REPUBLIC OF RWANDA

MINISTRY OF INFRASTRUCTURE

Draft ENERGY SECTOR STRATEGIC PLAN

2018/19 - 2023/24

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ACRONYMS AND ABBREVIATIONS

Table 1 List of Acronyms and Abbreviations

ACRONYM	DESCRIPTION
AfDB	African Development Bank
BEST	Biomass Energy Strategy
BTC	Belgian Technical Cooperation
CBOs	Community-Based Organizations
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CO_2e	Carbon Dioxide Equivalent
COMESA	Common Market for East and Southern Africa
DP	Development Partners
DSM	Demand Side Management
EAC	East African Community
EAPP	East African Power Pool
EDCL	Electricity Development Corporation Limited
EDPRS	Economic Development and Poverty Reduction Strategy
EE	Energy Efficiency
EIA	Environmental Impact Assessment
EICV	Enquête Intégrale sur les Conditions de Vie
EU	European Union
EUCL	Electricity Utility Corporation Limited
EWSA	Energy Water and Sanitation Authority
GDP	Gross Domestic Product
GIZ	German Technical Cooperation Agency
GoR	Government Of Rwanda
M/GWh	Mega/Giga-Watt hour
HFO	Heavy Fuel Oil
HLTO	High-Level Target Objectives
HPS	High Pressure Sodium-lamps
HV	High Voltage
ICS	Improved Cook Stoves
IPP	Independent Power Producer
IRST	Institute of Scientific and Technological Research
JICA	Japan International Cooperation Agency
KWh	Kilowatt-hour (Unit of electricity)
LCPDP	Least Cost Power Development Plan
LEDs	Light Emitting Diodes
LV	Low Voltage
LPG	Liquified Petroleum Gas
MDGs	Millennium Development Goals
MEPS	Minimum Energy Performance Standards
MINAFFET	Ministry of Foreign Affairs

MINAGRI	Ministry of Agriculture and Animal Resources
MINALOC	Ministry of Local Government
MINECOFIN	Ministry of Finance and Economic Planning
MINEDUC	Ministry of Education
MINICOM	Ministry of Trade and Industry
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
MINISANTE	Ministry of Health
MIS	Management Information System
MTEF	Medium Term Expenditure Framework
MV	Medium Voltage
NBI	Nile Basin Initiative
NDBP	National Domestic Biogas Programme
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NGO	Non-Governmental Organization
NIRDA	National Industrial Research and Development Agency
OGS	Office of The Government Spokesperson
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PSF	Private Sector Federation
PV	Photovoltaic
RSB	Rwanda Standards Board
RDB	Rwanda Development Board
RECO	Rwanda Electricity Corporation
REDF	Rwanda Energy Development fund
REFIT	Renewable Energy Feed-in Tariff
REG	Rwanda Energy Group
REMA	Rwanda Environment Management Authority
RHA	Rwanda Housing Authority
RICA	Rwanda Inspection Competition and Consumer Protection Authority
RPPA	Rwanda Public Procurement Agency
RURA	Rwanda Utilities Regulation Authority
RWASCO	Rwanda Water and Sanitation Corporation
RWF	Rwandan Franc
SE4ALL	Sustainable Energy For All
SINELAC	Société Internationale d'Electricité des Grands Lacs
SME	Small and Medium Sized Enterprise
e-SWAP	Energy Sector Wide Approach Program
SWG	Sector Working Group
SWH	Solar Water Heater
UNFCCC	United Nations Framework convention on Climate change
VAT	Value Added Tax

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

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. Key data, achievements and challenges are presented. From this context, a number of high-level target objectives (HLTOs) are set out, as outlined in Table 2, along with high-level plans to achieve them. These targets represent the key areas of progress to be achieved through the duration of the ESSP and will be measured under the NST-1 reporting framework. Beneath these HLTOs further targets will be monitored by the Ministry of Infrastructure (MININFRA).

Table 2 ESSP high-level target objectives

ESSP high-level target objectives
➢ Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained. ➢ Reliability of electricity supply improved: average number of power interruptions per year reduced to 14.2 and average number of hours without power to 91.7. ➢ Household access to electricity increased to 100%. ➢ Productive user access to electricity increased to 100%. ➢ Existing, New major national and urban roads provided with street lighting. ➢ Losses in the transmission, distribution networks and commercial reduced to 15%. ➢ Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass through promotion of most energy efficient technologies ➢ Petroleum strategic reserves increased to cover three months' supply.

This ESSP builds on the progress made under EDPRS II (Economic Development and Poverty Reduction Strategy), sets new targets and identifies new approaches, which will deliver improved performance.

Sufficient electricity supply is vital to economic growth and expanding household electricity access. Capacity is now 218 MW. To keep pace with anticipated increased demand for electricity and to facilitate achievement of NST-1 targets, a pipeline of projects will be delivered to ensure demand is met, with an additional 15% reserve margin to increase reliability of power supply. Forecasting future electricity demand in a high-growth country is challenging and so annual analysis will be carried out. Supply and demand side interventions will be used to ensure generation and demand remain aligned. The diversification of power sources will continue, with further peat-to-power and methane gas-to-power capacity planned, and the potential for solar, wind and geothermal to be further explored, alongside additional hydropower projects. This will reduce the use of expensive and polluting diesel generation and will enable Government to lower the long-term cost of service and work towards a cost-reflective consumer tariff.

Regional integration will increase significantly, with almost full interconnection expected by 2022. Connecting the power systems of regional countries will improve network stability and present opportunities for inter-country trading of power. Rwanda will continue to

support regional integration and analyse and assess import and export opportunities as they arise.

Access to electricity has increased significantly in recent years, to 34.5% as at June 2017, and by the end of the NST-1 period will be at 100% for households. Expansion of the grid will continue through the Energy Access Roll-out Program (EARP), with 52% of households connected to the grid. However, analysis has shown that grid connections will be economically inefficient in the short-to-medium term for households which use small volumes of electricity. Further, grid expansion is a slow process and it will take decades to reach all households. Therefore, off-grid solutions, including solar home systems (SHS), will play a key role. Off-grid technologies and commercial structures have developed significantly in recent years and now present a viable alternative to grid connections. The Rural Electrification Strategy (RES) published in June 2016 sets out a clear development plan for the off-grid sub-sector. It is expected that 48% of all households will have their electricity needs met by off-grid solutions by 2024.

Further, 100% of productive users will be connected, up from the current level of 72%. Productive users utilise energy for activities that enhance income and welfare and include health and education facilities, public infrastructure and industry. Connecting productive users away from cities will support rural economic development and, as they have a higher ability to pay for energy services than households, improve the sustainability of the sector.

Street lighting will be expanded to all National Roads (Existing & New) and urban roads. International experience has shown that street lighting results in significant reductions in crime and pedestrian traffic crashes. Further, it can revitalize communities as a whole and support continuous service delivery.

As well as connecting new consumers, the reliability of electricity supply will be improved significantly. In 2016/17, the average customer of REG was without power for 36 hours. By 2024, this figure will be reduced to 14.2 hours. Further, the average number of interruptions in a year will be reduced from 229 to 91. These improvements will benefit both households and commercial consumers.

Improving efficiency will be a priority across all sub-sectors. Within electricity, an Energy Efficiency Strategy is being finalised. This sets out a range of initiatives which will improve efficiency across the entire electricity value chain, from generation, through transmission and distribution to end-user consumption. End-user efficiency initiatives, such as the distribution of LEDs and the introduction of standards and labelling on appliances, will result in efficiency savings, relative to inefficient levels. Efficiency efforts are represented in the HLTOs through a target to reduce losses in transmission and distribution from current levels of 22% to 15%. As demand increases, reducing losses will have an increasingly significant impact on the financial performance of REG, as well as reducing the environmental impact of the sector.

It is acknowledged that progress in the biomass subsector has been limited. Therefore, an ambitious HLTO is in place to halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of Biomass. This target is driven by the currently unsustainable deficit between supply and demand of wood. Further, reducing reliance on firewood will improve the lives of Rwandans by reducing the harmful health impacts of burning, and reducing the time spent collecting, firewood. A Biomass Energy Strategy is being finalised. This forecasts supply and demand across scenarios,

identifies policy and institutional gaps and requirements, and establishes clear goals and strategic objectives. To achieve the HLTO, households will be shifted onto alternative fuels for cooking, such as high efficient Improved cooking technologies, LPG and biogas.

The target for the petroleum subsector is to establish reserves to cover three months of usage. Currently, Rwanda relies on imports for all petroleum and therefore it is vital that reserves are sufficient. Current storage levels are 74 million litres, with facilities under construction to take this figure to 112 million. By 2023/24, it is forecast that 198 million litres of petroleum will be in reserve across a number of storage facilities, both public and private. This target will be reviewed and amended based on the latest available demand projections.

The Sector Strategic Plan presented here is fully costed and an implementation plan is included. Energy is a capital intensive sector and the total estimated cost of all programs is around $3 billion [costs are initial estimates and will be revised]. Over half of this ($1.7 billion) total comes from building additional generation capacity and related infrastructure.

Table 3 Summary of HLTOs by subsector

ELECTRICITY	
On-Grid Electricity Supply	▶ *Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained.* • Forecasting demand for electricity in a high-growth economy is challenging. Current projections are for peak demand, including 15% reserve margin, to reach between 282 MW and 376 MW by 2024**.** • A number of projects are in development and will be progressed as required. Projects include large-scale peat and regional hydro projects, which are under construction, large-scale methane and hydro projects, which are progressing through technical and commercial studies, and small-scale hydro projects. The generation portfolio will be optimized to reduce long-term costs, increase energy security, and achieve environmental sustainability objectives. • New investments will be based on the Least Cost Development Plan (2017). This will ensure resources are directed efficiently. This will be updated regularly. • Cross-Government coordination will promote electricity consumption through attracting industrial and energy-intensive users. This will support alignment of supply and demand. ▶ *Reliability of electricity supply improved: average number of power interruptions per year reduced to 91.7 and average number of hours without power to 14.2.* • Reliable electricity supply will support economic growth by improving the Rwanda industrial value proposition. Further, households will benefit from a more stable supply of electricity. • Investments will continue to be made to strengthen transmission and distribution networks and upgrade infrastructure. Capacity will be built through training and processes improved to ensure that best practice is followed and faults quickly resolved.
Electricity Access	▶ *Household access to electricity increased to 100%.* • Grid access (52%): Grid expansion will continue, with priority given to productive end-users and households and settlements within defined distances of the grid. • Off-grid access (48%): The RES will continue to be implemented, with Government support provided to low-income households as required. Funding

	is being made available to support higher-income households in purchasing SHS. The private sector will continue to play a leading role in expanding access. The potential for mini-grids to be developed will continue to be assessed, with projects implemented where technically and economically feasible. ▶ *Productive user access to electricity increased to 100%.* • REG has used NISR and utility data to identify productive users across the country. A connection programme will be implemented to extend the medium voltage and low voltage sections of the grid, and deliver off-grid solutions where optimal. ▶ *Street lighting will be expanded to all Existing, New National Roads and urban roads.* • Electrification will focus on populated areas along main roads and major national roads to ensure efficient allocation of resources. Detailed implementation plans will be developed by REG and the Rwanda Transport Development Agency (RTDA). Efficient, high-quality technology will be used to reduce electricity demand and faults.
Energy Efficiency	▶ *Losses in the transmission, distribution networks and commercial reduced to 15%.* • The Energy Efficiency Strategy (2018) will be implemented. Technical losses will be reduced through targeted investments and operational improvements. Commercial losses will be reduced through awareness campaigns and the development of appropriate legal powers. • In addition to the reduction of losses, the efficiency of generation assets will be improved through technical and commercial interventions, and the efficiency of end-user consumption will be improved through a number of related initiatives, central to which will be the introduction of an appliance labelling and standards program.
BIOMASS	
Sustainable biomass solutions	▶ *Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass through promotion of most energy efficient technologies* • The Biomass Strategy (2018) will be implemented. This will deliver policy interventions and strategies to unlock barriers to the uptake of alternative fuel sources, such as LPG and biogas. This uptake will be supported by increased urbanisation, a target of NST-1. • The biomass subsector will be prioritised to ensure the rate of progress is significantly increased. Coordination between all stakeholders will be improved and an enabling environment for private sector market development established.
PETROLEUM	
Security of supply	▶ *Petroleum strategic reserves increased to cover three months' supply.* • New storage facilities will be constructed and made available (including commenced 60 million litre project) to increase reserves to 198 million litres – based on current demand forecasts. Private and Government investment and ownership models will be used. • The provision and sharing of data will be improved to ensure that current and future demand is known.

1 Introduction

Chapter outline

This chapter briefly presents the purpose of and methodology behind the ESSP.

1.1 Purpose of the ESSP

Energy is central to Rwanda's economy and development plans. It supports all other sectors, including housing and urbanization, manufacturing, agro-processing, mining, tourism and IT services. As such, a well-functioning, efficient energy sector is a prerequisite of achieving the country's national goals. The Energy Sector Strategic Plan (ESSP) is vital in delivering this.

The ESSP will ensure effective delivery of the targets for the energy sector as set out under the National Strategy for Transformation (NST-1) and guide the implementation of the National Energy Policy (REP). The ESSP thus functions as a plan that serves to translate policy directives and principles into concrete measures necessary to reach medium-term targets, reflecting current resource constraints and risk and uncertainties.

This ESSP follows on from the earlier 2013/14 – 2017/18 ESSP. This new ESSP reviews the current status of the sector and outlines high-level target objectives (HLTOs). These have been determined on the basis of political ambitions and rigorous technical analysis. The HLTOs apply to all subsectors and serve to translate the policy goals laid out in the REP and NST-1 into tangible outcome indicators achievable by the end of the NST-1 period (2018/19 to 2023/24).

1.2 Methodology

A detailed process has been undertaken to finalise the ESSP. This process has been led by MININFRA, with support and inputs from all sector stakeholders.

The ESSP reflects the current status of the sector and outlines plans for future development. As such, a number of important supporting activities have been undertaken, the results of which have been reflected in the ESSP:

- Analysis of medium-term supply and demand balance
- Assessment of policy gaps in the sector
- Development of a Least Cost Development Plan
- Development of Electrification Plan
- Development of Biomass Energy Strategy
- Development of Energy Efficiency Strategy

The results of the above activities have been incorporated into the ESSP, which has been developed through:

- Review of sector performance and sector profiling: Assessment of performance against key strategic documents, including the ESSP for EDPRSII, Vision 2020, 7-Year

Government Programme, Sustainable Development Goals, Backward Looking Joint Sector Review, imihigo annual performance reports and other planning documents.

- Stakeholder engagement: Energy sector stakeholders were consulted through the elaboration process, with key inputs provided.
- Agreement of HLTOs to be delivered: The HLTOs, which will be assessed through the NST-1 process, were agreed with stakeholders. This process included the analysis and update of baseline statuses on the sector indicator.
- Iterations and final report: Draft versions of the ESSP have been shared with stakeholders and final agreement was reached through the Sector Working Group (SWG).

2 OVERVIEW OF THE ENERGY SECTOR

Chapter outline

This chapter gives an overview of the energy sector, discussing the current status, achievements and challenges for electricity, biomass and petroleum.

2.1 Policy Context

The ESSP exists in a policy context which includes international, national and sectoral strategies, policies and goals. It is these policy documents which provide the main orientations for the sector. The ESSP collates these documents, prioritises key targets and presents plans to ensure their delivery.

2.1.1 International

The **Sustainable Development Goals** (SDGs), otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. The 17 Goals build on the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities.

The clearest link to the energy sector is Goal 7, Affordable and Clean Energy, which aims to achieve universal access to electricity by 2030. This is to be attained through investment in clean energy generation and the adoption of efficiency standards and processes. However, the SDG goals are interconnected, and often the key to success on one will involve tackling issues more commonly associated with another. This means that the energy sector will play a role in delivering all of the goals.

The **Sustainable Energy for All** (SE4ALL) initiative is a multi-stakeholder partnership between Governments, the private sector, and civil society. Launched by the UN Secretary-General in 2011, it has three interlinked objectives to be achieved by 2030:

1. Ensure universal access to modern energy services.
2. Double the global rate of improvement in energy efficiency.
3. Double the share of renewable energy in the global energy mix.

These objectives provide guidance for the energy sector, and an Action Agenda has been incorporated into sector planning.

This ESSP supports achievement of the above goals: universal energy access will be achieved by 2024; the Energy Efficiency Strategy will be implemented and supply-side solutions to delivering reliable, affordable electricity will be prioritised; and the generation mix is projected to be made up of around 52% renewable sources by 2024 – above the SE4ALL minimum and far above the international average.

2.1.2 National

Energy policies and strategies interact closely with wider, national policies. High-level national objectives are set by Vision 2050 and NST-1 (both 2018).

Vision 2050 replaces the previous Vision 2020. This sets out high-level sectoral targets which together will support Rwanda in achieving its ambitions. Vision 2050 sets out a clear path for Rwanda to achieve high income status by 2050. Energy will support the delivery of Vision 2050 by expanding affordable, reliable access to electricity to citizens and industrial users, ensuring sustainability in biomass supply and securing supplies of petroleum. International experience has shown that economic development is impossible without a well-functioning energy sector, and without minimum levels of capacity and consumption. A sub-target exists to achieve upper-middle income status by 2035.

