Rwanda Electricity Distribution Master Plan

December 2021 revision

APPROVALS

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I. INTRODUCTION

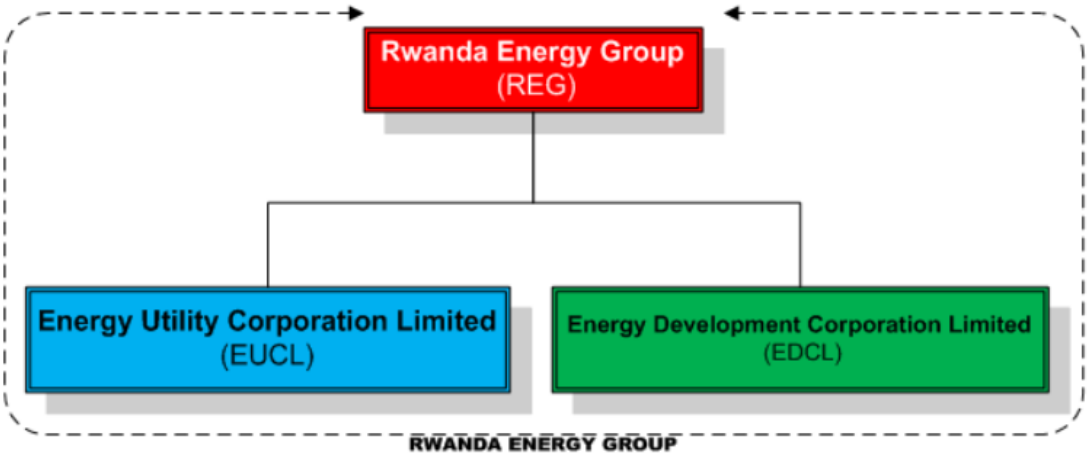
I.1. Overview and Structure of REG

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. Major Updates made in the Distribution Plan (December 2021 version)

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

1. Updates on Anticipated Major load demand on Distribution network from 2021-2023 by keeping in mind the high demand growth of 10% per year as stated in Least Cost Development Plan(LCDP):
    - Data were collected from different Institutions such as MINICOM, MINAGRI, WASAC, DISTRICTS and CITY OF KIGALI
    - Network strengthening initiatives so as the feeders affected will cope with the anticipated load demand
2. Improvement of Distribution Network Zoning and identification of all areas of the network with critical voltage drop issues

3. Assessment of all Distribution Transformers Loading profile countrywide to identify the status of each transformer whether are critically overloaded or under-loaded for a better planning

4. Consideration of all Planned On-Grid projects countrywide under RUEAP that will particularly leave 100% electrification of Kigali as a target and evaluate what percentage those projects will increase to national Electrification Plan

I.4. Expected Key Outputs of the development Plan

The expected key outputs of the devevopment 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.

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 308.37MW. The current electricity access plan (as of End October 2020) reveals that Rwanda's national electrification rate reached 66.86%, on which 47.76% was for HHs connected to National grid and 19.10% connected to off grid.

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 31 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, RUBAVU, RWABUSORO. 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:

The distribution network increased with a total length of 183.74 Km including 69.88 km of medium voltage lines and 113.86 km of low voltage lines, bringing the total distribution network from 27,217.9 km to 27,401.6 km, of which 9,953.48 km of medium voltage and 17,448.16 km of low voltage

By the end of December 2021, a total of 43,761 customers were connected to the National grid of which the 43,565 were households and 196 productive users. Again, the 44.970 customers were connected to off-grid electricity.

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.

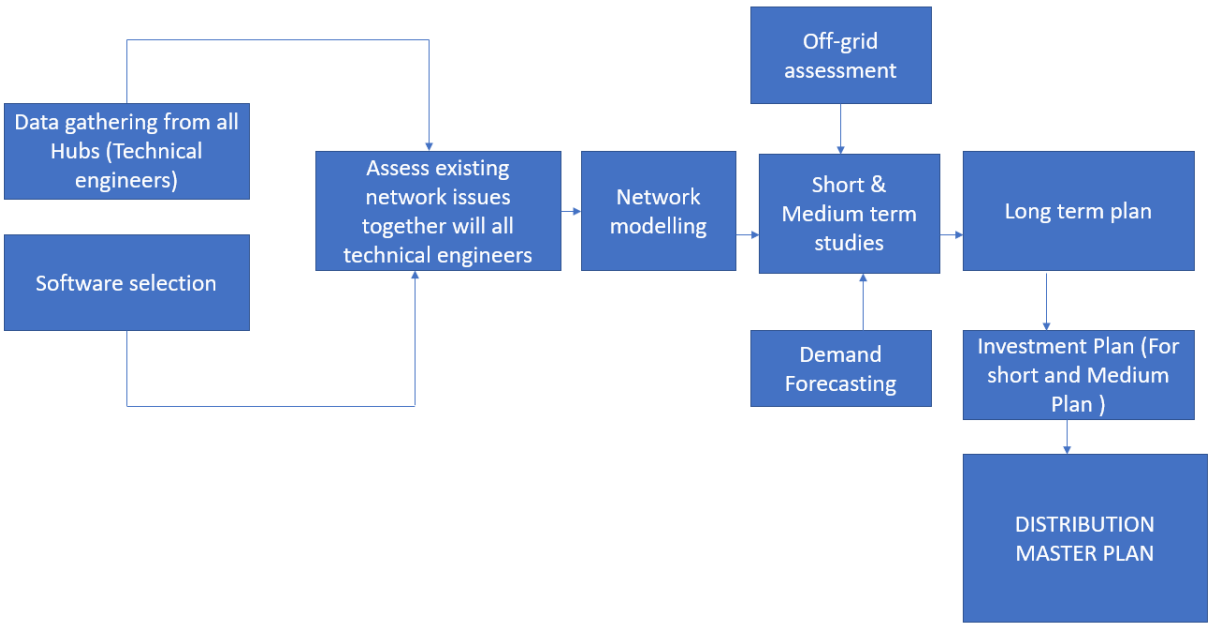
III. DISTRIBUTION MASTER PLAN APPROACH

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 will 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:

IV. Kigali Hub.
V. North Hub
VI. South Hub
VII. East Hub
VIII. 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.

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	173624	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

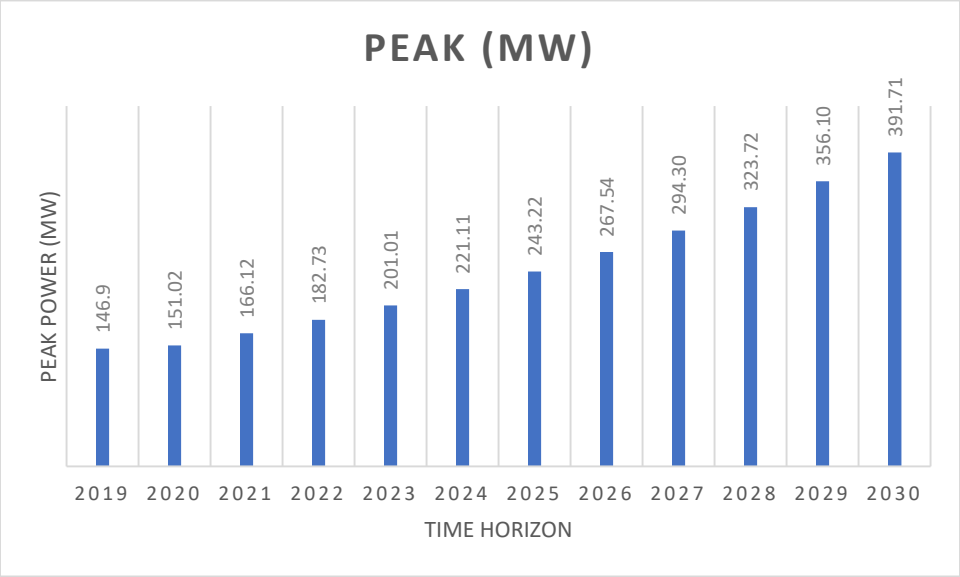
Table: National Installed Capacity throughout the planning horizon

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 if 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

No	Area	Indicator Name	2005/06	2010/11	2013/14	2016/17
			EICV2	EICV3	EICV4	EICV5
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

No	Area	Indicator Name	2005/06	2010/11	2013/14	2016/17
			EICV2	EICV3	EICV4	EICV5
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
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

No	Area	Indicator Name	2005/06	2010/11	2013/14	2016/17
			EICV2	EICV3	EICV4	EICV5
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
	SUCRERIE	0.5	3
	2 SPARES		
Mt KIGALI	KIYUMBA	152	87
	KANAZI	265	155
	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		

Substation	Feeder	Length(km)	Number of Transformers
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		
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
	MURURU1	33	27
	2 SPARES		
RUKARARA	Rukarara 2 from SS	**527**	**244**
	Rukarara 2 from HPP		
	2 SPARES		

Substation	Feeder	Length(km)	Number of Transformers
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		
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**	
BUGESERA(completed)			
SHANGO(completed)			
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	2025	Musanze
2	Nyabihu	2022	Nyabihu
3	Rubavu	2021 completed	Rubavu
4	Muhanga	2026	Muhanga
5	Huye	2024	Huye
6	Gisagara	2022	Gisagara
7	Kirehe	2023	Kirehe
8	Gicumbi	2025	Gicumbi

9	Nyagatare	2024	Nyagatare
10	Nyabarongo 2	2024	Muhanga
11	Bugesera ss	2021 completed	Bugesera
12	Bugesera Industrial Park ss	2024	Bugesera
13	Two Bugesera airport SS	2023	Bugesera
14	Shango	2021completed	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 96.68% in Kigali City with Kicukiro at 99.4%, Gasabo at 95.26%, Nyarugenge at 95.4%, Rwanda Energy Group (REG) through its subsidiary companies (EUCL & EDCL) is targeting to achieve **100% electricity access in Kigali City by 2022**, 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)

KIGALI HUB							
Feeder Name/Load Category		Total Load (MW) (2021-2023)	Additional Loads in each year			Status End 2021	Comment
			2021	2022	2023		
FEEDER NAME	**Big Industries**	**11.5**	**5.6**	**4.4**	**1.5**		
Freezone 1/Freezone 2	Rwanda Engineering and Manufacturing Corporation (REMCO)	4.5	3.5	1.0		2	constructed
Freezone 1/Freezone 2	Extension of Aldango Ltd Refineries	1.0	0.6	0.4			Not yet started
Nzove	Extension of SKOL Brewery Industry	2.0	0.5	1.0	0.5		Not yet started
Inyange	Extension of Inyange Industries	1.0		1.0			Not yet started
	Others	3.0	1.0	1.0	1.0		
	Commercial complexes + Big Offices	**23.3**	**9.0**	**5.7**	**9.4**		
Freezone 1 or Freezone 2	African Leadership University	0.5	0.5			0.5	constructed
Kimironko	Adventist University of Central Africa-Masoro	0.5	0.5			0.5	constructed
Kigali South	I & M Bank Building	1.0	1.0			1	constructed
Kibagabaga-Nyarutarama	Albert Supply Building	2.0	2.0			2	constructed
Kinyinya	National Archive Building	0.6	0.6			0.6	constructed
Kigali South/North	NSIT Office Building	0.8		0.8			under construction
Kigali South/North	Nobelia Business Center	1.0	0.4	0.6			under construction
Nyarurama	Defense Research & Development (DRD)	2.0	2.0			2	constructed
Kigali South/North	University of Rwanda Offices & Hostels	1.0	0.5	0.8			under construction
Kimihurura/KBC	Nzovu Mall (Former MINJUST)	2.5	0.5	1.0	1.0		under construction
Kigali South/North	Mall du Plateau	1.5		0.5	1.5		under construction
Abbatoir	West Gate Commercial Complex	1.2			1.2		Not yet started
Kigali South/North	Equity Bank Building	1.0			1.0		
Kigali South/North	CATCHUP Commercial Building (opposite UTC)	1.2			1.2		Not yet started
Kigali South/North	Kigali International Finance and Business Centre	2.0		0.5	1.5		under construction
Kimihurura/KBC	Extension of KBC (Jade Water Group)	1.5		0.5	1.0		Not yet started
Kimihurura/KBC	ADARWA Building					1	constructed
	Others	3.0	1.0	1.0	1.0		
	Hotels & Apartments	**6.2**	**3.4**	**1.8**	**1.0**		
Kigali South/North	Sheraton Hotel	1.0	1.0			1	constructed
Kigali North	Torch Africa	0.8	0.5	0.3			Not yet started
Gasogi	Pacific Hotel	0.5	0.5				Not yet started
Kibagabaga-Nyarutarama	New Century Hotels	0.8	0.4	0.4			Not yet started
Kibagabaga-Nyarutarama	Golf Course Developments	0.6	0.5	0.1		0.5	constructed
Kigali South/Ministerie	Kiyovu Hotels & Apartments	1.0		0.5	0.5		on-going
	Others	1.5	0.5	0.5	0.5		
	Small Industries (SMEs) & Modern Markets	**11.5**	**1.8**	**4.0**	**6.2**		
Kinyinya	Extension of King Faisal Hospital	1.5	0.5	1.0			constructed
Kanombe	Extension of Kanombe Military Hospital	1.0	0.3	0.5	0.2		Not yet started
New Masaka/kabuga	Extension of Masaka Hospital	2.0		0.5	1.5		under construction
Kimironko	Kimironko Market Expansion	1.2			1.2		Not yet started
Kanazi	Gako Beef project	1.0		0.5	0.5		Not yet started
Parc Industriel	NAEB Storage facility	0.8			0.8		Not yet started
New Masaka/kabuga	Extension of Dubai Ports World	1.0	0.5	0.5	0.5		Not yet started
Nyarurama	Rebero Cultural Village	1.5		0.5	1.0		constructed
	Others	1.5	0.5	0.5	0.5		
	Airport & Stadium Expansion	**5.8**	**0.5**	**2.4**	**2.9**		
Kanombe/Gasogi	Expansion of Kanombe International Airport	2.0	0.5	1.0	0.5		Not yet started
Pylon20	Gahanga Entertainment city	1.8		0.9	0.9		Not yet started
Nyarutarama/Remera	Extension of Amahoro Stadium	2.0		0.5	1.5		Not yet started
	Water Treatment plants	**5.5**	**2.5**	**2.0**	**1.0**		
Kanazi	Kanzenze Water plants	2.5	1.5	1.0			0n-going
	Others	3.0	1.0	1.0	1.0		
	Real Estate Projects	**13.9**	**2.5**	**5.2**	**6.1**		
Nyamirambo	Remote Group Estate (Nyamirambo)	0.6	0.3	0.3			on-going
Kanombe	Remote Group Estate (Masaka)	0.6		0.6			under construction
Kinyinya	Expansion of Vision City	1.6		0.6	1.0		under construction
Kibagabaga-Nyarutarama	Opulent Park Nearby Century Park	1.0			1.0		under construction
Kibagabaga-Nyarutarama	Norrsken Kigali House Project	1.2		0.5	0.7		under construction
Master steel	Gahanga industrial park	2.0	0.5	0.5	1.0		constructed
Master steel	Gahanga Model Village	0.5	0.5				Not yet started
Gasogi	Busanza Re-settlement Area	0.5		0.5			under construction
Deutsche Welle	Batsinda Real Estate Project	0.8		0.3	0.5		under construction
Gikomero	Next Generation Housing Estate-Bumbogo	1.0		0.5	0.5		under construction
Deutchwelle	Kigali Green City-Kinyinya	1.0	0.2	0.4	0.4		Not yet started
Free zone 1/2	Kigali Innovation City (KIC) Masoro	1.5	0.5	0.5	0.5		Not yet started
	Others	1.5	0.5	0.5	0.5		
	Street lights+ CCTV Cameras	**1.8**	**0.8**	**0.5**	**0.5**		
All kigali feeders	Street lights on newly constructed roads	1.2	0.6	0.3	0.3	0.4	constructed
All kigali feeders	Security Cameras on all Roads	0.6	0.2	0.2	0.2	0.05	constructed
	Total Projected load Growth	**79.5**				11.55	
	Maximum available Load (as of September 2021)	**173.2**					
	Yearly Total Load Increment (MW)		**26.1**	**26.0**	**28.6**		

OTHER ANTICIPATED LOADS ON ALL KIGAL FEEDERS

MAJOR BUILDING CONSTRUCTION PROJECTS 2022-2023				
NAME OF THE PROJECT &	**OWNER**	**LOCATION**	**LOADING 2022/23(MW)**	**CURRENT PROGRESS**
Asia Shine Hotel	LIANG ZHIWEI	Kiyovu, adjacent to hill view hotel	1	Under Construction
Gikondo Market	Eudes KAYUMBA	Former Kigarama Market location	1	Under the design process
MIG	Muhima Investment group	Infront of Yamaha / Muhima	0.8	Under construction
NYAMIRAMBO MARKET	MUKARUTESI GRACE	Former Nyamirambo Market location	1	Project approved
World bank office building	World bank	Kiyovu, adjacent to SONARWA	0.5	Project approved
Century park	Century Park Hotel and Residences Ltd		0.8	Under construction
LANDMARK BUILDING	LANDMARK LTD	Kiyovu, Adjacent to Belgium Embassy	0.5	Under Construction
WORLD VISION RWANDA HEAD OFFICE BUILDING	World Vision	Kacyiru, nearby Umubano hotel	0.5	Under Construction
KACYIRU MIXED USE COMPLEX	Karema Rwabuhungu Sam & Yacine	Kacyiru	0.8	Under construction

RSSB Building	RSSB	Former plot of centre culturel Franco-Rwandais	0.8	Project approved
RPF INKOTANYI GASABO DISTRICT & golfCITY OF KIGALI OFFICES	UMURYANGO FPR-INKOTANYI	Gisozi	0.8	Under construction
Sultani Commercial building	AL NAAMAN SULTANI HAMOOD HASSAN	Giporoso, adjacent to SAR MOTORS	1	Under construction
Petrocom Business centre	Egide Gatera	Kiyovu, in front of St Michel	0.8	Project approved
HUAFEIT MULTI-USE BUILDING	BEIJING PAPER CORPORATION LTD	Ubumwe cell, nearby the construction site of RURA	0.8	Project approved
Rusororo primary court	RHA & HIGH COURT	Rusororo	0.5	Design completed, under tender process
Kigali Catholic Cathedral	CATHOLIC CHURCH	Former prison plot	0.6	Under the design process
Karama ADHI Real Estate project	ADHI Corporate	Karama Nyarugenge	0.8	Under construction
Bwiza Riverside Homes Phase I	ADHI Rwanda Ltd	Karama, Nyarugenge	0.5	Under Construction
Ruliba Clays Building	Ruliba Clays	Rusororo, Gasabo	1	Project approved

Rusororo Gaz Plant		Rusororo, Gasabo	1	Under Construction
Ruhanga Industrial Free Zone	City Of Kigali	Ruhanga ,Gasabo	1	Under Construction
Mpazi Rehousing Project Phase II	City of Kigali	Gitega,Nyarugenge	1	Under Construction
Rwanda Vaccine Manufacturing		Gasabo	1	Under the design
Kigali Hospitality Management Institute	WDA	Kicukiro (IPRC)	0.5	Under Construction
See Far project	See Far/IGIHOZO	KICUKIRO/Kanombe/Kabeza/Rebero	0.5	Under Construction
Izuba City Apartments	Kubwimana Philippe	GASABO/Kinyinya/Kagugu/Nyakabungo	0.5	Under Construction
Satellite City /Galilee project /CAN	Workers Affordable Properties	KICUKIRO/Gahanga near industrial area	0.8	Under Construction
BUSANZA housing Project (Phase III)	CoK and RHA	KICUKIRO,Kanombe,Karama, Byimana	0.8	Under Construction
DND Triangle	Daniel Mehri	GASABO/Remera /Nyarutarama/KibiraroI	0.5	Under Construction
Girinzu's Umutuzo Urban Village	Girinzu/French company	KICUKIRO/Gahanga/Kagasa	0.5	Under Construction
GASOGI Affordable Housing project	RSSB	GASABO/Ndera/Bwiza	0.8	Under the design

Ndera afrfordable housing project	BRD,RHA Morrocan investor (Palmeraie)	GASABO/Ndera/Kibenga (near free trade zone)	0.8	Under the design
Rusororo (Kabuga) Housing project	UDL/RSSB	GASABO/Rusororo	0.5	Under the design
Rugarama housing development project	Rugarama Park Estate(BRD/SHAF/COK)	Nyarugenge ,Nyamirambo, Rugarama	0.8	Development agreement signed and phase I commenced
KIMISANGE HOUSING PROJECT	BRD /Millenial	KICUKIRO/Kigarama/Bwerankori	0.8	Land acquired, agreement signed and designs ongoing
KINYINYA HOUSING PROJECT	IFC, RSSB	GASABO/Kinyinya/ Murama	0.8	Land acquired and detailed Designs are ongoing
INZOZI HILL ESTATE	Rwandan Diaspora	Nyarugenge /Nyamirombo/Rugarama	0.5	Land registration in process
Other Anticipated load increment on ALL Kigali feeders in 2022/2023			**27.6MW**	

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:

Kigali Hub feeders As per December2021										
SUBSTATION	**Existing Transfo MVA**	**Feeder**	**Length (km)**	**Conductor Size**	**Maximum Current (A)**	**Max Power Capacity (MW)**	**Peak Power [MW]**	**% Loading at Peak (Calculated)**	**Load Increament on Feeders(MV) as per the anticipated major loads**	**% Feeder Loading increment (2021-2023)**
BIREMBO	**1*20**	Kbgbg/Nyarutarama	15	ACSR 120/20 mm²	410	8.52	4.1	48.12%	5.5	**64.55%**
		Kibagabaga /Remera	7.4	ACSR 120/20 mm²	410	8.52	5.8	68.08%	2	**23.47%**
		Kimironko	7.5	ACSR 70/12 mm²	290	6.03	3.9	64.68%	2.3	**38.14%**
		Kinyinya	19.3	ACSR 120/20 mm²	410	8.52	7.8	91.55%	3.7	**43.42%**
Total			**49.2**							
GAHANGA	**1*20**	Master Steel	16	ACSR 70/12 mm²	290	6.03	4.1	67.99%	2.5	**41.46%**
		Pylon 20	6	ACSR 70/12 mm²	290	6.03	1.04	17.25%	1.8	**29.85%**
Total			**22**							
GASOGI	**1*20**	Inyange	8.5	ACSR 70/12 mm²	290	6.03	1.682	27.89%	1	**16.58%**
		Kabuga(New Masaka)	99	ACSR 120/20 mm²	410	8.52	2.34	27.46%	3	**35.21%**
		Kanombe	136	ACSR 120/20 mm²	410	8.52	5.97	70.07%	3.6	**42.25%**
Total			**243.5**							
GIKONDO	**3*15**	Gasogi	34.93	ACSR 120/20 mm²	410	8.52	5.6	65.73%	1	**11.73%**
		Gikondo Haut	9	ACSR 70/12 mm²	290	6.03	1.06	17.58%		
		Kigali North	16	ACSR 120/20 mm²	410	8.52	3.6	42.25%	4.75	**55.75%**
		Kigali South	20	ACSR 120/20 mm²	410	8.52	4.29	50.35%	4.75	**55.75%**
		Kimihurura	11	ACSR 150/25 mm²	410	8.52	2.84	33.33%	4	**46.94%**
		Nyarurama	2.1	ACSR 70/12 mm²	290	6.03	0.27	4.48%	3.5	**58.04%**
		Ministerie1	3.72	CU/XLPE/PVC 1* 240 mm²	596	12.39	3.44	27.76%	0.7	**5.65%**
		Ministerie2	3.72	CU/XLPE/PVC 1* 240 mm²	596	12.39	2.47	19.94%		
		Parc Industriale	18	CU/XLPE/PVC 1* 95 mm²	323	6.71	0	0.00%	0.8	**11.92%**
Total			118.47							
JABANA 1	**2 *10**	D.Welle	39	ACSR 120/20 mm²	410	8.52	4.14	48.59%	1.8	**21.12%**
		Kigali	90	ACSR 120/20 mm²	410	8.52	4.54	53.29%	0.2	**2.34%**
		Rutongo	90	ACSR 70/12 mm²	290	6.03	2.14	35.49%	0.1	**1.65%**
		Sucrerie	0.5	CU/XLPE/PVC 1*50 mm²	210	4.36	0.23	5.28%	0.1	**2.29%**
		Utexerwa	22	ACSR 70/12 mm²	290	6.03	5.18	85.90%	0.2	**3.31%**
Total			241.5							
MONT KIGALI	**1*20**	Kanazi	265	ACSR 120/20 mm²	410	17.04	9.03	52.99%	3.5	**20.54%**
		Kiyumba	184	ACSR 120/20 mm²	410	17.04	2.1	12.32%	0.6	**3.52%**
		Nyamirambo	29.25	ACSR 120/20 mm²	410	17.04	4.57	26.82%	0.6	**3.52%**
		Nyarurama	2.5	ACSR 70/12 mm²	290	12.05	0.94	7.80%		
Total			480.75							
NDERA	**2*20**	Birembo	15	ACSR 120/20 mm²	410	8.52	1	11.74%		
		Free zone 1/2	1.5	ACSR 120/20 mm²	410	8.52	5.5	64.55%	3.2	**88.02%**
		Gikomero	28	ACSR 120/20 mm²	410	8.52	1.8	21.13%	0.6	**7.04%**
Total			44.5							
NZOVE	**1*20**	Abattoir	11.5	ACSR 120/20 mm²	410	8.52	2.1	24.65%	1.2	**14.08%**
		Nzove	8	ACSR 120/20 mm²	410	8.52	4.9	57.51%	2	**23.47%**
Total			19.5							

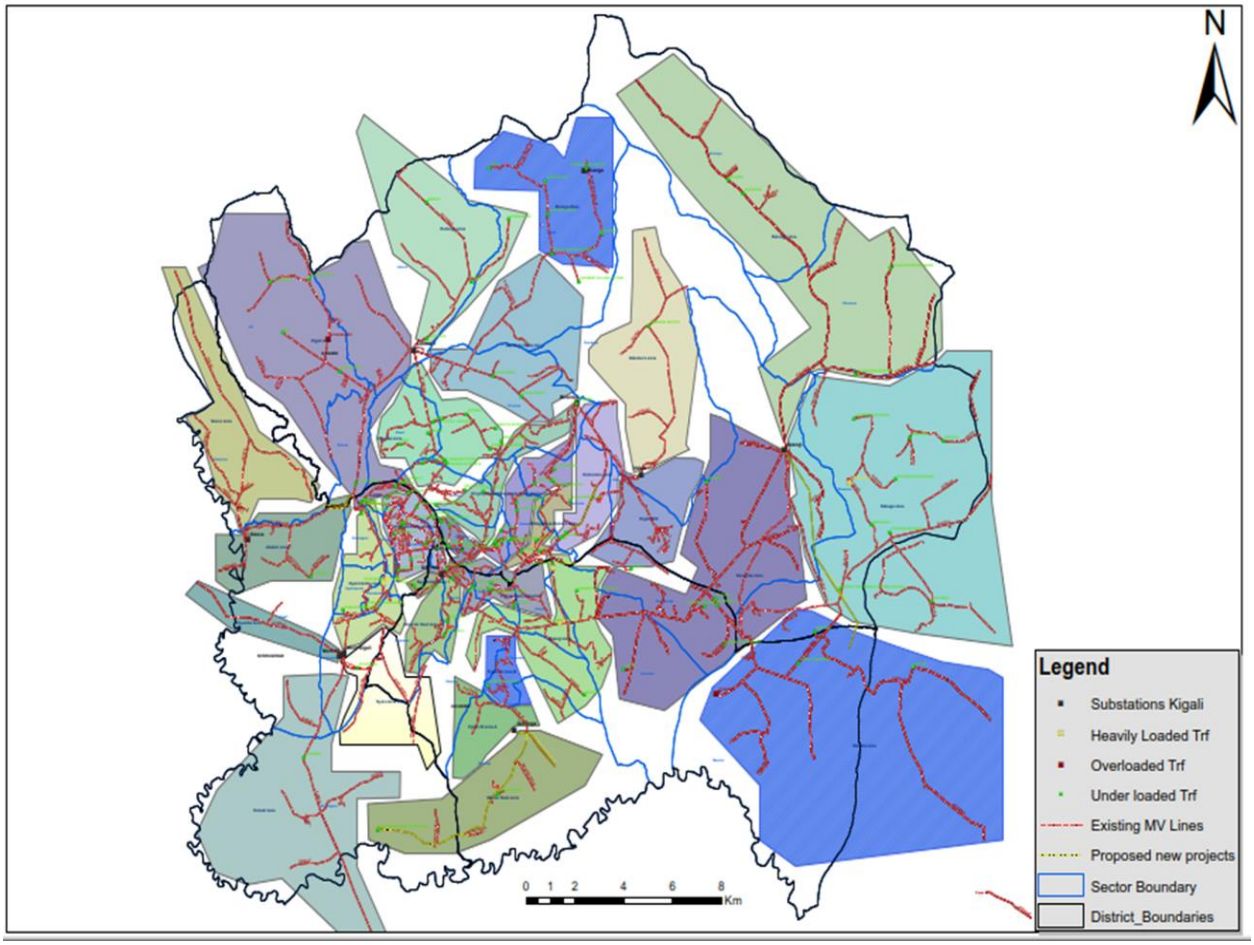
Currently the distribution network in Kigali is composed of **1207.1km** of medium voltage and **1884.453km** of low voltage. The distribution network is growing significantly to accommodate the increasing load and reinforcements to improve on the quality of power supply. The figure

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

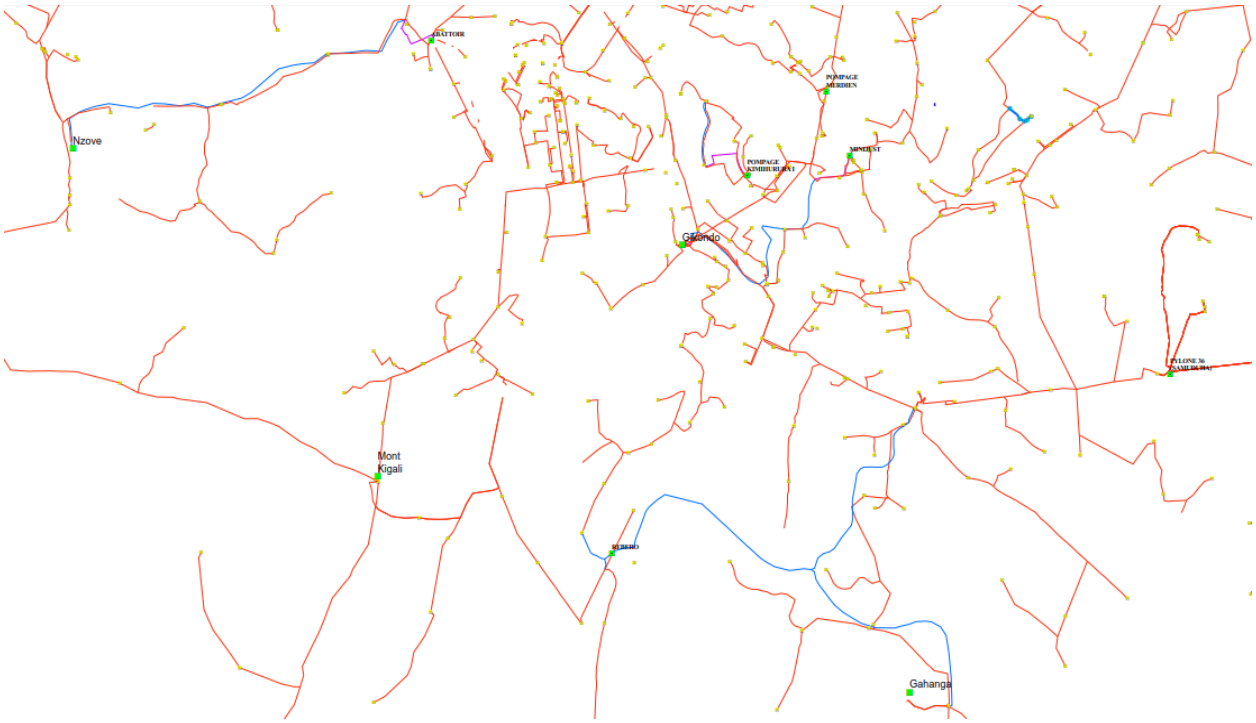
Projects being implemented consist of construction of 8 switching substations and their associated MV lines located in different parts of Kigali:

No	List of Cabins	Specific Area	District
1	Abattoir	Nyabugogo	Nyarugenge
2	Amba Zaïre	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

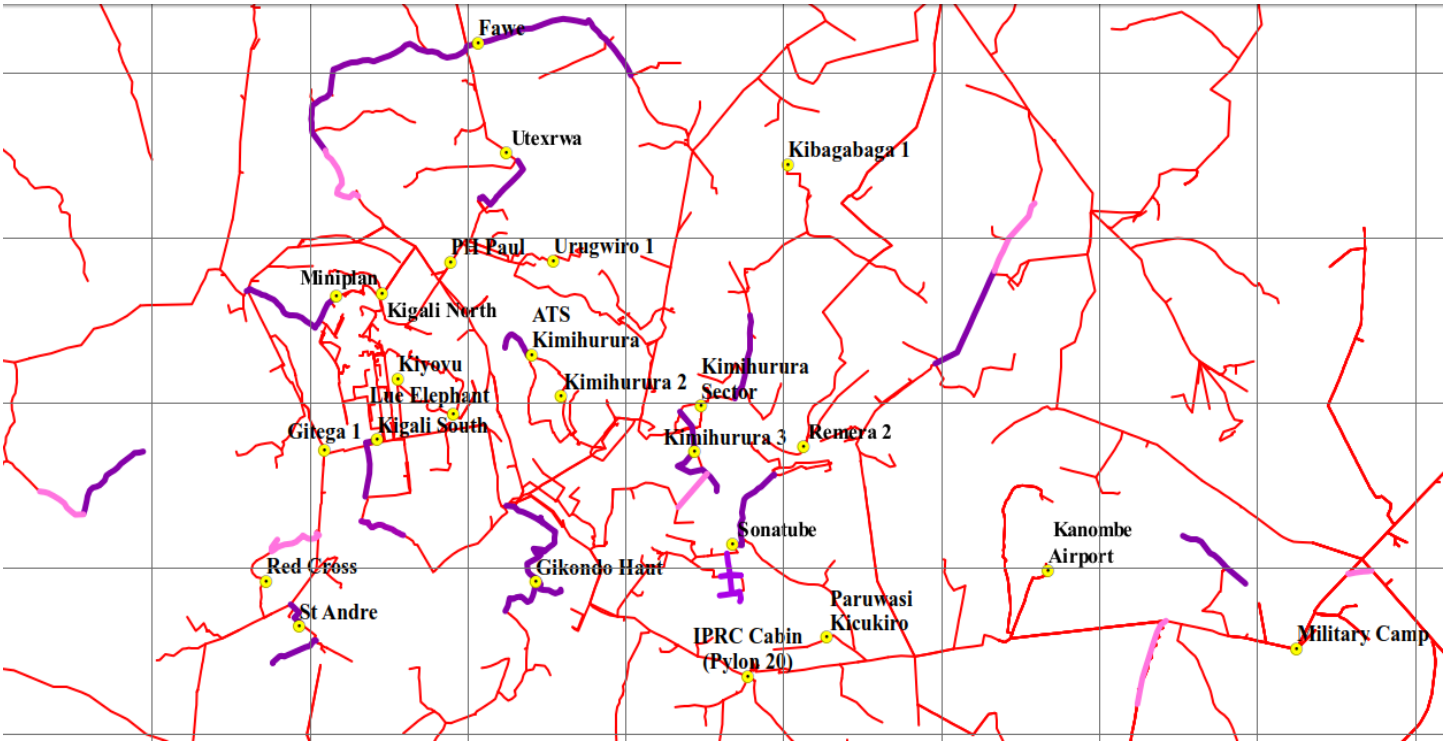
Section	Area in Nyarugenge	Total Length (km)	No of Distribution Panels
Ambassade Zaire	Kiyovu	4.636	27
Belle vie gakinjiro	City Center	1.785	24
Belle vie karamira	City Center	1.506	22
Boulevard Central	City Center	1.334	18
Bureau Pedagogique	City Center	2.513	15
Cercle sportif	Kiyovu	0.766	18
Chat Sauvage	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**

Rehabilitation of existing LV Underground cables in parts of Kacyiru

Section	New or Reconductoring	Total Length (km)	Underground Cable				No of Distribution Panels
			4*120mm²	4*95mm²	4* 70mm²	4* 50mm²	
Kacyiru							
ATS		4.23					37
Kimihurura 2		3.96					40
Pompage Kimihurura		1.48					12
Ruhamanya		2.56					17
GP3		2.8					28
Amba Egypt		4.6					31
CSR		6.3					54
Caisse Hypotequere		3.7					38
New Tx		2.3					21
MINJUST		2.2					17
Urugwiro		1.8					11
Pompage Meridien		1.93					18
Cabine Police_Kagugu		4.1					31
Pompage Gacuriro		1.1					9
Near SOS Kagugu		6.3					51
Total LV Upgrade (Kacyiru)		**49.36**					**415**
GRAND TOTAL(Nygenge & Kacyiru)		**93.435**					**840**

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



Switching Cabins in Kigali City						
S/N	**District**	**Name of MV/LV Cabin**	**Scope of Works**	**Voltage Level (kV)**	**GIS Location Coordinates**	
					X	**Y**
1	Nyarugenge	Kiyovu	New Switching Cabin	**15/0.4**	507113.6	4784286
2	Nyarugenge	Miniplan	New Switching Cabin		506334.2	4785300
3	Nyarugenge	Lue Elephant	New Switching Cabin		507812.2	4783868
4	Gasabo	Utexrwa	New Switching Cabin		508487	4787026
5	Gasabo	PH Paul	New Switching Cabin		507779	4785699
6	Gasabo	Kibagabaga 1	New Switching Cabin		512051.5	4786879
7	Gasabo	Urugwiro I	New Switching Cabin		509082.1	4785716
8	Kicukiro	Kanombe Airport	New Switching Cabin		515345.1	4781976
9	Kicukiro	Kanombe Military	New Switching Cabin		518492.6	4781021
10	Gasabo	Remera 2	Additional MV panels		512248.1	4783476
New Masonary cabins in Kigali						
1	Kicukiro	MERA	New Masonary cabin	**15/0.4**		
2	Kicukiro	APAPE	New Masonary cabin			
3	Remera	Rukiri	New Masonary cabin			

Construction and rehabilitation of MV Lines in Kigali

MV Line Sections to be rehabilitated in Kigali City						
No	Section		Branch	Method	Length (km)	
	From :	To:		New or Reconducting	O.H	U.G
1	Gikondo SS	Pele pallotin	Kicukiro	New		1.28
2	Pele pallotin	Nouvelle Cabin	Kicukiro	New & Reconduct	0.89	0.05
3	Nouvelle Cabin	PH APAPE	Kicukiro	New	0.65	0.24
4	Gacuriro-Fawe	FAWE-ULK-Café de Gisozi-Se	Kacyiru	Reconductoring	5.70	0.96
5	Mt-Kigali	Rebero-Radar	Kicukiro	Reconductoring	4.20	0.30
6	T-OFF SCAF	Rubangura	Kicukiro	New	1.20	
7	Kabuga 2 Cabin	Kabuga	Kanombe	New	0.50	
8	Caisse Hypotaicare-UTEXERWA	RWACOM-ADARWA buildin	Kacyiru	New	0.38	1.88
9	Miniplan	Abatoir	Jabana	New		1.50
10	Kigali sud	Onatracom Cabin	Nyarugen	New		0.81
11	Le printemp	Zindiro	Remera	New	3.56	
12	Medhil	ATS Cabin	Kacyiru	New		0.74
13	Busanza Cementry	Busanza AirForce	Kanombe	New		1.35
14	Kwiteme/Rubirizi	AVEGA/Rubirizi	Kanombe	New	0.98	
15	Murindi Cabin	T-OFF Masaka	Kanombe	New		0.31
16	Karama-Norvege	Mt-Kigali	Nyarugen	New	1.21	
17	Pompage Nyiranuma	Agatare	Nyarugen	New		0.60
18	Mumena	Kivugiza	Nyarugen	New		0.79
19	Munanira	Nyakabanda	Nyarugen	New		0.87
20	Kimihurura Sector	Kimihurura 3-T-OFF INILAK-	Kacyiru	New	1.65	0.84
21	Lapallise-	SAR MOTOR Giporoso-INAD	Remera	New	0.74	1.79
22	Nonko Cabin	Victory	Kanombe	New	0.65	2.10
23	Ex-Gasabo district o	Amba Egypt cabin via Mutsindashyaka cabin	Kacyiru	New		1.50
	Total				**22.31**	**17.90**

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 Trx	Undersized cables	Over-extended LV network	Extend MV and Insert new		LV NETWORK (reconduct and reconfuge)
	SECTOR	ADRESS					Length of MV (km)	Transformer size (kVA)	LV length (km)
REMERA	KIMIRONKO	Bibare(Hope house area)	190	No	No	Yes	0.1	250	0.3
		KIBAGABAGA (DV Appartement area)	182	No	No	yes	0	250	0.2
		GISHUSHU (Kagara)	180	No	No	YES	0.2	250	0.6
		Kibagabaga(SDA Area)	191	No	No	YES	0.1	250	0.3
	NDERA	GASOGI	187	No	No	YES	0.05	250	1.5
		Murwambariro	180	No	No	yes	1.6	100	2
		Rugazi	176	No	No	yes	0	160	2
		Gasogi(Shyaka area)	184	No	No	YES	1.5	160	2.5
		MASORO (Garre)	178	No	No	yes	0.05	160	0.5
		MUKUYU	170	No	No	YES	2	100	3
		RUDASHYA	187	No	No	yes	1.4	160	2
	BUMBOGO	Ruhinga	182	No	No	YES	1.5	100	3
		Ngara	185	No	No	YES	1.7	100	2
		Kayumba	180	No	No	YES	1.5	100	2
		Inkuge ya'amahoro area)	179	No	No	YES	2	200	2.5
		Kinyaga	183	No	No	YES	0.5	250	2
	Total/Remera						**14.2**	**16**	**26.4**
KACYIRU	KIMIHURURA	Rwintare	180 V	YES	no	YES	1.5	200	0.5
		Rugando	190V	no	no	yes	1	200	0.5
	KINYINYA	Rukingu	180V	No	yes	yes	1	200	3
		Gasharu	170V	No	yes	no			6
		Kabuhunde	190V	no	yes	no			1.5
		Murama	170V	no	yes	yes	1	200	6
		Ururebo	190V	yes	no	yes	1	400	1

