
Kazizi	KILINDA	BIRAMBO	70mm2_12 ACSR	30	1295.91	Rutsiro	Mukura	Kagano	Kazizi	NEW TFR
Kamonyi	KILINDA	BIRAMBO	70mm2_12 ACSR	30	2244.46	Rutsiro	Mukura	Kagano	Kamonyi	NEW TFR
Gabiro	KARONGI	KIBUYE	70mm2_12 ACSR	30	827.72	Rutsiro	Musasa	Gabiro	Gabiro	NEW TFR
Byiniro	KARONGI	KIBUYE	35mm2_6 ACSR	30	575.66	Rutsiro	Rusebeya	Kabona	Byiniro	NEW TFR
Nyamibombwe	KARONGI	KIBUYE	35mm2_6 ACSR	30	1692.1	Rutsiro	Rusebeya	Ruronde	Nyamibombwe	NEW TFR
Gasave	KARONGI	KIBUYE	70mm2_12 ACSR	30	235.31	Rutsiro	Gihango	Teba	Gasave	NEW TFR
Gihinga	KARONGI	KIBUYE	70mm2_12 ACSR	30	1173.06	Rutsiro	Musasa	Gisiza	Gihinga	NEW TFR
Gisunzu	KARONGI	KIBUYE	70mm2_12 ACSR	30	868.93	Rutsiro	Gihango	Shyembe	Gisunzu	NEW TFR
Karongi	KARONGI	KIBUYE	70mm2_12 ACSR	30	868.93	Rutsiro	Gihango	Shyembe	Karongi	NEW TFR
Nkamba	KARONGI	KIBUYE	35mm2_6 ACSR	30	476.82	Rutsiro	Kigeyo	Buhindure	Nkamba	NEW TFR
Bukumba	KARONGI	KIBUYE	35mm2_6 ACSR	30	208.56	Rutsiro	Kivumu	Karambi	Bukumba	NEW TFR
TBD	BWISHYURA	KIBUYE	70mm2_12 ACSR	30	500	Karongi	Murambi			
TBD	KILINDA	KILINDA MISSION	70mm2_12 ACSR	30	5300	Karongi				
Total					45,454					37

Transformer Name	Substation	Feeder	Conductor	Voltage	length (m)	District	Sector	Cell	Village/TFR Name	Countermeasure

VOLTAGE DROP PROJECTS

BRANCH	LOCATION	Voltage Level (V)	PROBLEM (YES or NO)			RECOMMENDED ACTION			
			Overloaded Transformers	Undersized cables	Over-extended LV network	Extend MV and Insert new Transformer		LV NETWORK RENEWAL (km)	
						Length of MV (km)	Transformer size (kVA)	LV length (km)	LV poles
KARONGI	GISAYO	200	No	Yes	YES	1	50	3	60
	NYAMAKORO	200	No	Yes	YES	0,2	50	2,5	50
	KIBILIZI	180	No	Yes	Yes	0,5	50	4	80
	RWIMPIRI	160	No	Yes	Yes	3	50	2	40
	MUBUGA	180	No	Yes	yes			3	60
	GASURA	180	No	Yes	YES	3	50	2	40
	MBONWA	200	No	Yes	NO			1	20
	NYAMUHEBE	200	No	Yes	NO			1,5	30
	KILINDA	180	No	Yes	yes	0,5	25	3	60
	GASHIHE	180	No	Yes	YES	0,5	25	2	40
	BUPFUNI	200	NO	Yes	YES		25	3	60
	GITEGA	180	No	Yes	Yes	0,5	25	2	40
	BIRAMBO	180	No	Yes	Yes			2,5	50

	RYABINAMA	200	No	Yes	NO			1,8	36
	GISANZE	180	Yes	Yes	Yes	0,3	50	4	80
	GISHYITA	200	No	yes	NO			1,5	30
	NGOMA	200	No	Yes	No			2	40
	NYARUSOZI	180	No	Yes	NO			1,5	30
	KIYOVU	200	No	Yes	NO			1,5	30
	WAKASIRIKA	200	No	Yes	No			0,8	16
	BWAKIRA	180	No	Yes	No			3	60
	GAKUTA	200	No	Yes	NO			2	40
	GITEGA (gitesi)	180	yes	yes	yes	3	50	4	80
	RWANKUBA	200	No	Yes	NO			1,5	30
	NYAMISHABA	180	No	Yes	yes			2	40
	RURAGWE	180	No	Yes	YES	1	25	2	40
	Total KARONGI					11	12	44	1182
NYAMASHEKE	kibogora- hopital+C9:L47	200	NO	Yes	YES			5	100
	Nyenyeri-Rwakagaju	180	No	Yes	YES	0.5	50	4	80
	Nyagacaca-BIZENGA	180	No	Yes	YES	1	50	3	60
	Kabuga-maseka	180	Yes	Yes	YES	0	100	4	80
	kirambo-	200	No	Yes	YES	0	0	3	60
	kigoya-bujanga	200	No	Yes	YES	2	50	5	100
	gihombo sector	180	No	Yes	YES			3	60
	kibingo	180	No	Yes	YES			3	40
	jarama	180	No	Yes	YES	4	100	5	100
	mbogo	180	No	Yes	YES	0	100	6	120
	mpombori	180	No	Yes	YES	1	50	3	60
	rugaragara	160	No	Yes	YES	1	50	2.5	50
	rushoka	160	No	Yes	YES	2	100	6	120
	nyabinaga	200	No	Yes	YES			2.5	50

giseseo	180	No	Yes	YES	2	100	3	60
Gitimuramba	200	No	Yes	YES			4	80
Mugonero centre	200	No	Yes	YES			6	120
kagarama	170	No	Yes	YES	4	100	6	120
kagarama	170	No	Yes	YES	4	100	6	120
rushyarara	180	No	Yes	YES	0.05	50	2.5	50
wisumo-musenyi	180	No	Yes	YES	4	50	4	80
kanombe-nyarusovu	180	No	Yes	YES			5	100
nyakabingo	180	No	Yes	YES	1	50	2.5	50
Rugali	170	No	Yes	YES	2	50	5	100
vision	180	Yes	Yes	YES	0	100	4	80
rupango	180	No	Yes	Yes	1.5	50	6	120
Gako-	180	No	Yes	Yes	1	50	3	60
kazibira	180	No	Yes	yes	2.5	50	5	100
kabuye-keru	180	No	Yes	YES			3	60
nyamirambo	180	No	Yes	yes			3	60
ninzi	200	No	Yes	yes			2	40
mubumbano	200	No	Yes	yes			3	60
rwesero	180	No	Yes	YES	2	50	5	100
rugabano	200	NO	Yes	YES			4	80
mutusa	180	No	Yes	Yes			3	60
nyirankomagurwe	170	No	Yes	Yes			2	40
rweza	180	No	Yes	Yes			3	60
keshero	170	No	Yes	Yes	4	100	5	100
kagarama	175	No	yes	yes	2	50	4	80
nyanza	180	yes	Yes	yes	0.05	100	4	80
kibingo	200	No	Yes	yes			2	80
mwaga	170	No	Yes	yes	0.3	50	4	80
winkamba-rwumba	180	No	Yes	yes		50	4	80