NST-1 replaces EDPRS II. It sets sectoral targets to be achieved by 2024. These link sectoral achievements and progress to national development. As a result, progress towards targets that appear in both the ESSP and NST-1 will be monitored by both MININFRA and MINECOFIN. **Table 4** outlines how NST-1 pillars and priority areas link to the HLTOs set out in the ESSP.

Table 4 NST-1 links to ESSP

NST-1 Pillar	NST-1 Priority Area	NST-1 Outcome	Energy SSP Outcome (HLTO)
1.0 Economic Transformation	**1.2** Accelerate Sustainable Urbanization from 17.3% (2013/14) to 35% by 2024	**1.2.1** Developed and integrated urban and rural settlements	Street lighting will be expanded to all Existing, New National Roads and urban roads
	1.4 Promote industrialization and attain a structural shift in the export base to high-value goods and services with the aim of growing exports by 17% annually	**1.4.3:** Upgraded minerals, oil & gas sector	Petroleum strategic reserves increased to cover three months' supply.
		1.4.4 Hard infrastructure developed for trade competitiveness	Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained.
			Productive user access to electricity increased to 100%.
			Losses in the transmission and distribution networks reduced to 15%.
			Reliability of electricity supply improved: average number of power interruptions per year reduced to 91.7 and average number of hours without power to 14.2.
	1.7 Sustainable Management of Natural Resources and Environment to Transition Rwanda towards a Carbon	**1.7.4** Accelerated growth in green innovation	Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of

	Neutral Economy		biomass through promotion of most energy efficient technologies
2.0 Social Transformation	**2.5** Moving Towards a Modern Rwandan household	2.5.1 Universal access to basic infrastructure (water, sanitation, electricity, ICT, shelter)	Household access to electricity increased to 100%.

2.1.3 Sector specific

2.1.4 The **National Energy Policy** (REP) (2015) is the high-level policy document which guides and influences decisions on the extraction, development and use of Rwanda's energy resources in a transparent and sustainable manner. It sets out governing laws and regulations and strategic Sector specific priorities.

The **National Energy Policy** (REP) (2015) is the high-level policy document which guides and influences decisions on the extraction, development and use of Rwanda's energy resources in a transparent and sustainable manner. It sets out governing laws and regulations, strategic directions and guiding principles that Rwandan institutions and partners shall adopt and adhere to, in subsequent implementation of actions.

The REP seeks to establish energy as one of Rwanda's most dynamic sectors and attractive investment destinations. It is founded upon three essential Government principles:

1. A resolve for transparent and effective sector governance
2. Easing doing business and reducing barriers to private investment
3. Enhancing institutional, organizational, and human capacities as well as the legal and regulatory framework.

The REP and ESSP are mutually reinforcing: the REP outlines a long-term vision, provides high-level goals, and recommends clear and coordinated approaches for achieving that vision; the ESSP outlines targets and an implementation framework against which to measure progress towards the realization of the policy.

Below these sector-wide documents, a number of policies and strategies cover specific subsectors and topics. The previous ESSP set as an objective the development, adoption and implementation of relevant strategies and policies. Prior to 2015, some papers were either not progressed from draft form, adopted or implemented. A summary of all energy sector documents which have influenced this ESSP is presented in Table 5.

Table 5 Summary of energy sector policies, strategies and laws

Type	Policy / Strategy	Year	Description
Electricity access	SE4All Action Agenda	2016	Presents plan to deliver energy efficiency and renewable energy (biomass, off-grid and power generation from renewable energies).
	Scaling up Renewable Energy Program (SREP) Investment Plan	2015	Supports implementation of the SE4All Action Agenda, with World Bank funding.
	Rural Electrification Strategy (RES)	2016	Sets out four programmes which deliver off-grid solutions (SHS and mini-grids).
	Electricity Access Roll-out Program (EARP)	2013	Key driver of on-grid access growth, with lots established for electrification to 2017/18.
	National Electrification Plan (NEP)	2018	Detailed plan of on and off-grid expansion.
Energy Efficiency	Energy Efficiency Strategy	2018	Outlines initiatives to improve efficiency across generation, transmission and distribution and end-user consumption.
Technical	Rwanda Master Plan & Least Cost Development Plan (LCDP)	2017	Present detailed analysis of current power system and future growth.
	Grid Code	2013	Details the technical running of the power system.
Resources	Management Prescriptions for the Development of Lake Kivu Gas Resources	2009	Sets out required standards and processes for gas extraction. Being updated.
	Peat Resource for Power Generation	2014	Details the peat reserves for power generation across Rwanda.
	Simplified Licensing Procedure	2015	Sets out requirements for small-scale off-grid renewables developers.
Biomass	Biomass Energy Strategy	2018	Forecasts demand and supply balance across scenarios and includes action plan to deliver targets – focused on efficiency.
	National Biomass Programme (NBP)	2018	Presents clear initiatives to promote use of efficient and alternative cooking technologies and establish sustainable biomass consumption.
Petroleum	Downstream Petroleum Strategy	2014	Detailed plan to establish effective regulatory and institutional frameworks, coupled with suitable and sufficient petroleum facilities to ensure supply and distribution.
Laws	Electricity Law of Rwanda	2018	Governs activities of electricity production, transmission, distribution and trading.
	PPP law	2016	Establishes processes and requirements for entering into PPPs (including procurement).
	Radiation Protection Law	2017	Establishes rules and requirements for the use of radiation.
	Renewable Energy and Energy Efficiency Law	2018	Governs renewable energy sources and energy efficiency in Rwanda with the aim of promoting further development, utilisation and sustainability.

2.2 National Context

2.2.1 Socio-economic indicators

Rwanda has a total area of 26,338 km^2 and a population of more 12 million people. Therefore, it is one of the most densely populated countries in Africa. The economy has seen significant, sustained growth, with an annual average growth rate of 8.3% since 2000. GDP in 2015 was RWF 4,864 billion, or $743 per capita. Agriculture contributes 33% of GDP. Great progress has been made in attracting investment and encouraging entrepreneurship. In 2017, the country ranked 42 amongst 190 world economies in the World Bank Doing Business indicators[1]. Sustained economic growth is targeted in coming years. Overall national objectives are in place to achieve upper middle-income status by 2035 and high-income status by 2050.

2.2.2 Climatic conditions

Rwanda is situated between 1° and 3° latitude south of the equator and has a subequatorial climate. The average annual temperature is 18° for the whole country. Recorded annual average rainfall is 989 mm.

2.3 Energy Consumption

The energy sector is made up of three subsectors: electricity, biomass and petroleum. Each of these is then divided into focus areas. This structure is presented in Figure 1.

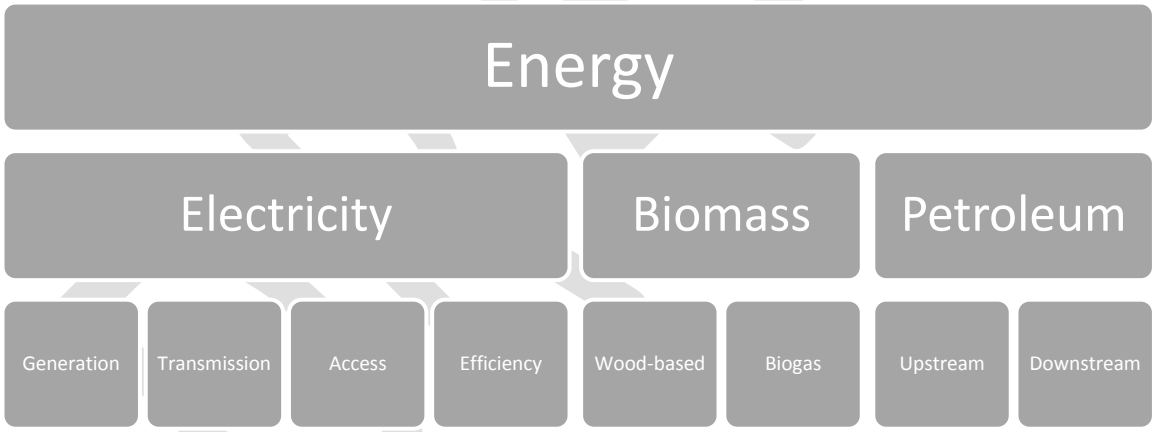

Figure 1 Energy sector structure

Electricity is increasingly used and will drive Rwanda's growth, but currently it accounts for only 2% of all energy consumed[2], as shown in Figure 2. Electricity is generated from a range of technologies and resources and the grid is being developed to expand access. The rise of off-grid technologies in recent years has been a major innovation, and they are now a major contributor to expanding access. Efficiency across generation and transmission, as well as consumption, is increasingly important, with significant economic and environmental benefits possible.

[1] World Bank, 'Doing Business, Rwanda Country Report', (2017)

[2] MININFRA, 'Energy Balance Study', (2016)

In contrast, biomass accounts for 85% of all energy consumed. The subsector covers bio-products. Bio-products are fuels developed from biological materials, split into those that are wood-based, such as wood and charcoal, and biogas, which is derived from waste matter. Biomass is largely consumed for cooking, with wood used by rural households and charcoal by urban households. The biomass subsector is being informed by the development of the Biomass Energy Strategy (2018). This analyses supply and demand of biomass and sets out a strategy to reduce reliance on wood and charcoal.

Petroleum focuses on the procurement and storage of petroleum and related products, such as diesel, kerosene, LPG and natural gas. 13% of the country's total energy consumption is from petroleum. Petroleum is used in transport, electricity generation and, as LPG, in cooking. The use of LPG in cooking is expected to increase significantly as urban households switch from using firewood.

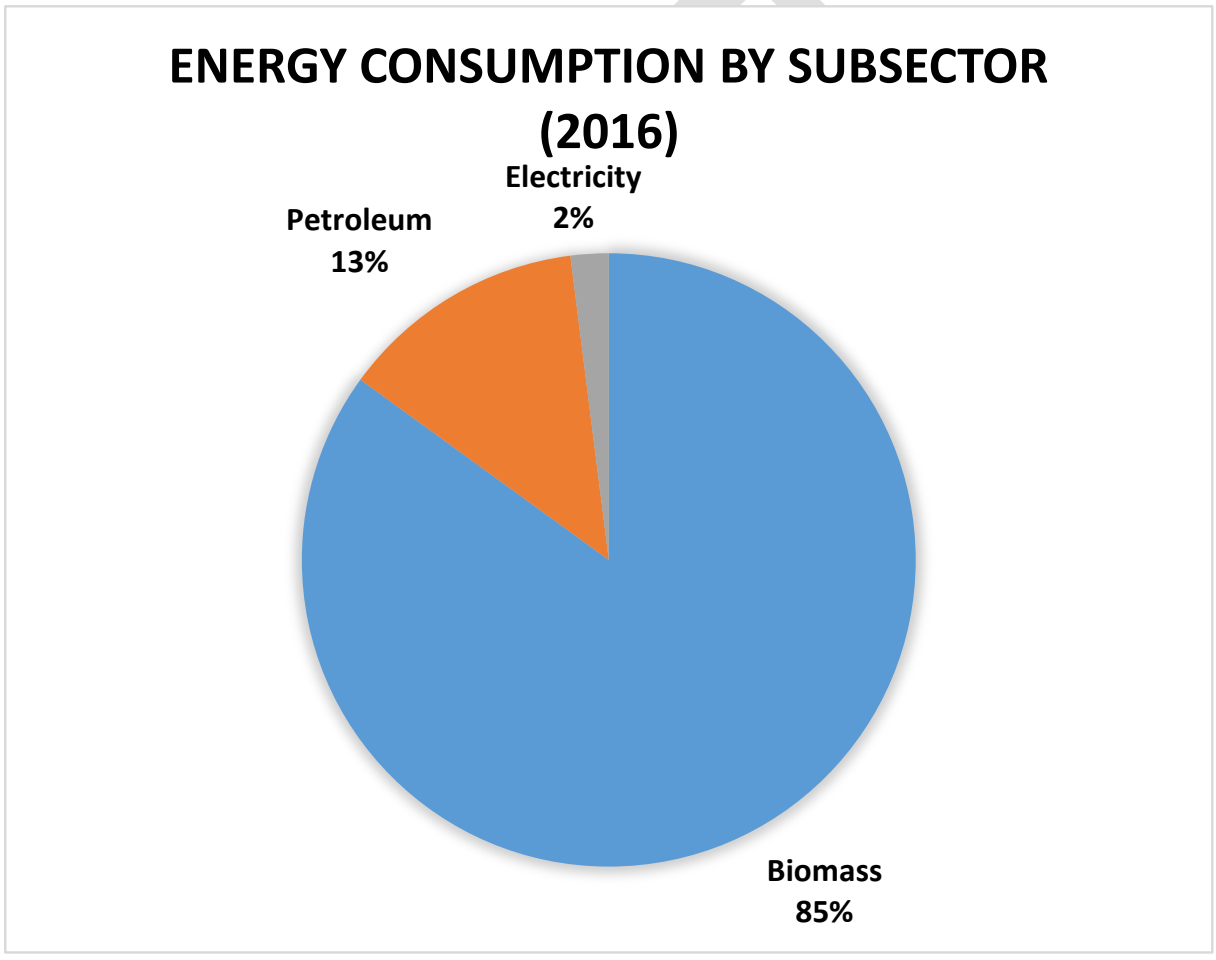

Figure 2 Energy consumption in Rwanda

Households are the largest category of energy consumer, at 82%, with transport at 8%, industries at 6% and others at 4%. This is illustrated in Figure 3.

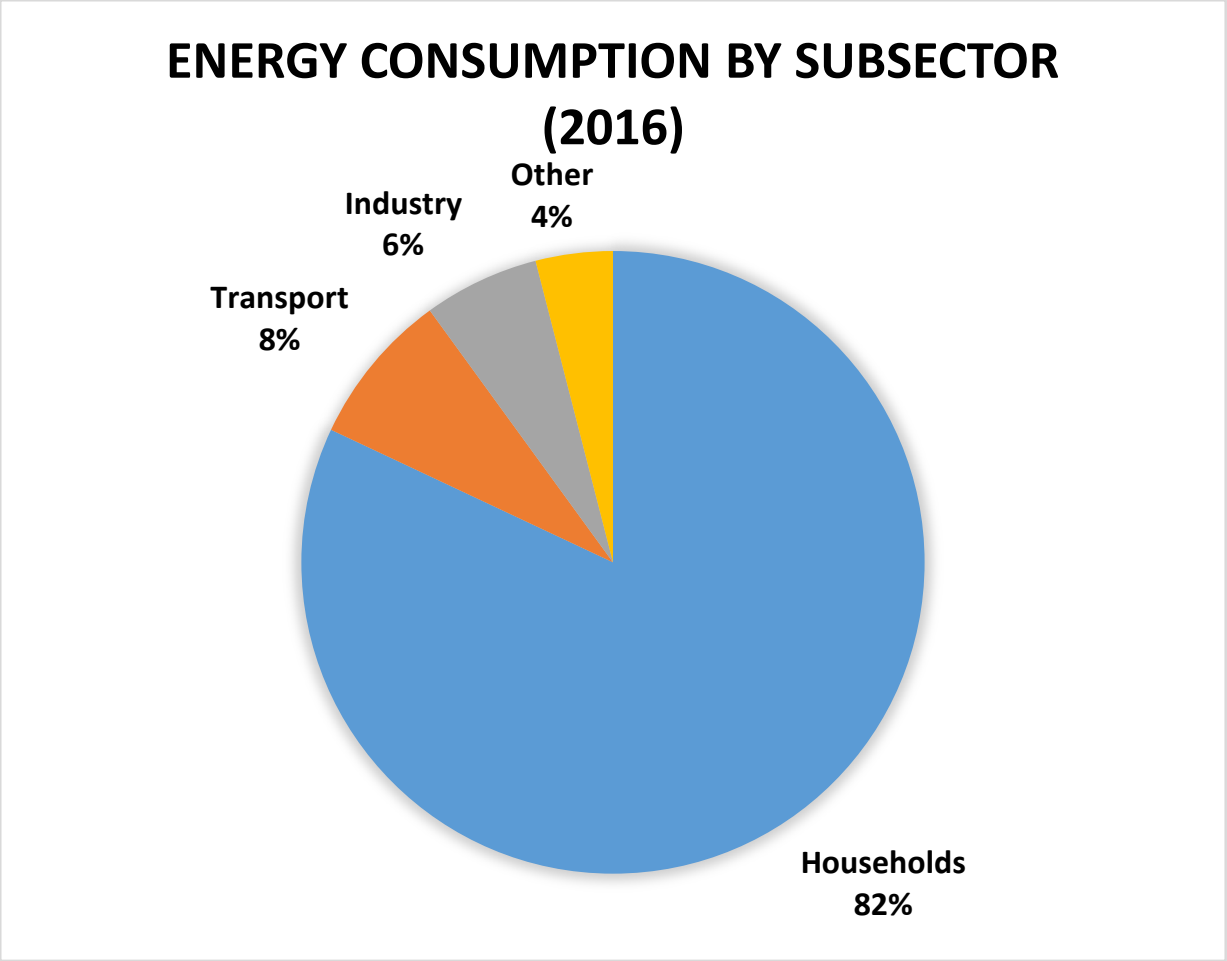

Figure 3 Energy consumption per user category

2.4 Achievements

The major achievements of the energy sector are now set out by subsector, starting with those of the electricity subsector.