		Urugarama	190V	yes	yes	yes	1.5	200	1.5
	GISOZI	Ntora	160V	no	yes	Yes	1	315	4
		Byimana	200V	No	Yes	Yes			1.5
	KACYIRU	Kibaza/ Kacyiru	190V	No	no	yes	1.5	315	1
	Total/Kacyiru						**9.5**	**8**	**26.5**
KANOMBE	KANOMBE	Busanza(nyarugugu)	160		yes	no	1.5	160	1
		Busanza /Gakorokombe	160		yes	yes	1	200	1.5
		busanza(gashyushya)	175		yes	no	0		1
		Gasaraba/Kanombe	202		no	yes	0		0.6
	MASASKA	CYIMO RUI IKINAMBA	161	no	yes	no	0		1
		masaka(ayabaraya)	180		yes	no			1.5
		nyagahinga (gisharara)	180		yes	no	1	200	3
	MUYUMBU	Kampigika	165		mixed	yes	2.2	100	1.5
		Murehe ku ma kawa	190		no	yes	1	160	0.8
		Bihembe model village	180		yes	yes	1.5	100	3
	NYARUGUNGA	nyarugunga(gasaraba)	175		yes	no	0		1
		nyarugunga (bpr)	180		yes	no	0.5	200	1.5
	RUSORORO	Nyagahinga under Former Sector	182		no	Yes	0.4	250	1
	Total/Kanombe						**9.1**	**8**	**18.4**
KICUKIRO	KAGARAMA	Rukatsa	180V	YES	no	yes			
		Muyange	195v		yes		0		2
		nyaza-taba	190v			yes	0.8	400	1
	GAHANGA	KAGASA	175v			yes			2
		rwabutenge	180v			YES	2	160	3
		murinja	180v			YES	2	200	2
		karembure	160v			YES	3	315	4
		nyabikenke	155v			yes	5	400	5
		nyacyonga	205v	yes			need 3phase	160	1
		kiyanja	200v	yes			need 3phase	100	2
		kanyekoma	200v			yes	0.5	100	1
	KIGARAMA	nyarurama-zuba	175v		yes		0		2
		miduha	200v	yes			1	100	2
		karugira	205v			yes	0.4	250	1
	GATENGA	nyarurama-bisambu	180v			YES	1	250	1
	Total/Kicukiro						**15.7**	**11**	**29**
JABANA	JABANA	Nyagasozi /kabuye	185V	NO	YES	YES	0		1.5

		Nyacyonga CENTRE	200V	YES	NO	NO	0	500	0.8
		Amakawa 2/ Kabuye	190V	NO	yes	NO	0		2
	NDUBA	Ruhetse/Gasanze	190V	NO	YES	NO	0		2.5
		Gatagara / Gasanze	170V	YES	YES	YES	0.3	160	2
		Primaire/ Gasanze	185V	NO	YES	NO	0		1.7
		Primaire/ Gatunga	180V	NO	YES	NO	0		1.5
	GATSATA	Rwinyana/Gatsata	155V	YES	yes	YES	0		0.5
		Mont-Julu/Gatsata	170V	YES	NO	Yes	1	160	0.5
		Nyagasozi/Gatsata	147V	YES	YES	yes	0.2	250	1.2
	JALI	Gashyushya	190V	No	yes	yes	1	160	1.5
	KANYINYA	Nyamweru	186	no	yes	yes	1	100	2.1
		Nzove /Rutagara	180V	No	yes	yes	0.7	400	1.5
	Total/Jabana						**4.2**	**6**	**19.3**
KAMONYI	RUGALIKA	Kigese - Rugarama	220	YES	YES	yes	0.5	100	1.5
		Kigese - Ngenzi	200	YES	YES	yes	0.5	50	2
		Mibirizi	182	YES	YES	yes	0.8	50	2
		Sheli	180	yes	no	yes	0	100	1.5
	RUNDA	Runda - Muganza	188	yes	no	yes	0.5	50	2.5
		Ruyenzi - Tambwe	170	yes	no	yes	0	100	0
		Ruyenzi - Kimoteri	180	no	no	yes	0		1.5
		Bimba	178	yes	no	yes	0.2	50	1
		Musebeya - Rugogwe	179	yes	no	yes	0.5	100	1
		Rugazi- Ruyenzi	178	YES	no	yes	0.5	100	2.5
		Rugazi- Ubumwe	190	YES	no	yes	0.5	100	2.5
		Gihara - Rukaragata	179	YES	YES	yes	0.8	250	1.5
	MUGINA	Mbati - Kigorora	180	yes	no	yes	0.5	50	0.5
		Mbati - Cyeru	210	YES	YES	yes	0.8	50	2
	MUSAMBIRA	Karengera	195	YES	YES	yes	0.8	50	2
		Ruyanza - Uwimana	198	YES	YES	yes	0.8	50	2
	Total/Kamonyi						**7.7**	**15**	**26**
GICUMBI	BYUMBA	GISUNA	160	YES	YES	YES	1	200	3
		KINIHIRA	145	NO		YES	0		2
		KAMITSINGA	160	NO	YES	YES	0		1.5
		GASHARU	180	NO	YES	YES	0		1
		KABUGA	180	YES	YES	YES	0.5	100	2
		KIBALI/BURESHI	150	YES	YES	YES	1.5	100	2
		MURAMA/KIVUGIZA	150	YES	YES	YES	2	100	2
		KARAGO	160	YES	YES	YES	0		2
	MIYOVE	KACYIRU	170	YES	YES	YES			1

		BANDA	180	YES	YES	YES	0.5	100	1
	SHANGASHA	BUSHARA	170	YES	YES	YES	1	100	3
		NYABUBARE	170	YES	YES	YES	1	100	2.5
	NYANKENKE	KINISHYA	140	YES	YES	YES	2	100	4
	CYUMBA	GATUNA	160	YES	YES	YES	0.2	100	1
	Total/Gicumbi						**9.7**	**9**	**28**
BUGESERA	NYAMATA	GASENGA	190V	no	yes	YES	0	50	1.5
		GATARE (Kwa Majoro)	160V	no	yes	Yes	0		2
		GATARE (Munsi yo ku impinganzima)	200V	NO	yes	YES	0.5	100	2
	MAYANGE	AGAKIRIRO MAYANGE (Kavumu)	170V	no	yes	yes	0	100	0.5
		GACUCU	190V	no	no	yes	0	50	0.5
		KIVUNDE (hafi na WASAC)	190V	NO	yes	yes	0	50	1.5
		GAKAMBA (near Mayange office)	200V	NO	yes	YES	0		1
		KIRUHURA (near Mayange office)	190V	No	no	yes	0		1
	NTARAMA	KABAHA	195V	yes	yes	YES	1	50	2
		KIBUNGO (Nyarunazi)	200V	yes	yes	YES	0.5	100	1
	SHYARA	KAGARAMA-NZIRANZIZA	180V	No	yes	YES	1	50	1
	RUHUHA	MUBANO	190V	yes	no	yes	0	100	3
	Total/Bugesera						**3**	**9**	**17**
RULINDO	SHYORONGI	Rutonde / Nyamirembe	160 V	No	Yes	No	1.5	160	2
		Shyorongi market	190 V	No	No	Yes	1.5	50	2
		Nyabyondo	195V	No	Yes	Yes	-		2
	BUSHOKI	Ngarama	195V	No	Yes	Yes	2	50	2
		Nyirangarama	198V	No	Yes	Yes	2	50	2
	BASE	Kiruri/ Kidomo	185V	No	Yes	Yes	0.3	50	1.5
		Base/ Gitovu village	185V	No	Yes	Yes	0.1	50	2.2
	Total/RULINDO						**7.4**	**6**	**13.7**
NYARUGENGE	NYAMIRAMBO	Mumena/Irembo	180V	No	Yes	Yes	0.5	400	1.5
		Bonsejour/Akarekare	185V	No	Yes	Yes	2	250	1.2
		Gasiza	160V	No	Yes	Yes	3	250	1.1
	RUGARAMA	Rwarutabura	145-165V	No	Yes	Yes	1.5	250	2.4
		Gasharu	170	No	Yes	Yes	2	250	2.6

	NYAKABANDA	Munanira	165V	No	Yes	Yes	0.6	160	1.5
	MAGERAGERE	Rubete-Nyarurama	170V	No	yes	yes	0.5	100	1.4
		Nyarurenzi-Amahoro	170V	No	no	yes	0.5	100	3.5
		Maya	170V	NO	yes	yes	2	50	1.6
		Mataba	170	NO	yes	yes	3	100	2.9
		Karambi	170V	NO	yes	YES	0.05	50	1.8
	KIGALI	Karama/Norvege	170	No	yes	YES	1	250	3.1
		Karama/Agatare	160	No	yes	YES	3	250	4
		Rweza	180	No	yes	YES	0.05	250	2.3
		Rwesero	180	No	yes	YES	0.05	250	2
	Total/Nyarugenge						**19.75**	**15**	**32.9**
TOTAL/KIGALI HUB							**100.25**	**103**	**237.2**

KIGALI HUB(10 Branches) Voltage drop				
	Cost for supply & Installation			
Scope of works	UoM	Qty	Unit Price(USD)	Total Price(USD)
Extension of MV lines	km	100.25	45,000	4511250
Insertion of new Transfo(with protective devices & LVDB)	pc	103	5954.81	613345.43
LV network reconductoring and configuration	km	237.2	20,000	4744000
Total Investment (USD)				**9868595.43**

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 100% 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
NyarugugI	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 100% Electrification Progress (as December 2021)

District	*MV (km)*	*LV (km)*	*Transformers*	*Customers*	*Required Budget (RWF)*	*Progress as per December 2021*
Nyarugenge(10sectors)	*28*	*111*	*36*	*2,758*	2,774,350,203.46	Access **95.4%** Total households= **48,653** Current households connected= **46,434** Remaining Households to be connected= **2,219**
Kicukiro(10 sectors)	*36*	*196*	*38*	*5,349*	*4,590,226,726.41*	Access **99.4%** Total households= **98,393** Current Households connected= **97,814** Remaining Households to be connected =**579**
Gasabo(15 sectors)	*111.58*	*549.016*	*140*	*14101*	*15,926,789,852.50*	Access **95.26%** Total households= **165,917** Current Households connections= **157,967** Remaining Households to be connected **=7,950**
Total	**175.58**	**856.016**	**214**	**22,208**	**23,291,366,782.37**	

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)	2022	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	2022	Secured	JICA
Link of new Shango Substation to distribution Network	2022		
Electricity Access			
Electricity Access in all parts of Kigali	2022	Ongoing	World Bank
Reinforcement of the Distribution Network			
Construction of 8 Switching MV/LV Cabins in Kigali: **Ongoing**	2022	Ongoing	World Bank
Construction and Rehabilitation of MV lines (**28.2km 0verhead & 8.63km Underground): Ongoing**	2022	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 exising MV/LV Cabins	2022	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)**	2022	Secured	EIB
Construction and upgrade of MV & LV lines in areas with voltage drops **(45.603km of MV and 117.5km of LV)**	2022	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

- Distribution feeders supplying Bugesera area are minimum (Kanazi and Ntongwe)
- 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(completed)**, 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.

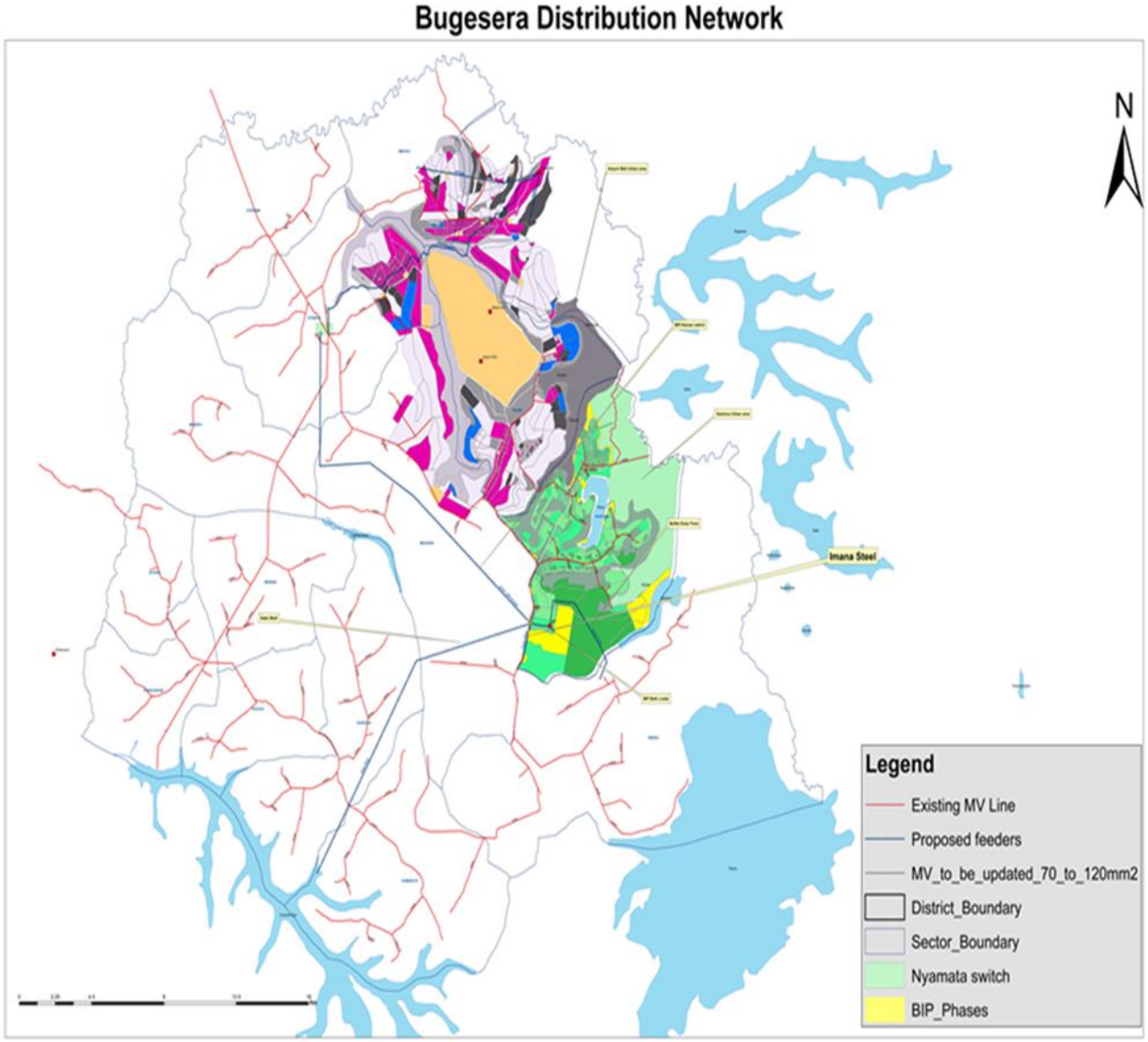
3. Network reinforcement projects in Bugesera area

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


Bugesera Distribution Network
N
Imana Steel
Legend
Existing MV Line
Proposed feeders
MV_to_be_updated_70_to_120mm2
District_Boundary
Sector_Boundary
Nyamata switch
BIP_Phases

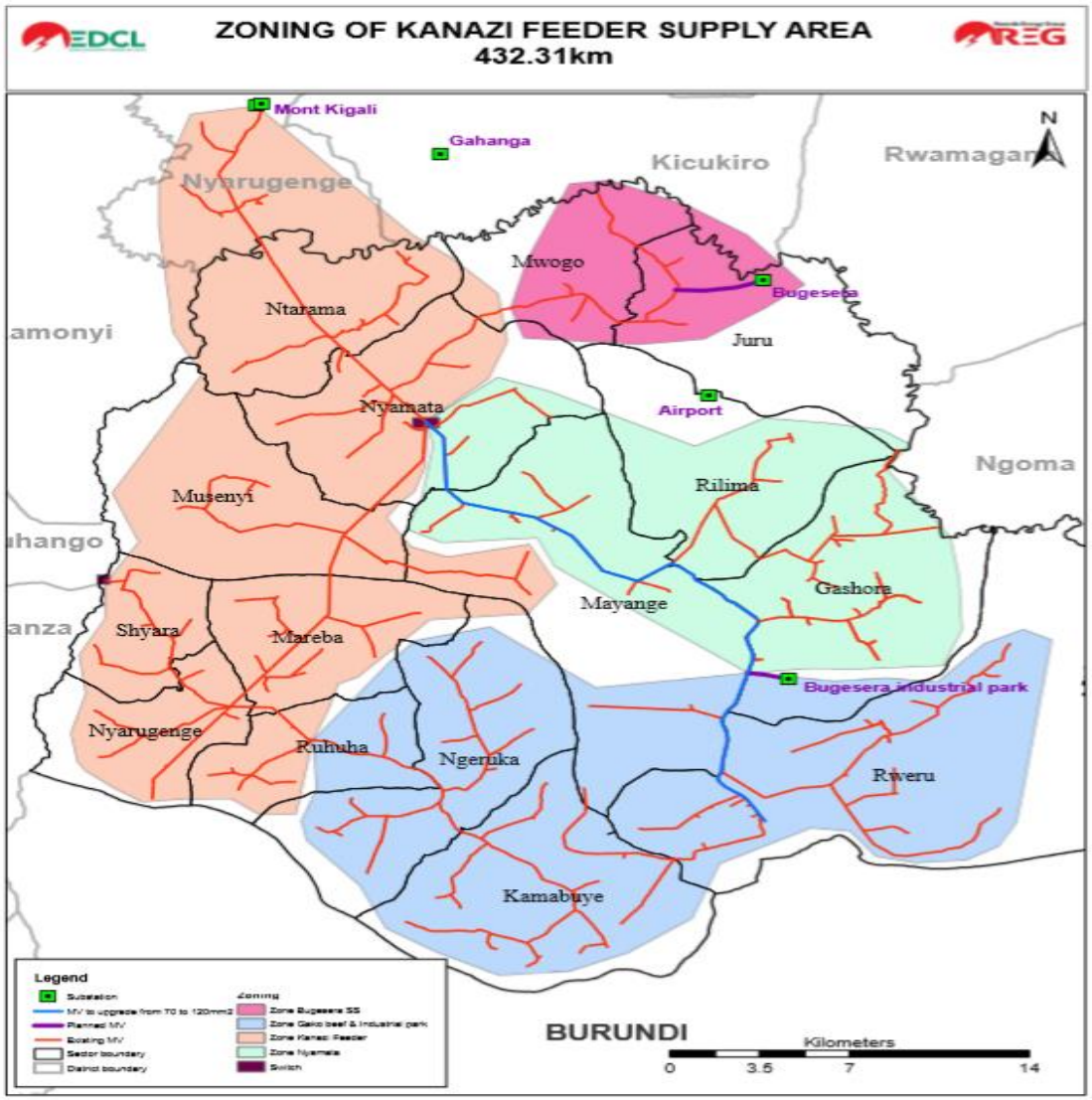
4. Bugesera Area Distribution Network and Zoning

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


ZONING OF KANAZI FEEDER SUPPLY AREA
432.31km
EDCL
REG
Mont Kigali
Gahanga
Kicukiro
Rwamagana
N
Nyarugenge
Mwogo
Bugesera
Ntarama
amonyi
Juru
Nyamata
Airport
Ngoma
Rilima
Musenyi
hango
Gashora
Mayange
anza
Shyara
Mareba
Bugesera industrial park
Nyarugenge
Ruhuha
Ngeruka
Rweru
Kamabuye
BURUNDI
Legend
Substation
Planned MV
Existing MV
Sector boundary
District boundary
Zoning
Zone Bugesera SS
Zone Gako beef & Industrial park
Zone Kanazi Feeder
Zone Nyamata
Switch
Kilometers
0
3.5
7
14

VIII. SOUTH SHORT-MEDIUM TERM PROJECTS

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.