	muramazi	160	No	Yes	yes	1.5	50	4	80
	yove	160	No	Yes	yes	3	50	4	80
	buhinga	200	No	yes	yes			3	60
	buvungira	180	No	Yes	yes	0.05	50	5	100
	Ntendezi-muko	180	No	Yes	yes	3	50	5	100
	rukuta	200	No	Yes	YES			3	60
	ntendezi-izari	200	NO	Yes	YES			2	40
	risansi	180	NO	Yes	YES	2	50	3	60
	wimana	200	No	Yes	YES			2	40
	kibazi	200	No	Yes	YES			4	80
	bigutu	180	No	Yes	YES	2	50	4	80
	Kagatamu	180	No	Yes	YES	2	50	4	80
	bushenge sector	180	No	Yes	YES	2	50	4	80
	bushenge market	180	Yes	Yes	YES	1	50	3	60
	Shangi cell	180	No	Yes	YES			4	80
	E.S.Gafunzo	200	No	Yes	YES			2	40
	jurwe	180	No	Yes	YES	2	50	3	60
	rangiro sector	200	No	Yes	YES			2	40
	Muhororo	200	No	Yes	YES			3	60
	nduba	180	No	Yes	YES	1	50	4	80
	gisesero	180	No	Yes		1	50	3	60
	nyarusange	170	Yes	Yes	YES	0.3	50	3	60
	Kinunga	180	Yes	Yes	YES	0.3	50	6	120
	cyato	180	Yes	Yes	YES			1	60
	Karengera centre	180	no	Yes	YES	3	50	2	40
	Total					66.05	42	251	5080
RUTSIRO	Shyembe	200	Yes	Yes	Yes	1.5	50	4	80
	Murambi- Nyagahinga	180	Yes	Yes	Yes	1.5	50	4	80

	Karugaju	200	No	Yes	Yes	-	-	2	40
	Rwamiyaga	180	No	Yes	Yes	-	-	3.5	70
	Shyembe- Gasutamo	160	No	Yes	Yes	-	-	2.5	50
	Bugina	180	Yes	Yes	Yes	2.5	100	5	100
	Bumba- Gikoni	200	Yes	Yes	No	-	-	2.5	50
	Rukiniro	160	No	Yes	Yes	1	50	2	40
	Bumba- Kabiraho	200	No	Yes	Yes	-	-	1	20
	Cyarusera	200	No	Yes	Yes	-	-	8	160
	Mageragere- Nyakabuye	200	No	Yes	Yes	-	-	1.5	30
	Model village	180	Yes	Yes	Yes	1.5	50	3	60
	Nkomero	200	Yes	Yes	No	-	-	4	80
	Gisiza	180	No	Yes	Yes	-	-	2	40
	Murambi- Rwintanga	200	No	Yes	Yes	-	-	1.5	30
	Murambi- Kabatoni	200	No	Yes	Yes	-	-	1.5	30
	Near Gasutamo	160	No	Yes	Yes	-	-	1.5	30
	Gahotora	160	Yes	Yes	Yes	3	50	4	80
	Nkora	200	No	Yes	Yes	-	-	2.5	50
	Rukaragata	160	Yes	Yes	Yes	2	50	3	60
	Nyagahinika- Rusisiro	200	No	Yes	Yes	-	-	1.5	30
	Nyagahinika- Nyarusuku	200	No	Yes	Yes	-	-	1.5	30
	Nyagahinika- Rupango	200	No	Yes	Yes	-	-	1.5	30
	Buhindure	180	No	Yes	Yes	-	-	2	40
	Cyimbili	200	No	Yes	Yes	-	-	1.5	30
	G.S Kavumu	200	No	Yes	Yes	-	-	2.5	50
	G.S Apacape	210	No	Yes	Yes	-	-	2	40
	Rundoyi- Rugaragara	200	No	Yes	Yes	-	-	1.5	30
	Rundoyi- Gakararanka	200	No	Yes	Yes	-	-	1.5	30

	Kavumu	180	No	Yes	Yes	-	-	2.5	50
	Nyakarera	180	No	Yes	Yes	-	-	4	80
	Kabujenje	210	No	Yes	Yes	-	-	2	40
	Bunyoni- Kimpanga	160	No	Yes	Yes	-	-	4	80
	Bunyunju- Tarafiporo	180	No	Yes	Yes	-	-	1.5	30
	Bunyunju- Mpinga	160	No	Yes	Yes	-	-	1.5	30
	Nganzo- Bugarishya	180	No	Yes	Yes	-	-	1.5	30
	Kabere	160	Yes	Yes	Yes	2	50	2.5	50
	Karambi	200	No	Yes	Yes	-	-	1.5	30
	Kabuga	180	Yes	Yes	Yes	2.5	100	3	60
	Kageyo- Karumbi	180	No	Yes	Yes	-	-	1.5	30
	Kaguriro	180	No	Yes	Yes	-	-	4	80
	Marine HQ	200	No	Yes	Yes	-	-	3	60
	Kivumu	200	No	Yes	Yes	-	-	1	20
	Magaba	180	No	Yes	Yes	-	-	2	40
	Rurara	200	No	Yes	Yes	-	-	2	40
	Nkira	200	No	Yes	Yes	-	-	2	40
	Gahabwa- Bikono	180	Yes	Yes	Yes	3	100	5	100
	Gaseke	200	No	Yes	Yes	-	-	1	20
	Bushaka- Bikono	180	No	Yes	Yes	-	-	1	20
	Bushaka- Kabirizi	180	No	Yes	Yes	-	-	1	20
	Kabihogo	180	No	Yes	Yes	-	-	1.5	30
	Remera- Gabiro	180	No	Yes	Yes	-	-	2.5	50
	College Indashyikirwa	200	No	Yes	Yes	-	-	3	60
	Kirwa- Bukongora	180	No	Yes	Yes	-	-	1.5	30
	Kirwa- Kajugujugu	180	No	Yes	Yes	-	-	1.5	30
	Kirwa- Muremure	180	No	Yes	Yes	-	-	1.5	30

						20.5	10	133.5	2670
RUSIZI	NJAMBWE	160	No	Yes	No			2	40
	NYAMARONKO	160	No	Yes	No			3	60
	MIBILIZI	160	No	Yes	Yes			2	40
	MUGANZA SECTOR OFFICE	140	No	Yes	Yes			3	60
	MUGANZA MARKET	160	No	Yes	No			3	60
	CIMERWA	160	No	Yes	No			3	60
	NYAKABUYE SECTOR OFFICE	160	No	Yes	Yes			2.5	50
	KARANGIRO	160	No	Yes	Yes			3	60
	GAHINGA-BUREMERA	160	No	Yes	yes	1	50	3	60
	AEROPORT-MUHARI	140	No	Yes	No	3	50	3.5	70
	KAMUKOBE	110	Yes	Yes	Yes	4	100	3	60
	GIHEKE-NTURA	120	No	Yes	Yes	1.5	100	3	60
	MONT CYANGUGU	120	No	Yes	No			3	60
	MURANGI	140	No	Yes	Yes	0.5	100	2	40
	NZAHABA- MURYA	140	No	Yes	Yes	3	100	3	60
	NZAHABA	140	Yes	Yes	Yes	1	160	3	60
	KIZIHO-NYABIHANGA	140	No	yes	yes	4	50	4	80
	GACAMAHEMBE	160	No	Yes	No			1.5	30
	GASHONGA-MISAVE	140	No	Yes	Yes			1	20
	BUTAMBAMO- NGOMA	140	No	Yes	Yes			2	40
	BUTAMBAMO- GISHOMA PP	160	No	Yes	No	0.5	50	2.5	50
	AEROPORT-Qtier MUSINGA	160	No	Yes	No			1	20
	MASHESHA-RWIHENE	160	No	Yes	Yes	1.5	50	4	80
	GIHUNDWE - KARORABOSE	140	No	Yes	Yes			1	20
	BIROGO/RUSIZI I	160	No	Yes	Yes			1	20
	RYANKANA/ VIA KAMANYOLA	160	No	Yes	Yes	1	50	3	60