2.4.1 Electricity achievements

2.4.1.1 Generation achievements

Generation capacity increased from 160 MW to 218 MW

Generation capacity has been increased by 43.5 MW since the previous ESSP was published (and has tripled since 2010). The EDPRS II target of 563 MW was based on an overoptimistic assessment of demand growth, and therefore has not been met, but capacity is sufficient to meet all household and industrial demand. No load shedding has occurred since January 2015. By investing in generation to meet increasing demand, the energy sector has supported Rwanda's economic growth. Further, a pipeline of projects to be delivered in the medium term has been established. These projects can potentially increase capacity to around 446.8 MW.

Generation mix diversified

Large-scale, non-hydro generation projects have been commissioned. These include Gigawatt (8.5 MW), East Africa's first utility scale PV solar plant and Kivuwatt (26.5 MW), a globally unique industrial scale methane-to-power plant. Kivuwatt represents great innovation and technical excellence and has proven the potential of Lake Kivu's methane gas reserves. The use of peat as a fuel has been proven by Gishoma, a 15 MW peat-to-power plant. An 80 MW peat station is now under construction. This will be Rwanda's largest power station. Although hydro will continue to be central to Rwanda's generation mix, diversification will reduce the impact of seasonal variations and improve the dispatch options for the utility.

2.4.1.2 Transmission achievements

Transmission network expanded and upgraded

The high voltage transmission network has been extended to 744 km from 462 km in 2014 (and has doubled since 2010) to support the expansion of access for households and industry. Further, the Kigali ring strengthening started in 2016 and is till ongoing. Reliability of supply has improved significantly, with outages reduced to 229.3 and 36 hours per year

2.4.1.3 Access achievements

Continued implementation and update of the EARP

Government, in partnership with development partners, launched the Rwanda Electricity Access Roll out Programme (EARP) in 2009 as its flagship programme to realise the primary electricity access targets of the EDPRS. EARP remains the key driver of on-grid electricity access in Rwanda. Since the last ESSP, connections have continued and on-grid access has been expanded to 32.7%. In 2017, the connection policy was reviewed to ease connection requirements where customers and the initial connection fee (around $50) removed to ensure continuing roll out.

Off-grid electricity access established as viable access solution

Off-grid electricity access is now viewed internationally as an important tool in the drive to increase global electricity access. Off-grid incorporates all non-grid connected households, from mini-grids to solar home systems (SHS) fitted to individual houses. Off-grid access in Rwanda has been increased from around 0% to over 10.7%, equivalent to 258,670 households in 2017. This has largely been achieved through SHS. Key to the growth has been the publication of the Rural Electrification Strategy (2016). The RES realigned access targets to place greater emphasis on off-grid, and established programmes to distribute systems to low-income households and support the development of the private sector. A burgeoning private sector now exists and this will drive further expansion of off-grid access.

Tariff reductions from January 2017

The Rwanda Utility Regulatory Authority (RURA) carried out a major tariff review through 2016, with a new pricing regime introduced in January 2017. The tariff has been updated to disaggregate customers, price progressively based on consumption and encourage non-peak usage. Prices for industrial users have been reduced by up to 31% and prices for low-income households have been reduced by 50%, through the introduction of a life-line tariff. Further, RURA committed to regularly review the impact of the new tariff, with changes to be made as required by factors such as exchange rate fluctuations and subsector costs.

2.4.1.4 Energy efficiency achievements

Energy Efficiency Strategy developed

Although ad hoc initiatives had been carried out, no coordinated approach to energy efficiency was in place prior to the Energy Efficiency Strategy (2018). The Strategy covers the full electricity value chain, from generation, through transmission and distribution to end-user consumption. Initial analysis has identified significant environmental and economic benefits for sector stakeholders and consumers. The Strategy sets clear initiatives and its implementation will form the basis of energy efficiency interventions through the NST-1 period.

Some initiatives that were launched are:

- **Compact Fluorescent Lights (CFL):** Supported by Government subsidy, REG distributed 800,000 CFLs in place of incandescent light bulbs between 2007 and 2014. Benefits of this included a reduction in annual energy demand and in savings for consumers.
- **Street Lighting:** A pilot project was implemented by the City of Kigali to replace high-pressure sodium (HPS) lamps with LEDs in street lights which proved significant savings.
- **Loss Reduction**: REG has launched programs for the reduction of technical and commercial losses to improve the overall efficiency of the Utility. Losses has already been reduced to 22% and this is expected to be reduced to 15% by 2024.

2.4.2 Biomass achievements

Biomass Energy Strategy published

MININFRA, MINIRENA and REMA, along with other Government institutions, worked with consultants through 2017 to develop a comprehensive Biomass Energy Strategy (BEST). This was a key requirement for the subsector, with the previous Strategy having been developed in 2009. BEST presents detailed analysis of the current status of the subsector. Detailed modelling was completed to assess supply and demand under different scenarios in the medium term. The identified biomass deficit (more wood being used than is grown), along with concerns for the health and economic well-being of citizens, makes clear the requirement for change.

2.4.3 Petroleum achievements

Expansion of storage

Petroleum reserves have been increased significantly since the last ESSP was published, from 30 million litres to 74 million litres. New storage facilities have been opened in Rusororo Sector, Gasabo District (22 million litres) and Jabana (21 million litres). A further 40 million litres of capacity is due online in 2018, part of a 60 million litre storage facility in Kigali. Further development of storage facilities remains a key objective for the petroleum subsector.

Realigned institutional oversight

Two key developments have improved institutional oversight of the petroleum subsector. First, in May 2016 responsibility for regulation of downstream petroleum was transferred to RURA. This had previously sat with MINICOM, which was performing the twin roles of policy

maker and implementer. A Prime Minister's Order vested RURA with a mandate to regulate all operations, activities, installations, equipment and other facilities directly or indirectly in relation to trade of petroleum and petroleum products. MINICOM's Petroleum Unit had been under-resourced and the role did not naturally fit with the Ministry's wider activities. Second, in 2016, a new institution, the Rwanda Mines, Petroleum and Gas Board (RMB) was established. RMB will focus on the development of Rwanda's upstream assets and processes, with exploration to be increased.

2.5 Challenges

The major challenges of the energy sector are now set out by subsector, starting with those of the electricity subsector.

2.5.1 Electricity challenges

2.5.1.1 Generation challenges

Balancing supply and demand

Rwanda's economy has grown at an average rate of 7.2% over the past five years. As a result, demand for electricity is increasing at a rate of almost 8% per year. New generation capacity must be added to the system to meet this demand. However, the majority of the costs of new power stations are fixed, and payable whether or not the available electricity purchased is consumed. Therefore, a surplus of capacity will be a costly burden on the sector, but a lack of capacity may constrain economic growth. This balance is complicated by the long lead times of large-scale generation projects (5-10 years) and the uncertainty around future demand in a high-growth economy. As a result, investment decisions must be based on sound planning, projects must be delivered to agreed timelines and flexibility must be built into commercial arrangements.

Achieving the correct mix of generation

Different generation technologies and fuels have different commercial and operational characteristics. Hydro, methane and peat are baseload capacity. They have high fixed and low variable costs and should be run constantly or almost constantly to be economically efficient. In contrast, diesel is a peaking plant. It has low fixed costs and high variable costs and should be run for short periods of time when required, such as over the evening peak or when other generation capacity is unavailable. Operating generation outside of its intended purpose can add significant costs to meeting demand (if it is possible under technical parameters). Exacerbating this problem is Rwanda's daily demand profile, which has a pronounced evening peak, therefore necessitating a mix of baseload and peaking capacity. Investment in generation must not only focus on adding MW capacity, but on optimising the overall technology mix of the country.

Ensuring timely maintenance and servicing of infrastructure

Power plants require regular maintenance to ensure optimum productivity. Failure to carry out regular maintenance can reduce effective capacity, necessitating investment in additional capacity, and increase the likelihood of breakdowns, threatening the reliability of supply. Significant expertise and investment is required to ensure existing and new generation capacity is maintained effectively.

Funding infrastructure investments

Building power stations requires significant investment, with average capital costs of recent new projects at around $4 million per MW. A mixture of funding sources must be used, including Government budget, development partner support and the private sector. Even so, funding is limited and projects must be prioritised, with the most efficient option chosen.

2.5.1.2 Transmission challenges

Ensuring transmission is aligned with new generation

Delivering large-scale generation and transmission projects is difficult. International experience shows that delays are common. However, delays are costly and mitigating actions should be taken to reduce their impact. In Rwanda, significant costs have been incurred when electricity supplied by new generation capacity has been too great for the network to transport. In this situation, capacity charges (fixed costs) are still paid for the new generation, and additional generation – often expensive diesel generators – is required to meet the shortfall. This challenge requires improvement of, and cooperation between, planning, project management and commercial and management teams. Further complications are experienced when building interconnections with neighbouring countries.

Ensuring timely maintenance and servicing of infrastructure

As with generation assets, maintenance and servicing is a costly, challenging and ongoing process. Transmission networks are complex, with large infrastructure and large numbers of smaller pieces of equipment dispersed across wide, sometimes remote areas. In Rwanda, much of the existing equipment is decades old. Regular, planned maintenance is required in order to ensure that performance remains efficient. Without such interventions, significant losses can be incurred, with electricity lost as it is transported. Further, failures on the network can cut off electricity to households and industry. Significant expertise and investment is required to ensure existing and new generation transmission lines are maintained effectively.

Funding infrastructure investments

After new capacity, expanding the transmission and distribution networks are the largest capital expenditure in the electricity subsector. A mixture of funding sources must be used, including Government budget, development partner support and the private sector. Even so, funding is limited and projects must be prioritised and the most efficient option chosen.

2.5.1.3 Access challenges

Expanding access to remote areas

Although off-grid solutions are being increasingly utilised, it is the grid that will drive industrial growth and ultimately deliver a high level of electricity access to consumers as incomes increase. Expanding the network to reach more remote households presents two important issues: grid expansion brings in increasingly scattered households in difficult terrain, and these households tend to be low income, with low consumption of electricity. As a result, the marginal cost of grid expansion is increasing, which increases the cost of delivering on-grid access targets.

Consumption of newly connected households is not high enough to cover the costs of being connected. The average annual cost of each connected consumer is around $50. Under the January 2017 tariff structure, a consumer would need to use approximately 130-140 kWh per month in order to fund the cost of their own connection, far higher than current average consumption of 29 kWh[3]. This means that many grid connected customers do not pay for the ongoing cost of their connection. Grid expansion, and the social and indirect economic benefits it brings, therefore must be balanced against the financial sustainability of the utility and sector.

Ensuring on- and off-grid access is aligned

Clear, well-communicated, regularly updated plans are vital in ensuring that on- and off-grid technologies do not overlap. The grid moving into areas that have previously been targeted for off-grid access (SHS or mini-grids) results in wasted investment and damages private sector confidence. Similarly, the correct division of on and off-grid areas should be made to ensure that costs are minimised and the speed of connections remains high. Short, medium and long-term plans must be in place and published so that investments can be planned and the most suitable access methods delivered.

Maintaining off-grid solutions

Preventive maintenance and proper technical support are fundamental to the sustainability of off-grid electrification projects. Off-grid solar systems require minimal maintenance to maintain on-going functionality. However, failure to carry out this maintenance can result in failure and the need for expensive rehabilitation. Previous initiatives have resulted in lanterns and SHS quickly becoming unusable. There is a need to establish suitable maintenance and support procedures for all projects, incorporating sustainability into the design of programs and strategy. Guidelines and standards are required to ensure that private sector companies sell high-quality products and adhere to warranty obligations.

Accessing consumer finance

Achieving a large scale-up in electricity access hinges upon greater household access to finance. Due to their low purchasing power, consumer finance and credit mechanisms are pivotal to assist rural households to switch to solar lighting over kerosene, or to pay off new electricity connections over time. Significant progress has been made in this area. The up-front household payment ($50) for connection via the EARP has been removed for those who cannot afford to pay, with the amount now amortised over a number of years. Further, Programme 2 of the RES will distribute $50 million via financial institutions to support financing of off-grid technologies.

2.5.1.4 Energy efficiency challenges

Developing individual and institutional capacity

Although some ad-hoc initiatives have been carried out by REG, no large-scale, strategic programmes have been implemented. As such, energy efficiency remains a relatively new policy area. Further, energy efficiency requires a wide range of specialist skills and knowledge (for example, energy audits, standards and labelling, demand-side response).

[3] World Bank, 'Rwanda: Energy Access Diagnostic Results Based on Multi-Tier Framework', 2017

Individual and institutional capacity must be developed as a priority to enable the development, implementation and roll-out of initiatives. This capacity should be developed within REG, Government and the private sector.

Raising awareness and removing barriers to uptake

Many energy efficiency initiatives require changes to consumer behaviour and/or the purchase of new technologies. Such initiatives will not succeed if consumers are not educated on their benefits, both financial and environmental. In particular, financial benefits must be understood in terms of lifecycle savings. Up-front costs may deter uptake, even though financial savings are provable. Even if the potential pay-back period is not especially long, disposable income in Rwanda is very low. There are few sources of financial support for meeting the up-front costs of efficiency technologies. Government and development partner funding should be used to reduce financing costs.

Coordinating the implementation of initiatives

Although MININFRA, REG and the Rwanda Standards Board (RSB) will lead the design, implementation and monitoring of the Strategy and its initiatives, the input of other institutions will be required (for example, RURA, MINICOM, CESB). Further, the nature of end-user efficiency programs will require significant involvement at the local level (MINALOC). This has the possibility to result in duplication, gaps and misaligned allocation of responsibility and accountability. Coordination, including clear roles and responsibilities, will be required to ensure the efficient design, implementation and monitoring of initiatives.

Ensuring the sustainability of initiatives

Energy efficiency initiatives can be derailed by poor quality technologies being supplied. These technologies may fail or perform so badly they are rejected by consumers. In Rwanda, previous initiatives to distribute efficient lightbulbs have suffered from poor quality bulbs being supplied. Failure or reduced impact of initiatives has the direct impact of wasting resources through reduced environmental and economic benefits. Further, such incidents damage confidence in efficient technologies, reducing consumer demand. Appropriate standards, backed up by testing procedures and strict enforcement, must be used to ensure minimum standards of all items on the market.

2.5.2 Biomass challenges

Maintaining wood supplies in the medium term

Analysis prepared for the Biomass Energy Strategy shows that there is currently a deficit in the supply and demand of wood. Under current trends, wood stocks will be depleted in the medium term. Interventions will be needed to bridge this supply gap and this is a major driver of reducing the use of firewood for cooking. Further analysis is required to improve the accuracy of projections and model the impact of interventions.

Ensuring roles and responsibilities are clear

Biomass is a complex, cross-cutting subsector which involves a number of institutions, both Government and non-Government, central and local. These institutions play different roles, from regulatory and supervisory, to implantation and support. This complexity, and the subsector's diverse resource base, gives the opportunity for unclear allocation of responsibility, duplication of roles and gaps in action and decision making. A distinct

institutional framework is important in achieving sustainable biomass energy and ensuring efficiency and clean biomass energy along the value chain. It is therefore imperative that institutional mandates and responsibilities align with legal and legislative frameworks governing their respective sectors. BEST has identified policy and institutional gaps and proposed interventions to tackle them.

Identifying and promoting economically and culturally acceptable alternatives

A previous policy target aimed for a reduction in the share of woody biomass, from 85% to 50% of total energy consumption. However, little progress has been made on this and biomass continues to be the primary source of energy consumption. The lack of alternatives to biomass for cooking, such as LPG, biogas or electricity, has contributed significantly to this lack of progress. Similarly slow progress has been seen internationally over a number of years.

Many rural households have a low incentive to switch away from traditional biomass fuels, such as firewood, as they pay little to nothing for them or simply cannot afford cleaner alternatives. In addition, changing predominant cooking fuel use is a behaviour adjustment that is deeply culturally conditioned. As a result, programs focusing solely on disseminating new technologies without accompanying behavioural change or social marketing campaigns are likely to fail. Further, barriers must be overcome to grow the use of alternative technologies. Currently, LPG is imported, with the supply chain acting as a bottleneck, and, like electricity, LPG is expensive. Affordable, practical alternatives must be available if large-scale change is to be achieved.

2.5.3 Petroleum challenges

Managing price volatility

Rwanda has very low security over petroleum-based energy products and the global market for petroleum products can be volatile. Although international oil prices have been exceptionally low in in recent years compared to other periods of time, price volatility and shocks are a cause of concern due to Rwanda's extremely high vulnerability.

Ensuring quality of supplies

Uneven product quality results from a lack of clear standards, quality control mechanisms, and capacities to carry out adequate quality control.

Developing required infrastructure

In order to meet national policy objectives, additional investment in infrastructure development, which has been lagging over recent years, is required. The storage capacity for petroleum imports is insufficient to cope with rising demand and existing infrastructure does not all comply with international environmental, health and safety risk management standards. Significant resources are required to upgrade existing infrastructure and build new infrastructure to increase storage. Infrastructure development strategies must be closely aligned to anticipated market demand and appropriate reserve levels.

Accessing and sharing data

Petroleum is imported and sold by private companies and used in a range of industries. This, coupled with the split roles of government institutions such as RURA and MINICOM, has resulted in limited data being available and shared. Lack of clear consumption figures

reduces the potential to monitor and improve the subsector's performance, or to plan appropriately. Efforts are underway to improve data collection and sharing across institutions. These improvements must be delivered if expansion of the petroleum subsector is to be achieved.

2.6 Energy Sector Status

2.6.1 Electricity Subsector Status

Electricity is an essential driver of modern technology and socio-economic development. It powers small appliances, such as lights and mobile phones, which improve the lives of citizens, as well as industrial processing activities, which contribute to economic value-added products and job creation.