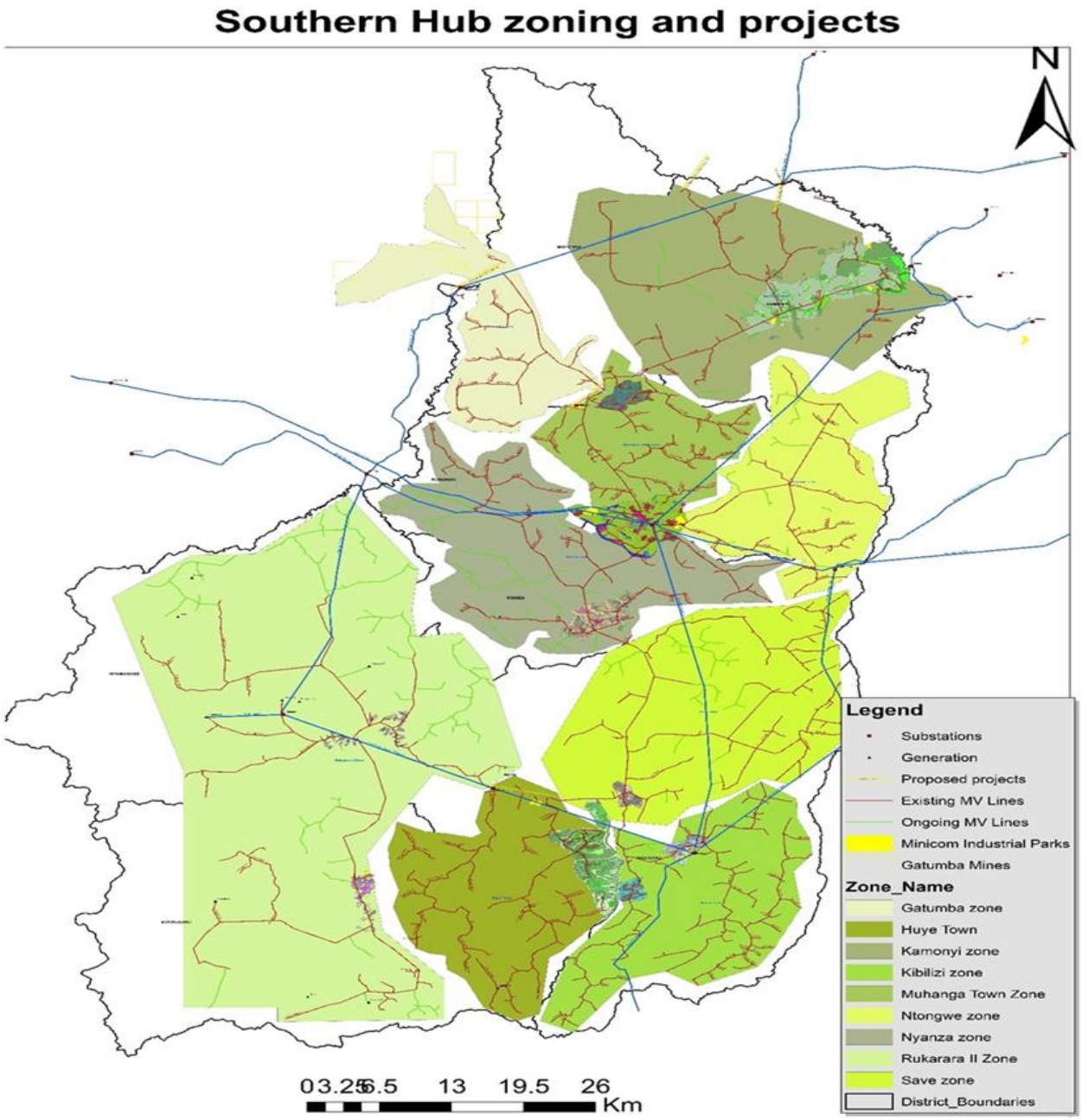
In addition to the mentioned substations, New lines and interconnection projects have been planned to be implemented including Kiyumba- Musasa, Huye SS-Rukarara 2, Nyabarongo 1 SS-Gatumba, Double Circuit Muhanga SS-Gatumba, Double Circuit Huye SS-Rukarara 2-Butare and Gisagara SS-Butare.

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



Map of Zoning

3. Anticipated Major load in Southern Hub

Anticipated feeder loading Southern Hub							
	Load Category	Total Load (MW) (2021-2023)				Status End 2021	Comment
		Total Load (2021-2023)	2021	2022	2023		
FEEDER NAME	**Gisagara Branch**						
Butare	Youth Center	0.1	0.1				Not yet started
Butare	Head Craft Center	0.1	0.1				Not yet started
Butare	Maternity	0.1	0.1				Not yet started
Butare	Banana Processing Plant	0.1	0.1			0.1	constructed
Butare	Meat processing Plant	0.1					Not yet started
Butare	Maize Milling Plant	0.1					Not yet started
Butare	Markets	0.1					Not yet started
Butare	Water Pump Stations	0.2	0.1	0.1			Not yet started
Butare	Street lights	0.2	0.1	0.1			Not yet started
	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**1.1**	**0.7**	**0.3**	**0.1**	**0.1**	
FEEDER NAME	**Ruhango Branch**						
Butare	Extension of Industrial at Bweramana	0.3	0.1	0.1	0.1		Not yet started
	Ruhango Car parking & commercial buildings	0.2		0.1	0.1		Not yet started
Butare	New Hotel under construction	0.1	0.1				on-going
Butare	Extension Agakiriro	0.3	0.1	0.1	0.1		Not yet started
Butare	Water Treatment plants	0.2		0.1	0.1		Not yet started
Butare	Street lights	0.1	0.1				Not yet started

	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**1.5**	**0.5**	**0.5**	**0.5**		
FEEDER NAME	**Huye Branch**						
RukararaII	six food processing Factories	0.3	0.1	0.1	0.1		not yet started
RukararaII	Upgraded Street lights on the main road Kigali-Kanyaru (huye part)	0.1	0.1				not yet started
RukararaII	Four big Commercial Buildings in HUYE city	0.3	0.1	0.1	0.1		not yet started
RukararaII	New Hotel 5star	0.1	0.1				not yet started
RukararaII	Huye Industrial Park(9 to15MW)	3	1	1	1		not yet started
	Others	0.3	0.1	0.1	0.1		not yet started
	Yearly Total Load Increment (MW)	**4.1**	**1.5**	**1.3**	**1.3**		

Anticipated feeder loading Southern Hub

	Load Category	**Total Load (MW) (2021-2023)**				**Status End 2021**	**Comment**
		Total Load (2021-2023)	**2021**	**2022**	**2023**		
FEEDER NAME	**Muhanga Branch**						
Gatumba	Commercial Buildings in Muhanga city	0.4	0.1	0.1	0.2		on-going
Gatumba	New Hotels under construction	0.2	0.1	0.1			not yes started
Gatumba	New Modern Markets	0.3	0.1	0.1	0.1		constructed
Gatumba	Industrial Park(4.4 to 8MW)	2	0.6	0.7	0.7		on-going

Gatumba	Water Treatment plants	0.3	0.1	0.1	0.1		on-going
Kiyumba	Kiyumba and Kabgayi hospitals	0.1	0.1				on-going
Kiyumba	New street lights	0.3	0.1	0.1	0.1		not yes started
Kiyumba	TVT Kiyumba under consrtuction	0.1	0.1			0.1	constructed
Gatumba	Cement factory	5		2	3		not yet started
Kiyumba	Rwasare Water Pumping			0.1			not yet started
	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**9.1**	**1.4**	**3.4**	**4.3**	0.1	
FEEDER NAME	**Nyamagabe Branch**						
RukararaII	Tea factories	0.3	0.1	0.1	0.1		not yet started
RukararaII	Coffee Washing stations	0.1	0.1				not yet started
RukararaII	Commercial Banks	0.1	0.1				not yet started
RukararaII	Street lights	0.1	0.1				not yet started
	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**0.9**	**0.5**	**0.2**	**0.2**		
FEEDER NAME	**Nyanza Branch**						
Ntongwe	Mark cable industry	1	0.5	0.3	0.2	0.2	started operation
Ntongwe	New Hotel	0.1	0.1				not yet started
Ntongwe	Nyanza Modern Market and car parking	0.1	0.1				not yet started
Ntongwe	Busogwe Water Treatment Plant	0.1	0.1				not yet started

Ntongwe	Street lights	0.3	0.1	0.1	0.1		not yet started
	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**1.9**	**1**	**0.5**	**0.4**	0.2	
FEEDER NAME	**Nyaruguru Branch**						
RukararaII	Big Commercial Buildings in Nyaruguru	0.1			0.1		not yet started
RukararaII	New Hotel under construction	0.1					not yet started
RukararaII	Tea factories	0.3	0.1	0.1	0.1		not yet started
RukararaII	Water Treatment plants	0.3	0.1	0.1	0.1		not yet started
RukararaII	Street lights	0.1			0.1		not yet started
	Others loads	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**1.2**	**0.3**	**0.3**	**0.5**		
	TOTAL	**19.8**					

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

Expected load increment on SOUTHERN NETWORK SUBSTATIONS

SUBSTATION	Existing Transfo MVA	Feeder	Length (km)	Conductor Size	Maximum Current (A)	Max Power Capacity (MW)	Peak Power [MW]	% Loading at Peak (Calculated)	Load Increament on Feeders(MV) as per the anticipated major loads	% Feeder Loading (2021-2023)
KIGOMA	**1 *10**	Butare	552	ACSR 70/12 mm²	290	12.05	5.3	43.98%	3.1	**25.72 %**
		Gatumba	266	ACSR 70/12 mm²	290	12.05	4.9	40.66%	8.2	**68.05 %**
		Ntongwe	286	ACSR 70/12 mm²	290	12.05	2.1	17.42%	1.9	**15.76 %**
Total							**12.3**	69.70%		
KILINDA	**1*1.6**	Birambo	74	ACSR 120/20 mm²	410	17.04	0.358	1.42%		
		kilinda mission	1.5	ACSR 120/20 mm²	410	17.04	0.000	0.00%		
Total							**0.358**	1.42%		
RUKARARA	**2*10**	Rukarara II from substation	527	ACSR 120/12 mm²	410	17.04	4.27	25.05%	5.3	**31.10 %**
		RUKARARA 2 HPP		ACSR 120/20 mm²	410	17.04	2.3	13.49%	1.3	**7.63%**

		MAZIMERU		ACSR 35/6 mm²						
		NSHILI MHPP								
Total							**6.57**		**19.8**	

5. Projects proposals for Network reinforcement in Southern Hub

5.1.Interconnection Projects (N-1 Solutions)

5.2. 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**

5.3. Renewal 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 reconfuge)
						Length of MV (km)	Transformer size (kVA)	LV length (km)
MUHANGA	NYABISINDU-ADEPR CEFOCA	200	No	Yes	No			1.5
	SHYOGWE-KABUNGO-MBARE	198	No	Yes	No			3.8
	GIHUMA-KAMAZURU	195	No	Yes	No			2.5
	RUVUMERA-NYABISINDU	199	No	Yes	No			1
	BURINGA-BERESHI	199	No	Yes	No			4.5
	SHYOGWE-AIDEL	195	No	Yes	No			3
	NYABISINDU-NETE	190	Yes	yes	Yes	1.2	100	4
	MUSHUBATI-MERU-BIGURUBE	190	No	Yes	Yes		50	2.5
	MUSHUBATI-MISIZI-NYAMUKURA	190	No	Yes	No			2.5
	KABGAYI-GARAGE	199	No	Yes	No			3
	SHYOGWE-MUBUGA	195	No	Yes	No			5.5
	KIYUMBA-RUHINA-BUSUMBA	200	No	Yes	Yes	1	50	2.5
	NYARUSANGE-RUSOVU	200	No	Yes	No			3
	MBARE-KAVUMU	199	No	Yes	No			2.5
	GIHUMA-MIGURAMO-GASHINGE	190	No	Yes	No			4
	GASHARU-BAHIMBA	197	No	Yes	No			2
	MBARE-KINYAMI	198	No	Yes	No			2.5
	KIVUMU	200	No	Yes	No			5
	GIFUMBA-RUGARAMA	192	No	yes	yes	2	100	3.5

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

	Total					**1.8**	**2**	**4.2**
GISAGARA	GISAGARA DISTRICT	180	No	Yes	No			2
	RUTURO	180	No	Yes	No			2.5
	TTC	190	No	Yes	No			2
	GIKONKO	160	No	Yes	No			3
	GAKOMA	190	No	Yes	No			3
	MAMBA MARCHE	190	No	Yes	YES	1	100	1
	MUSHA	180	No	Yes	No	0.5	250	2
	KINTEKO	180	No	Yes	No			2
	BAZENGA	190	No	Yes	No			2
	Total GISAGARA					**1.5**	**2**	**19.5**
HUYE	MATYAZO -KAMUCUZI	201	No	Yes				1
	CYARWA-CYILI-SUMO	200	Yes	Yes		1	200	4.9
	RANGO-KIGARAMA(TUMBA)	204	No	Yes				3.3
	TUMBA-REBERO-AGASENYI	198	No	Yes				2.5
	KIBABARA-RUGANGO	199	No	Yes				3
	KABUREMERA-RUNGA	198	Yes	Yes		0.5	100	3.1
	KIZI-CENTER	201	No	Yes				1
	GISHAMVU-BUSORO	206	No	Yes				2.1
	SOVU-GAKINJIRO-KIGARAMA	198	Yes	Yes		1	100	1.5
	MUKURA -NKUBI	200	No	Yes				2
	SIMBI-PAROISSE	205	No	Yes				1.5
	MBAZI-RWABUYE	207	Yes	Yes		1	100	1
	Total				**0**	**3.5**	**4**	**26.9**
NYAMAGABE	TABA	180	YES	NO	No	1	250	
	SUMBA	160	No	Yes	YES			2.5
	KINUETE	180	YES	Yes	NO	1	100	
	KIBUMBWE	160	YES	NO	NO	1	50	
	DUSEGO	160	YES	YES	No	1	160	2

	UWINKINGI	160	YES	Yes	No	1	100	2
	NYABIVUMU	160	YES	Yes	Yes			2.5
	KIZIBA	160	No	Yes	Yes			2.5
	GASARENDA	160	No	Yes	yes			3
	THE MATA	140	No	Yes	No			2
	NZEGA	160	NO	Yes	NO			1.5
	KITABI	180	NO	Yes	NO			2
	KIGEME	160	No	Yes	YES			2
	NYARUSIZA	160	No	Yes	Yes			1
	TOTAL					**5**	**5**	**23**
NYARUGURU	MUGANZA-RUKORE	130	No	Yes	Yes	2.5	50	3
	NGOMA-NKOMERO	140	No	Yes	Yes		50	5
	VILO CENTRE-CYAHINDA	230	Yes	Yes	No		400	1
	RWAMIKO	140	No	Yes	Yes	1	50	2.5
	VILO-KIBEHO	160	No	NO	Yes	1	50	2
	NYAGISOZI-BIRAMBO	180	No	NO	Yes	1	50	2.5
	RUHERU-KABERE	230	No	Yes	No			1
	Total					**5.5**	**6**	**17**
TOTAL FOR SOUTHERN HUB						**30.2**	**39**	**186.5**

SOUTHERN HUB(7 Branches) Voltage drop				
	Cost for supply & Installation			
Scope of works	UoM	Qty	Unit Price(USD)	Total Price(USD)
Extension of MV lines	km	30.5	45,000	1372500
Insertion of new Transfo(with protective devices & LVDB)	pc	39	5954.81	232237.59
LV network reconductoring and configuration	km	186.5	20,000	3730000
Total Investment (USD)				**5334737.59**

Required Investment for network reinforcement South

Quantity	MV length (km)	MV length (km)	Number of Transformers
	117.2	186.5	39
Investment Required (USD)	**5,274,000**	**3,730,000**	**232,237.59**
Total Investment (USD)	**9,236,237.59**		

Note: The total length of MV lines to be constructed comprises 22.5km for New extenstion,64.5km for conductor size upgrade and 30.2km for extending the network required 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.

IX. NORTH SHORT- MEDIUM TERM PROJECTS FROM MODEL RESULTS

1. 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 cabines in Musanze and Rubavu will also be constructed.

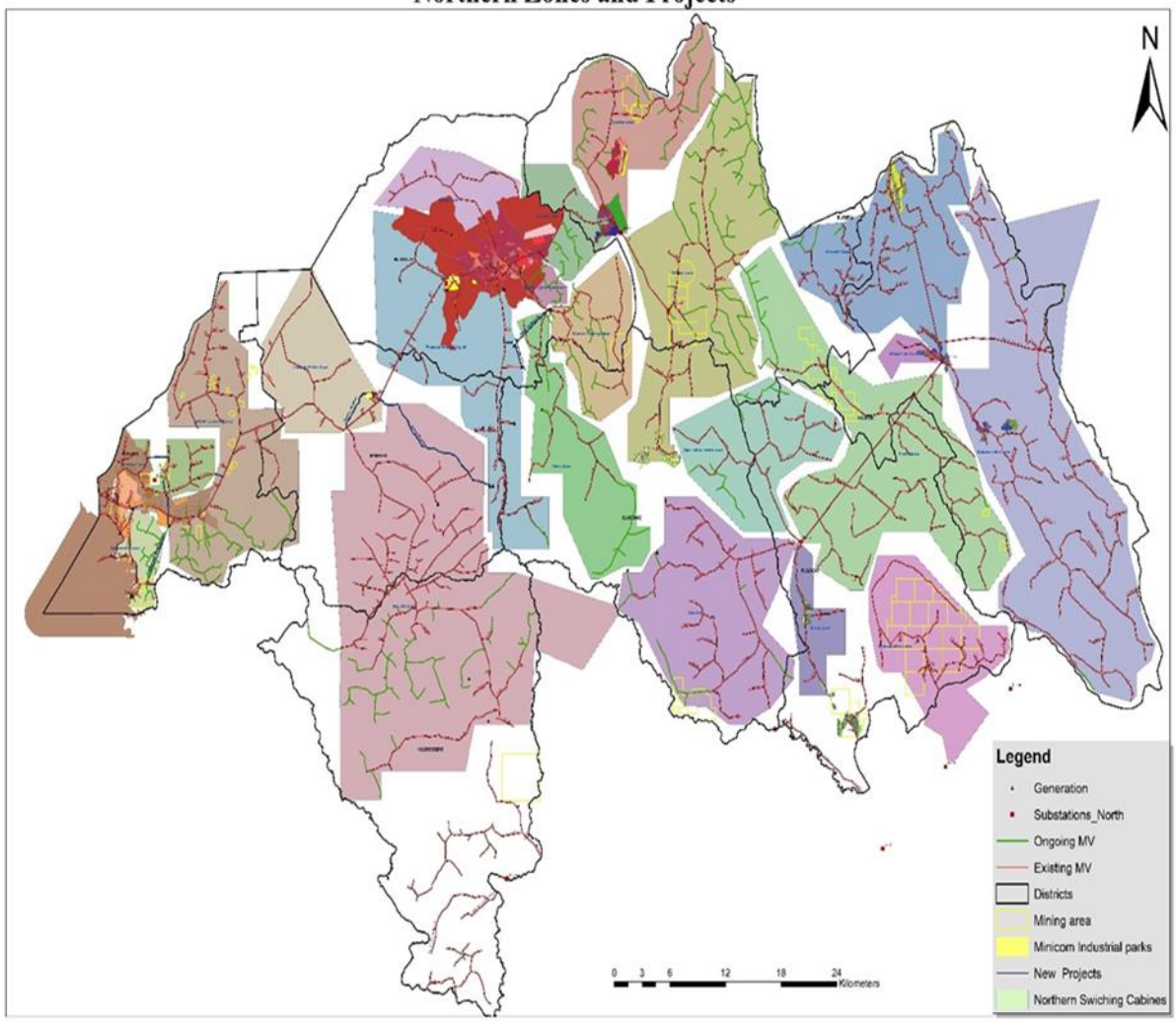
2. Zones in Northern Hub Network and key zoning factors

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



3. Anticipated feeder loading in Northern Hub

	Anticipated feeder loading in Northern Hub						
	Load Category	Total Load (2021-2023)	Additional Loads in each year			Status End 2021	Comment
			2021	2022	2023		
FEEDER NAME	**Rubavu Branch**						
Poids Lourd	Five big Commercial Buildings in Gisenyi city	1	0.5	0.3	0.2	0.1	one constructed
SELENA/CEPGL	New Hotel under construction	0.2	0.1	0.1		0.2	constructed
Poids Lourd	Gisenyi Modern Market	0.1	0.1				on-going
Gisenyi	Cement Factory	1	0.5	0.3	0.2		Not yet started
Gisenyi	Water Treatment plants	0.2	0.2			0.2	constructed
Poids Lourd	Extension of Rubavu Air port	0.2		0.1	0.1		Not yet started
Poids lourd	Street lights	0.3	0.1	0.1	0.1	0.2	constructed
	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**3.2**	**1.6**	**0.9**	**0.7**	**0.7**	
FEEDER NAME	**Musanze Branch**						
Gisenyi	Small Industries (SMEs) & Modern Markets	1	0.2	0.6	0.2	0.2	constructed
Gisenyi	Musanze Airport Expansion	0.2	0.1	0.1			Not yet started
Gisenyi	Water Treatment plants under upgrade	0.3	0.1	0.1	0.1	0.1	Mutobo WTP
Gisenyi	Real Estate Projects	0.1	0.1			0.1	Model village
Gisenyi	Extension Musanze industrial	3	1	1	1	2	Supply to Prime
Kinigi	KINIGI Model village	0.1	0.1	0		0.1	constructed
Kinigi	Street lights on newly constructed roads Kinigi, Cyanika and Nyakinama	0.3	0.1	0.1	0.1	0.1	constructed
	Others	0.4	0.1	0.1	0.2		
	Yearly Total Load Increment (MW)	**5.4**	**1.8**	**2**	**1.6**	**2.6**	
FEEDER NAME	**Nyabihu Branch**						
Gisenyi	GITWA Pumping station	0.1	0.1				Not yet started
Gisenyi	KORA Pumping station	0.1	0.1			0.1	constructed
	Other loads	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**0.5**	**0.3**	**0.1**	**0.1**	**0.1**	
FEEDER NAME	**Burera Branch**						
Cyanika	Electrify Cyanika dairy	0.1	0.1				Not yet started
Cyanika	Electrify Burera stadium	0.4	0.2	0.1	0.1		Not yet started
Cyanika	Burera 8 Hotels project	0.2		0.1	0.1		Not yet started
Kirambo	Burera District Hospital	0.1		0.1			Not yet started
Kirambo	Mining sites(60Ha)	0.2		0.1	0.1		Not yet started