	GIHUNDWE - KARUSHARIRIZA	160	No	Yes	No			2	40
	Total RUSIZI					21	11	68	1360
TOTAL FOR WESTREN HUB						118.55	75	496.5	10,292

Upgrade and Interconnection Projects

Descrption	Substation	Feeder	Conductor	Voltage	Province	District	Sector	Length (m)
Upgrade	Karongi	Kibuye	35mm2_6 ACSR	30	West	Rutsiro	Manihira	2800.30
Upgrade	Karongi	Kibuye	35mm2_6 ACSR	30	West	Rutsiro	Mushubati	9702.38
Upgrade	Karongi	Kibuye	35mm2_6 ACSR	30	West	Rutsiro	Rusebeya	7359.13
Interconnection Mururu - Cimerwa	Mururu	MASHYUZA	35mm2_6 ACSR	30	West	Nyamasheke	Karengera	529.42
Interconnection Mururu - Cimerwa	Mururu	MASHYUZA	35mm2_6 ACSR	30	West	Rusizi	Nyakabuye	391.37
Interconnection Kibogora - Karongi	Karongi	Kibuye	35_6ACSR - 70_12 ACSR	30	West	Nyamasheke	Kirimbi	3606.75
Interconnection Kibogora - Karongi	Karongi	Kibuye	35_6ACSR - 70_12 ACSR	30	West	Nyamasheke	Macuba	1192.50
Interconnection Kilinda - Karongi	Kilinda	Birambo	35_6ACSR - 70_12 ACSR	30	West	Karongi	Rubengera	1487.99
Interconnection Kilinda - Karongi	Kilinda	Birambo	35_6ACSR - 70_12 ACSR	30	West	Karongi	Rugabano	4139.84
Interconnection Kibogora - Karongi	Karongi	Kibuye	35_6ACSR - 70_12 ACSR	30	West	Nyamasheke	Karambi	5027.67
Interconnection Kibogora - Karongi	Karongi	Kibuye	35_6ACSR - 70_12 ACSR	30	West	Nyamasheke	Mahembe	754.15
Interconnection Nyabarongo I- Kilinda	Kilinda	Birambo	50_CU - 70_12 ACSR	30	West	Ngororero	Nyange	1466.92
Interconnection Kilinda - Karongi	Kilinda	Birambo	50_CU - 70_12 ACSR	30	West	Karongi	Gashari	3748.89
Interconnection Kilinda - Karongi	Kilinda	Birambo	50_CU - 70_12 ACSR	30	West	Karongi	Gitesi	3990.08
Interconnection Kilinda - Karongi	Kilinda	Birambo	50_CU - 70_12 ACSR	30	West	Karongi	Rugabano	1373.02
Total								47570.41

Required Investment for network reinforcement in West

Quantity	MV length (km)	LV length (km)	Number of Transformers
----------	----------------	----------------	------------------------

	211.57	496.5	112
Investment Required (USD)	9,520,650	9,930,000	666,938.72
Total Investment (USD)	20,117,588.72		
	The cost of 1Km MV Line is 45,000USD		

XI. UPGRADE OF SWITCHING CABINS IN SECONDARY CITIES

No	District	Name of MV/LV Substation	Voltage Level(kV)	Planned Budget
1	Huye	Gihindamuyaga	30/0.4	930,707
		Ngoma		972,974
		CHUB		910,044
2	Muhanga	Kabgayi		907,656
		RIAM		862,489
3	Nyagatare	Ryabega		1,051,227
		Mirama		1,009,395
4	Gicumbi	Byumba		1,150,230
5	Rusizi	Cyapa		964,851
		Pendeza		871,742
		Shagasha		1,010,074
		Cathedralle		547,177
		Rusizi Duane		
		Rwandatel (Telecom Mont cyangugu)		
6	Rubavu	Poids Lord		938,958
7	Bugesera	Nyamata (Maranyondo)		3,073,155
Total Required Investment				15,200,679

Rwanda's six secondary cities include Musanze in Northern Province, Rubavu and Rusizi in Western Province, Muhanga and Huye in Southern Province and Nyagatare in Eastern Province. Bugesera District being also one of the fastest growing Districts it has been considered during the development of distribution masterplan.

The aim of this planning is to plan for reliable infrastructure that suit the development of secondary cities to make sure that reliable electricity will be supplied to secondary cities to allow smooth running of all activities without interruption.

The modern switching cabins (supervision and control included) will be constructed into secondary cities and critical cabins have been considered during this planning stage.

Single Phase Transformers to replace countrywide

HUBS	MV Lines (km)	LV Lines (km)	No of transformers to be Replaced
KIGALI	37.1	101	23
EAST	243.7	680	325
WEST	30.9	86.2	198
SOUTH	73.4	265.8	238
NORTH	10.4	56.3	138
TOTAL	395.5	1189.3	922

Distribution transformers Loading Profile countrywide (As of 26 OCT - 01 NOV 2020)

District	Feeder	STATUS	DT_Name	MaxLoad
Bugesera	KANAZI BUGESERA	Heavy_Loaded	3	88.52
		Normal_Loaded	44	46.51
		Over_Loaded	5	120.17
		Under_Loaded	80	12.65
	NTONGWE	Heavy_Loaded	2	87.57
		Normal_Loaded	35	43.50
		Over_Loaded	4	111.19
		Under_Loaded	66	12.98
Burera	BYUMBA	Normal_Loaded	9	45.49
		Under_Loaded	17	12.01
	CYANIKA	Normal_Loaded	6	45.70
		Under_Loaded	8	14.47
	KIRAMBO	Normal_Loaded	2	38.02
		Under_Loaded	5	14.19
	NTARUKA	Heavy_Loaded	1	82.65
		Normal_Loaded	11	44.07
		Under_Loaded	17	17.43
	RUHENGARI	Heavy_Loaded	1	80.64
		Normal_Loaded	2	44.34
		Under_Loaded	1	8.94
Gakenke	BASE	Normal_Loaded	2	52.67
		Under_Loaded	8	7.95
	CYANIKA	Normal_Loaded	1	55.20

	GAKENKE	Heavy_Loaded	1	99.88
		Normal_Loaded	6	39.58
		Over_Loaded	1	173.77
		Under_Loaded	15	12.87
	GISENYI	Normal_Loaded	1	39.34
		Under_Loaded	7	11.21
	JANJA	Normal_Loaded	4	38.29
		Under_Loaded	18	8.91
	KINIGI	Under_Loaded	1	13.58
	MUSASA	Normal_Loaded	8	36.14
		Under_Loaded	43	11.03
	REMERA	Normal_Loaded	2	38.99
		Under_Loaded	5	13.80
Gatsibo	GABIRO AUXILIARY	Under_Loaded	1	7.80
	KIZIGURO	Heavy_Loaded	6	87.28
		Normal_Loaded	56	44.83
		Over_Loaded	2	118.67
		Under_Loaded	113	14.39
	KKK	Under_Loaded	2	4.75
	NGARAMA	Normal_Loaded	6	38.24
		Over_Loaded	1	116.96
		Under_Loaded	22	13.56
	NYAGATARE	Under_Loaded	2	12.21
Gicumbi	BYUMBA	Normal_Loaded	1	64.79
	GATUNA	Normal_Loaded	6	40.59
		Under_Loaded	10	16.28
	GATUNA AUXILIARY	Normal_Loaded	1	31.81
		Under_Loaded	4	10.11
	NGARAMA	Normal_Loaded	2	33.18
		Under_Loaded	7	9.60
Gisagara	BUTARE	Heavy_Loaded	3	89.56
		Normal_Loaded	32	43.90
		Under_Loaded	75	12.77
Huye	BUTARE	Normal_Loaded	11	45.33
		Under_Loaded	23	12.69
	RUKARARA 1	Heavy_Loaded	1	86.74
		Normal_Loaded	1	46.49
	RUKARARA 2	Heavy_Loaded	5	87.01
		Normal_Loaded	26	46.09
Jabana	DEPART D-WELLE	Under_Loaded	58	11.04
		Normal_Loaded	3	46.44
	DEPART KIGALI	Under_Loaded	8	14.50
		Heavy_Loaded	1	92.59
		Normal_Loaded	13	42.36