2.6.1.1 Generation

Installed capacity in Rwanda is 218 MW, with 212.5 MW connected to the grid and an import option of 5.5 MW. This is an increase from the 160 MW installed at the time of the previous ESSP. The technology mix has also been diversified. Hydro makes up 45% of installed capacity, Diesel & HFO 27%, methane gas 14%, peat 7% and solar 6%.

The evolution of installed electricity generation capacity is presented in Figure 4.

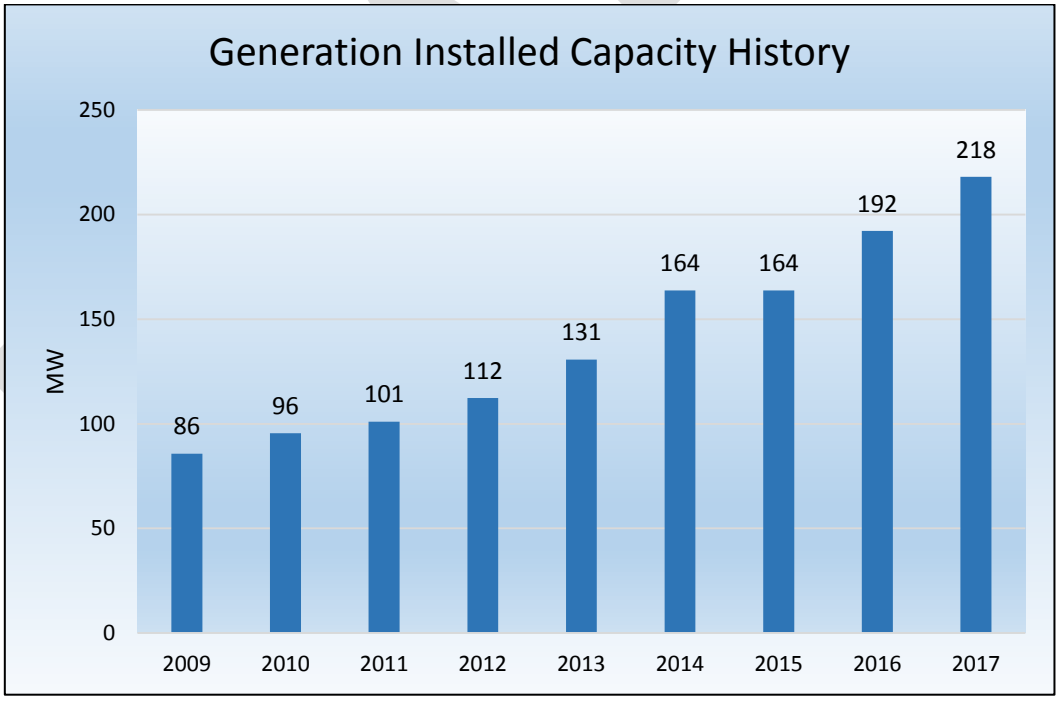

Figure 4 Evolution of installed electricity generation capacity

The generation plant currently in Rwanda are listed in Table 6.

Table 6 Rwanda electricity generation capacity

Power Plant Name	Generation	Commissioning/	Technology	Status
Gisenyi	1.2	1957	Hydro	Operational
Rusizi I(SNEL)	3.5	1957	Import	Operational
Ntaruka	11.3	1959	Hydro	3.75MW Not Operational
Mukungwa I	12.0	1982	Hydro	Operational
Gihira	1.8	1984	Hydro	Operational
Rusizi II	12.0	1986	Hydro	Operational
Jabana I	7.8	2004	Diesel	1.2MW not Operational
Gikondo Agreko	10.0	2005	Diesel	Operational
Mukungwa Diesel	5.0	2006	Diesel	Operational
Jali	0.3	2007	Solar	Operational
Nyamyotsi I	0.1	2007	Hydro	Operational
KP1	3.6	2008	Methane	Not Operational
Mukungwa Diesel	-5.0	2009	Diesel	Operational
Jabana II	20.0	2009	Diesel	Operational
Nyamata Solar	0.0	2009	Solar	Operational
Kabale (UEB)	2.0		Import	Operational
Mutobo	0.2	2009	Hydro	Operational
Murunda	0.1	2010	Hydro	Operational
Rukarara I	9.5	2010	Hydro	Operational
Agatobwe	0.2	2010	Hydro	Operational
Rugezi	2.2	2011	Hydro	Not Operational
Keya	2.2	2011	Hydro	Operational
Cyimbili	0.3	2011	Hydro	Operational
Nkora	0.7	2011	Hydro	Operational
Nyamyotsi II	0.1	2011	Hydro	Operational
Rushaki	0.0	2011	Hydro	Operational
Mukungwa Agreko	10.0	2012	Diesel	Operational
Mazimeru	0.5	2012	Hydro	Operational
Nshili I	0.4	2012	Hydro	Not Operational
Janja	0.2	2012	Hydro	Operational
Nyabahanga I	0.2	2012	Hydro	Operational
Gigwatt Grobal	8.5	2013	Solar	Operational
Musarara	0.4	2013	Hydro	Operational
Mukungwa II	2.5	2013	Hydro	Operational
Rukarara II	2.2	2013	Hydro	Operational
Giciye I	4.0	2013	Hydro	Operational
Nyirabuhombohombo	0.5	2013	Hydro	Operational
Gashashi	0.2	2013	Hydro	Operational
Gikondo Agreko Gikondo	-10.0	2014	Diesel	Operational
Mukungwa Agreko	-10.0	2014	Diesel	Operational
Ndera KSEZ	11.0	2014	Diesel	Operational
SES Cimerwa	14.0	2014	Diesel	Operational
Nyabarongo I	28.0	2014	Hydro	Operational
Kivuwatt Ph 1	26.4	2016	Methane	Operational
Giciye II	2.0	2016	Hydro	Operational
Biomass	0.1	2016	Waste	Operational
Ndera KSEZ	-11.0	2017	Diesel	Operational

Gaseke	0.6	2017	Hydro	Operational
Giciye II	2.0	2017	Hydro	Operational
SES CIMERWA	-14.0	2017	Diesel	Operational
Gishoma	15.0	2017	Peat	Operational
So Energy	30.0	2017	Diesel	Operational
Nasho Solar	3.3	2017	Solar	Operational
Accumulative total	**218.0**			

The total installed power of 218 MW is not available steadily. The operation of the hydro units is limited by the water level in the upper ponds and their interdependence, and hydro availability lowers significantly during the dry season. In addition, the PV solar capacity is not significantly available during the evening peak hours. Further, losses are incurred on the transmission and distribution lines (about 2% of the total installed power) and some of the units may be unavailable during certain periods due to maintenance or failure.

Rwanda's evening peak is around 130 MW and meeting this cost-effectively is a challenge. Hydro, which runs 24 hours a day, contributes 41% of generation over the evening peak. The next largest source is diesel (28%) and then methane (21%) and imports (10%). Table 7 details the contribution of different generation types to meeting peak demand in 2017.

Table 7 Generation used to meet peak demand[4]

	Peak generation (MW)									
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg	Avg %
Diesel	28.4	32.6	25.1	31.5	40.4	28.6	34.2	38.0	32.3	**28**
Hydro	43.2	43.0	51.4	50.0	44.4	51.2	42.5	52.9	47.3	**41**
Import	8.4	12.2	10.3	11.3	15.6	13.5	12.4	10.3	11.7	**10**
Gas methane	29.3	29.3	29.3	26.3	17.6	19.9	26.4	17.6	24.5	**21**
Total generation	**109.3**	**117.1**	**116.1**	**119.1**	**118.0**	**113.2**	**115.4**	**118.9**	**115.9**	

Rwanda has a range of indigenous resources that complement each other in the energy mix. Table 8 summarises these resources.

[4] IEC, 'Transmission System Development Sector' (2017)

Table 8 Overview of Rwanda's indigenous energy resources

Resource potential	Summary of current and potential contribution
Hydropower 313-400 MW[5]	Hydropower has generated the bulk of electricity in Rwanda since 1960s. Its overall potential is estimated at up to 400 M W, with the current installed hydro capacity is 98.5 MW. As a result of extremely low operational costs however, hydro is still one of the cheapest forms of generation in the long run.
Methane 140-180 MW	Kivuwatt, a 27 MW generation facility, has demonstrated the commercial and technical viability of extracting methane from Lake Kivu. Further utilisation of methane resources is planned, with significant investor interest.
Peat 121-161 MW	A Peat master plan was first developed in 1993. Estimates of potential capacity have since been revised downwards from the initial 700 MW to 121 MW-161 MW in 2016. About 77% of peat reserves are near Akanyaru and Nyabarongo rivers and the Rwabusoro Plains. Gishoma, a 15 MW station, is currently generating electricity and is primarily used in the dry season. Hakan, an 80 MW station, is under construction and will be commissioned in 2021.
Geothermal (TBD)	Rwanda's geothermal resource is yet to be proven. However, studies have identified Karisimbi, Kinigi, Gisenyi and Bugarama as promising areas, with potentially 47.3 MW of generation available from five promising sites. Further studies, exploration and test sites are required to confirm this.
Solar Energy (TBD)	Rwanda's solar radiation varies between 4.3 and 5.2 kWh per m2 per day over all regions. Gigawatt Global constructed Rwanda's only large-scale solar station in 2014. There is high interest from the private sector in on-grid solar power development. However, penetration is limited by the technical capacity of the grid. Also, peak demand in Rwanda occurs between 19:00 and 21:00, meaning storage must be used for solar to contribute.
Biomass (TBD)	Small-scale power generation using agricultural residues (such as bagasse or rice husks) or biomass briquettes (from compacted waste residues or charcoal dust) is feasible at low levels of capacity. A private bagasse power plant of 0.7 MW has been developed in Eastern Province and a feasibility study is being completed on a waste-to-power plant.
Wind Energy (TBD)	Commercialy wind power resources are not expected to be significant based on past resource assessments and modeling work. However, MININFRA will continue to assess the potential for wind to contribute to the generation mix.

2.6.1.1.1 Hydro Power

Studies suggest that Rwanda's topography is most suitable for medium- to high-head pico- and micro-hydro run-of-river schemes. Rwanda's overall technical hydropower potential has been estimated at up to 400 MW, although this varies by study. An assessment of the energy sector undertaken by the African Development Bank in 2013 estimated Rwanda's domestic hydropower potential at 313 MW, broken down into 130 MW of domestic and 183 MW of regional hydro resources.

A significant proportion of national hydro resources have been exploited by private developers as a result of the promotion of investment opportunities in power generation by Government. Government is now focusing on the exploitation of very small hydro resources to power local communities as mini-grids. These are communities that would otherwise not be reached by the grid in the medium term. Regional hydro resources are also being developed. Rusumo Falls Hydro Power Plant is under construction and will supply power to Rwanda, Burundi and Tanzania, and Rusizi III and IV are in the pipeline, with power to be shared with DRC and Burundi.

[5] Consisting of 250 MW of Domestic potential and 150MW of regional potential

2.6.1.1.2 Peat to power

Peat generation is currently limited to Gishoma, a 15 MW peat power station which became operational in 2016. Hakan, an 80 MW peat power station, will come online in 2021. This will be the largest power station in Rwanda, with the potential to supply over 600 GWh per year. Rwanda's large resources of peat and the desire to diversify the generation mix may see further peat power stations commissioned in the medium term.

A 2016 report concluded that from the 13,571 ha area studied, approximately 23 to 33 million dry tonnes of peat can be produced[6] from an exploitable area of 4,057 ha. This peat can produce between 97 and 129 TWh for 30 years, at an estimated level of between 121 and 161 MW.

[6] SWECO, 'Detailed study and assessment of peat bogs in Rwanda and their potential use as a source of fuel for power generation', (2016)

Name of peat bog	Total area (ha)	Exploitable area (ha)	Energy content in exploitable peat reserves (TWh)		Power output from exploitable peat reserves, based on 30 years of operation (MW)	
			Sod peat [TWh]	Milled peat [TWh]	Sod peat [MW]	Milled peat [MW]
Akanyaru North						
Cyato	312	67	0.97	0.64	1.2	0.80
Murago	542	167	2.8	2.2	3.5	2.7
Rucyahabi	925	182	3.4	2.9	4.2	3.6
Akanyaru North (Others), north part	1,321	118	2.1	0.30	2.6	0.37
Akanyaru North (Others), middle part	1,994	564	18	11	23	14
Akanyaru North (Others), south part	3,208	1,533	56	44	71	55
Bishya	115	14	0.38	0	0.48	0
Akanyaru South						
Akanyaru South (Others)	2,108	922	33	29	41	36
Mukindo	959	185	4.8	2.8	6.0	3.4
Rusizi						
Gishoma	423	54	0.66	0.37	0.83	0.46
Gihitasi	90	6	0.05	0.05	0.07	0.07
Mashya	36	23	0.44	0.38	0.55	0.47
Other Region						
Kaguhu	195	14	0.31	0.29	0.39	0.36
Northern and Eastern Rwanda						
Bahimba	233	17	0.27	0.07	0.34	0.09
Bisika	93	0	0	0	0	0
Kageyo	383	20	0.22	0.17	0.27	0.22
Ndongozi	124	50	0.93	0.54	1.2	0.67
Nyirabirande	511	120	3.55	2.34	4.4	2.9
Total	**13,571**	**4,057**	**129**	**97**	**161**	**121**

Table 9 Peat resources in Rwanda

2.6.1.1.3 Geothermal energy resources

Geothermal energy refers to the heat found within the earth. This can be harnessed by drilling into the ground and using steam to drive generators. Rwanda's geothermal resource is yet to be proven. However, studies have identified Karisimbi, Kinigi, Gisenyi and Bugarama as promising areas, with potentially 47.3 MW of generation available from five promising sites[7]. However, given the complexity involved in determining the commercial viability of geothermal power, much more detailed exploration studies and sub-surface drilling are required.

[7] JICA, 'The Project for Preparation of Electricity Development Plan for Sustainable Geothermal Energy Development in Rwanda', (2015)

2.6.1.1.4 Solar energy

Rwanda's solar radiation and solar resources have been assessed by the U.S. National Air and Space Agency (NASA) as well as the University of Rwanda. Rwanda's Eastern Province has the greatest potential for generating energy from solar resources, as shown Figure 5. Another academic assessment, undertaken in partnership with the MININFRA Department of Meteorology in 2007, used a meteorological data set to estimate monthly averaged global solar radiation. This was found to vary between 4.3 and 5.2 kWh per m^2 per day over all regions of Rwanda.[8]

Gigawatt Global constructed East Africa's first large-scale solar station (8.5 MW) in 2014. It is expected that as the cost of solar generation and storage decreases, solar energy will play an increasing role in the country's electricity generation mix.

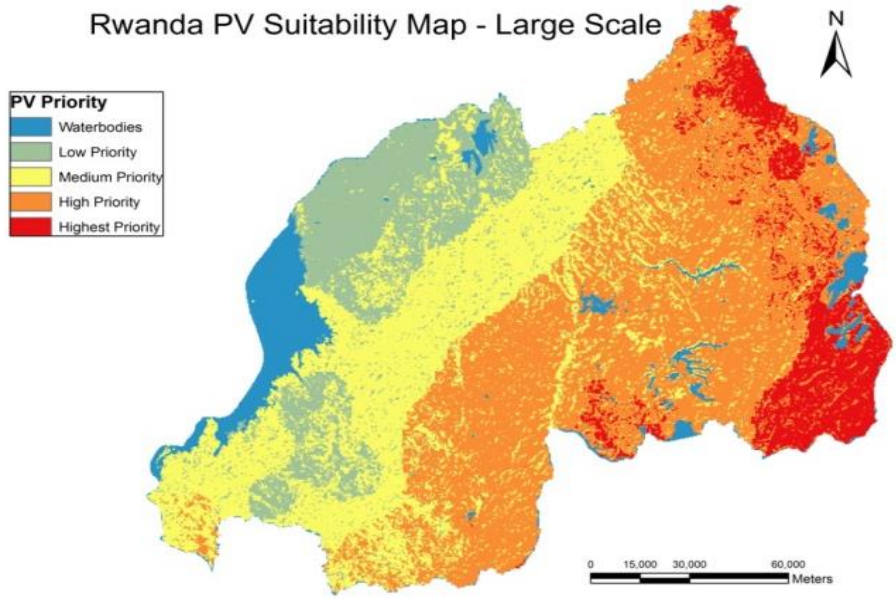

Figure 5 Rwanda PV suitability map

Source: NASA, 'Rwanda Agriculture & Energy', (2013)

2.6.1.1.5 Wind

Being located close to the equator, Rwanda's inherent resource potential for wind energy is low. A rapid wind energy resource assessment was carried out in Rwanda in five locations over the course of 2011. Preliminary indications from the analysis of recorded field measurements of wind speeds and climate data were that most of Rwanda is not highly suitable for wind energy. The Eastern Province was identified as the location with the most promising potential, and a simple analysis comparing wind and solar energy feasibility suggested that wind energy could be competitive in this region. Another academic study using modelling analyses based on recorded wind measurements at selected Rwandan meteorological stations noted that electricity production in the area of the Gisenyi station

[8] C. Museruka and A. Mutabazi, '*Assessment of Global Solar Radiation over Rwanda* – Proceedings of the International Conference on Clean Electrical Power (ICCEP), 21-23 May', (2007)

could be possible with a good mean value of both wind speed and power density. In contrast, in areas such as Kigali, Butare and Kamembe, wind energy potential is only sufficient for windmills or water pumping for agricultural and intuitional needs[9]. More detailed resource assessments and feasibility studies are required to determine commercially viable wind energy potential in Rwanda.