Kirambo	Burera ModernMarket, District Office	0.1		0.1			Not yet started
	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment(MW)	**1.4**	**0.4**	**0.6**	**0.4**		
FEEDER NAME	**Gakenke Branch**						
Janja	Street lights Ruli, Muhondo, Rushashi,Karambo and Janja sectors.	0.1	0.1				
Janja	WASAC puming station						
Base	Electrification projects Electrify Ruhanga,Kiraho and Butereri sites in Busengo sector.	0.6	0.2	0.2	0.2		
	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)	**11.4**					

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

Expected load increment on NORTHERN NETWORK SUBSTATIONS										
SUBSTATION	**Existing Transfo MVA**	**Feeder**	**Length (km)**	**Conductor Size**	**Maximum Current (A)**	**Max Power Capacity (MW)**	**Peak Power [MW]**	**% Loading at Peak (Calculated)**	**Load Increament on Feeders(MV) as per the anticipated major loads**	**% Feeder Loading (2022-2024)**
RULINDO	**2*10MVA**	BASE	76	50/6 mm² Cu	210	8.73	0.487	5.57%	**0.6**	**6.87%**
		BYUMBA	469	ACSR 70/12 mm²	290	12.05	2.137	17.73%	**0.3**	**2.48%**
		GASIZA		ACSR 70/12 mm²	290	12.05	0.357	2.96%		
		GATUNA		ACSR 70/12 mm²	290	12.05	1.026	8.51%		
		MUSASA	95	50/6 mm² Cu	210	8.73	0.378	4.32%		
Total						53.61	**4.385**	39.09%		
CAMP BELGE	**None**	GISENYI	426	ACSR 120/20 mm²	410	17.04	-14.204	44.60%	**6.3**	**36.97 %**
		KINIGI	34	ACSR 70/12 mm²	290	12.05	1.707	38.20%	**0.8**	**6.64%**

		MUKUNGWA	4	ACSR 70/12 mm²	290	12.05	-13.393	50.30%		
		NTARUKA	27	ACSR 70/12 mm²	290	12.05	-1.708			
		PRIME CEMENT		ACSR 120/20 mm²	410	17.04	2.803			
Total						53.19	**-24.795**	133.10%		
GISENYI	**None**	KITRAKO/Gihira	15.5	50 mm²CU	210	4.36	**Prime Energy**			
		JUDICIAIRE/Poids Lourd	24.6	50 mm²CU	210	4.36	**Prime Energy**		**1.3**	**29.81 %**
		SELENA/CEPGL	0.8	50 mm²CU	210	4.36	**Prime Energy**		**0.2**	**4.58%**
Total										
GATUNA	**1*5MVA**	RULINDO	2.4	ACSR 70/12 mm²	290	12.05	1.8	14.93%		
Total							**1.8**	14.93%		
RUBAVU	**1*10MVA**	RUBAVU		ACSR 120/20 mm²	410	17.04	**2.92**	17.13%		
		Goma		ACSR 120/20 mm²	410	17.04	**0.79**	4.63%		
GIFURWE	**1*10MVA**	GAKENKE	36	ACSR 70/12 mm²	290	12.05	0.317	2.63%	**0.8**	**6.64%**
		KIRAMBO		ACSR 70/12 mm²	290	12.05	-0.747	-6.19%		
		NTARUKA	95	ACSR 70/12 mm²	290	12.05	3.8	31.53%		
Total							**3.37**	27.97%	**11.4**	

5. 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 Trx	Undersized cables	Over-extended LV network	Extend MV and Insert new		LV NETWORK (reconduct and reconfuge)
	SECTOR	ADRESS					Length of MV (km)	Transformer size (kVA)	LV length (km)
MUSANZE	MUHOZA	KIZUNGU-BURERA	177	No	Yes	No	0.2	160	3
		SUSA BIRIRA KADAHENDA	188	No	Yes	Yes	1.5	50	3
		GARE-EP MUBONA	181	No	Yes	Yes	0		2
		GREAT LAKES CIMENT-GASANZE	190	No	Yes	No	0.5	50	2
		BWUZURE	194	No	Yes	Yes	0		3
		MPENGE	201	No	Yes	No	0		1.5
	BUSOGO	BYANGABO-MUGOGO	189	No	Yes	No	**0**		2
		BYANGABO-SAHARA	191	No	Yes	Yes	**0.2**	**50**	2
		JABIRO AGGLOMERATION	170	No	Yes	Yes	**0.5**	**50**	2

		KAGEZI-NYAGISOZI	184	No	Yes	Yes	**0**		2
	KIMONYI	KIMONYI-RUREMBO	190	No	Yes	Yes	1	50	2
		KIMONYI-KIVUMU	200	No	Yes	Yes	1.5	50	2.5
	GATARAGA	CYAMAHESHI-NYARUBARA	181	No	Yes	No	**1.5**	**50**	3
		GATOVU-RUNGU	160	No	Yes	No	**2**	**160**	3
		MURAGO-RWINZOVU	160	No	Yes	Yes	**4**	**100**	3.5
		BUTAKANYUNDO	192	No	Yes	Yes	**0**		2.5
	MUSANZE	RWAMBOGO-BUHUNGE	179	No	Yes	yes	3	50	3
		KABEZA-CYABAGARURA-RUVUMU	110	Yes	Yes	Yes	1.2	100	3
		NYARUBARA-RWUNGA-KIREREMA	120	No	Yes	Yes	2	100	3
	MUKO	KABERE-MUBAGO-NYAGASAMBU	174	Yes	Yes	Yes	2	100	3
		KABERE-MUSENYI	185	No	yes	yes	1.5	50	2.5
		MUKO-RWASIRIZO	181	No	Yes	No	1.1	50	2.5
		MUKO-CYIVUGIZA	196	No	Yes	Yes	0.5	50	2
		MUKO-MBURABUTURO-KUMAZI	189	No	Yes	Yes	2	50	2.5
		MWANGANZARA	194	No	Yes	No	0		1.5
	NKOTSI	KIRUHURA-RUYUMBA	170	No	Yes	No	2	50	2
	RWAZA	CONCASSEUR NYAKINAMA-GASYATA	192	No	Yes	Yes	1	50	3
		CONCASSEUR KIRYI-BUHAMA	183	No	Yes	Yes	0.9	50	2
		GICUBA NPD-GICUBA CENTER	175	No	Yes	Yes	1.5	25	1
	KINIGI	RDB-BUTORWA I-BUTORWA II	199	No	Yes	Yes	0		2
		NYABIGOMA-KARYASENGE	185	No	Yes	No	0		2
		KINIGI-CYIVUGIZA	200	No	Yes	Yes	0		2.1
		CYIVUGIZA-EP KAGANO	178	No	Yes	No	0.7	50	2
		KINIGI-CYANTURO-KAMPANGA	170	No	Yes	Yes	2	100	3.5

	CYUVE	NYARUBANDE-BURUBA-CYUVE SECTOR	191	No	Yes	Yes	1.3	50	2.5
		KUNGO-NGANZO-MU RUKORO	196	No	Yes	No	0.5	100	2
		CYANYA-BUTARE	198	No	Yes	Yes	0		2
	GACACA	KABIRIZI-RUNGU	189	No	Yes	No	0.3	50	2
		CONCASSEUR-GITOVU	192	No	Yes	Yes	0		2
	REMERA	FOYER-KUMPALA-MATEUS	174	No	Yes	Yes	1	50	2
	NYANGE	NYANGE	194	Yes	Yes	No	0		4
	Total/ Musanze						**37.4**	**28**	**98.1**
BURERA	GAHUNGA	KIDAKAMA	180	No	Yes	YES	3.5	50	5
		KANYIRAREBE	230	No	Yes	YES			3
	CYANIKA	GASIZA	175	No	Yes	Yes	1.5	50	4
		RYABITEYI	180	No	Yes	Yes	3	50	4
		GISOVU	220	No	YES	No			4
		BUTETE	220	No	Yes	No			5
	KINONI	NKENKE	170	No	Yes	Yes	3	100	4
		NTARUKA	170	No	Yes	Yes	2.5	50	5
		GAFUKA	220	No	Yes	No			4
		NKUMBA	220	No	Yes	No			4
	CYERU	BUTARE	180	No	Yes	Yes	4	50	3
		RYUYANGE	220	No	Yes	No			4
		MURAMBO	220	NO	Yes	No			2
	RWERERE	MOMA	220	No	YES	No			4
		GASHORO	170	No	Yes	Yes	0.05	50	2
		KABYINIRO	170	No	Yes	Yes	0.05	50	4
		NDAGO	220	No	Yes	No			3
	NEMBA	KIVUMU	160	YES	Yes	Yes	0.05	50	4

		NYAMUGARI	220	No	Yes	No			2
	RUGENGABARI	MUCACA	170	No	YES	YES	2	50	4
		SETA	180	No	YES	YES	1.5	50	3.5
		KIRIBATA	180	No	Yes	YES	1.5	50	3
		TABA	175	No	Yes	YES	3.5	50	5
		REMYA	200	No	Yes	No			2
	RUKANDABYUMA	RUKANDABYUMA	200	No	Yes	No			1
	GITOVU	MUSASA	220	No	Yes	No			2
	RUSARABUYE	KABONA	220	No	Yes	No			6
	RUHUNDE	MATYAZO	220	No	Yes	No			4
	BUTARO	MUGARI	220	No	Yes	No			5
		KAMONYI	180	YES	Yes	YES	2	50	4
		RUNABA	230	No	Yes	Yes			4
	KINYABABA	BUGAMBA	220	No	Yes	No			3
		KIRWA	220	No	Yes	No			1
		MUSASA	220	No	Yes	No			3
		MURAMBO	220	No	Yes	No			3
	KAGOGO	MASANGABO	220	No	Yes	No			1
		MUGU	220	No	Yes	No			1
		NYAMABUYE	170	No	Yes	Yes	2.5	50	5
		KARUSIZI	220	No	Yes	No			2
		RWARA	220	No	Yes	No			4
	RUGARAMA	NYARWONDO/RUGARAMA	220	No	Yes	No			6
		MAYA/RUGARAMA	220	No	Yes	No			4
		MAYA/RUGARAMA	220	No	Yes	No			3
		RUREMBO/RUGARAMA	170	No	Yes	Yes	1.5	50	5

		KARANGARA/RUGARAMA	170	No	Yes	Yes	2.5	100	6
		CYAHI/RUGARAMA	170	No	Yes	Yes	3	50	4.5
	Total/ Burera						**37.65**	**18**	**165**
NYABIHU	JENDA	REGA - TERIMBERE	168	YES	NO	YES	1	50	1.4
		GASIZI	170	NO	Yes	YES	2	100	2
	KARAGO	BUSORO - KADAHENDA	180	No	YES	YES	1.3	50	0.5
	MUKAMIRA	AGASOKO -NYIRABASHENYI	160	No	Yes	Yes	0.5	200	0.8
	KINTOBO	KABASHUMBA -RYINYO	160	No	YES	YES	4	160	1
	KABATWA	GAHARAWE - KIRAMIRA	160	YES	NO	No		100	0.5
	RUGERA	MURAMA - NYAKIRIBA	156	YES	Yes	YES	1.5	100	15
	BIGONGWE	REGA-BIGONGWE	174	YES	NO	YES	1	100	1
	RAMBURA	RUSOGO-GURIRO	180	NO	Yes	NO			0.7
	Total/Nyabihu						**11.3**	**8**	**22.9**
GAKENKE	Gakenke center	Nganzo/gahondo,Rusagara/mazinga	200V	YES	No	Yes	2	160	2.5
	Muhondo	Kabeza/Gahabwa	200V	No	Yes	Yes	1	100	2
	Kamubuga	Rukore/taba,Kidomo/njugi,Kamubuga/kasheshe ,Kabyaza/mwisha	160V	No	Yes	Yes	2	50	4
	Rushashi	Joma/nyagasozi,Kageyo/nganzo,Rwankuba/karu shashi	180V	No	Yes	No	1	160	1.5
	Ruli	Ruli/bariza,Ruli/mugambazi,Ruli/gatagara	180V	No	Yes	No	1	250	2
	Mugunga	Munyana/cyarubaye,Nkomane/rusebeya	180V	No	Yes	Yes	1.5	50	4
	Nemba	Mucaca/ntakabavu,Gisozi/kanama	180V	No	Yes	Yes	0		2
	Karambo	Karambo/karambo	180V	No	Yes	Yes	0		1.5
	Kivuruga	Sereri/masoro	200V	Yes	Yes	Yes	0	50	1.5
	Cyabingo	Rukore/Murehe,Muramba/gatare	180V	No	Yes	No	0		3

	Total/Gakenke						**8.5**	**7**	**24**
RUBAVU	**Nyamyumba**	Nyamyumba	160	No	Yes	yes	**2**	100	2
		Munanira-Kabiza	160	No	Yes	No	8	250 (2)	10
		Rugerero-Rushibi	180	No	Yes	Yes		100	2
		Nyaneja-Buruseri	170	No	Yes	Yes			4
		Nyamyumba-Buraseli	160	No	Yes	Yes			3
	Rugerero	Rugerero-Hotelerie	170	No	Yes	yes			3
		Rugerero-Cyanika	160	No	Yes	yes		160	2
		Rugerero-Kabirizi	150	No	Yes	No	0.8	100	2
		Rugerero-Muhira	180	No	Yes	Yes	3	160	4
	Kanama	Mahoko-Kanama	140	No	Yes	Yes			3
		Mahoko-Mucyondo	170	Yes	Yes	Yes	2	100	3
		Mahoko-Kayove	165	yes	NO	No		100	0
	Nyundo	Mpfunda-Keya-Kinigi	160	No	yes	yes			1
		Nyundo-Terimbere	160	No	Yes	No	2	160	2.5
	Bugeshi	Kabumba-Buringo	160	No	Yes	Yes	5.5	50(2), 100(1)	5
	Gisenyi	Mbugangali-Karundo	140	Yes	No	No			1
		G. Boarder-Nyakabungo	170	No	Yes	Yes	1.2	250	1
	Rubavu	Byahi-Zone	170	No	Yes	Yes	1	400	1
	Nyakiriba	Nyakiriba-Kanyefurwe	140	No	Yes	Yes	1.5	100	1.5
	Kanzenze	Kanzenze	160	No	Yes	Yes	1	100	2
	Total Rubavu						**28**	**17**	**53**
NGORORERO	NGORORERO	KAMPALA	180	NO	NO	YES	3	50	0.5

		MANOGO	185	NO	NO	YES	1.5	50	2
	MUHORORO	MWIHA	190	NO	NO	YES	2.5	50	3
		RYABADANGA	220	NO	NO	NO	0		2.5
	BWIRA	RUHINDAGE	185	NO	NO	YES	4	50	0.5
	GAKARARANGA	KABAYA	230	NO	NO	NO	0		3
	Tatal NGORORERO						**11**	**4**	**11.5**
TOTAL NORTHERN HUB							**124.45**	**82**	**374.5**

NORTHERN HUB(6 Branches) Voltage drop				
	Cost for supply & Installation			
Scope of works	UoM	Qty	Unit Price(USD)	Total Price(USD)
Extension of MV lines	km	124.45	45,000	5600250
Insertion of new Transfo(with protective devices & LVDB)	pc	82	5954.81	488294.42
LV network reconductoring and configuration	km	374.5	20,000	7490000
Total Investment (USD)				**13578544.42**

Required Investment for network reinforcement in Northern Hub

Quantity	**MV length (km)**	**LV length (km)**	**Number of Transformers**
	182.3	**374.5**	**106**
Investment Required (USD)	**8,203,500**	**7,490,000**	**631,209.86**
Total Investment (USD)	**16,324,709.86USD**		

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.

XI. EASTERN HUB SHORT-MEDIUM TERM PROJECTS FROM MODEL RESULTS

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

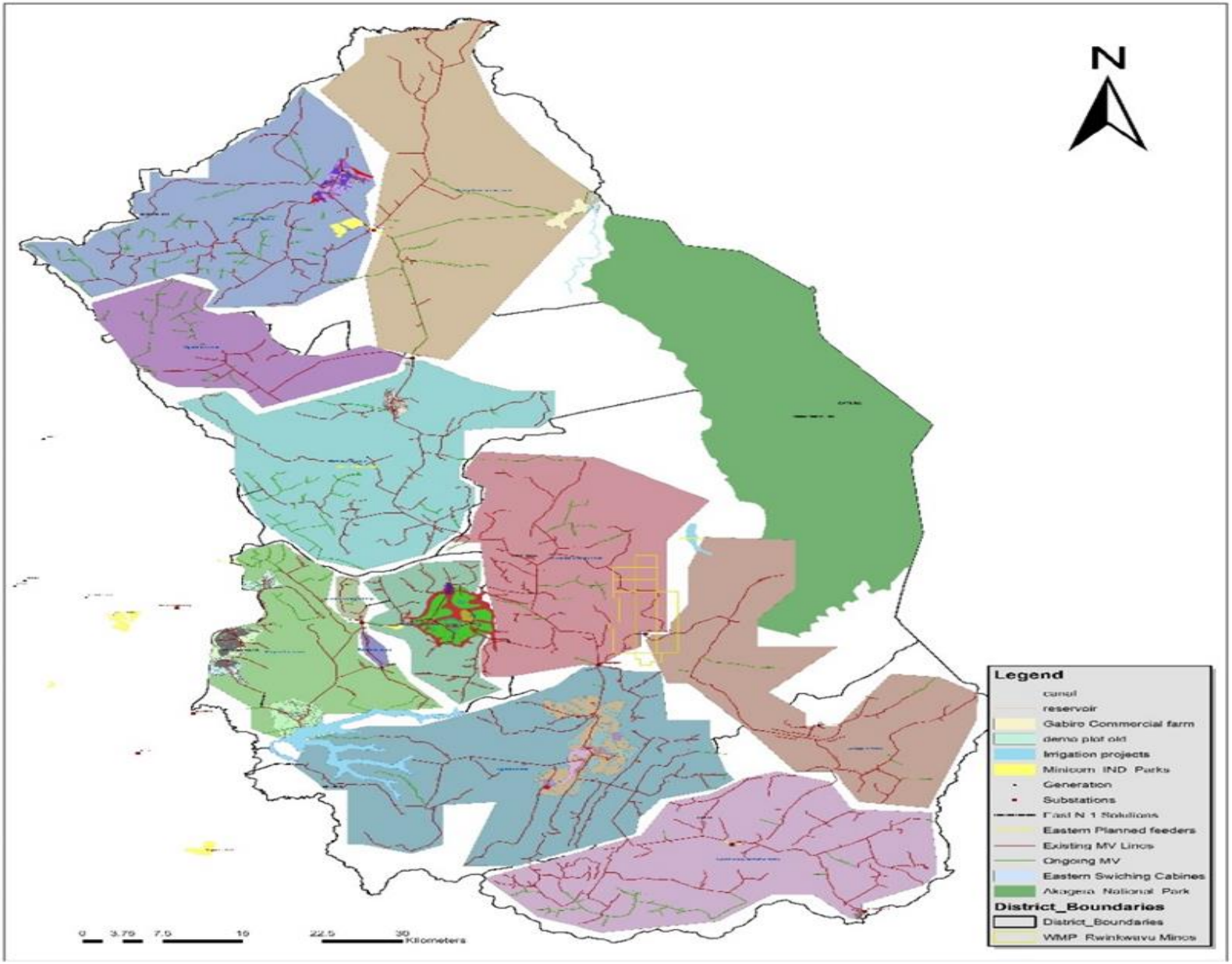
Twelve (12) zones have been proposed in line with available feeders and substations in the Eastern Hub. Key factors for zoning were also mentioned as found on the table below:

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 Feeder loading in EASTERN HUB						
		Total Load MW (2021-2023)					
FEEDER NAME	Load Category	Total Load (2021-2023)	2021	2022	2023	Status End 2021	Comment
Zaza	RUSUMO BORDER cross border market	0.1	0.1			0.1	Constructed
Zaza	KIYANZI stone crusher KIREHE	0.1	0.1				Not yet constructed
Zaza	Street lights KAYONZA- RUSUMO	0.2	0.1	0.1			on-going
Zaza	Street lights KIBUNGO- RAMIRO	0.2	0.1	0.1			Not yet constructed
KKK	KAGITUMBA BORDER cross border market	0.1	0.1				Not yet constructed
KKK	MIRAMA meat Plant NYAGATARE	0.2		0.1	0.1		Not yet constructed
KKK	Kayonza Industrial Zone	0.4	0.1	0.1	0.2		Not yet constructed
Akagera	Mahama irrigation project	0.5		0.2	0.3		Not yet constructed
Akagera	Agakiriro near Mahama refuge camp	0.4		0.2	0.2		Not yet constructed
Akagera	Mpanga irrigation project	0.5		0.2	0.3		Not yet constructed
Akagera	Agakiriro near Mahama refuge camp	0.4		0.2	0.2		Not yet constructed
Akagera	Akagera touristic zone at kabare	0.3		0.1	0.2		2 construction on-going
Akagera	Water treatment plant WASAC Ndego KAYONZA	0.5	0.2	0.2	0.1		Not yet constructed
Nyagatare	Nyagatare Golf	0.1	0.1				Not yet constructed
Nyagatare	NYAGATARE Industrial zone RUTARAKA	3.7	0.9	1.4	1.4	0.9	2 industries constructed
Nyagatare	GABIRO Airport extension	0.2		0.1	0.1		Not yet constructed