		Under_Loaded	16	15.46
	GIKOMERO/TPP	Under_Loaded	3	9.30
	GIKONDO HAUT	Under_Loaded	1	12.70
	JABANA I AUXILIARY I	Under_Loaded	1	3.88
	JABANA I AUXILIARY II	Under_Loaded	1	0.01
	KIGALI NORTH	Under_Loaded	3	22.01
	NYAMIRAMBO	Normal_Loaded	6	45.98
		Under_Loaded	3	7.37
	RUTONGO	Normal_Loaded	5	53.50
		Under_Loaded	2	21.00
Kacyiru	DEPART D-WELLE	Normal_Loaded	1	61.81
		Under_Loaded	5	15.95
	KIBAGABAGA/NYARUTARAMA	Normal_Loaded	2	40.20
		Under_Loaded	9	15.67
	KIGALI NORTH	Normal_Loaded	2	38.33
		Under_Loaded	4	12.20
	KIGALI SOUTH	Under_Loaded	1	4.70
	KIMIHURURA	Normal_Loaded	1	31.81
		Under_Loaded	6	25.71
	KINYINYA	Normal_Loaded	7	45.00
		Under_Loaded	6	17.49
	NYAMIRAMBO	Under_Loaded	3	20.36
	UTEXRWA	Normal_Loaded	14	49.07
		Under_Loaded	17	16.79
Kamonyi	KIYUMBA	Heavy_Loaded	2	81.98
		Normal_Loaded	11	53.80
		Under_Loaded	4	12.88
Kanombe	GASOGI	Heavy_Loaded	1	81.73
		Normal_Loaded	4	53.18
		Under_Loaded	1	26.63
	GIKOMERO/TPP	Normal_Loaded	3	35.98
		Under_Loaded	1	4.27
	GIKONDO HAUT	Under_Loaded	1	1.81
	INYANGE	Under_Loaded	1	13.08
	KANOMBE	Heavy_Loaded	4	84.67
		Normal_Loaded	28	52.36
		Over_Loaded	1	280.30
		Under_Loaded	42	13.47
	KIMIRONKO	Normal_Loaded	1	52.25
	NYAMIRAMBO	Normal_Loaded	2	33.44
		Under_Loaded	1	26.48
	UTEXRWA	Normal_Loaded	1	54.58
Karongi	BIRAMBO	Normal_Loaded	5	50.00
		Under_Loaded	4	15.97

	GISOVU	Normal_Loaded	2	38.08
		Under_Loaded	5	14.59
	KARONGI AUXILIARY	Under_Loaded	1	11.86
	KIBUYE	Heavy_Loaded	1	83.26
		Normal_Loaded	8	45.12
		Under_Loaded	16	14.05
	KILINDA AUXILIARY	Under_Loaded	1	8.38
	KILINDA MISSION	Normal_Loaded	1	54.40
		Under_Loaded	1	5.26
	MUGONERO	Normal_Loaded	1	54.38
		Under_Loaded	3	14.36
Kayonza	AKAGERA	Normal_Loaded	6	47.85
		Over_Loaded	1	166.46
		Under_Loaded	9	12.92
	KABARONDO AUXILIARY	Under_Loaded	1	2.73
	KKK	Heavy_Loaded	4	87.40
		Normal_Loaded	43	42.85
		Over_Loaded	1	107.50
		Under_Loaded	58	13.59
	REDEMI 2	Under_Loaded	1	4.06
	RWINKWAVU AUXILIARY	Under_Loaded	1	7.10
Kicukiro	ZAZA	Heavy_Loaded	1	80.11
		Normal_Loaded	5	49.12
		Under_Loaded	15	10.57
	GAHANGA AUXILIARY	Under_Loaded	1	8.40
	GASOGI	Heavy_Loaded	1	91.74
		Normal_Loaded	13	55.87
		Under_Loaded	15	13.57
	GIKONDO AUXILIARY I	Under_Loaded	1	0.89
	GIKONDO AUXILIARY II	Under_Loaded	1	9.80
	GIKONDO HAUT	Normal_Loaded	7	46.17
		Under_Loaded	5	21.69
	KIBAGABAGA/REMERA	Normal_Loaded	3	40.96
		Under_Loaded	6	10.99
	KIGALI SOUTH	Normal_Loaded	3	34.31
		Under_Loaded	2	28.38
	KIMIRONKO	Normal_Loaded	1	44.34
		Under_Loaded	1	23.25
	MASTER STEEL	Heavy_Loaded	1	94.29
		Normal_Loaded	4	42.43
		Over_Loaded	1	104.83
		Under_Loaded	7	11.61
	NYAMIRAMBO	Normal_Loaded	2	67.55
	NYARURAMA	Normal_Loaded	7	46.74

		Under_Loaded	3	15.63
	PARC INDUSTRIEL	Normal_Loaded	3	39.33
		Under_Loaded	5	18.66
	PYLONE 20	Heavy_Loaded	2	89.37
		Normal_Loaded	7	55.13
		Under_Loaded	7	7.62
	UTEXRWA	Under_Loaded	1	29.04
Kirehe	AKAGERA	Heavy_Loaded	2	89.18
		Normal_Loaded	14	46.67
		Over_Loaded	2	119.44
		Under_Loaded	16	14.70
	ZAZA	Heavy_Loaded	3	87.47
		Normal_Loaded	39	42.73
		Over_Loaded	1	124.97
		Under_Loaded	107	12.57
Muhanga	GATUMBA	Heavy_Loaded	1	85.20
		Normal_Loaded	20	43.07
		Over_Loaded	1	132.44
		Under_Loaded	57	11.97
	GISENYI	Under_Loaded	5	4.76
	KIYUMBA	Heavy_Loaded	1	80.83
		Normal_Loaded	4	52.66
		Over_Loaded	1	101.59
		Under_Loaded	16	13.28
	NYABARONGO	Under_Loaded	1	5.98
Musanze	CAMP BELGE AUXILIARY	Under_Loaded	1	21.36
	GISENYI	Heavy_Loaded	2	83.67
		Normal_Loaded	15	45.89
		Under_Loaded	27	14.83
	KINIGI	Heavy_Loaded	1	87.73
		Normal_Loaded	9	52.70
		Under_Loaded	10	14.62
	MUKUNGWA	Heavy_Loaded	2	86.33
		Normal_Loaded	7	44.02
		Under_Loaded	16	8.24
	NTARUKA	Normal_Loaded	1	55.78
		Under_Loaded	4	14.02
	REMERA	Normal_Loaded	2	36.07
		Under_Loaded	5	15.61
Ngoma	ZAZA	Heavy_Loaded	15	88.87
		Normal_Loaded	55	49.16
		Over_Loaded	6	111.39
		Under_Loaded	90	13.23
Ngororero	BIRAMBO	Normal_Loaded	1	56.92