2.6.1.1.6 Methane Gas

The methane gas contained within Lake Kivu is Rwanda's largest natural resource. The methane gas is the result of the globally unique geology of the lake and the naturally regenerating methane gas that is found there. KivuWatt, a 27 MW power station, is already generating power using extracted gas. It is anticipated that the methane resources will be exploited further as generation capacity increases in line with demand.

Lake Kivu has 60-70 km^3 of Methane (CH4) of which 44.7 km^3 can be extracted. There is a small annual accumulation of 0.14 km^3 per year. The amount of electricity that can be generated from this methane depends on the achieved through extraction and generation. This efficiency is currently estimated at 28%, lower than the 40-60% initially expected[10]. Therefore, initial forecasts of 700 MW of generation for 50 years (to be split between Rwanda and DRC) have been revised downwards to 280 MW[11].

Although it is currently anticipated that the primary end-use of the resource will be for electricity, methane gas has a variety of commercial and industrial uses. Further studies will be required to assess the potential of these.

2.6.1.1.7 Biomass

Small-scale power generation using agricultural residues (such as bagasse or rice husks) or biomass briquettes (from compacted waste residues or charcoal dust) is feasible at low levels of capacity. A private bagasse power plant of 0.7 MW has been developed in Eastern Province and a feasibility study is being completed on a waste-to-power plant.

2.6.1.2 Transmission

Significant investment has been made in expanding and strengthening the transmission network. By the end of June 2017, 744 km of high voltage (HV) transmission lines had been laid, up from 462 km in 2014. These lines evacuate power from various points of generation across the country, as well as facilitating regional interconnectivity. These are mainly 110 kV (470.5) and 220 kV transmission lines (273.5 km).

In 2013, the 70 kV lines previously running through Birembo-Musha to Kabarondo substation were upgraded to 110 kV. This was to improve network reliability and power supply stability amidst the country's changing power demand profile. Meanwhile, since 2015, investment has been directed towards more advanced transmission infrastructure.

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[9] Bonfils Safari, 'Modelling wind speed and wind power distributions in Rwanda', Renewable and Sustainable Energy Reviews 15, (2011) 925–935

[10] Wüest, A., Jarc, L., Bürgmann, H., Pasche, N., & Schmid, M., Methane Formation and Future Extraction in Lake Kivu', in J.-P. Descy, F. Darchambeau, & M. Schmid (Eds.), Lake Kivu: Limnology and biogeochemistry of a tropical great lake (Aquatic Ec, pp. 165–180). Dordrecht: Springer Netherlands, (2012)

[11] Wuëst, A., Jarc, L., & Schmid, M., ,Modelling the reinjection of deep-water after methane extraction in Lake Kivu', (2009)

A key feature of the transmission network is the high proportion of electricity consumed in Kigali which is around 50% of total national consumption over evening peak. The high level of consumption in Kigali Province is reflected in the recorded load flows, as shown in Figure 6. The main power flow is from the south-west region of the country, where the major power generation stations operate.

The flow of power from the south west of the country has created significant challenges. The existing network has been unable to transport all the power generated in that area of the country – in particular, the 27 MW from Kivuwatt. This resulted in significant congestion charges.

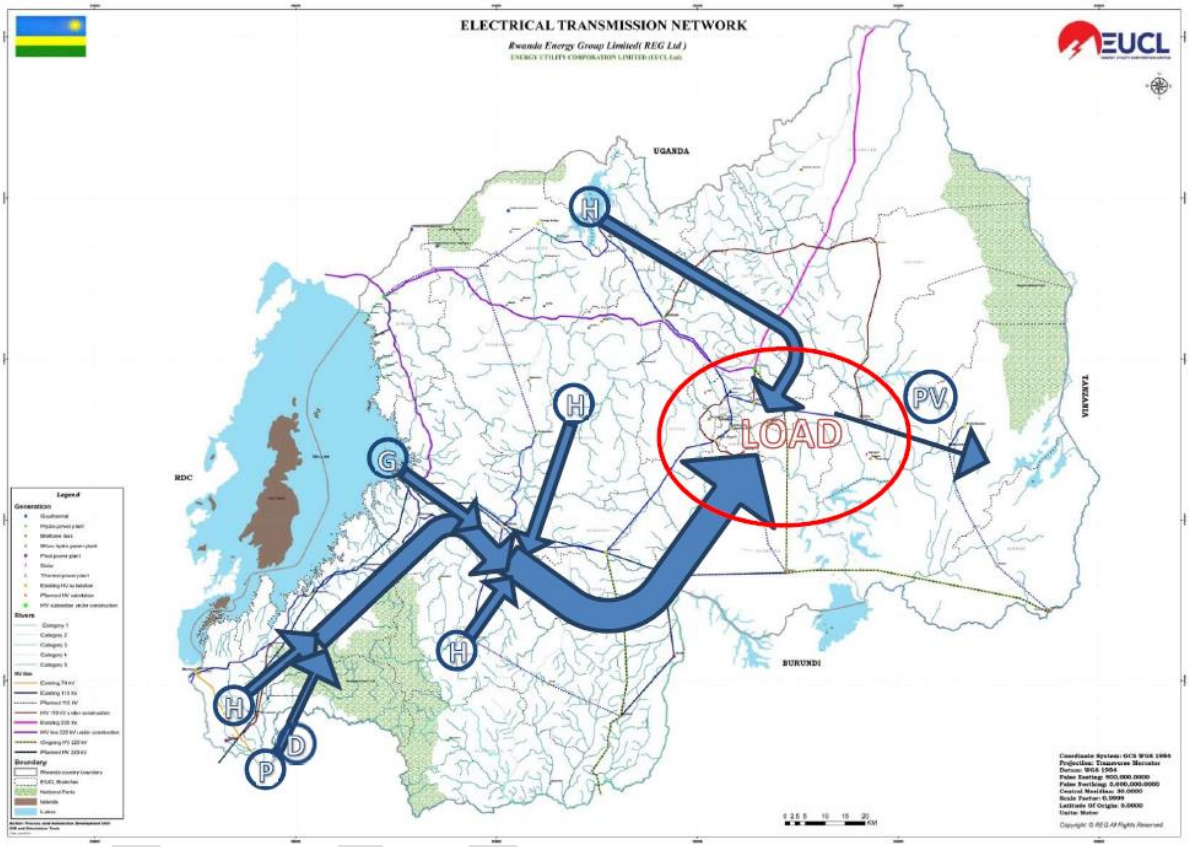


Figure 6 Main load flows

To solve the issue, the 220 kV transmission line (Bwishyura – Rubavu – Shango) from West and its associated substations was completed. Further a 220 kV ring (Bwishyura – Kigoma – Rwabusoro – Rilima – Shango – Rubavu – Bwishyura) will be completed in the coming seven years to avoid network congestion. In order to strengthen the Kigali network, a 110 kV ring network (Jabana – Gikondo – Mont Kigali – Gahanga – Ndera – Gasogi – Birembo - Gikondo) called “Kigali Ring” is under construction. This will significantly improve power reliability in Kigali.

The current performance of the distribution network (medium voltage (MV) and low voltage (LV)) across the country and within Kigali is below the standards required. This will be strengthened to ensure a reliable electricity supply, as set in RURA regulations and ESSP and NST-1 targets.

2.6.1.2.1 Regional integration

Currently, the only major inter-country power flow in the region is the export from Ethiopia to Sudan. However, a number of transmission lines are under construction between countries in the region and it is expected that by 2022 East Africa should be almost fully integrated. Further, the region will be connected to the South Africa Power Pool (SAPP) via the Tanzania-Zambia line. Figure 7 shows planned HV lines expected to be built by 2022.

Figure 7 Expected HV interconnections by 2022[12]

Rwanda is developing connections with the DRC, Burundi, Uganda and Tanzania. These connections will support network stability and enable regional trading of power.

2.6.1.2.2 Losses

All electricity systems incur losses. Losses refers to electricity injected into the transmission and distribution grids that is not paid for by users. Total losses consist of two components:

1. *Technical losses* caused mainly by electricity dissipation in system components such as transmission and distribution lines, transformers, and measurement systems
2. *Commercial losses* caused mainly by errors in accounting and record-keeping, theft and non-payment by customers

Transmission and distribution losses in Rwanda as at June 2017 were 22%, significantly higher than the international benchmark of 6% to 8%. Of this total, 17% were technical losses and 5% commercial. This was equivalent to 128 GWh in lost energy, resulting in a financial cost of $28 million. For comparison, total losses of 6% would have resulted in a financial cost of $8 million.

Table 10, below, provides the annual T&D losses, and associated costs, between 2010 and 2015. Percentage losses have moved between 20% and 23%, while GWh losses have generally increased through the period, to 129 GWh in 2015. This is due to the progressive

[12] Power Africa analysis (2017)

increase in electricity generated each year. The equivalent financial loss has also increased, reaching around $28 million in 2017[13].

Table 10 - T&D Losses in Rwanda: 2010 - 2015

Year	Total sales [GWh]	Total generated [GWh]	Losses [GWh]	Losses [%]	Cost of Losses [$]
2010	287	358	71	20	14,910,000
2011	326	416	90	22	18,900,000
2012	379	481	102	21	21,420,000
2013	391	502	111	22	23,310,000
2014	437	566	129	23	27,038,769
2015	469	596	129	21	26,789,295
Total					**132,368,064**

Even if losses are held at current levels, the financial cost to REG will increase significantly as demand grows. Figure 8 shows that if losses remain at 22%, the annual cost will increase to $102 million by 2030. The cumulative cost from 2016-2030 will be $826 million. By reducing losses by 1% each year (to 9% in 2030) the annual cost will reach $36 million in 2027 and then decline. Cumulative losses over the period will be $470 million. This is a saving of $356 million.

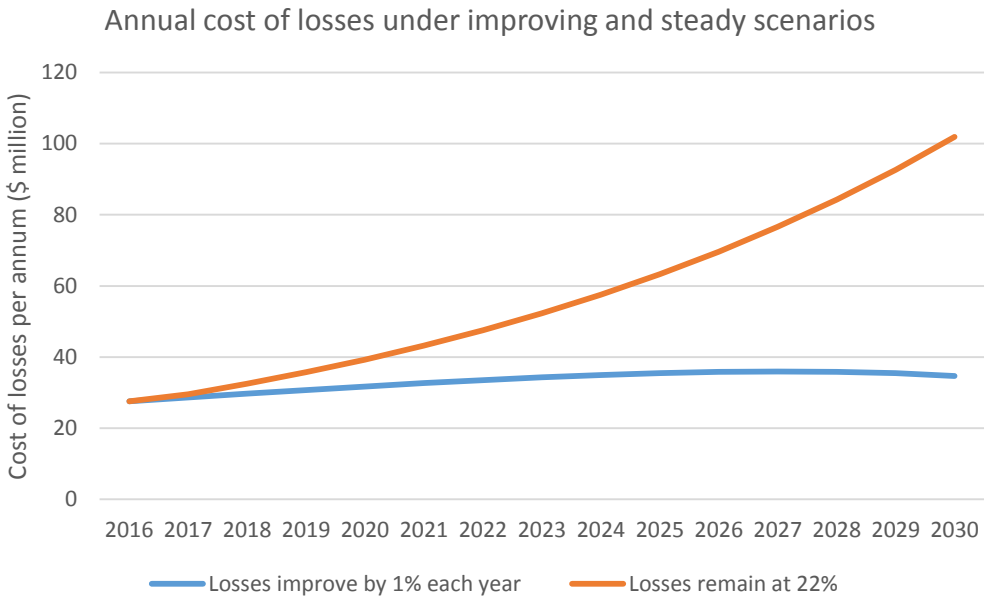


Figure 8 Annual cost of losses under improving and steady scenarios

A number of initiatives are underway. To reduce technical losses, infrastructure, such as capacitor banks and advanced metering, which can support the quantification of losses, is being installed, and transmission and distribution lines, and substations, are being upgraded. To reduce commercial losses, smart metering is being installed at large customers.

[13] REG calculations

A study, commissioned in 2017, will provide detailed data on the level of losses in Rwanda. This will inform further initiatives to be undertaken.

2.6.1.3 Access

2.6.1.3.1 On-grid access

Consumption of on-grid electricity is split between households, industry and the public sector. Households are the largest consumer category (51%), with lighting the primary use. The industrial sector is the second largest consumer of electricity (42%), with motor-drivers and lighting the main uses. Industrial consumption is dominated by a small number of major consumers which operate in cement manufacturing, mining, textiles and the agricultural sector (including tea estates). Public sector consumption of electricity (7%) is mainly for powering public buildings, street lighting and water pumping.

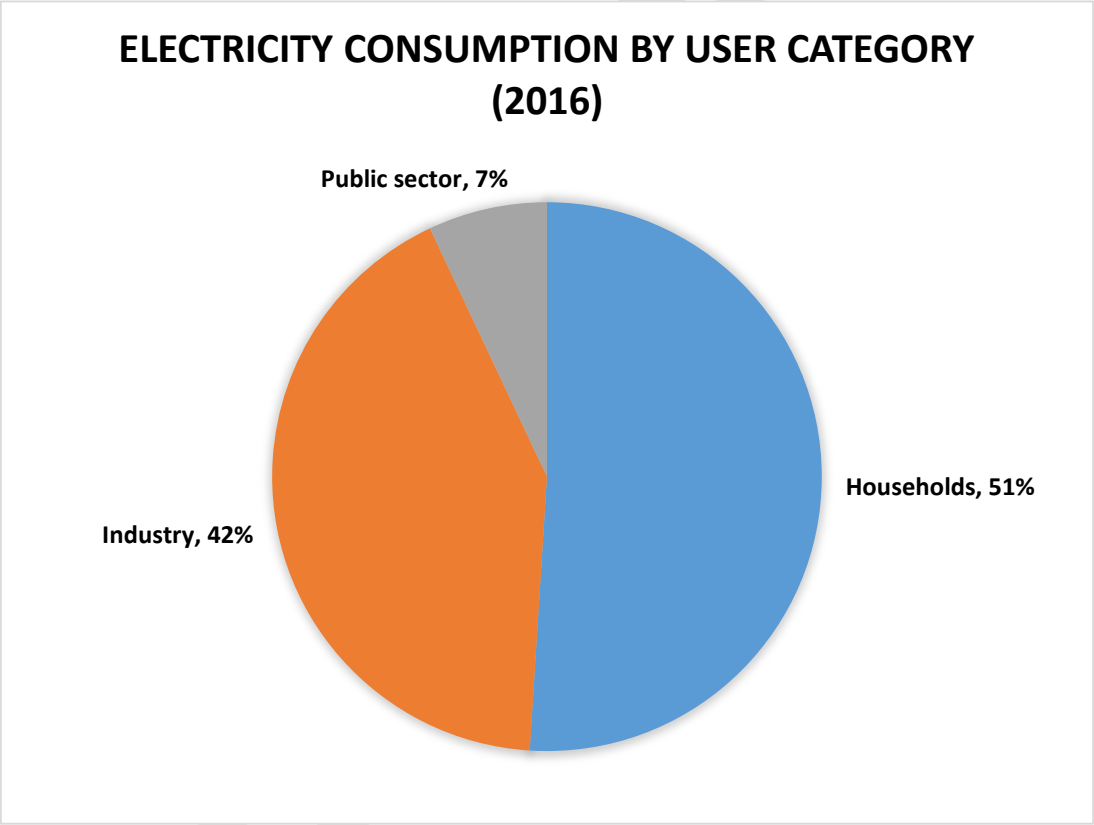


Figure 9 Electricity consumption by user category

Consumption of electricity in Rwanda is low, at 10 kWH for rural grid-connected households and 29 kWh for urban grid-connected households[14]. On-grid electricity access to households has increased significantly in recent years, from 364,000 in June 2012 to 696,952 in June 2017. This is 27.8% of all households. The low level of electricity access reflects both the previous unaffordability of electricity for many Rwandans, which has been addressed to some extent through the introduction of the life-line tariff, and the geo-spatial realities of the country. Settlements are dispersed and the mountainous geography render the infrastructure costs of grid extension projects expensive.

[14] World Bank, 'Rwanda: Energy Access Diagnostic Results Based on Multi-Tier Framework', 2017

A key driver of expanding on-grid access has been the Electricity Access Roll-out Program (EARP). The EARP was launched in 2009 by Government and development partners as the flagship initiative to meet EDPRS I access targets. Figure 10 illustrates how on-grid electricity access has increased since its introduction. In 2017 the EARP was updated to increase the speed of connections. The requirement for an up-front consumer payment was relaxed, with the cost amortised over a number of years for customers unable to pay it, and the parameters for connections were altered, with all households within 37 meters, and settlements within 500 metres, to be connected. However, the increasingly scattered nature of settlements as the grid moves across the country is acknowledged as a challenge, as is the continuing requirement for funding.