Nyagatare	Water treatment plant WASAC CYONDO NYAGATARE&GIHENGERI	0.9	0.5	0.2	0.2		Not yet constructed
Nyagatare	Street lights KAGITUMBA KAYONZA	0.2		0.1	0.1		on-going
Kiziguro	Irrigation BRAMIN	0.5	0.1	0.2	0.2		Pipeline
Ngarama	GABIRO Agribusiness Hub	1	0.3	0.3	0.4	0.3	on-going
Ngarama	Karangazi commercial farm	1	0.4	0.3	0.3		Not yet constructed
Rwamagana	Rwamagana Modern Market	0.2		0.1	0.1		Not yet constructed
Steelrwa	Rwamagana Industrial Park	1.3	0.4	0.4	0.5		Not yet constructed
	Others	0.1	0.1				
	Yearly Total Load Increment in EASTERN HUB (MW)	**13.1**	**3.6**	**4.6**	**4.9**	**1.3**	

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

Expected load increment on EASTERN SUBSTATIONS										
SUBSTATION	**Existing Transfo MVA**	**Feeder**	**Length (km)**	**Conductor Size**	**Maximum Current (A)**	**Max Power Capacity (MW)**	**Peak Power [MW]**	**% Loading at Peak (Calculated)**	**Load Increament on Feeders(MV) as per the anticipated major loads**	**% Feeder Loading (2021-2023)**
GABIRO	**2 *10**	Nyagatare	362	ACSR 120/20 mm²	410	17.04	2.6	15.25%	**5.1**	**29.93 %**
		Kiziguro	425	ACSR 120/20 mm²	410	17.04	0.9	5.28%	**0.5**	**2.93%**

		Ngarama	105	ACSR 120/20 mm²	410	17.04	0.7	4.10%	**1.6**	**9.38%**
Total			892							
RWINKWAVU	**1*6**	Akagera	102	ACSR 70/12 mm²	290	12.05	1.31	10.87%	**2.6**	
		Redemi		ACSR 35/6 mm²	145	6.03	0	0.00%		
Total			102							
MUSHA	**1*20**	Rwamagana	108	ACSR 70/12 mm²	290	12.05	2	16.59%	**0.2**	**10.78 %**
		Karenge	70.5	ACSR 70/12 mm²	290	12.05	1.9	15.76%		
		Redemi	11.4	ACSR 70/12 mm²	290	12.05	0.2	1.66%		
		Rubona	9.2	ACSR 70/12 mm²	290	12.05	6.6	54.77%		
		Steelrwa		ACSR 120/20 mm²	410	17.04	7.8	45.77%	**1.3**	
Total			199.1				17.5			
KABARONDO	**1*10**	Kabarondo, Kayonza (KKK)		ACSR 70/12 mm²	290	12.05	2	16.59%	**1.2**	**9.96%**
		ZAZA	561	ACSR 70/12 mm²	290	12.05	2.8	23.23%	**0.6**	**4.98%**
Total			561						**13.1**	

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		
							Extend MV and Insert new		LV upgrade
	SECTOR	ADRESS		Overloaded Transformers	Undersized cables	Over-extended LV network	Length of MV (km)	Transformer size (kVA)	LV length (km)
NGOMA	GAHURIRE		180	YES	Yes	YES	**1**	**100**	1.5
	GATORO, ASPEC, KARUTANESHWA		170	YES	NO	YES	**1.5**	**100**	1
	SOEUR THERAPEUSTINE		230	No	Yes	NO			1
	KINUNGA REMERA		180	No	Yes	YES			1.5
	NYAMAGARA REMERA		180	No	Yes	YES	**0.4**	**100**	2
	ZAZA JYAMBERE		180	No	Yes	NO			1
	SAKE RUKOMA		230	No	Yes	NO			1.5
	KARENGE SEKODO		230	No	Yes	NO			1
	Total ngoma						**2.9**	**3**	**10.5**
KAYONZA	MUKARANGE	KINYEMERA/PADIRI	184	NO	yes	No			3.1
		IREBERO	200	NO	yes	Yes			3
		MBURABUTURO	172	NO	yes	yes			2.5
	NYAMIRAMA	GIKAYA/KINKORONGO	205	NO	yes	yes		50	3.55
		RWINGERI	192	NO	yes	yes			1.65
		RUVUMU	176	NO	yes	yes			4
		URUGAGI	153	NO	yes	yes	1	100	2.15

		SHYOGO	198	NO	yes	yes			2.8
	KABARONDO	CYABAJWA	209	NO	yes	No	1	160	3
		RUSERA	193	NO	No	yes	1	100	0.8
	GAHINI	KIYENZI	205	NO	Yes	yes	0.5	50	2.3
	RUKARA	KARUBAMBA	172	NO	Yes	yes			2
	RWINKWAVU	MUKOYOYO	208	NO	Yes	yes			2.5
	Total						**3.5**	**5**	**29.8**
RWAMAGANA	KIGABIRO	RIZICULTURE	187	NO	YES	NO			2
		MIYANGE	152	NO	YES	YES	1	200	2.5
		KIGABIRO	164	NO	YES	YES			3
		RWAMAGANA IGA -PLAGE	184	NO	YES	YES	0.5	200	2
		EUCL BRANCH NYAGASENYI	190	NO	YES	YES	1	160	3
	MUHAZI	NYARUSANGE	182	NO	YES	YES	2	200	4
		NSINDA	205	NO	YES	YES			3
		KABARE	192	NO	YES	YES			2.5
		KAVURA	160	NO	YES	YES	2	315	4
	GISHALI	POLICE GISHALI	230	NO	YES	NO			1.5
		GASI	200	NO	YES	NO			2
	KARENGE	BIHEMBE A	156	NO	YES	NO			3
		KARENGE C.S	163	NO	YES	YES			3
		SP KARENGE 1	175	NO	YES	YES			2.5
		SP KARENGE 2	170	NO	YES	YES			3
		KABASORE	160	NO	YES	YES	0.5	160	4.5
	MUSHA	GAHOKO	195	NO	YES	YES			3.5
		NYIRABIGAJI	190	NO	YES	YES			2.5
		HAMEAUX DES JEUNES	190	NO	YES	NO			4
		KAREFURU	165	NO	YES	YES			3
	MWULIRE	BUSHENYI	155	NO	YES	NO			3.5

		GISENYI	165	NO	YES	YES	1.5	100	4
	NZIGE	NZIGE/KIBABARA	160	NO	YES	YES	2.5	160	4.5
	RUBONA	RUBONA/KIBABARA	170	NO	YES	YES			3.5
	Total						**11**	**8**	**74**
GATSIBO	KIRAMURUZI	GAKENKE	190 V	NO	YES	YES	0.5	200	2
		NYABISINDU	200V	NO	yes	yes	1	50	2
		GASAVE	200V	NO	YES	YES	1	50	1.5
	KABARORE	KABARORE	200V	No	yes	YES	1	250	1.5
		KARENGE	190V	NO	YES	YES			1
	MUHURA	TABA	200V	No	Yes	Yes			1
	ITSINZI	ITSINZI	190V	no	yes	YES	1	250	1.5
	Total						**4.5**	**4**	**10.5**
NYAGATARE	NYAGATARE	KAMAGIRI	230	No	Yes	No			1
		RYABEGA	220	No	Yes	yes	0.5	50	5
		RUHUHA 1(Bushoga)	220	No	Yes	No			2
		RUHUHA 2(Bushoga)	220	No	Yes	No			2
		GAKIRAGE(Nkonji)	220	No	Yes	No			2
		CYABAYAGA	220	No	Yes	Yes			3
		NYAGATARE Town	220	No	Yes	No			2.5
	RWIMIYAGA	BUGARAGARA	220	No	Yes	yes	0.5	100	3
		KABEZA	220	yes	Yes	Yes		250	2
		RWIMIYAGA	220	yes	Yes	Yes	0.2	250	6
	MUSHERI	NTOMA	220	No	Yes	No			0.5
		MUSHERI	220	No	Yes	No			3
	MATIMBA	MATIMBA	220	Yes	Yes	Yes	0.3	100	4
		KAGITUMBA	220	No	Yes	No			1
	KARANGAZI	KANGUKA(Mbare)	220	No	Yes	No			1.5

		KANGUKA	220	No	Yes	No			2
	RUKOMO	RURENGE(Nyakagarama)	220	No	yes	No			1.5
		RURENGE(MUKOMA)	220	No	Yes	No			5
		RUKOMO(Urugwiro+ Bukamba)	220	No	Yes	Yes			3
	MIMURI	MIMURI	220	No	Yes	Yes			2
	GATUNDA	GATUNDA(Buguma)	220	No	Yes	Yes			6
	KARANGAZI	MUSENYI	220	No	No	No		250	0.5
	Total NYAGATARE						**1.5**	**6**	**58.5**
KIREHE	**RUBIRIZI RWANDARUSHYA KABIGEMBE KAGEYO**		140	YES	YES	YES	2	250	7.9
	GASHIRU		220	NO	YES	YES			1.25
	KABUYE		220	NO	YES	YES			0.4
	KAGESE		190	NO	YES	YES			2
	CYAMBWE		190	YES	YES	YES			0.25
	RUHANGA		190	YES	YES	YES	1	100	7
	RWAKARINDA		220	NO	YES	YES			0.25
	RWAGASARE		220	NO	YES	YES			0.25
	RUBARE		220	NO	YES	YES			0.4
	RWAMAKARA		220	NO	YES	YES			0.15
	NYAMUGARI KAZIZI TETERO		220	NO	YES	YES			0.45
	URUREMBO		220	NO	YES	YES			0.45
	ISANGANO		220	NO	YES	YES			0.25
	KABEZA		220	NO	YES	YES			0.3
	KARAMBI		220	NO	YES	YES			0.9
	IRAMA		220	NO	YES	YES			1
	RUSUMO		190	YES	YES	YES			1.33
	KIREHE CENTRE		220	NO	YES	YES			2.5
	GATORE IHEMA		220	NO	YES	YES			1

	GATORE-GAHEZI		190	YES	YES	YES			1.2
	GATORE-CYUNUZI		220	YES	YES	YES			2
	GAHARA(DAGAZA , KU MURENGE)		220	YES	YES	YES			1
	KIREHE-NYABIKOKORA		220	NO	YES	YES			1.25
	TOTAL						**3**	**2**	**33.48**
TOTAL/ESTERN HUB							**26.4**	**28**	**216.78**

EASTERN HUB(6 Branches) Voltage drop				
	Cost for supply & Installation			
Scope of works	UoM	Qty	Unit Price(USD)	Total Price(USD)
Extension of MV lines	km	26.4	45,000	1188000
Insertion of new Transfo(with protective devices & LVDB)	pc	28	5954.81	166734.68
LV network reconductoring and configuration	km	216.78	20,000	4335600
Total Investment (USD)				**5690334.68**

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							**91.46479**

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)**	**LV length (km)**	**Number of Transformers**
	130.864	**216.78**	**53**
Investment Required (USD)	**5,888,880**	**4,335,600**	**315,604.93**
Total Investment (USD)	**10,540,084.93USD**		

XII. WEST SHORT -MEDIUM TERM PROJECTS FROM MODEL RESULTS

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.

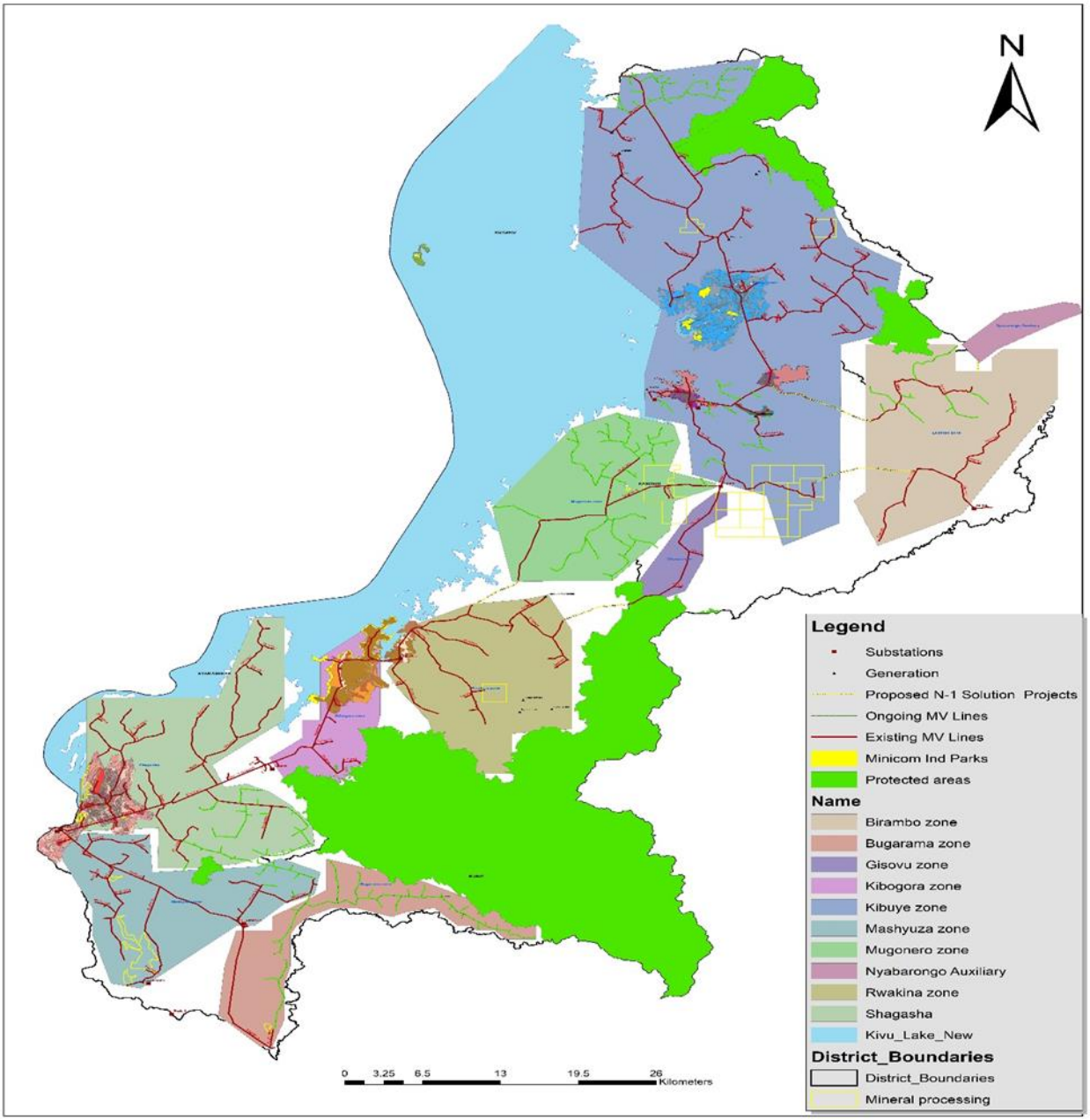
In the western hub, only 10 zones were identified based on the feeders and electricity generation infrastructure available. In addition, key zones were founded based on the pulling factors available and planned to be established in the western hub as per the following table:

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 feeder loading in WESTERN HUB							
	Load Category	**Total Load (2021-2023)**	**Additional Loads in each year**			**Status End 2021**	**Comment**
			2021	**2022**	**2023**		
FEEDER NAME	**Rusizi Branch**						
Shagasha	Two big Commercial Buildings in Rusizi-Kamembe	0.4	0.2	0.1	0.1	0.1	constructed
Shagasha	Three New Hotels under construction	0.4	0.1	0.2	0.1		on-going
Bugarama	2 Bugarama Market & Agakiriro	0.5	0.1	0.3	0.1		on-going
Bugarama	COTCORI Rice Factory Extension	0.1	0.1				Not yet started
Cimerwa	CIMERWA Factory Extension	2	0.5	0.5	1		Not yet started
Mashyuza	Gikundamvura Water Treatment Plant	0.6	0.2	0.3	0.1		on-going
Shagasha	Banana beer processing factory-Nkungu	0.4	0.2	0.1	0.1	0.1	constructed
Shagasha	Construction Rusizi Port	0.4	0.2	0.1	0.1		on-going
Shagasha	Rusizi Airport Extension plus Surrounding lights	0.4	0.2	0.1	0.1	0.1	constructed
Shagasha	Giheke-Ruhwa public road lighting	0.4	0.1	0.1			on-going
Shagasha	Rusizi Industrial Park(8MW)	2.5	0	1.2	1.3		Not yet started
	Commercials and HHs connection in 18 sectors	0.3	0.1	0.2	0.1	0.1	constructed
Shagasha	Street Lights in Rusizi city (kurya 1-kurya 4)	0.4	0.1	0.2	0.1		on-going
	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**9.1**	**2.2**	**3.5**	**3.3**	**0.3**	

FEEDER NAME	Rutsiro Branch						
Kibuye	Two big Commercial Buildings in Rutsiro	0.2		0.1	0.1		Not yet started
Kibuye	New Hotel under construction	0.1	0.1				on-going
Kibuye	Nkora Modern Market/ lake Port	0.1	0.1				Not yet started
Kibuye	Mineral processing plant	0.1	0.1				Not yet started
	Rambura market			0.1			Not yet started
Kibuye	Kivu Hills Medical Clinics			0.1			Not yet started
Kibuye	Street lights	0.2	0.1	0.1		0.1	constructed
Kibuye	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**1.2**	**0.5**	**0.5**	**0.2**	0.1	
FEEDER NAME	**Karongi Branch**						
Kibuye	4 Hotel under constraction+4 not yet started but they have construction permits anytime they may construct	0.2		0.1	0.1	0.2	constructed
Kibuye	Two New Hotels under construction	0.1	0.1			0.1	constructed
Kibuye	Affrinest Factory (ship assembling)	0.1		0.1		0.1	constructed
Kibuye	Stadium and District head office planned to be constructed in 2021/2022	0.4	0.2	0.1	0.1		Not yet started
Kibuye	Electrification of HHs and Productive Uses in 10 sectors of Ruganda, Murundi, Gitesi,Rubengera, Bwishyura, RUGABANO, Murambi, Gishyita, Mubuga, Rwankuba	0.7	0.2	0.2	0.3		4sectors not constructed
Kibuye	construction of port in Karongi	0.4	0.2	0.1	0.1		Not yet constructed
Kibuye	Increasing the power in Rubengera hand craft	0.1	0.1			0.1	Constructed

Kibuye	KOPAKAMA coffee factory	0.1	0.1				Not yet constructed
Kibuye	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**2.4**	**1**	**0.7**	**0.7**		
FEEDER NAME	**Nyamasheke Branch**						
NYAMASHEKE	World vision Building; Ibigabiro Building, Kibogora Hospital Extension (Maternity), Inzu yàbajyanama b ubuzima	0.1	0.1				on-going
NYAMASHEKE	Street lights(Kabeza-Murwa and roads in Ninzi, Gashirabwoba-Bushenge Hospital, Bushenge centre, Ntendezi centre)	0.3	0.1	0.1	0.1	0.1	constructed
NYAMASHEKE	Others	0.3	0.1	0.1	0.1		
	Yearly Total Load Increment (MW)	**0.7**	**0.3**	**0.2**	**0.2**	**0.1**	
	Total Load Increment in WESTERN HUB(MW)	**13.4**					

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

Expected load increment on WESTERN SUBSTATIONS										
SUBSTATION	**Existing Transfo MVA**	**Feeder**	**Length (km)**	**Conductor Size**	**Maximum Current (A)**	**Max Power Capacity (MW)**	**Peak Power [MW]**	**% Loading at Peak (Calculated)**	**Load Increament on Feeders(MV) as per the anticipated major loads**	**% Feeder Loading (2021-2023)**
KARONGI	**1 *10**	Kibuye	281	ACSR 70/12 mm²	290	12.05	5.3	43.98%	4.2	**28.21%**
		Mugonero	34	ACSR 70/12 mm²	290	12.05	1	8.29%		
		Gisovu	36	ACSR 70/12 mm²	290	12.05	0	0.00%		
Total										
KIBOGORA	**1*6**	Rwakina	66	ACSR 120/20 mm²	410	17.04	2.1	12.32%		
		Nyamasheke	7	ACSR 120/20 mm²	410	17.04	1.6	9.38%	0.8	**4.10%**
Total							**3.7**			
MURURU1	**1*10**	SHAGASHA	84	ACSR 120/20 mm²	410	17.04	1.69	9.91%	5.6	**22.88%**
		MASHYUZA	85	ACSR 120/20 mm²	410	17.04	1.65	9.68%	0.6	**1.17%**