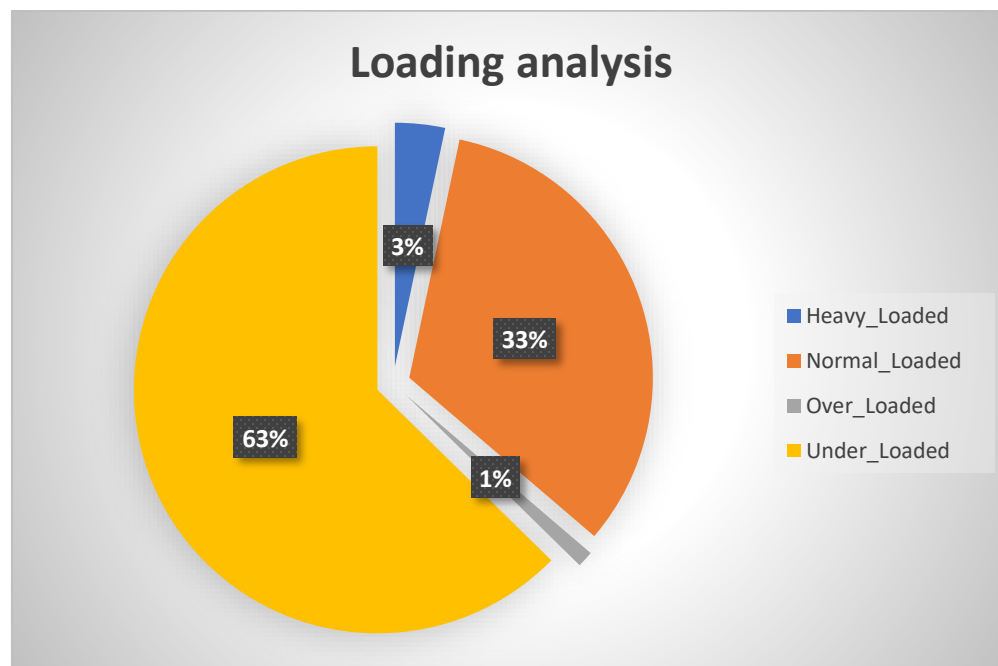
		Under_Loaded	16	3.41
		Normal_Loaded	6	45.78
		Under_Loaded	28	7.67
	GISENYI	Normal_Loaded	7	38.71
		Under_Loaded	33	11.84
	NYABARONGO	Under_Loaded	8	3.00
Nyabihu	GISENYI	Normal_Loaded	15	42.63
		Under_Loaded	42	13.28
	KINIGI	Under_Loaded	1	5.37
Nyagatare	NYAGATARE	Heavy_Loaded	8	84.81
		Normal_Loaded	75	46.42
		Over_Loaded	2	111.67
		Under_Loaded	157	13.23
Nyamagabe	RUKARARA 2	Heavy_Loaded	1	96.30
		Normal_Loaded	16	42.08
		Under_Loaded	34	12.69
Nyamasheke	KIBOGORA	Under_Loaded	1	7.53
	KIBOGORA AUXILIARY	Under_Loaded	1	15.07
	MASHYUZA	Under_Loaded	1	18.09
	MUGONERO	Normal_Loaded	1	54.36
		Under_Loaded	4	16.22
	MURURU I AUXILIARY	Normal_Loaded	4	41.86
		Under_Loaded	22	8.35
	MURURU-1	Normal_Loaded	11	42.37
		Under_Loaded	13	17.51
	NYAMASHEKE	Normal_Loaded	2	35.45
		Under_Loaded	7	15.77
	RWAKINA	Heavy_Loaded	2	84.79
		Normal_Loaded	17	40.38
		Under_Loaded	20	14.96
Nyanza	BUTARE	Heavy_Loaded	1	89.23
		Normal_Loaded	29	42.98
		Under_Loaded	59	15.65
	NTONGWE	Normal_Loaded	8	40.43
		Under_Loaded	20	12.36
Nyarugenge	DEPART KIGALI	Normal_Loaded	1	57.52
	GASOGI	Normal_Loaded	1	58.32
	KANAZI BUGESERA	Normal_Loaded	1	39.16
	KIGALI NORTH	Normal_Loaded	1	33.87
	KIGALI SOUTH	Heavy_Loaded	1	80.02
		Normal_Loaded	5	47.81
		Under_Loaded	5	13.45
	KIYUMBA	Normal_Loaded	1	31.56
		Under_Loaded	1	16.28

	NYAMIRAMBO	Normal_Loaded	3	45.59
		Under_Loaded	9	5.45
	NYARURAMA	Under_Loaded	1	25.19
Nyaruguru	KANAZI BUGESERA	Under_Loaded	1	7.97
	RUKARARA 1	Normal_Loaded	2	31.21
		Under_Loaded	8	12.33
	RUKARARA 2	Heavy_Loaded	1	80.09
		Normal_Loaded	14	44.06
		Under_Loaded	56	10.54
Remera	BIREMBO AUXILIARY	Under_Loaded	1	5.89
	GASOGI	Normal_Loaded	1	37.74
		Under_Loaded	3	12.15
	GIKOMERO/TPP	Normal_Loaded	2	51.89
		Under_Loaded	2	6.14
	KANOMBE	Normal_Loaded	2	43.15
	KIBAGABAGA/NYARUTARAMA	Heavy_Loaded	2	87.12
		Normal_Loaded	8	47.28
		Under_Loaded	8	10.97
	KIBAGABAGA/REMERA	Normal_Loaded	5	47.62
		Under_Loaded	12	21.25
	KIMIHURURA	Normal_Loaded	1	54.82
	KIMIRONKO	Normal_Loaded	7	40.73
		Under_Loaded	6	20.87
	KINYINYA	Normal_Loaded	3	45.88
		Under_Loaded	2	6.54
	PARC INDUSTRIEL	Heavy_Loaded	1	83.92
		Normal_Loaded	2	42.47
Rubavu	CPGL	Normal_Loaded	1	59.74
	GISENYI	Normal_Loaded	11	44.02
		Under_Loaded	36	14.17
	GOMA	Heavy_Loaded	1	90.83
		Normal_Loaded	10	45.32
		Under_Loaded	27	14.63
	HOPITAL	Normal_Loaded	2	49.04
		Under_Loaded	3	13.96
	KIBUYE	Heavy_Loaded	1	81.10
		Normal_Loaded	5	49.36
		Under_Loaded	6	23.59
	KITRAKO	Under_Loaded	1	9.93
Ruhango	BUTARE	Normal_Loaded	4	45.73
		Under_Loaded	1	12.06
		Heavy_Loaded	1	80.39
		Normal_Loaded	15	44.29
		Under_Loaded	31	13.66