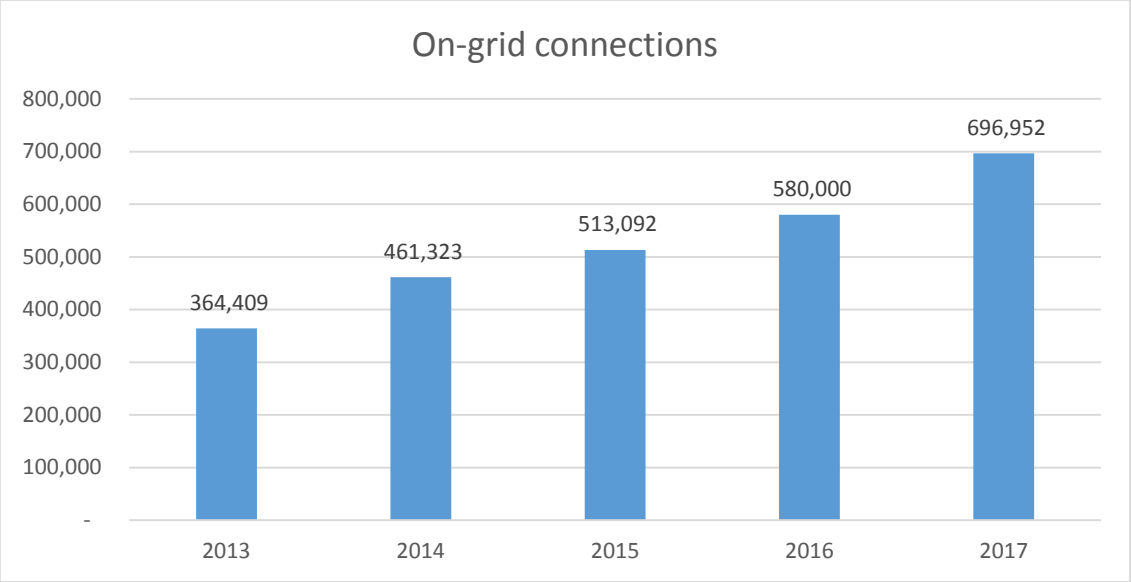


Figure 10 On-grid connection numbers

2.6.1.3.2 Off-grid access

The challenges associated with expanding on-grid access outlined above mean that off-grid electricity access is now recognised as the primary means by which access will be expanded across Africa in the short-to-medium term. In Rwanda, the development of off-grid electricity has been one of the key achievements for the electricity subsector in recent years. Off-grid access for households has grown from around 0% to 10.7%, with 283,507 households connected at June 2018.

Solar home systems (SHS) are the key technology in providing access. These systems use solar panels to generate electricity, storing it in a battery so that it can be used both during daytime and in the evening. A range of products are available at sizes and prices to suit different budgets and consumption patterns. The cost of these systems has fallen significantly in recent years, at the same time as their performance has increased. Further, the commercial structures around their sale have progressed. The previous requirement for an up-front payment ($50-$100 for a mid-sized system) made them unaffordable to many households. However, systems are now more commonly leased or sold on hire purchase, with a small monthly payment made by the consumer.

Government has supported the provision of off-grid access through the Rural Electrification Strategy (2016). This sets out four programmes:

1. Government will establish a mechanism to allow low-income households to access modern energy services through a basic solar system as a basic necessity.
2. Government will establish a risk-mitigation facility targeting the private sector such that solar products will be made available on financial terms that the population can afford.
3. Mini-grids will be developed by the private sector with Government playing a key role in identifying sites and establishing a framework through which these can become financially viable investments.
4. Government will continue to roll out the electricity network via EARP, focusing on connecting high consumption users and driving economic growth.

Programme 1 is underway, with Government supporting low-income households in accessing SHS that meet minimum technical specifications and warranty requirements. Programme 2 is also progressing, with $50 million of Scaling up Renewable Energy Program (SREP) funding being used to support higher-income households in purchasing systems. These programmes have supported the development of a thriving off-grid market. Over 20 companies are now operating in Rwanda, supplying systems to houses both through Government programmes and independently.

Detailed analysis on mini-grids has been carried out under Programme 3, both of potential economic models to make mini-grids sustainable and the identification of potential sites in Rwanda. This analysis is ongoing and mini-grids will be developed where they are economically sustainable.

Under Programme 4, the EARP continues to be rolled out. Coordinating the expansion of on- and off-grid connections is a key challenge.

2.6.1.4 Productive user access

Productive use of electricity involves the utilisation of electricity for activities that enhance economic and social welfare. These activities cover a range of sectors, as summarised in Table 11. Beyond supporting economic and social development, connecting productive users increases the financial sustainability of the sector, as they use electricity away from the evening peak (when it is cheaper to supply) and use sufficient electricity to more than cover the cost of their connection (unlike households which may use little electricity).

Table 11 Summary of productive user categories

Public infrastructure	Schools	Health Facility	Markets	Administrative offices	Mining and quarry areas	Industries	Small industries
Airport and aerodrome	Preprimary	Hospitals	Markets	Province	Mining	Beverages	Food Processing
IDP Model Villages	Primary	Health Centers		District		Cement	Coffee Washing Stations
Water Pumping Station	Secondary	Health post		Sector		Chemicals/ rubber/ plastics	Milk Collection Centers
	Technical Schools			Cell		Furniture and Printing	Integrated craft production centers
	University					Tea Factory	
						Textiles/ clothing	
						Industrial parks	

REG recently undertook an assessment of the connection status of productive users across Rwanda. Data from recent studies and surveys was used as the basis, with further information requested from national and local Government institutions and checked by local REG branches. Collated information was plotted using GIS, with required low- and medium voltage extension requirements identified.

Out of 8,855 productive users identified, 2,733 (31%) do not have an electricity connection. Of the 69% that are connected, 6,100 have on-grid connections and only 22 off-grid. A summary of these results is presented in Table 12.

Table 12 Summary of productive user connections

	Total	Proportion of total
Productive users	8,855	
Non-electrified productive users	2,421	27.4%
Grid-connected	6,412	72.6%
Off-grid (solar) connected	22	0%
Total connected	6,434	72.6%

2.6.1.5 Electricity tariff

The electricity tariff was reviewed in 2016, with a new tariff regime put in place from January 2017. A number of important changes were made:

- **Customer types have been disaggregated**. Industrial customers are categorised based on voltage levels into small (including water treatment plants, water pumping stations and telecom towers), medium (0.4 kV<V≤ 15 kV) and large (15 kV<V≤ 33 kV). Low-voltage customers are split into Residential and Non-Residential. This is

efficient, as voltage is the main underlying determinant of the economic cost of service provision. Medium-voltage customers are charged based on kVA, which includes active and reactive power. This ensures all costs incurred are covered by the tariff paid.

- **Progressive rates have been introduced** for Residential and Non-Residential consumers. A 'life-line' tariff for low-income (low consumption) households has been introduced, with the price of electricity up to 15 kWh per month reduced to RWF 89 per kWh (a reduction of 51%). The price then increases to RWF 182 per kWh up to 50 kWh per month and RWF 189 per kWh after that.
- **Three categories of charges are now in place for medium-voltage customers**. The energy charge is the total kWh consumed multiplied by the relevant kWh price, the customer service charge is a flat rate multiplied by the number of customers (connections) and the demand charge is the highest half-hourly rate of demand recorded in a month multiplied by a charge that changes depending on when the period of highest use occurred. The highest demand charges are in place over the evening peak. Therefore energy-intensive users are encouraged to move demand away from the evening peak and to flatten their demand profile. In simplistic terms, energy charges cover the variable costs of the energy consumed, whereas demand charges cover the fixed costs in capacity required to serve that rate of consumption.
- **A commitment to continually review the tariff was made**. RURA will monitor the tariff to ensure it is driving the intended consumer behaviours, meeting consumer needs and contributing to improved financial performance in the sector.

The changes had four objectives:

i. Improve the financial performance of REG
ii. Increase the affordability of electricity for low-income households
iii. Increase the competitiveness of industry
iv. Reduce peak demand

However, the high cost of generation means that the tariff is not cost reflective and significant Government subsidies are still required. Over 80% of the costs incurred by REG come from fuel and PPAs. The costly use of diesel away from the evening peak is a major factor in this. Also, rapidly expanding generation capacity to meet demand has resulted in high-cost generation. Future capacity additions will place greater emphasis on costs. Although the gap has reduced, the cost of electricity remains higher than the regional and sub-Saharan averages.

2.6.1.6 Energy Efficiency

2.6.1.6.1 Programmes undertaken

A small number of energy efficiency programs have been continued or undertaken since 2014. These include:

- **Compact Fluorescent Lights (CFL):** Supported by Government subsidy, REG distributed 800,000 CFLs in place of incandescent light bulbs between 2007 and 2014. To further support this initiative, an exemption of VAT on energy saving lamps was introduced in 2013. Benefits of this included a reduction in annual energy

demand of 54 GWh and $11 million in savings for consumers. Further, carbon revenue of around $8,000,000 million is expected by the end of 2017.

- **'SolaRwanda' Solar Water Heaters (SWH):** A major ongoing initiative is the SolaRwanda Solar Water Heater Program, which promotes the use of solar water heaters, with the aim of reducing the use of electricity from the grid for water heating. The program was initiated in 2009 with the support of development partners and was formally launched in March 2012 with a pilot phase of 100 SWHs. Loans and grants are used to subsidise the cost of purchasing a SWH. Implementation commenced in April 2013 and a total of 2,256 SWHs have been installed.
- **Street Lighting:** A pilot project was implemented by the City of Kigali to replace high-pressure sodium (HPS) lamps with LEDs in street lights. This led to a 60% reduction of power consumption from the baseline level. The financial savings or payback of the program will be analysed to inform future initiatives.
- **Loss Reduction**: REG is currently improving efficiency in two key areas. First, a program is in place to reduce network losses, which are currently 22%. Technical losses require additional generation to be undertaken, with negative environmental and financial impacts. Commercial losses reduce REG's revenues, reducing its ability to invest. Second, the network is being expanded and strengthened. Significant investment is being made to upgrade the network around Kigali, which carries serves over half of Rwanda's demand. Improving the reliability and performance of the network will reduce the use of expensive, polluting diesel generators.

2.6.1.6.2 Energy Efficiency Strategy

An Energy Efficiency Strategy was developed through 2017. This assesses the potential for energy efficiency in Rwanda across the electricity value chain, from generation, through transmission and distribution to end-user demand. The Strategy proposes a number of initiatives to be implemented, and these will be taken forward over the coming years.

2.7 Biomass energy subsector

2.7.1 Land use

Rwanda has a forested[15] area of approximately 600,000 hectares which is about 22% of the country's land area, as shown in Table 7. These forest resources comprise of 260,000 ha of natural forests and 340,000 ha public and private plantations (productive forests). Natural forests are mainly composed of protected forest areas consisting of Nyungwe National Park in the southwest and Volcano National Park in the northwest. Other national reserves include the forests of Gishwati and Mukura, the savannah and gallery forest of the Akagera National Park and remnants of gallery forests and savannas of Bugesera, Gisaka and Umutara.

[15] Based on FAO's definition of a forest. This excludes agroforestry, a common land use practice in Rwanda.

Table 13 Land use in Rwanda by classification

Land use	Area (ha)	%
Forest	600,000	22
Agriculture	1,612,068	58
Built up areas	100,000	4
Water bodies	176,050	6
Wetlands	278,536	10
Total	**2,766,000**	**100**

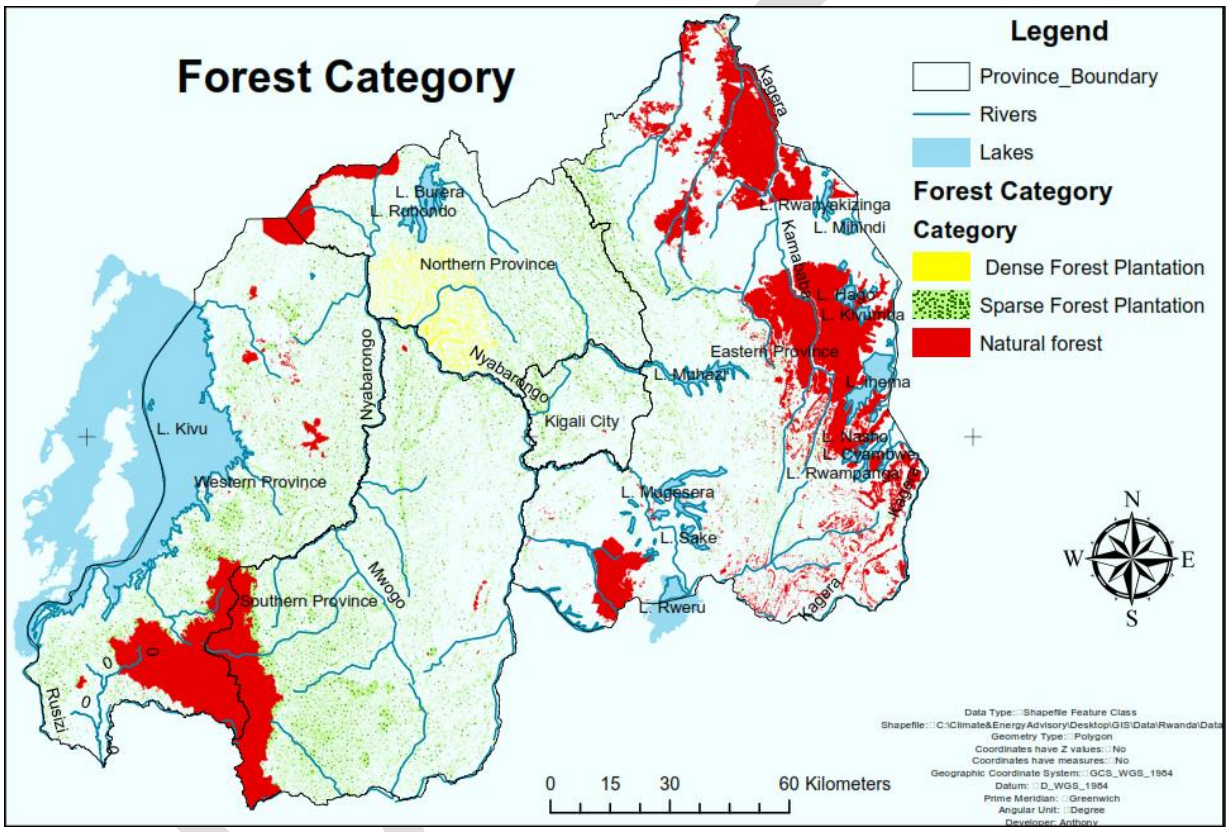


Figure 11 Location and categorisation of forests in Rwanda

In 2015, the Rwanda Natural Resources Authority (RNRA) commissioned a National Forest Inventory (NFI) to provide quantitative and qualitative information on the wood resources of Rwanda. According to the NFI data, the country has 2,102,508 hectares of forest resources. Most of the forest resources are located in the Eastern, South and Western provinces. At a national level, the following the total amount of forest resources available for energy wood use according to the NFI (2015) is 8.9 million m^3 as shown in the table below.

Table 14 Forest resources available for energy wood use (2015)

Category	Area	Volume of energy wood per hectare (cc/ha)	Total volume available for energy wood (m^3)
Trees Inside Forest (TIF) in Productive Forests	257,624	11.57	2,980,710
Trees Outside Forest (TOFs) in Shrubland (incl. Wooded Savannah)	142,730	4.99	712,224
Trees Outside Forest (TOFo) on Agroforestry (incl. Agriculture)	1,503,377	3.52	5,291,887
Total			8,984,822

Data source: NFI, 2015

There is additional biomass resources available in form of total harvestable residue amounting to about 1,375,000 m³ and 1,117,000 MT from agricultural residues.

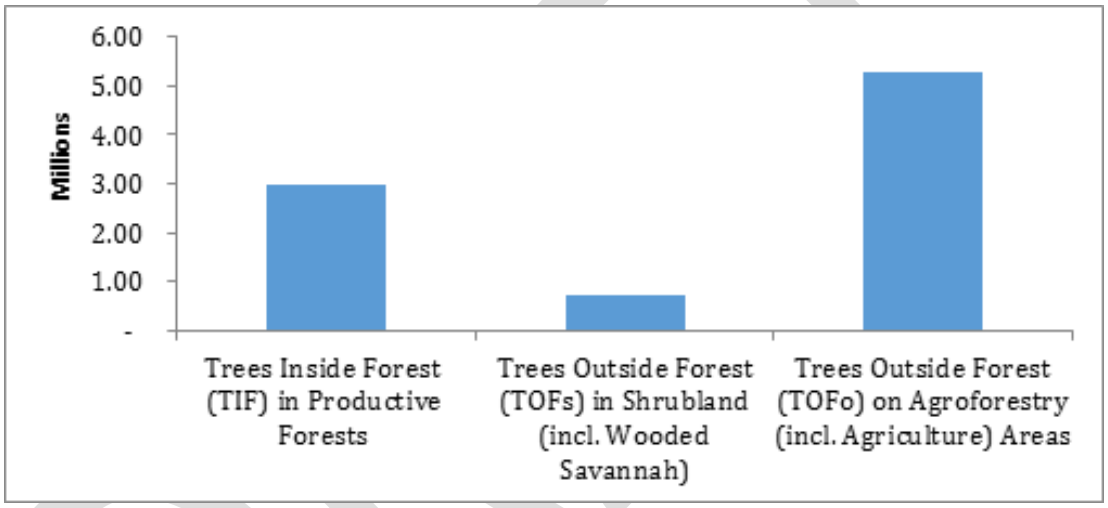


Figure 12 Forest resources available for biomass energy use

2.7.2 Consumption of biomass

At 85%, biomass energy is the most important source of energy in Rwanda. Households use 91% of biomass, with the remaining consumption shared between industry (4%), non-energy usage (2%) and commercial and the public sector (both 1%). Industrial use is largely in tea industries and small-scale brick making, with biomass used for drying.