Total										
NTENDEZI	**1*10**	MURURU I	33	ACSR 120/20 mm²	410	17.04	0.5	2.93%		
		KIBOGORA	32	ACSR 120/20 mm²	410	17.04	0.8	4.69%		
Total										
MASHYUZA	**1*3.5**	CIMERWA1	0.2	240 mm²CU	596	24.77	No data		2	**8.07%**
		BUGARAMA	18	ACSR 70/12 mm²	290	12.05	No data		0.2	**1.66%**
Total										
BUGARAMA	**1*15**	CIMERWA2		240 mm²CU	410	24.77	9.46	38.19%		
Total							9.46		**13.4**	

Network Strengthnening 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 AREAS IN WESTERN 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		LV Upgrade
	SECTOR	ADRESS					Length of MV (km)	Transformer size (kVA)	LV length (km)
RUTSIRO	GIHANGO	Shyembe	200	Yes	Yes	Yes	**1.5**	**50**	4
		Murambi- Nyagahinga	180	Yes	Yes	Yes	**1.5**	**50**	4
		Karugaju	200	No	Yes	Yes	-	-	2
		Rwamiyaga	180	No	Yes	Yes	-	-	3.5
		Shyembe- Gasutamo	160	yes	Yes	Yes	**2**	**100**	2.5
		Teba-Rwanika	180	No	Yes	Yes	**1**	**50**	2.5
		Bugina	180	Yes	Yes	Yes	**2.5**	**100**	5
	MUSHUBATI	Bumba- Gikoni	200	Yes	Yes	No	-	-	2.5
		Rukiniro	160	No	Yes	Yes	**1**	**50**	2
		Bumba- Kabiraho	200	No	Yes	Yes	-	-	1
		Cyarusera	200	No	Yes	Yes	-	-	8
		Mageragere- Nyakabuye	200	No	Yes	Yes	-	-	1.5
		Foyer	180	Yes	Yes	Yes	**1.5**	**50**	3
	MUSASA	Nkomero	200	Yes	Yes	Yes	**2**	**100**	4
		Gisiza	180	No	Yes	Yes	-	-	2
		Murambi- Rwintanga	200	No	Yes	Yes	**1.5**	**50**	3

		Murambi- Kabatoni	200	No	Yes	Yes	-	-	1.5
		Near Gasutamo	160	No	Yes	Yes	-	-	1.5
	Kigeyo	Gahotora	160	Yes	Yes	Yes	**3**	**50**	4
		Nkora	200	No	Yes	Yes	-	-	2.5
		Rukaragata	160	Yes	Yes	Yes	**2**	**50**	3
		Nyagahinika- Rusisiro	200	No	Yes	Yes	**2**	**50**	1.5
		Nyagahinika- Nyarusuku	200	No	Yes	Yes	-	-	1.5
		Nyagahinika- Rupango	200	No	Yes	Yes	-	-	1.5
		Buhindure	180	No	Yes	Yes	-	-	2
		Cyimbili	200	No	Yes	Yes	-	-	1.5
	RUHANGO	G.S Kavumu	200	No	Yes	Yes	-	-	2.5
		G.S Apacape	210	No	Yes	Yes	-	-	2
		Rundoyi- Rugaragara	200	No	Yes	Yes	-	-	1.5
		Rundoyi- Gakararanka	200	No	Yes	Yes	-	-	1.5
		Kavumu	180	No	Yes	Yes	-	-	2.5
		gatare	180	no	Yes	Yes	**4**	**100**	5
		Nyakarera	180	No	Yes	Yes	-	-	4
	KIVUMU	Kabujenje	210	No	Yes	Yes	-		2
		Bunyoni- Kimpanga	160	No	Yes	Yes	-	-	4
		Bunyunju- Tarafiporo	180	No	Yes	Yes	-	-	1.5
		Bunyunju- Mpinga	160	No	Yes	Yes	-	-	1.5
		Nganzo- Bugarishya	180	No	Yes	Yes	-	-	1.5
		Kabere	160	Yes	Yes	Yes	**2**	**50**	2.5
		Karambi	200	No	Yes	Yes	-	-	1.5
	MUKURA	Kabuga	180	Yes	Yes	Yes	**2.5**	**100**	3
		Kageyo- Karumbi	180	No	Yes	Yes	-	-	1.5
	MUSHONYI	Kaguriro	180	No	Yes	Yes	-	-	4
		Marine HQ	200	No	Yes	Yes	-	-	3
		Kivumu	200	No	Yes	Yes	-	-	1
		Magaba	180	No	Yes	Yes	-	-	2
		Biruyi	180	NO	Yes	Yes	**2**	**50**	3

		Rurara	200	No	Yes	Yes	-	-	2
	BONEZA	Nkira	200	No	Yes	Yes	-	-	2
		Gahabwa- Bikono	180	Yes	Yes	Yes	**3**	**100**	5
		Gaseke	200	No	Yes	Yes	-	-	1
		Bushaka- Bikono	180	No	Yes	Yes	-	-	1
		Bushaka- Kabirizi	180	No	Yes	Yes	-	-	1
		Kabihogo	180	No	Yes	Yes	-	-	1.5
		Remera- Gabiro	180	No	Yes	Yes	-	-	2.5
		College Indashyikirwa	200	No	Yes	Yes	-	-	3
	MURUNDA	Kirwa- Bukongora	180	No	Yes	Yes	-	-	1.5
		Kirwa- Kajugujugu	180	No	Yes	Yes	-	-	1.5
		Kirwa- Muremure	180	No	Yes	Yes	-	-	1.5
	Total						**35**	**17**	**145.5**
NYAMASHEKE	KANJONGO	kibogora- hopital+C9:L47	200	NO	Yes	YES			5
		Nyenyeri-Rwakagaju	180	No	Yes	YES	**0.5**	**50**	4
		Nyagacaca-BIZENGA	180	No	Yes	YES	**1**	**50**	3
		Kabuga-maseka	180	Yes	Yes	YES	**0**	**100**	4
		kirambo-	200	No	Yes	YES			3
		kigoya-bujanga	200	No	Yes	YES	**2**	**50**	5
	GIHOMBO	gihombo sector	180	No	Yes	YES			3
		kibingo	180	No	Yes	YES			3
		jarama	180	No	Yes	YES	**4**	**100**	5
		mbogo	180	No	Yes	YES	**0**	**100**	6
		mpombori	180	No	Yes	YES	**1**	**50**	3
		rushoka	160	No	Yes	YES	**2**	**100**	6
	KILIMBI	rugaragara	160	No	Yes	YES	**1**	**50**	2.5
		nyabinaga	200	No	Yes	YES			2.5
		gisesero	180	No	Yes	YES	**2**	**100**	3
		wisumo-musenyi	180	No	Yes	YES	**4**	**50**	4
		Muhororo	200	No	Yes	YES			3

		nduba	180	No	Yes	YES	**1**	**50**	4
		gisesero	180	No	Yes		**1**	**50**	3
		nyarusange	170	Yes	Yes	YES	**0.3**	**50**	3
		Karengera centre	180	no	Yes	YES	**3**	**50**	2
	BUSHEKERI	keshero	170	No	Yes	Yes	**4**	**100**	5
		kagarama	175	No	yes	yes	**2**	**50**	4
		nyanza	180	yes	Yes	yes	**0.05**	**100**	4
		kibingo	200	No	Yes	yes			2
		mwaga	170	No	Yes	yes	**0.3**	**50**	4
		winkamba-rwumba	180	No	Yes	yes		**50**	4
		muramazi	160	No	Yes	yes	**1.5**	**50**	4
		yove	160	No	Yes	yes	**3**	**50**	4
		buhinga	200	No	yes	yes			3
		buvungira	180	No	Yes	yes	**0.05**	**50**	5
	RUHARAMBUGA	Ntendezi-muko	180	No	Yes	yes	**3**	**50**	5
		rukuta	200	No	Yes	YES			3
		ntendezi-izari	200	NO	Yes	YES			2
		risansi	180	NO	Yes	YES	**2**	**50**	3
		wimana	200	No	Yes	YES			2
		kibazi	200	No	Yes	YES			4
		bigutu	180	No	Yes	YES	**2**	**50**	4
	KAGANO	Gako-	180	No	Yes	Yes	**1**	**50**	3
		kazibira	180	No	Yes	yes	**2.5**	**50**	5
		kabuye-keru	180	No	Yes	YES			3
		nyamirambo	180	No	Yes	yes			3
		ninzi	200	No	Yes	yes			2
		mubumbano	200	No	Yes	yes			3
		rwesero	180	No	Yes	YES	**2**	**50**	5
		rugabano	200	NO	Yes	YES			4
		mutusa	180	No	Yes	Yes			3
		nyirankomagurwe	170	No	Yes	Yes			2

		rweza	180	No	Yes	Yes			3
	MACUBA	nyakabingo	180	No	Yes	YES	**1**	**50**	2.5
		Rugali	170	No	Yes	YES	**2**	**50**	5
		vision	180	Yes	Yes	YES	**0**	**100**	4
		rupango	180	No	Yes	Yes	**1.5**	**50**	6
	MAHEMBE	Gitimuramba	200	No	Yes	YES			4
		Mugonero centre	200	No	Yes	YES			6
		kanombe-nyarusovu	180	No	Yes	YES			5
	KARAMBI	kagarama	170	No	Yes	YES	**4**	**100**	6
		rushyarara	180	No	Yes	YES	**0.05**	**50**	2.5
	BUSHENGE	Kagatamu	180	No	Yes	YES	**2**	**50**	4
		bushenge sector	180	No	Yes	YES	**2**	**50**	4
		bushenge market	180	Yes	Yes	YES	**1**	**50**	3
	SHANGI	Shangi cell	180	No	Yes	YES			4
		E.S.Gafunzo	200	No	Yes	YES			2
	RANGIRO	jurwe	180	No	Yes	YES	**2**	**50**	3
		rangiro sector	200	No	Yes	YES			2
	NYABITEKERI	Kinunga	180	Yes	Yes	YES	**0.3**	**50**	6
	CYATO	cyato	180	Yes	Yes	YES			1
	Total						**62.05**	**40**	**245**
KARONGI	BWISYURA	GISAYO	200	No	Yes	YES	**1**	**50**	3
		NYAMAKORO	200	No	Yes	YES	**0.2**	**50**	2.5
		GASURA	180	No	Yes	YES	**3**	**50**	2
		NYAMUHEBE	200	No	Yes	NO			1.5
		BUPFUNE	200	NO	Yes	YES		**50**	3
		NYARUSOZI	180	No	Yes	NO			2.5
		KIYOVU	200	No	Yes	NO			1.5
		WAKASIRIKA	200	No	Yes	No			0.8
		RYABINAMA	200	No	Yes	NO			1.8
		NYAMISHABA	180	No	Yes	yes			3

	RUBENGERA	GISANZE	180	Yes	Yes	Yes	**0.5**	**50**	4
		KIBILIZI	180	No	Yes	Yes	**0.5**	**50**	4
		RWIMPIRI	160	No	Yes	Yes	**3**	**50**	2
		MBONWA	200	No	Yes	NO			2
		RURAGWE	180	No	Yes	YES	**1**	**50**	2
	MUBUGA	MUBUGA	180	No	Yes	yes			3
	MURAMBI	BWAKIRA	180	No	Yes	No			3
		KILINDA	180	No	Yes	yes	**0.5**	**50**	3
	TWUMBA	GASHIHE	180	No	Yes	YES	**0.5**	**50**	2
		GAKUTA	200	No	Yes	NO			2
	GASHALI	BIRAMBO	180	No	Yes	Yes			2.5
	GISHYITA	GISHYITA	200	No	yes	NO			1.5
		NGOMA	200	No	Yes	No			2
	GITESI	GITEGA	180	No	Yes	Yes	**0.5**	**50**	2
		GITEGA (gitesi)	180	yes	yes	yes	**3**	**50**	4
	RWANKUBA	RWANKUBA	200	No	Yes	NO			1.5
	Total KARONGI						**11**	**12**	**62.1**
RUSIZI	NJAMBWE		160	No	Yes	No			2
	NYAMARONKO		160	No	Yes	No			3
	MIBILIZI		160	No	Yes	Yes			2
	MUGANZA SECTOR OFFICE		140	No	Yes	Yes			3
	MUGANZA MARKET		160	No	Yes	No			3
	CIMERWA		160	No	Yes	No			3
	NYAKABUYE SECTOR OFFICE		160	No	Yes	Yes			2.5
	KARANGIRO		160	No	Yes	Yes			3
	GAHINGA-BUREMERA		160	No	Yes	yes	1	50	3
	AEROPORT-MUHARI		140	No	Yes	No	3	50	3.5
	KAMUKOBE		110	Yes	Yes	Yes	4	100	3
	GIHEKE-NTURA		120	No	Yes	Yes	1.5	100	3
	MONT CYANGUGU		120	No	Yes	No			3

	MURANGI		140	No	Yes	Yes	0.5	100	2
	NZAHAHA- MURYA		140	No	Yes	Yes	3	100	3
	NZAHAHA		140	Yes	Yes	Yes	1	160	3
	KIZIHO-NYABIHANGA		140	No	yes	yes	4	50	4
	GACAMAHEMBE		160	No	Yes	No			1.5
	GASHONGA-MISAVE		140	No	Yes	Yes			1
	BUTAMBAMO- NGOMA		140	No	Yes	Yes			2
	BUTAMBAMO- GISHOMA PP		160	No	Yes	No	0.5	50	2.5
	AEROPORT-Qtier MUSINGA		160	No	Yes	No			1
	MASHESHA-RWIHENE		160	No	Yes	Yes	1.5	50	4
	GIHUNDWE - KARORABOSE		140	No	Yes	Yes			1
	BIROGO/RUSIZI I		160	No	Yes	Yes			1
	RYANKANA/ VIA KAMANYOLA		160	No	Yes	Yes	1	50	3
	GIHUNDWE - KARUSHARIRIZA		160	No	Yes	No			2
	Total RUSIZI						**21**	**11**	**68**
TOTAL/WESTERN HUB							**129.05**	**80**	**520.6**

WESTERN HUB(4 Branches) Voltage drop				
	Cost for supply & Installation			
Scope of works	UoM	Qty	Unit Price(USD)	Total Price(USD)
Extension of MV lines	km	129.05	45,000	5807250
Insertion of new Transfo(with protective devices & LVDB)	pc	80	5954.81	476384.8
LV network reconductoring and configuration	km	520.6	20,000	10412000
Total Investment (USD)				**16695634.8**

Upgrade and Interconnection Projects

Desrciption	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
	176.65	520.6	80
Investment Required (USD)	**7,949,250**	**10,412,000**	**476,384.8**
Total Investment (USD)	**18,837,634.8USD**		
	The cost of 1Km MV Line is 45,000USD		

XIII. UPGRADE OF SWITCHING CABINS IN SECONDARY CITIES(updated)

No	District	Name of MV/LV Substation	Voltage Level(kV)	Planned Budget
1	Huye	Gihindamuyaga	30/0.4	930,707
		Ngoma		972,974
2	Muhanga	Kabgayi		907,656
		RIAM		862,489
3	Nyagatare	Ryabega		1,051,227
5	Rusizi	Cyapa		964,851
		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				**11,259,268**

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.

XIV. Single Phase Transformers to replace countrywide

This project covers the upgrade of the single phase network that need to be upgraded to three phase in all parts of the country

The scope of this project will be covered under RUEAP program as the funding of it has been secured.

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**

XV. Assessment of Distribution Transformers Loading Profile countrywide

The exercise of assessing the loading of all distribution transformers connected to the network was done for the purpose of quantifying the contribution of distribution transformers on the network technical losses.

Distribution Transformers loading profiles (As of 20-26th December2021)				
Substation Name	**Line Name**	**Status**	**DT Number**	**Average of Load Rate (%)**
BIREMBO	BIREMBO AUXILIARY	Under-Loaded	1	4.628
	GIKOMERO/TPP	Normal-Loaded	4	48.293
		Under-Loaded	6	15.076
	KIBAGABAGA/NYARUTARAMA	Normal-Loaded	9	45.635
		Under-Loaded	16	16.139
	KIBAGABAGA/REMERA	Heavy-Loaded	1	94.040
		Normal-Loaded	8	41.001
		Under-Loaded	17	15.152
	KIMIRONKO	Normal-Loaded	8	42.921
		Under-Loaded	9	22.099
	KINYINYA	Normal-Loaded	11	43.504
		Under-Loaded	7	15.930
CAMP BELGE	CAMP BELGE AUXILIARY	Under-Loaded	1	29.987

	GISENYI	Heavy-Loaded	5	86.432
		Normal-Loaded	48	41.643
		Under-Loaded	141	13.785
	KINIGI	Heavy-Loaded	1	83.982
		Normal-Loaded	10	43.943
		Under-Loaded	12	16.420
	MUKUNGWA	Normal-Loaded	5	39.620
		Under-Loaded	19	13.408
	NTARUKA	Heavy-Loaded	1	83.340
		Normal-Loaded	14	42.610
		Under-Loaded	22	16.409
GABIRO	GABIRO AUXILIARY	Under-Loaded	1	10.769
	KIZIGURO	Heavy-Loaded	6	90.421
		Normal-Loaded	58	43.763
		Under-Loaded	169	12.346
	NGARAMA	Normal-Loaded	20	37.419
		Under-Loaded	61	11.852
	NYAGATARE	Heavy-Loaded	6	87.109
		Normal-Loaded	67	44.157
		Under-Loaded	147	15.495

GAHANGA	GAHANGA AUXILIARY	Under-Loaded	1	7.920
	MASTER STEEL FEEDER	Heavy-Loaded	1	81.173
		Normal-Loaded	9	46.592
		Under-Loaded	12	13.083
	PYLONE 20 FEEDER	Heavy-Loaded	1	92.397
		Normal-Loaded	4	47.116
		Over-Loaded	1	106.020
		Under-Loaded	9	14.508
GASOGI	INYANGE	Under-Loaded	2	13.521
	KABUGA	Heavy-Loaded	1	86.755
		Normal-Loaded	2	70.264
	KANOMBE	Heavy-Loaded	6	85.755
		Normal-Loaded	45	50.428
		Under-Loaded	49	15.074
GATUNA	BYUMBA	Normal-Loaded	6	48.220
		Under-Loaded	25	9.835
	GATUNA AUXILIARY	Normal-Loaded	1	35.615
		Under-Loaded	4	14.862
GIFURWE	GAKENKE	Normal-Loaded	6	43.311
		Under-Loaded	13	15.064

	KIRAMBO	Heavy-Loaded	1	88.364
		Normal-Loaded	3	48.771
		Under-Loaded	5	12.515
GIHIRA	GOMA	Normal-Loaded	9	41.410
		Under-Loaded	26	15.508
GIKONDO	GASOGI	Heavy-Loaded	3	87.579
		Normal-Loaded	23	52.078
		Under-Loaded	19	16.773
	GIKONDO AUXILIARY I	Under-Loaded	1	0.864
	GIKONDO AUXILIARY II	Under-Loaded	1	10.924
	GIKONDO HAUT	Heavy-Loaded	1	80.060
		Normal-Loaded	7	46.656
		Under-Loaded	5	22.772
	KIGALI NORTH	Normal-Loaded	4	38.408
		Under-Loaded	16	14.313
	KIGALI SOUTH	Heavy-Loaded	1	81.410
		Normal-Loaded	19	44.579
		Under-Loaded	32	15.028
	KIMIHURURA	Normal-Loaded	2	47.493
		Under-Loaded	6	25.261

	NYARURAMA	Normal-Loaded	1	40.742
		Under-Loaded	1	27.249
	PARC INDUSTRIEL	Heavy-Loaded	1	88.423
		Normal-Loaded	6	40.086
		Under-Loaded	6	21.272
GISENYI	HOPITAL	Under-Loaded	3	15.270
	KITRAKO	Under-Loaded	1	7.400
JABANA 1	DEPART D-WELLE	Normal-Loaded	8	42.922
		Under-Loaded	9	18.322
	DEPART KIGALI	Heavy-Loaded	1	81.340
		Normal-Loaded	18	44.732
		Under-Loaded	17	15.745
	JABANA I AUXILIARY I	Under-Loaded	1	6.382
	JABANA I AUXILIARY II	Under-Loaded	1	0.010
	RUTONGO	Heavy-Loaded	1	85.340
		Normal-Loaded	3	52.876
		Under-Loaded	2	23.345
	UTEXRWA	Heavy-Loaded	1	94.860
		Normal-Loaded	12	43.804
		Under-Loaded	14	15.714

KABARONDO	KABARONDO AUXILIARY	Under-Loaded	1	2.805
	KKK	Heavy-Loaded	3	81.670
		Normal-Loaded	41	46.435
		Under-Loaded	66	15.628
	ZAZA	Heavy-Loaded	19	86.749
		Normal-Loaded	99	46.403
		Under-Loaded	201	14.947
KARONGI	GISOVU	Normal-Loaded	2	37.148
		Under-Loaded	2	10.773
	KARONGI AUXILIARY	Under-Loaded	1	21.929
	KIBUYE	Heavy-Loaded	3	90.774
		Normal-Loaded	40	43.295
		Under-Loaded	52	0.969
	MUGONERO	Normal-Loaded	3	42.356
		Under-Loaded	7	17.594
KIBOGORA	KIBOGORA AUXILIARY	Under-Loaded	1	15.058
	NYAMASHEKE	Normal-Loaded	2	44.969
		Under-Loaded	6	15.720
	RWAKINA	Heavy-Loaded	1	95.420
		Normal-Loaded	11	44.465