	GATUMBA	Heavy_Loaded	2	87.95
		Normal_Loaded	28	42.50
		Over_Loaded	1	102.93
		Under_Loaded	71	12.39
	KIGOMA AUXILIARY	Under_Loaded	1	5.59
	NTONGWE	Heavy_Loaded	3	89.29
		Normal_Loaded	14	49.72
		Under_Loaded	26	10.82
Rulindo	BASE	Normal_Loaded	3	41.52
		Under_Loaded	3	18.35
	BYUMBA	Under_Loaded	4	10.02
	GASIZA	Under_Loaded	2	9.07
	NZOVE	Heavy_Loaded	1	92.41
		Normal_Loaded	1	39.44
		Over_Loaded	1	102.37
		Under_Loaded	2	18.80
Rusizi	BUGARAMA	Normal_Loaded	1	32.03
		Under_Loaded	2	14.46
	MASHYUZA	Normal_Loaded	5	43.60
		Under_Loaded	16	14.98
	MURURU I AUXILIARY	Under_Loaded	1	6.00
	MURURU-1	Normal_Loaded	1	42.24
		Under_Loaded	1	19.34
	SHAGASHA	Heavy_Loaded	2	88.96
		Normal_Loaded	15	49.80
		Under_Loaded	18	16.41
Rutsiro	KIBUYE	Heavy_Loaded	2	86.23
		Normal_Loaded	26	42.57
		Over_Loaded	1	100.41
		Under_Loaded	41	15.71
Rwamagana	KANOMBE	Heavy_Loaded	1	87.82
		Normal_Loaded	4	40.04
		Under_Loaded	7	14.64
	KARENGE	Heavy_Loaded	3	86.34
		Normal_Loaded	15	48.86
		Under_Loaded	14	16.00
	KKK	Normal_Loaded	5	45.89
		Under_Loaded	7	14.72
	MUSHA AUXILIARY	Under_Loaded	1	11.00
	REDEMI 1	Normal_Loaded	4	49.60
		Under_Loaded	3	20.38
	RWAMAGANA	Heavy_Loaded	4	92.59
		Normal_Loaded	18	49.76
		Over_Loaded	1	126.03

	Under_Loaded	43	10.72
--	--------------	----	-------

Transformer loading profile analysis



STATUS	Loading range	NUMBER
Heavy_Loaded	80% ↔ 100%	105
Normal_Loaded	30% ↔ 80%	1044
Over_Loaded	≥ 100%	34
Under_Loaded	0% ↔ 30%	1985
TOTAL		3168

Recommendations on transformer issues

- ✓ Some transformers need LV lines extension, to connect new customers around
- ✓ Transformers having high capacity, possible connections done and need to be downgraded.
- ✓ Some transformers need to be merged.
- ✓ Checking connections of meters is needed

IV. On-Grid Access Program Countrywide(RUEAP)

District	Sector	Total connections	MV	LV	Trf	Funder
Gisagara	Gikonko,Gishubi,Kansi,Kibirizi,Kigembe,Mamba,Muganza,Mugombwa,Mukindo,Musha,Ndora,Nyanza,Save	8,143	55.7	233.0	98.0	AfDB
Huye	Gishamvu,Huye,Karama,Kigoma,Maraba,Mbazi,Mukura,Ngoma,Ruhashya,Simbi,Tumba	27,156	146.0	357.0	149.0	
Nyamagabe	Buruhukiro,cyanika,gasaka,Gatare,Kaduha,kamegeri,kibirizi,kibumbwe,kitabi,Mbazi,musange,musebeya,nkomane,Tare,Uwinkingi	9,130	97.5	212.0	83.0	
Nyanza	Busasamana,Busoro,Cyabakamyi,Kibilizi,Kigoma,Mukingo,Muyira,Ntyazo,Nyagisozi,Rwabicuma	11,945	68.0	326.0	154.0	
Nyaruguru	Busanze,Cyahinda,Kibeho,kivu,Mata,muganza,Munini,Nyabimata,nyagisozi,Ruheru,Ruramba	4,253	34.0	126.0	34.0	
Ruhango	Bweramana,Byimana,Kabagali,Kinazi,Kinihira,Mbuye,Mwendo,Ntongwwe,Ruhango	9,213	72.0	216.3	67.0	
Gakenke	Busengo;Coko;Cyabingo;Gakenke;Gashenyi;Janja;Kamubuga;Karambo;KivurugaMataba;Minazi;Mugunga;Muhondo;Muyongwe;Muzo;Nemba;Ruli;Rusasa;Rushashi	12,841	71	218	130	OFID/SFD
Muhanga	Cyeza,Kabacuzi,Kiyumba,nyabino ni,nyamabuye,nyarusange,rongi,Rugendabari,Shyogwe	20,947	103	357	160	

Kamonyi	Gacurabwenge, Karama, Kayenzi, Kayumbu, Mugina, Musambira, Ngamba, Nyamiyaga, Nyarubaka, Rugarika, Rukoma, Runda	32,570	136.7	727.1	231	
Bugesera	Gashora, Juru, Mareba, Mayange, Musenyi, Mwogo, Ntarama, Nyamata, Rilima, Ruhuha	19,866	170.8	400	74	EIB
Gatsibo	Gatsibo, Gitoki, Kabarore, Kageyo, Kiramuruzi, Kiziguro, Muhura, Mumbi, Nyagihanga, Remera, Rugarama, Rwimbogo	22,021	120	543	87	
Kayanza	Gahini, Kabare, Kabarondo, Mukarange, Murama, Murundi, Mwiri, Ndegro, Nyamirama, Rukara, Ruramira, Rwinkwavu	20,256	113	440.2	90	
Kirehe	Gahara, Gatore, Kigarama, Kagina, Kirehe, mahama, Mpanga, Musaza, Mushikiri, Nasho, Nyamugari, Nyarubuye	16,375	102	163	84	
Ngoma	Gashanda, Jarama, Kazo, Kibungo, Mugesera, Murama, Mutenderi, Remera, Rukira, Rukumberi, Rurenge, Sake, Zaza	13,734	123	320	95	
Nyagatare	Gatunda, Karama, Karangazi, Kiyombe, Matimba, Mimuri, Mukama, Musheri, Nyagatare, Rukomo, Rwempasaha, Rwimiyaga, tabagwe	14,754	126	242.5	67	
Rwamagana	Fumbwe, Gahengeri, Gishali, Karengye, Kigabiro, Muhazi, Munyaga, Munyiginya, Musha, Muyumbu, Mwulire, Nyakaliro, Nzige, Rubona	12,205	132	296	107	
Ngororero	Bwira, Gatumba, Hindiro, Kabaya, kageyo, kavumu, Matyazo, Muhanda, Muhororo, Ndaro, Nyange, Sovu	22,052	180	604	244	WB

Nyabihu	Mukamira,Jenda,Bigogwe,Kabatwa, Kintobo,Rugera,Rurembo,Shyira,J omba,Muringa,Rambura,Karago	26,923	164	384	148	
Rubavu	Bugeshi,Busasamana,Cyanzarwe, Gisenyi,Kanama,Kanzenze,Muden de,Nyakiriba,Nyamyumba,Nyundo ,Rubavu,Rugerero	17,228	136	245	66	
Gicumbi	Bukure;Bwisige;Byumba;Cyumba; Giti;Kageyo;Manyagiro;Miyove;M ukarange;Muko;Mutete;Nyamiyag a;Nyankenke;Rubaya;Rukomo;Rus hakiRutare;Ruvune;Rwamiko;Sha ngasha	15,225	155.5	245.9	81	
Musanze	Busogo;Cyuve;Gacaca;Gashaki;Ga taraga;Kimonyi;Kinigi;Muhoza;M usanze; Muko, Nkotsi;Nyange;Remera;Rwaza;Shi ngiro	17,090	151.1	236.0	128	
Rulindo	Base;BushokiBuyoga;Cyinzuzi;Cy ungo;Kinihira;Kisaro;Masoro;Mbo go;Murambi;Ngoma;Ntarabana;Ru kozo;RusigaShyorongi;Tumba	11,361	124.2	375.4	69	
Burera	Bungwe;Butaro;Cyanika;Cyeru;Ga hunga;Gatebe;Gitovu;Kagogo;Kin oni;Kinyababa;Kivuye;Nemba;Rug arama;Rugengabari;Ruhunde;Rusa rabuye;Rwerere	17,171	146.7	283.0	144	