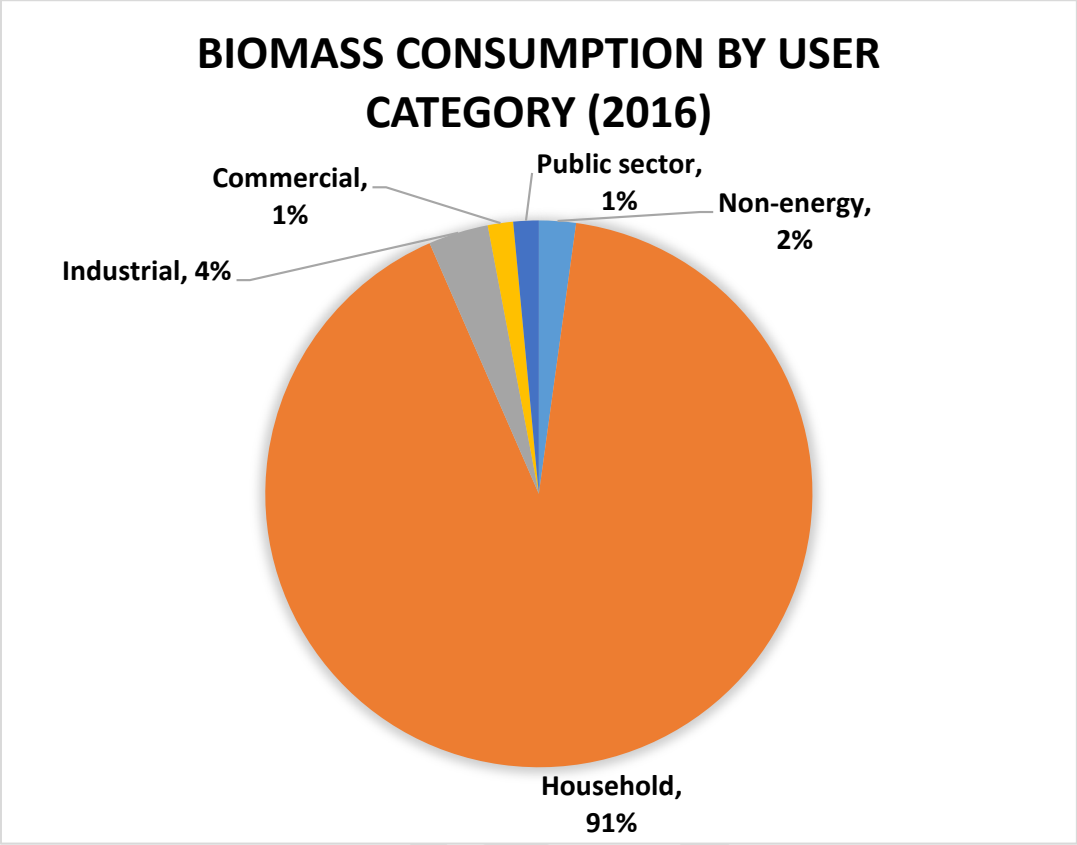


Figure 13 Biomass consumption by user category

Based on a review of recent data, five key market segments have been defined for biomass energy usage for cooking, heating and drying processes in Rwanda: Household sector (Rural and Urban), Commercial food industry, Public institutions and Processing and Production sectors.

Table 15 Main biomass market segments

Segment	User Types
1. Rural Households	Rural consumers who rely mostly on firewood for cooking and heating purposes
2. Urban Households	Urban consumers who rely heavily on charcoal for cooking and heating purposes
3. Commercial food industry	Hotels, bakeries and restaurants who rely on charcoal and firewood for cooking
4. Public institutions	Schools, prisons, military, refugee camps relying on charcoal and firewood for cooking purposed
5. Processing and Production sector	Tea factories utilise firewood for tea curing, and brick making processes utilise firewood for brick making

A national survey showed that 83.3% of households use firewood for their cooking needs. The use of firewood by rural households is an attractive option as it is freely available to most households. In urban areas, charcoal is the preferred fuel. This is due to its long-life storage and relatively low-cost transportation, given its smaller volume and weight compared to firewood. Experience across Africa suggests that demand for charcoal will

increase rapidly with urbanisation trends. Households will first use it as a complementary fuel to firewood but gradually shift entirely as it is more convenient.

Alternatives such as LPG and electricity are currently expensive, with a recent Multi-Tier Framework survey showing that they are used by only 0.5% of households. However, pay-as-you-go LPG is increasingly being offered by private companies. This model removes a significant barrier to LPG uptake by removing the requirement to purchase a canister and fuel up front. Customers pay a canister deposit and then use their mobile phone to pre-pay for LPG as they require it. Purchasing LPG in this way can result in lower costs than for charcoal. This approach follows the successful expansion of off-grid electricity access seen in recent years. Similar business models are in place for pellets, with consumers agreeing to purchase a set number of pellets from a supplier, with a high-efficiency stove provided for no initial cost.

Biogas, which requires the user to have access to domestic animals such as cows and pigs, is another potential alternative. The 2007 National Domestic Biogas programme supported the use of biogas, targeting 9,500 rural households with at least two cows. Since 2007, around 3,700 digesters, based on standard construction design using local materials, have been disseminated. The government provided a 50% subsidy and the remaining provided through local credit institutions. However, recent site visits suggest that use of biogas digesters is limited, with users citing unreliability and insufficient fuel. At the institutional level, there have been 68 installations, with 11 out of 14 prisons reached and the remaining 3 under development.

Reducing reliance on firewood, and in doing so improving health, developing economic opportunities by reducing the time spent collecting wood, and preserving the country's forests is a priority for Government.

2.7.3 Improved cooking technologies

As well as the fuel used, the type of stove has a significant impact on the amount of fuel required and health of households. Most households (66%) use three-stone cookstoves (the most simple cookstove, made by placing a pot on three stones, which are positioned around a fire) or traditional cooking stoves. These are normally used with firewood. The average household uses around 1.8 tonnes of firewood each year to satisfy its cooking needs with this type of cookstove. The average monthly consumption per household on firewood is RWF 1,930 ($2.27).

A Government programme to support the use of improved cooking technologies has been running since the 1980s with 30% household penetration. Private sector led efforts are also distributing cook stoves that are up to three times more efficient than the traditional 3-stone stove and can reduce biomass consumption by anywhere between 68-94%[16]. This will free up the time spent by women and children in collecting firewood, giving them more time to study and undertake more productive commercial activities

A simple comparison of cookstove types is presented in Figure 14.

[16] Inyenyeri Promotion Material, 2014

Combustion technologies	3-stone fires	Improved stoves (first generation)	Improved stoves (second generation)	Stoves of high efficiency
				
Efficiency	8 to 12%	20 to 25%	25 to 35%	>35%
Particulate matter per m^3	2,800 ppm	1,700 ppm	<1,000 ppm	< 250 ppm
Energy type	Thermal energy	Thermal energy	Thermal energy, electric energy	Thermal energy, electric energy, chemical energy
Conversion type	Combustion	Combustion	Combustion, gasification	Combustion, gasification, liquefaction

Figure 14 : GACC tier-based performance standards for cook-stoves

Source: (The World Bank, 2012)

2.8 Petroleum subsector

2.8.1 Petroleum supply and demand

Rwanda currently relies on imports of petroleum fuels from international sources through the Northern Corridor (the port of Mombasa in Kenya) for 7.1% of imports and the Central Corridor (the port of Dar-es-Salaam in Tanzania) for 92.9% of imports. Currently, the Dar-es-Salaam port is preferred due to cheaper transport costs, faster loading capacity and the payment flexibility of the Bulk Procurement System (BPS) unlike the Open tendering System (OTS) in Kenya.

Official petroleum products demand projections are contained in the Downstream Petroleum Policy (2012), which forecasts annual growth of 12% from 2012 up to 2020. However, actual growth has been lower than this. Current projections assume an annual 8% increase in demand, as shown in Table 16. It is this forecast that gives a requirement of 198 million litres in reserve by 2024. Current fuel consumption is around 38 million litres per month. The regular review and update of consumption and forecast figures is a required area of improvement for the petroleum subsector.

Table 16 Petroleum products demand projections[17]

Year	Projected Fuel demand in m^3 (8% annual increase)	Monthly Average
2012	258,291	21,524
2015	362,880	30,240
2017	461,880	38,490
2018	498,830	41,569
2019	538,737	44,894
2020	581,836	48,486
2021	628,383	52,365
2022	678,653	56,554
2023	732,946	61,078
2024	791,581	65,965

RURA has taken over regulatory responsibilities for petroleum from MINICOM and MININFRA is responsible for the development of petroleum strategic reserves. A Downstream Petroleum Law[18] is in place. This permits development of an appropriate regulatory and institutional framework. The market players are largely private companies which import products for distribution, mainly through retail outlets. Reflecting the significant increase in demand, the number of such entities has increased to over 40 from 20 at the time of the previous ESSP.

The key demand segments for petroleum products are road transportation, thermal power generation and aviation. The reduction of imported diesel for electricity production will be more than off-set by the increased need for petroleum products in transportation, particularly aviation and heavy industry, and also increased re-exports. For example, more

[17] 2012 and 2015 figures from MININFRA, 'Brief on National Petroleum Storage', (2016). 2017 figures from Rwanda Revenue Authority.

[18] Law N° 85/2013 of 11/09/2013.

transport vehicles on the road and expansion of air traffic at Kigali International airport will contribute to rising demand for petroleum products.

As illustrated in Table 17, diesel and petrol are the dominant petroleum product imports, where diesel is being mainly used in the generation of electricity whilst petroleum products are used in transport.

Table 17 Petroleum products importation (Litres) – 2011/12

Product	Annual consumptions (litres)
Petrol	91,668,658
Diesel	127,122,598
Illuminating kerosene	15,300,848
Heavy fuel oils	37,001,988
JET A-1	1,584,645
TOTAL	**272,678,737**

The demand for petroleum products is forecast to grow at rates commensurate with GDP growth each year[19] between now and 2020, but will not be evenly distributed:

1) **Diesel imports** will gradually decline as new (non-diesel) generation projects are brought online and diesel units are converted to run on gas (which is more efficient).
2) **Aviation fuel** demand is expected to grow at a significantly higher rate, as Rwanda is positioned to be a preferred hub for air transportation in the region, with a new airport at Bugesera being developed.

2.8.2 Upstream petroleum sub-sector

Upstream relates to the exploration and production of petroleum, along with the supporting infrastructure to undertake these activities, and is the responsibility of MINIRENA and RMB. The National Petroleum Exploration and Production Policy, which was developed and adopted by Cabinet in 2013, is being implemented. It addresses key issues of exploration and development, licensing, institutional and regulatory frameworks. The upstream policy provides Rwanda with long-term policy clarity and the proper regulatory and institutional set-up, along with incentives for investors.

In particular, strategies and policies have been developed covering:

- Preliminary Exploration work
- Development of the Legal and Regulatory Framework
- Petroleum sharing agreement on Lake Kivu
- Upstream petroleum policy issues and recommendations

In 2016, a law governing Petroleum Exploration and Production was passed. Under this law, an exploration license is valid for three years while a production investor is given a license valid for up to 25 years. The law now provides that Government holds the majority share of petroleum exploitation proceeds and has the power to regularly assess progress.

[19] Kurrent Technologies, 'Final Report on Developing a Rwandan Downstream Petroleum Strategy', 2014

The amount of petroleum in the Lake Kivu belt is not known, but it is believed that all Great Lakes regional countries share a significant base for petroleum deposits. An EAC report from 2016 detailed discoveries of 2.3 billion barrels of recoverable oil in Uganda and Kenya, and more than 50 trillion cubic feet of natural gas in Tanzania. Significant deposits are also anticipated in Rwanda, as well as Burundi. Confirming and commencing development of the Lake Kivu oil reserves will be a priority for the subsector through the ESSP period.

2.8.3 Downstream petroleum subsector

Rwanda has no domestic production of natural gas. The country relies on imported gas, especially LPG. There are currently 11 importers operating, with the top five being Société Pétrolière-SP (42%), Kobil (22%), Merez (9%), Mohamed Hashim (8%) and Sulfo (5%)[20]. All LPG is imported by road tankers of 10-20 metric tons through either Kenya or Tanzania. Retail distribution is done through service stations, independent distributors, and supermarkets in an assortment of cylinder sizes ranging from 1 kg to 50 kg. Tanks for non-retail use range from 100 kg to 5 tons.

LPG consumption has increased by over 50% since 2012. All LPG sold on the Rwandan market is imported from Kenya and Tanzania, independently stored in tanks by each importer, and either filled in cylinders for distribution or imported in filled cylinders and directly distributed to retailers. Although consumption of LPG at the household level remains low relative to other fuels, progress is being made, with an increasing number of suppliers operating in urban and peri-urban areas. However, at the institutional level demand is still low. REG is currently assessing entry into this market through installing filling plants and delivering LPG to institutions.

RURA in its mandate to regulate the downstream petroleum sub sector adopted LPG regulations in 2012 and commenced granting LPG business and installation licenses. These regulations were updated in 2017. Revisions were made to add new provisions that will remove gaps and resolve problems relating to their technical, legal and economic aspects.

Table 18 shows the capacities of Government and private depots including airport aviation fuel storage. The total storage capacity is insufficient for efficient commercial storage and distribution resulting in heavy delays in trucks offloading. Further, the storage capacity is inadequate to provide the minimum strategic storage for two months (60 days) commercial stocks as required by the National Energy Policy (and that minimum is increased to 90 days in this ESSP).

[20] Figures from RRA

Table 18 Petroleum storage capacity

Product	Petroleum Storage Capacity in M^3							
	Government Owned					**Private Owned**		
	Gatsata	Kabuye (ERP)	Rwabuye	Bigogwe	Kigali Airport	Rusororo (SP)	Jabana (OILCOM)	**Total**
Gasoline (PMS)	6,600	3,000	1,800	3,000	-	10,000	7,200	**31,600**
Gas Oil (Diesel)	4,800	2,100	1,800	2,000	-	10,000	14,400	**35,100**
Kerosene	1,500	-	-	-	-	-		**1,500**
Fuel Oil	1,900	600	-	-	-	-		**2,500**
Jet A-1	-	-	-	-	1,500	2,000	-	**3,500**
Total	**14,800**	**5,700**	**3,600**	**5,000**	**1,500**	**22,000**	**21,600**	**74,200**

A significant development in the subsector is the 60 million litre National Strategic Stocks project, which was announced by MININFRA in 2015. The tender was awarded to SP Ltd through an international competitive tendering process by REG Ltd under a build, operate and transfer model. So far, 22 million litres of capacity has been built, with the remainder under construction.

2.9 Institutional Overview

A number of institutions contribute to the development and operation of the energy sector.

2.9.1.1 REG, EDCL and EUCL

Since the late 1990s the utility has undergone a number of changes:

- ELECTROGAZ lost its monopoly power by a law enacted in 1999.
- It was placed under a management contract with Lahmayer International in 2003. This ended in 2006, when the company management reverted to the Government.
- It was split into the Rwanda Energy Corporation (RECO) and the Rwanda Water and Sewerage Corporation (RWASCO) in 2008.
- These two entities were integrated in 2011 and the Energy and Water and Sanitation Authority (EWSA) was created.
- EWSA was split into two corporations Rwanda Energy Group Ltd (REG Ltd) and Water and Sanitation Corporation Ltd (WASAC Ltd), focused on service delivery of energy and power and water and sanitation, respectively, in 2014.

The creation of REG Ltd was intended to address key problems in the sector. These included a lack of focus on planning and investment, low operational performance and transparency and a lack of autonomy over delivery. A key strategic aim of the restructure to REG Ltd was to 'corporatize' its governance structures to inject more autonomy and accountability in management decision-making and to streamline its processes with the support of state-of-the-art modern management information systems.

REG Ltd now operates as the holding company over Energy Utility Corporation Limited (EUCL) and Energy Development Corporation Limited (EDCL).

Rwanda Energy Group Ltd (REG Ltd): REG Ltd sits above EUCL and EDCL. It monitors and evaluates the operations and performance of the two subsidiaries and provides senior leadership. REG is the highest corporate entity of the utility and as such reports to shareholders (MININFRA and MINECOFIN).

REG Ltd is ultimately responsible for delivering the entity's vision and mission:

- Vision: To be the leading regional provider of innovative and sustainable energy solutions for national development
- Mission: Developing and providing reliable and affordable energy while creating value for our stakeholders

Energy Utility Corporation Limited (EUCL): EUCL is in charge of day-to-day operations of power generation, transmission, distribution and sales to final customers. EUCL is responsible for planning the transmission and distribution grid in areas already reached by electrification and promoting energy efficiency and demand side management programmes. Key objectives for EUCL include cost reductions, technical and non-technical loss reductions, improving customer satisfaction and the economic dispatch of generation to meet demand.