		Under-Loaded	18	17.021
KIGOMA	BUTARE	Heavy-Loaded	8	88.669
		Normal-Loaded	85	85.000
		Over-Loaded	1	117.590
		Under-Loaded	174	14.249
	GATUMBA	Heavy-Loaded	3	95.937
		Normal-Loaded	63	41.870
		Under-Loaded	153	12.354
	KIGOMA AUXILIARY	Under-Loaded	1	8.205
	NTONGWE	Heavy-Loaded	9	89.126
		Normal-Loaded	70	42.973
		Under-Loaded	117	14.418
KILINDA	BIRAMBO	Heavy-Loaded	1	81.410
		Normal-Loaded	6	47.878
		Under-Loaded	19	6.448
	KILINDA AUXILIARY	Under-Loaded	1	8.306
	KILINDA MISSION	Normal-Loaded	1	49.673
		Under-Loaded	1	5.196
MASHYUZA	BUGARAMA	Normal-Loaded	1	41.070
		Under-Loaded	2	15.700

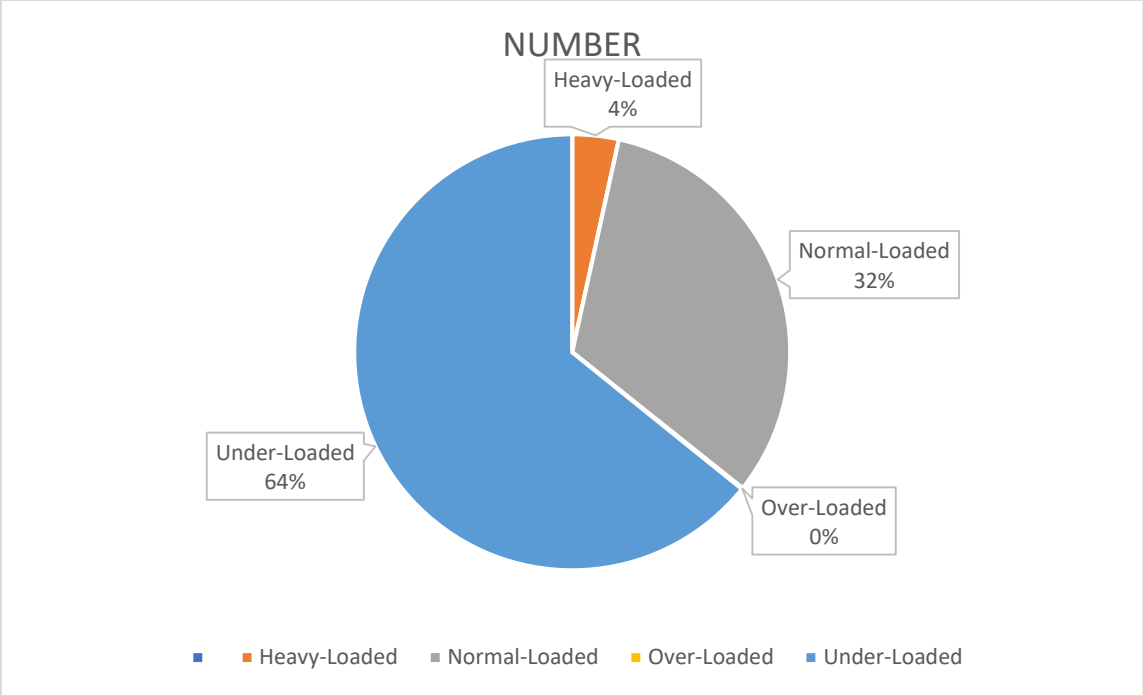
	MASHYUZA AUXILIARY	Under-Loaded	1	3.000
MONT KIGALI	KANAZI BUGESERA	Heavy-Loaded	12	88.929
		Normal-Loaded	59	47.078
		Over-Loaded	1	101.110
		Under-Loaded	81	15.208
	KIYUMBA	Heavy-Loaded	8	86.024
		Normal-Loaded	38	46.876
		Under-Loaded	48	16.372
	MONT KIGALI AUXILIARY	Under-Loaded	1	0.032
	NYAMIRAMBO	Heavy-Loaded	2	90.118
		Normal-Loaded	20	45.662
		Under-Loaded	12	14.172
	NYARURAMA	Normal-Loaded	7	48.958
		Under-Loaded	4	14.303
MUKUNGWA 1	JANJA	Normal-Loaded	3	41.392
		Under-Loaded	18	9.191
	REMERA	Normal-Loaded	3	39.727
		Under-Loaded	10	16.161
	RUHENGERI	Heavy-Loaded	1	92.830
		Normal-Loaded	2	47.840

		Under-Loaded	1	15.763
MURURU-1	MASHYUZA	Heavy-Loaded	1	94.800
		Normal-Loaded	8	39.325
		Under-Loaded	19	16.264
	MURURU I AUXILIARY	Normal-Loaded	2	43.207
		Under-Loaded	22	9.154
	SHAGASHA	Normal-Loaded	14	48.819
		Under-Loaded	20	14.921
MUSHA	KARENGE	Heavy-Loaded	3	90.417
		Normal-Loaded	19	47.525
		Under-Loaded	11	20.733
	MUSHA AUXILIARY	Under-Loaded	1	7.928
	REDEMI 1	Normal-Loaded	3	42.665
		Under-Loaded	4	18.057
	RWAMAGANA	Heavy-Loaded	3	87.489
		Normal-Loaded	24	45.273
		Under-Loaded	46	13.388
NTARUKA	CYANIKA	Normal-Loaded	5	39.322
		Under-Loaded	9	13.092
NTENDEZI	KIBOGORA	Normal-Loaded	1	31.572

		Under-Loaded	5	21.314
	MURURU-1	Heavy-Loaded	1	80.910
		Normal-Loaded	12	47.159
		Under-Loaded	13	20.022
NYABARONGO	NYABARONGO	Normal-Loaded	1	58.193
		Under-Loaded	9	2.875
NZOVE	ABBATOIRE	Heavy-Loaded	1	96.410
		Normal-Loaded	3	39.377
		Under-Loaded	6	15.163
	NZOVE	Normal-Loaded	2	37.030
		Under-Loaded	1	6.240
RUKARARA	RUKARARA 1	Normal-Loaded	1	46.596
		Under-Loaded	8	12.790
	RUKARARA 2	Heavy-Loaded	8	85.354
		Normal-Loaded	56	44.926
		Under-Loaded	156	12.325
RULINDO	BASE	Normal-Loaded	1	46.645
		Under-Loaded	11	9.887
	BYUMBA	Normal-Loaded	9	43.066
		Under-Loaded	24	12.827

	GASIZA	Normal-Loaded	1	37.075
		Under-Loaded	3	14.603
	GATUNA	Heavy-Loaded	1	84.830
		Normal-Loaded	22	38.834
		Under-Loaded	82	12.305
	MUSASA	Normal-Loaded	12	43.105
		Under-Loaded	42	12.839
RWINKWAVU	AKAGERA	Heavy-Loaded	3	93.967
		Normal-Loaded	18	44.337
		Under-Loaded	24	18.174
	REDEMI 2	Under-Loaded	1	1.437
	RWINKWAVU AUXILIARY	Under-Loaded	1	6.610

Transformer loading profile analysis



STATUS	**Loading range**	**Average Loading (%)**	**NUMBER**
Heavy_Loaded	80% ↔ 100%	87.91%	130
Normal_Loaded	30% ↔ 80%	44.94%	1220
Over_Loaded	≥ 100%	108.24%	3
Under_Loaded	0% ↔ 30%	13.40%	2427
TOTAL			**3780**

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

XVI. On-Grid Access Program Coutrywide(RUEAP&RBF)

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	
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	**AfDB**

Ruhango	**Bweramana,Byimana,Kabagali,Kinazi,Kinihira,Mbuye,Mwendo,Ntongwe, 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	
Muhanga	**Cyeza,Kabacuzi,Kiyumba,nyabinoni,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	**OFID/SFD**

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,Murambi,Nyagihanga,Remera,Rugarama,Rwimbogo**	22,021	120	543	87	
Kayonza	**Gahini,Kabare,Kabarondo,Mukarange,Murama,Murundi,Mwiri,Ndego,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,Rwempasha,Rwimiyaga,tabagwe**	14,754	126	242.5	67	
Rwamagana	**Fumbwe,Gahengeri,Gishali,karenge,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	
Nyabihu	**Mukamira,Jenda,Bigogwe,Kabatwa,Kintobo,Rugera,Rurembo,Shyira,Jomba,Muringa,Rambura,Karago**	26,923	164	384	148	
Rubavu	**Bugeshi,Busasamana,Cyanzarwe,Gisenyi,Kanama,Kanzenze,Mudende,Nyakiriba,Nyamyumba,Nyundo,Rubavu,Rugerero**	17,228	136	245	66	
Gicumbi	**Bukure;Bwisige;Byumba;Cyumba;Giti;Kageyo;Manyagiro;Miyove;Mukarange;Muko;Mutete;Nyamiyaga;Nyankenke;Rubaya;Rukomo;RushakiRutare;Ruvune;Rwamiko;Shangasha**	15,225	155.5	245.9	81	**WB**

Musanze	**Busogo;Cyuve;Gacaca; Gashaki;Gataraga;Kimonyi;Kinigi;Muhoza;Musanze; Muko, Nkotsi;Nyange;Remera ;Rwaza;Shingiro**	17,090	151.1	236.0	128	
Rulindo	**Base;BushokiBuyoga;Cyinzuzi;Cyungo;Kinihira;Kisaro;Masoro;Mbogo ;Murambi;Ngoma;Ntarabana;Rukozo;RusigaShyorongi;Tumba**	11,361	124.2	375.4	69	
Burera	**Bungwe;Butaro;Cyanika;Cyeru;Gahunga;Gatebe;Gitovu;Kagogo;Kinoni;Kinyababa;Kivuye;Nemba;Rugarama;Rugengabari;Ruhunde;Rusarabuye;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	**AFD**

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	
TOTAL		**498,386**	**3,919.9**	**9,265.3**	**3,065**	
TOTAL COST	**361,701,635USD**					

Overall Summary of Required Investment for 5 Hubs

- Network reinforcement: 1) New proposed lines to link substations for N-1solution
  2)Upgrade of MV lines (conductor sizes)
  3)Quality of Supply (voltage drop reduction)
  4)Single phase Network Upgrade to 3-phase countrwide
  6) Construction and rehabilitation of Switching Cabines
- On-Grid Electricity Access Program Countrywide

Total required Investment for all Projects in 5 Hubs

Major Project	MV Length (km)	LV Length (km)	Switch Cabins	Transformers
Extension for new access	3920	9,265.3		3065
Single phase to 3-phase	395.5	1189.3		922
Voltage drop issues	410.35	1535.58		332
Renovation of LV lines, Upgrade and creation of MV lines link between substations	357.65			
Switching MV/LV Cabins in Kigali			13	

Switching cabins in Secondary cities			12	
TOTAL	**5,083.5**	**11,990.18**	**25**	**4319**
Investment	**228,757,500**	**239,803,600**	**8,985,000**	**25,718,825**
Total Investment(USD)	**503,264,925**			

XVII. DISTRIBUTION PROJECTS WITH AND WITHOUT FUNDS

PROJECTS WITH SECURED FUNDS

	DISTRIBUTION NETWORK PROJECTS WITH FUNDS							
S/N	**Project Name**	**Project Scope**	**Financier**	**Estimated Budget**	**Current Status**	**Needed Date**	**Priority (1,2,3)**	**Impact on the Plans**
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	AFDB	US$ 22,500,000	-Financing Secured -procurement process is ongoing	June 2023	2	-Visualization and fault finding& troubleshooting -Real time data/status of the network
2	Building of GIS system	Building of Rwanda's power system GIS	World Bank	US$ 6,000,000	Financing Secured -procurement process is ongoing	June 2023	2	This project impact on the use of improved planning tools, reduce the discrepancies of stock of infrastructures.

3	Completing installation of smart metering for all distribution transformers and medium/large customers.	Installation of smart meters on all Distribution transformers	World Bank	US$ 4,500,000	-Financing Secured - Preparation of Bidding Document is ongoing	Jun-22	1	-counting network losses -Provide means to measure the energy dispatched and billed for revenues collection
4	Upgrade and extension of different MV lines for improved supply and Upgrade of Karisimbi 6.6kV line to 30kV	Upgrade of three existing substations i.e. KABATWA, CRATER and SOMMET with construction of 8km of MV underground	AFDB	US$ 46,140,000	-Financing Secured -Technical tender document prepared and pending to procurement to launch tender	Jun-22	1	This project will improve the supply in the area supplied
5	Refurbishment of Distribution Network (Voltage drop and loss reduction)	Refurbishment of 358.85km of MV lines and 1499.9km of LV lines and 283 Transformers	AFDB		-Financing Secured	Jun-22	1	This exposes customers to unacceptable supply voltage , no more network expansion and no new connections in areas with poor power quality

6	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)	AFDB	17,990,000 US$	-Financing Secured	Jun-23	2	If this project is delayed, the existing network will not be able to cope with the high demand growth in secondary cities with their emerging industrial parks
7	Renovation of Low voltage underground cables & MV/LV cabins in Nyarugenge	44.1km of LV Underground and 17 MV/LV cabins	AFDB	14,400,000US$	-Financing Secured -Pending approval from the financier	Jun-22	1	Big buildings and other infrastructures in Nyarugenge need steady power, if the network is not renovated, it will not withstand the load growth, there will be ONs/OFFs that require regular interventions
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	AFDB	6,000,000 US$	During 2020/2021 FY, 366 applied in doing business, 155projects are completed while 72 projects are ongoing	Continuous		Voltage surge at end of lines due to light loading (low demand) Increased demand helps the company to sustain financially itself.

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	AFDB	22,090,000 US$	-Financing Secured -to be implemented in RUAEP program	June-2024	3	-Reduced losses - increased number of big customers
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)	EIB	US$ 20,295,625	-Financing Secured -Feasibility study done	June 2022	1	-Reduced number of interruptions and the number of hours that customers stay without electricity (SAIDI and SAIFI) -Reduced feeders length with N-1 reliability supply in the region
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	RBF	US$ 2,000,000	- Financing Secured - Technical tender document submitted to procurement to re-launch the tender	Jun-22	1	Reduced feeder length with N-1 reliability supply in the region
12	Construction of double circuit line from Gisagara substation to link with Butare feer and associated Switching	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	RBF	US$2,128,000	-MV line is under construction	June -2023	2	-Strengthening of southern network by linking feeders from different substations to ensure contingency supply -shortened feeders=reduced losses

	cabines(Creating link between Gisagara ss, Kigoma SS and Rukarara SS)	Rukarara feeder through Cyarwa switching cabin.Constrution of 2 switching cabins of Rugarama and Ruturo-Ntobo in Gisagara						
13	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	RBF	US$499,200	-MV line is under construction by CEC	June-2024	3	-Network strengthened by shortening Kibuye feeder -Ensure N-1 reliability supply by linking Karongi and Rubavu substations
14	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	RBF	US$62,400	-MV line is under construction by CEC	Jun-2022	1	-Strengthening Northern-West network by shortening Gisenyi feeder -Contingency supply (N-1 Solution) is ansured by linking Camp Belge Substation to Nyabihu Substation
15	Construction of Double circuit MV Line linking Nyabihu	Construction of the 3km Double circuit MV Line linking Nyabihu Substation	RBF	US$312,000	-MV line is under construction by CEC	Jun-2022	1	This project has a good impact on REG loss reduction strategy by shortening Gisenyi and Kibuye feeders as well as ensuring N-1 reliability

	Substation and Gisenyi Feeder towards Ngororero	and Gisenyi Feeder towards Ngororero						supply philosophy by linking Camp Belge and Nyabihu substations
Total required Investment				**US$ 164,917,225**				

PROJECTS UNDER FUNDS MOBILIZATION

		DISTRIBUTION NETWORK PROJECTS UNDER FUND MOBILIZATION						
S/N	**Project Name**	**Project Scope**	**Financier**	**Estimated Budget**	**Current Status**	**Needed Date**	**Priority (1,2,3)**	**Impact on the Plans**
1	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	INDIA-EXIM	US$ 2,500,000	-Proposal for financing was submitted -No feasibility study yet done	Jun2022	1	The delay of this project will cause more maintenance interventions, limit the network expansion and connection of new customers

2	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	INDIA-EXIM	US$ 1,500,000	Proposal for financing was submitted -No feasibility study yet done	Jun2022	1	The delay of this project will cause more maintenance interventions, limit the network expansion and connection of new customers
3	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	INDIA-EXIM	US$ 2,500,000	-Proposal for financing was submitted -No feasibility study yet done	Jun-2022	1	The delay of this project will cause more maintenance interventions, limit the network expansion and connection of new customers
4	Construction of new MV/LV switching Substation at Kanzenze in Bugesera district	Construction of new MV/LV switching Substation at Kanzenze in Bugesera district	INDIA-EXIM	US$ 1,000,000	-Proposal for financing was submitted -No feasibility study yet done	Jun-2024	3	This cabin will provide N-1 supply solution and enhance the network of that area to cope with the demand growth.

5	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	INDIA-EXIM	US$ 1,500,000	-Proposal for financing was submitted -No feasibility study yet done	Jun-2024	3	Rwamagana town and industrial park to relay on a single substation (Musha) that may go off anytime
6	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)	INDIA-EXIM	US$ 6,300,000	-Proposal for financing was submitted -No feasibility study yet done	June-2024	3	The purpose of switching cabins are to increase switching flexibility from different feeders .The delay of this project will impact on having N-1 solution in the areas indicated
7	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	INDIA-EXIM	US$7,248,800	-Proposal for financing was submitted -No feasibility study yet done	Jun-2024	3	-Increased power carrying capability of the network -Impact on loss reduction strategy and compliance to regulatory requirements

		Huye Districts, 54.9km in Gakenke district.						
8	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)	INDIA-EXIM	US$1,274,000	-Proposal for financing was submitted -No feasibility study yet done	Jun-2023	2	This project has purpose of shortening feeders and establishing links between different substations. If this project is delayed, long feeders will increase system losses and lack of N-1 solution
9	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	INDIA-EXIM	US$1,643,720	-Proposal for financing was submitted -No feasibility study yet done	Jun-2024	3	This project has the purpose to supply the industrial parks and cities which are being expanded. If this project is delayed, proposed industrial parks will start without reliable power

10	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)	INDIA-EXIM	US$10,000,000	-Proposal for financing was submitted -No feasibility study yet done	June-2024	3	The delay of this project will cause the network to stay radial with less switching flexibility instead of being meshed Network which is more strong with N-1 reliability.
11	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)	None	US$2,100,000	-No Proposal for financing was submitted -No feasibility study yet done	Jun-2024	3	This project has the purpose to link Mont Kigali and Nzove substations (N-1 Solution). If this project is delayed, Nzove water treatment plant will stay supplied by only Nzove SS whereas the fast growing urbanization in Ruyenzi/Kamuhanda will stay be supplied by only Mont Kigali SS
12	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)	None	US$2,500,000	-No Proposal for financing was submitted -No feasibility study yet done	Jun-2024	3	This project has the purpose to link Mont Kigali and Gahanga substations. If this project is delayed, Karumuna water treatment plant and the fast growing urbanization in Bugesera will stay supplied by only Mont SS thus N-1 solution will be missing.

13	Rehabilitation of Low Voltage Underground Network in Kacyiru Branch	Construction of 16.2km of old low Voltage Underground Network in Kacyiru branch	None	US$3,512,219.74	-No Financing Line - Feasibility study is done	Jun2023	2	If this project is delayed, these strategic areas comprising the big offices, big hotels and planned malls will continue 2to be supplied by old unreliable power that requires regular interventions
14	Construction of the ring line of Rubavu (Poids Lourds)	Construction of 2.4km ring line of Rubavu (Poids Lourds)	None	US$124,800	-No Financing Line - Feasibility study is done	Jun2023	2	This project has a big impact on the operation of the border with DRC and other tourism activities in Rubavu town that need reliable power supply
15	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	None	US$5,000,000	-No Financing Line -No feasibility study	Jun2024	3	This project has a big impact on reducing the waste of materials and failure of equipment.
Total required Investment				**US$ 60,103,539.74**				

XVIII. CONCLUSIONS AND RECOMMENDATIONS

The main conclusions that may be drawn from the study are briefly described below.

Assessment of Existing Networks

Network assessment were conducted for each of the five Hub through an organized workshop. The models were refined, 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 drawn as the solution to the issues identified.

Short-Medium Term Plan

A short-medium term (2019-2024) distribution network reinforcement and expansion plan was developed for each of the hub. 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 substation was identified and be 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

Planning Tools and Data

During the data collection phase of this project organized in form of workshop with all concerned technical engineers managing our distribution network together with hub managers, it was observed that essential network planning data is not always readily available. In order to improve the efficiency and effectiveness of the network planning process, it is essential that improvements are made in the quality and accessibility of network and metering information available to the planning department.

REG need to have an updated database of network to all easy update of the distribution masterplan and this will improve the planning process and assist with prudent investment decisions for the company.

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