Karongi	Bwishyura, Gishyita, Gitesi, Mubuga, Murambi, Murundi, Mutuntu, Rubengera, Rugabano, Rwankuba, Twumba	28,885	207.0	407.2	118	
Rusizi	Bugarama, Butare, Bweyeye, gashonga, Giheke, Gihundwe, Gikundamvura, Gitambi, Kamembe, Mururu, Nkanka, Nkombo, Nkungu, Nyakarenzo, Nzahaha, Rwimbogo	28,939	357.0	260.6	69	
Rutsiro	Boneza, Gihango, Kigeyo, Kivumu, Manihira, Mukura, murunda, Musasa, Mushonyi, Mushubati, Nyabirasi, Ruhango, Rusebeya	31,958	287	344	77	
Nyamasheke	Bushekeri, Gihombo, Karengera, Kirimbi, Macuba, Nyabitekeri, Shangi	26,145	342.3	703.6	211	AFD
TOTAL		498,386	3,919.9	9,265.3	3,065	
TOTAL COST	361,701,635USD					

V. SUMMARY OF ALL DISTRIBUTION PROJECTS AND REQUIRED INVESTMENT

➤ Network reinforcement:

1. New proposed lines for N-1 solution
2. Upgrade of MV lines (conductor sizes)
3. Quality of Supply (voltage drop reduction)
4. Single phase Network Upgrade
5. Replacement of Single phase transformers countrywide
6. Construction and rehabilitation of Switching Cabines

➤ On-Grid Electricity Access Program Countrywide

List of Major Network Strengthening projects in Financing pipeline with Development Partners

SN	Project Name	Project Scope	Project Objectives	Impact on losses	Financier	Estimated Budget	Status	Needed Date
	Distribution							
1	Advanced Distribution Management System	Equip both NCC and DNCC Control rooms with SCADA/EMS/GIS and SCADA/ADMS/GIS Platforms respectively main and backup sites, Installation of Feeder automation Devices (Auto-Reclosers, Automatic Load break switches, Fault detectors and associated RTUs & associated telecom equipment	Improve safety and reliability through better visualization of distribution networks status and use of switching plan tools	Medium	AFDB	US\$ 22,500,000	Financing Secured	Nov-23
2	Building of GIS system	Building of Rwanda's power system GIS	use of improved planning tools	Medium	World Bank	US\$ 6,000,000	Financing Secured	Nov-23
3	Completing installation of smart metering for all distribution transformers and medium/large customers.	Installation of smart meters on all Distribution transformers	Provide means to measure the energy dispatched and billed	Medium	World Bank	US\$ 4,500,000	Financing Secured	Continuous
4	Upgrade of Karisimbi 6.6kV line to 30kV	Upgrade of three existing substations i.e. KABATWA, CRATER and SOMMET with construction of 6.92km of MV underground	Increase efficiency and reliability in the area supplied	Medium	AFDB	US\$ 2,000,000	Financing Secured	Jun-23

5	Installation of MV switching substations, upgrade of existing cabins and construction of medium voltage line in secondary cities of Rwanda	Construction of 12, new 30kV switching substations located in the different secondary cities of Rwanda i.e. in Rusizi (3), Rubavu (1), Bugesera (1), Huye (3), Muhanga (2), Nyagatare (2), rehabilitation of 3 existing cabins in Rusizi and construction of associated MV lines (overhead and Underground)	Increase efficiency and reliability in the area supplied	High	AFDB	US\$ 17,867,715	Financing Secured	Jun-22
6	Renovation of Low voltage underground cables & MV/LV cabins in Nyarugenge	44.1km of LV Underground and 17 MV/LV cabins	Increase efficiency and reliability in the area supplied	High	AFDB	US\$ 33,529,827 + Additional Amount (US \$22,074,105) Re-allocated from Access Component	Financing Secured	2021
7	Refurbishment of Distribution Network (Voltage drop and loss reduction)	Refurbishment of 383km of MV lines and 1720km of LV lines	Increase efficiency and reliability in the area supplied		AFDB			Jun-22
8	Demand Stimulation in all parts of the country	Connection of 300 Large customers and construction of 180km of MV line in a period of 5 years i.e. 60 applicants and 36km per year	Increased demand and thus improved system voltage due to reduced mismatch between generation and demand	High	AFDB			Continuous
9	Upgrade of single to three phase lines countrywide	Upgrade of 395.5km of MV lines, 1189.3km of LV and replacement of 922 transformers in the entire network	Increase efficiency and reliability in the area supplied	Medium	AFDB	US\$ 22,050,208	Financing Secured	Dec-23

10	Installation of MV switching cabins, construction and upgrade of medium voltage (Overhead & Underground) line in Kigali	25 switching Cabins and 36.24km of MV (U.G & O.H)	Increase efficiency and reliability in the area supplied	High	EIB	US\$ 20,295,625	Financing Secured	Dec-23
11	Construction of Switching cabin and associated MV lines at Rwaza MHPP	Construction of a Switching cabin at Rwaza MHPP, 3km of MV line from Mukungwa 2, cut in and out of existing Nyakinama sub-feeder feeding into Camp Belge Substation	Increased efficiency and reliability in the area supplied	High	RBF	US\$ 2,000,000	Financing Secured	Dec-23
12	Rehabilitation and upgrade of 50km, 0.4kV Overhead Distribution Lines at Musanze Town (Northern Province):	Rehabilitation and Upgrade of 50km, 0.4kV Overhead Distribution Lines in Musanze Town	Increased efficiency and reliability in the area supplied	High	INDIA-EXIM	US\$ 2,500,000	Proposal submitted	Jun2022
13	Rehabilitation and upgrade of 30km, 0.4kV Overhead Distribution Lines in Huye Town (Southern province);	Rehabilitation and Upgrade of 30km, 0.4kV Overhead Distribution Lines in Huye Town	Increased efficiency and reliability in the area supplied	High	INDIA-EXIM	US\$ 1,500,000	Proposal submitted	Jun2022
14	Rehabilitation and Upgrade of LV Network in Rubavu 50km, 0.4kV Overhead Distribution Lines in Rubavu Town (Western province);	Rehabilitation and Upgrade of 50km, 0.4kV Overhead Distribution Lines in Rubavu Town	Increased efficiency and reliability in the area supplied	High	INDIA-EXIM	US\$ 2,500,000	Proposal submitted	Jun2022

15	Construction of new MV/LV switching Substation at Kanzenze in Bugesera district	Construction of new MV/LV switching Substation at Kanzenze in Bugesera district	Increased efficiency and reliability in the area supplied	Medium	INDIA-EXIM	US\$ 1,000,000	Proposal submitted	Jun2022
16	Construction of a 5MVA, 30/15kV Substation and associated feeders' connections to link Musha and Kabarondo S/S	Construction of a 5MVA, 30/15kV Substation and associated feeders' connections to link Musha and Kabarondo S/S	Increased efficiency and reliability in the area supplied	Medium	INDIA-EXIM	US\$ 1,500,000	Proposal submitted	Jun2023
17	Construction of MV Switching Cabins in districts where switching is taking place on poles (Nyabihu, Rubavu, Bugesera, Nyamasheke & Kigali)	Construction of new MV Switching Cabins in districts where switching is taking place on poles (Nyabihu, Rubavu, Bugesera, Nyamasheke & Kigali)	Increased efficiency and reliability in the area supplied	Medium	INDIA-EXIM	US\$ 6,300,000	Proposal submitted	Jun2023
18	Upgrading existing feeders	139.4km of different MV lines constructed with 35sqmm cable size will be upgraded to 70sqmm or 120 sqmm i.e (20km on Kibuye feeder, 35.4km on Rukarara feeder in Nyaruguru district, 29.1 on Rukarara feeder in Gisagara and Huye Districts, 54.9km in Gakenke district.	Increased efficiency and reliability in the area supplied	Medium	INDIA-EXIM	US\$7,248,800	Proposal submitted	Jun2023

19	Construction of links between feeders from different Substations	Construction of meshed network between Mururu & Cimerwa feeders (2km), Kilinda & Karongi feeders (15km), Kiyumba-Musasa & Nyabarongo 2-Kiyumba feeders (7.5km)	Increased efficiency and reliability in the area supplied	High	INDIA-EXIM	US\$1,274,000	Proposal submitted	Jun2024
20	Construction 31.61km of new 30kV feeders from Ongoing and planned Substations	Construction of new 30kV feeders i.e. 2.5km from Ongoing Gisagara substation, 2km from planned Gicumbi Substation, 5.5km from planned Huye substation, 3km from planned Muhanga substation, 3km from planned Nyagatare substation, 6km from planned Kirehe substation	Increased efficiency and reliability in the area supplied	Medium	INDIA-EXIM	US\$1,643,720	Proposal submitted	Jun2023
21	Improvement of existing Radial network to meshed distribution networks (loop ties-MV lines)	Improvement of existing Radial network to meshed distribution networks (loop ties-MV lines)	Increased efficiency and reliability in the area supplied	High	INDIA-EXIM	US\$10,000,000	Proposal submitted	Jun2023
22	Construction of 30/15kV, 5MVA Cabin at Ruyenzi/ Kamuhanda and associated MV lines (creating link between Nzove S/S and Mont Kigali S/S (Kiyumba feeder)	Construction of 30/15kV, 5MVA Cabin at Ruyenzi/ Kamuhanda and associated MV lines (creating link between Nzove S/S and Mont Kigali S/S (Kiyumba feeder)	Increased efficiency and reliability in the area supplied	Medium	NA	US\$2,100,000	No Financing Line	Jun2022

23	Construction of 30/15kV, 6MVA cabin at Karumuna and associated MV lines (creating link between Gahanga S/S & Mont Kigali S/S (Kanazi feeder)	Construction of 30/15kV, 6MVA cabin at Karumuna and associated MV lines (creating link between Gahanga S/S & Mont Kigali S/S (Kanazi feeder)	Increased efficiency associated reliability in the area supplied	Medium	NA	US\$2,500,000	No Financing Line	Jun2023
24	Rehabilitation of Low Voltage Underground Network in Kacyiru Branch i.e. strategic areas (Kimihurura, Kacyiru and Gacuriro)	Construction of 49.36km of old low Voltage Underground Network in Kacyiru Branch i.e. strategic areas (Kimihurura, Kacyiru and Gacuriro)	Increased efficiency Branch reliability in the area supplied	Medium	NA	US\$14,912,219.74	No Financing Line	Jun2022
25	Construction of double circuit line from Gisagara substation to link with Butare feer and associated Switching cabins(Creating link between Gisagara ss, Kigoma SS and Rukarara SS)	Construction of 12 km double circuit line, one toward Save and other toward Nyanza. Construction of 2km Medium voltage line to link Gisagara feeder with Rukarara feeder through Cyarwa switching cabin.Constrution of 2 switching cabins of Rugarama and Ruturo-Ntobo in Gisagara	Increased efficiency and reliability in the area supplied	Medium	NA	US\$2,128,000	No Financing Line	Jun2023
26	Construction of 9.6km Double Circuit MV Line from Rubavu Substation to Rutsiro and associated links	Construction of 9.6km Double Circuit MV Line from Rubavu Substation to Rutsiro and associated links	Increased efficiency and reliability in the area supplied	High	NA	US\$499,200	No Financing Line	Jun2024

27	Construction of the ring line of Rubavu (Poids Lourds)	Construction of 2.4km ring line of Rubavu (Poids Lourds)	Increased efficiency and reliability in the area supplied	High	NA	US\$124,800	No Financing Line	Jun2023
28	Construction of Double circuit MV Line Linking Camp Belge Substation to Nyabihu Substation	Construction of 1.2km Double circuit MV Line Linking Camp Belge Substation to Nyabihu Substation	Increased efficiency and reliability in the area supplied	High	NA	US\$62,400	No Financing Line	Jun2023
29	Construction of Double circuit MV Line linking Nyabihu Substation and Gisenyi Feeder towards Ngororero	Construction of the 3km Double circuit MV Line linking Nyabihu Substation and Gisenyi Feeder towards Ngororero	Increased efficiency and reliability in the area supplied	High	NA	US\$312,000	No Financing Line	Jun2024
30	Improve protection of distribution transformers by installation of Cut-out and Surge arrestors combinations	Improve protection of distribution transformers by installation of Cut-out and Surge arrestors combinations	Increased efficiency Cut reliability in the area supplied	Low	NA	US\$5,000,000	No Financing Line	Jun2024
Total Required investment						US\$ 216,125,220		

XII. CONCLUSION AND RECOMMENDATIONS

The main conclusions that may be drawn from the latest development plan update exercise are briefly described below.

Assessment of existing network

Network assessment was conducted for each of the five hubs by using computer simulations. The models were refined using inputs from detailed discussions with the technical engineers and hub managers. Network analysis of the existing system was then conducted with the primary purpose of validating the existing issues. Specific network weaknesses were identified through this analysis and these are described in the report and new projects were proposed as the solution to the identified issues.

Short to medium term plan

A short to medium term (2019 – 2024) distribution network reinforcement and expansion plan was developed for each of the hubs. This plan is based on detailed network analysis and identifies proposed 30 kV and 15 kV projects that are required beyond the ongoing and committed projects. The need for additional distribution substations was identified and captured in the transmission master plan, beyond the committed transmission projects, and reinforcement of existing substation in order to support the distribution network has also been identified.

The need for the projects is driven by the current issues and the demand forecast which has been disaggregated to county level and then applied to the individual substations across the network. The proposed projects should be considered the minimum requirement to meet the forecast demand whilst complying with the planning criteria.

Interconnection of Off-grid Areas

The National Grid does not currently extend to all parts of Rwanda and the current plan is to connect around 48 % with the off-grid solution, either standalone system or mini grid solutions. After 2024, the existing plan will be revised and consider the new plan of connecting off grid customer to the grid progressively until we have 100 % access with grid solution. This will be

defined in detail with the NEP and Distribution master plan to be developed after NST1 and this will be considered as our long-term investment plan.

Recommendations

It has been noted that some sections of the distribution network need urgent interventions considering the substantial development projects to be implemented and the normal running of business contributing to the development of the Country.

Among the supply areas that need quick solutions, Eastern province networks as well as the reinforcement for Kigali City network that supplies a big load centre must be given priority while thinking also about the Southern network especially Butare and Rukarara feeders which suffer from instability due to the length of the Feeders.

We have estimated the projects costs in this report and therefore recommend to secure the fund and look for alternative solutions for projects that need immediate action.

Annexes: All maps inserted in the report are annexed hereto for purposes of clear visibility