Energy Development Corporation Limited (EDCL): EDCL is responsible for developing both generation and transmission projects, exploiting new energy resources, and executing a least cost power development plant. Its core objective is to facilitate the development and exploitation of domestic energy resources and investments. In pursuing this objective, it has autonomy in managing its affairs, but regularly reports to MININFRA on progress towards set targets. Specifically, EDCL:

- Collaborates with MININFRA in conducting all activities necessary to explore and assess the country's indigenous resource base;
- Collaborates with MININFRA and RDB to reduce the risk profile of energy projects to a level acceptable to the private sector;
- Executes generation and transmission and distribution projects necessary to expand on-grid assets to new areas. are handed over to EUCL once commissioned;
- Defines and updates the overall power system master plan, and a least cost power development plan;
- Negotiates along with MININFRA long-term electricity import agreements with neighbouring countries.

2.9.1.2 Ministries and Government Institutions

Ministry of Infrastructure (MININFRA): The Ministry of Infrastructure (MININFRA) is the lead Ministry responsible for developing energy policies and strategies, and for monitoring and evaluating projects and program implementation. It is in charge of setting an enabling policy and legal framework for the sector, including a suggested general approach to the optimal use of state subsidies in the sector, budget preparation, resource mobilization (together with MINECOFIN), and political oversight over Government programs designed to expand energy access and service provision. With regards to petroleum, it is in charge of developing and managing petroleum related infrastructure. MININFRA's specific energy responsibilities were set out in a February 2015 Prime Minister's Order:

1. Formulate and disseminate policies, strategies and programs in the field of energy
2. Draft laws and issue instructions in the energy sector
3. Develop institutional and human resource capacities in the energy sector
4. Support energy development programs under the decentralised entities
5. Monitor and evaluate the implementation of national energy policies, strategies, programs and projects
6. Oversee the institutions under its supervision
7. Mobilise resources for energy sector activities

Ministry of Trade and Industry (MINICOM): MINICOM drives trade and private sector engagement. Impacts the energy sector through developing large-scale demand projects, such as Special Economic Zones. MINICOM is responsible for the development and oversight of the petroleum subsector, including implementation of the downstream petroleum policy, establishing and developing petroleum-related legislation, setting the strategic reserve requirement, and creating an enabling environment for petroleum products trade in line with the national energy policy objectives. MINICOM acts as a coordinating body for EAC and Rwandan priorities within EAC Protocols, Treaties and Strategies. MINICOM follows commitments signed by Rwanda on energy projects and ensures Rwanda and Partner States deliver on them. The Ministry advocates on energy-related Government positions and interests in regional meetings and forums.

Ministry of Finance and Economic Planning (MINECOFIN): The Ministry of Finance and Economic Planning leads on resource mobilization to support energy investment and related financing requirements. MINECOFIN ensures the fiduciary framework to manage grants, loans, and other concessional finance from development partners into the sector.

Ministry of Natural Resources (MINIRENA): The Ministry of Natural resources is responsible for ensuring the sustainability of natural resources exploitation, including water extraction, and for developing and managing compliance to the national environment policy and law. MINIRENA is in charge of developing and implementing policies on petroleum exploration and development until the point of resource extraction.

Ministry of Education (MINEDUC): The Ministry of Education and its affiliated research agencies (NIRDA and NCST), plays a role in the energy sector by building the competency and human resources base for sector development and by helping to link sector policies and strategies to research, technology development, and innovation. MINEDUC ensures that TVETs address skill shortages in the sector, including jobs related to electrical engineering and renewable energy technology installation and maintenance.

Ministry of Local Government (MINALOC): Local Governments have the authority and mandate to coordinate the implementation of discrete enabling policies to drive local economic transformation. Districts are responsible for maintaining the District's infrastructure. Specifically, they have direct responsibility for all decentralized service delivery, including those that may be related to energy at the grassroots (such as ICS, Biogas and many more). This includes national programs to scale up sustainable energy consumption currently being implemented by the electricity utility targeting communities.

Rwanda Development Board (RDB): Rwanda Development Board plays the lead role in investment mobilization and promotion for the energy sector, acting as a gateway and facilitator. It actively promotes private investor participation in the energy sector, including

local financial institutions. It leads on facilitation of foreign direct investment (FDI) into strategic energy generation projects, as well as other programs and activities involving cleaner, more energy-efficient technologies. RDB also issues Environmental Impact Assessments for all energy projects for which one is required. It is expect to also host a centralized authority or advisory agency for PPPs across Government.

Rwanda Utilities Regulatory Authority (RURA): The scope of its mandate extends to public utilities involved in renewable and non-renewable energy, electricity, industrial gases, pipelines and storage facilities, and conventional gas extraction and distribution. As the regulator, RURA's principal mandate is to ensure consumer protection from uncompetitive practices while ensuring that such utilities operate in an efficient, sustainable, and reliable manner. RURA also has the important role of updating the electric grid code, ensuring quality of service standards for power, assessing and reviewing energy tariff structures, licensing all power generation, transmission, and distribution companies as well as retail petroleum filling stations and related storage facilities.

National Industrial Research Development Authority (NIRDA): Its scope will evolve around continuous research on energy mix to feed the growing industries and will also provide the necessary information after thorough research on which industries employ clean efficient energy needs.

Rwanda Environment Management Authority (REMA): REMA has the mandate to coordinate, oversee and implement environmental policy. Generally speaking, all infrastructure development is subject to environmental impact assessment. REMA is mandated to enforce environmental compliance in the development of energy resources.

Rwanda Standards Board (RSB): RSB develops national technical regulations including national technology and performance standards. RSB plays an increasingly important role in establishing, publishing, and disseminating national standards for energy technologies such as biogas digesters and solar appliances.

National Commission of Science and Technology (NCST): NCST, with aid from higher institutions of learning, will continue to oversee the scientific tools and provide modern necessary technology to be employed in the energy sector.

2.9.1.3 Development partners

The energy sector is supported by a number of development partners. These are both national and MFIs. Support is provided through funding – both sector support and for specific programs and initiatives – and the provision of technical assistance.

2.9.1.4 Private sector

The private sector is being encouraged to play an increasing role in the energy sector. Power Purchase Agreements (PPA) have been signed with a number of independent power producers (IPPs), the expansion of off-grid access is being driven by private companies, petroleum storage facilities are being built by private companies and private companies will be central in delivering alternative cooking fuels to firewood. More generally, the private sector can provide capital and operational and management capacity, drive competition and innovation and reduce the burden on Government.

3 The Strategic Framework

Chapter outline

This chapter provides an overview of the key measures and instruments that will be deployed to deliver the HLTOs of this ESSP.

3.1 Vision, Mission and Objectives

3.1.1 Vision of the sector

The vision of the energy sector is to contribute effectively to the growth of the national economy and thereby improve the standard of living for the entire nation in a sustainable and environmentally sound manner.

3.1.2 Mission of the sector

The mission of the Rwanda energy sector is to create conditions for the provision of sufficient, safe, reliable, efficient, cost-effective and environmentally appropriate energy services to households and to all economic sectors on a sustainable basis.

3.1.3 Overall objectives of the sector

The overall goal of the sector, as set out in the REP, is to ensure that all residents and industries can access energy products and services that are sufficient, reliable, affordable, and sustainable. Specific core global objectives of the REP include:

- ensuring the availability of sufficient, reliable and affordable energy supplies for all Rwandans;
- creating an enabling environment for increased private sector participation in energy supply and service provision;
- encouraging and incentivizing more rational, efficient use of energy in public institutions, and amongst industrial and household end-users;
- ensuring the sustainability of energy exploration, extraction, supply, and consumption so as to prevent damage to the environment and habitats;
- promoting safe, efficient, and competitive production, procurement, transportation, and distribution of energy; and
- developing the requisite institutional, organizational, and human capacity to increase accountability, transparency, national ownership and decentralized implementation capacity for sustainable energy service delivery.

Collaborating with the private sector, the Government will also work towards meeting national, regional, and global targets to enhance access to modern energy services. Rwanda is a signatory to the United Nations Sustainable Energy for All Initiative (SE4ALL) and the Regional Strategy on Scaling up Access to Modern Energy Services adopted by the EAC Council of Ministers. In order to increase access, electricity and clean fuels must be available and affordable. For this reason, policies aim to create a sound enabling environment for:

- off-grid energy service provision including the development of distributed, small-scale renewable energy solutions and business models; and
- clean fuels energy service provision, including the development of infrastructure and distribution for LPG and biogas.

3.2 Energy Sector Priorities and Targets for National Strategy for Transformation

The starting point for deciding the HLTOs included in this ESSP were the sector priorities. Table 19 maps the HLTOs presented in this ESSP against the sector priorities.

Table 19 Sector priorities and ESSP HLTOs

	Priority	HLTOs
1	Support continued economic development and growth in household electricity access through least-cost expansion of electricity generation capacity.	Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained.
2	Improve industrial competitiveness through increased reliability of electricity supply.	Reliability of electricity supply improved: average number of power interruptions per year reduced to 91.7 and average number of hours without power to 14.2.
3	Improve the health, well-being and economic opportunities available to Rwandans through increased household access to electricity.	Household access to electricity increased to 100%.
4	Improve public service provision and support economic development through increased productive user access to electricity.	Productive user access to electricity increased to 100%.
5	Increase safety of communities and support 24-hour service delivery through expansion of street lighting.	Street lighting expanded to all populated areas and main roads.
6	Reduce sector costs and environmental impacts through improved efficiency in the use of resources.	Losses in the transmission and distribution networks reduced to 15%.
7	Improve the health of Rwandans and promote the efficient use of forests through reduced reliance on inefficient cooking fuels and technologies.	Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass through promotion of most energy efficient technologies
8	Safeguard continued economic development through the security of supply of petroleum.	Petroleum strategic reserves increased to cover three months' supply.

1	**Priority**	Support continued economic development and growth in household electricity access through least-cost expansion of electricity generation capacity.
	HLTO	Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained.

Generation capacity has been increased significantly since the last ESSP, with 212.5 MW now connected to the grid (218 MW available). This has been achieved through exploiting natural resources such as peat and methane gas from Lake Kivu. Demand for electricity is expected to increase at an annual rate of over 10% in the short-to-medium term. Planning, financing and building power stations can be a timely process, with significant uncertainties. Therefore, a pipeline of projects has been established which will deliver the required additional capacity to 2024. EDCL will align supply and demand, giving consideration to a number of factors, including the requirement to increase access to the grid, ensuring the long term financial sustainability of the utility, maintaining a reliable supply of electricity and making electricity more affordable.

Independent Power Producers (IPPs) will continue to be encouraged to finance and deliver generation projects through Power Purchase Agreements (PPAs). This will reduce the pressure on Government resources, attract internationally state-of-the-art technologies and reduce costs through competition. However, the inclusion of capacity payments (fixed costs) in PPAs necessitates that underutilisation is minimised, with tight alignment between supply and demand.

To ensure the efficient development of the power system, a Least Cost Development Plan (LCDP) and Master Plan for the sector has been developed by REG, with support from international experts. This will guide future investment and ensure a coordinated approach to the development of generation, transmission and distribution infrastructure. Based on the LCDP, a demand driven approach will be taken to capacity expansion. To support the balancing of supply and demand, demand from development sectors like industry, mining, service, agriculture, construction and ICT will be analysed and stimulated. This will be achieved through cross-Government cooperation and the implementation of policy interventions and incentives.

To ensure the system can withstand outages, there is need for a sufficient reserve margin of power to be available. Following international best practice, the plan is to establish and maintain a 15% reserve margin by 2024. EUCL as custodians of the Grid Code shall reflect this new guideline into subsequent Grid Code updates. Ensuring this reserve margin is in place will support the delivery of the reliability targets (HLTO 2).

REG is currently collecting data on the efficiency of generation. Initial analysis suggests that some power stations may be operating below their theoretical maximum. Further assessments will be required and cost-benefit analysis will be carried out to determine where maintenance and investment will be targeted. Improving efficiency may offer a cost-effective means of increasing available capacity.

While expanding capacity, key REP objectives will be considered:

- Reduce the long-run cost of supply: Projects will be taken forward if they contribute to bringing down the cost of electricity, and thus to moving towards a cost-reflective tariff.
- Ensure security of supply: As well as the 15% reserve margin, the generation mix will continue to be diversified, with excessive dependency on any one source (e.g. hydro) limited and imports assessed against requirements.
- Maximise exploitation of indigenous resources: Rwanda has limited resources and so these will be used efficiently to meet demand in the medium term.
- Reduce reliance on petroleum-based generation: Petroleum (diesel) generation can be a cost-effective means of meeting peak demand, but should not be used as baseload generation. The generation mix will be developed and dispatched to minimise the use of diesel away from the peak. The technical and economic feasibility of converting existing diesel units to run on gas will be explored.
- Accelerate regional integration: Significant investment will continue in connecting Rwanda to its neighbours. Commercial arrangements, operational guidelines and the required institutional and regulatory capacity will be built to enable integration. Further, Rwanda will continue to contribute to and support regional bodies and initiatives.
- Consider environmental and social impact: Projects will be assessed against their environmental impact, both on climate (macro level) and the local environment. Rwanda's SE4ALL AA has set a target of 60% of renewable energy share in electricity generation mix by 2030. This target is far over the global target of around 44%.

Table 20 outlines generation projects planned up until 2024. Additional capacity will be delivered through hydro, peat and methane. The level of investment required in electricity generation is significant, with roughly $1.2 billion required to deliver the projects.

Table 20 Planned generation projects

Power Plant Name	Generation Capacty	Commissioning/Expected CoD	Type
Kavumu	0.4	2018/2019	Hydro
Kigasa	0.2	2018/2019	Hydro
Rukarara V & Mushishito	5.0	2018/2019	Hydro
Muhembe	0.3	2018/2019	Hydro
Rwaza I-Muko	2.6	2018/2019	Hydro
Gisenyi	0.6	2018/2019	Hydro
Mukungwa II	1.0	2019/2020	Hydro
Gashashi	-	2019/2020	Hydro
Nyirabuhombohombo	-	2019/2020	Hydro
KPLC	-	2019/2020	Import
Nyirantaruko	1.3	2019/2020	Hydro
Nyirahindwe I	0.3	2019/2020	Hydro
Nyirahindwe II	0.9	2019/2020	Hydro
Mpenge I&III	1.0	2019/2020	Hydro
Nyundo	4.0	2019/2020	Hydro
Mutobo	0.8	2019/2020	Hydro
Agatobwe	0.2	2019/2020	Hydro
Rukarara 6	9.6	2020/2021	Hydro
Hakan-Mamba	80.0	2020/2021	Peat
So Energy	(30.0)	2020/2021	Diesel
Rubagabaga	0.3	2021/2022	Hydro
Ngororero	2.7	2021/2022	Hydro
Ntaruka A	2.1	2021/2022	Hydro
Base 1	2.9	2021/2022	Hydro
Base 2	2.9	2021/2022	Hydro
Rwondo	2.3	2021/2022	Hydro
Bihongore	5.4	2021/2022	Hydro
Giciye III	7.2	2021/2022	Hydro
Rusumo FHPP	26.7	2021/2022	Hydro
Kivuwatt I extension	8.0	2021/2022	Methane
Rukore	2.0	2022/2023	Hydro
Symbion	13.0	2022/2023	Methane
Kore I	1.3	2022/2023	Hydro
Muganza	0.3	2022/2023	Hydro
Rucanzogera	1.6	2022/2023	Hydro
Kabavu	0.1	2022/2023	Hydro
Solar	30.0	2022/2023	Solar
Waste to energy project	5.0	2023/2024	Waste
Symbion	37.0	2023/2024	Methane
TOTAL	**228.8**		

Further investment of $ 321billion is required to build the related transmission network.

2	**Priority**	Improve industrial competitiveness through increased reliability of electricity supply.
	HLTO	Reliability of electricity supply improved: average number of power interruptions per year reduced to 91.7 and average number of hours without power to 14.2.

Electricity outages cause inconvenience for households and can cost large industrial users significant amounts in lost production. Further, where regular outages are expected, large industrial users will take on the cost of installing diesel back-up generators. It is acknowledged that the reliability of supply in Rwanda has been insufficient, with past efforts more focused on increasing generation capacity. This ESSP sets out improving the reliability of electricity supply as a key objective. Supporting the ESSP, RURA has put in place regulations governing electricity quality of service. These set clear targets for REG and will require continuous monitoring and regular reporting at a greater level of detail.

REG has developed plans and commenced implementation of improving the distribution system at both low and high voltage levels. A number of key interventions will be continued through the ESSP period:

- Rehabilitate and expand the LV and MV networks, including the development of a Kigali Ring. This will significantly improve the reliability of supply in and around Kigali, which is the country's highest load area.
- Build HV lines and upgrade from a radial network to a robust ring network. Ring infrastructure will be built through Shango – Rubavu – Bwishyura – Kigoma – Rwabusoro – Rilima – Shango and will evacuate power from the country's major power plants and connect Rwanda to neighbouring countries as part of the regional power pool.
- Upgrade feeders to increase capacity, improve reliability and reduce losses.
- Upgrade substations linking the transmission and distribution networks to reduce outages.

Supporting the above interventions, more underlying initiatives will be implemented:

- Basic interruption data will be compiled, including date, time and cause of outage. This data will be tracked.
- Key metrics will be calculated so that the impact of outages can be understood and the performance of REG can be measured against international benchmarks.
- Data gathered will allow REG to better understand the cause of outages and put in place appropriate prevention technologies and processes. Feeder design and construction and proactive maintenance programmes can reduce the frequency and duration of outages. Data gathered will allow the costs and benefits of any such interventions to be assessed.
- No network can be fault free. Therefore, where faults occur their impact will be minimised. Basic technologies can be installed on feeders to reduce the number of customers losing supply during an outage.
- Where faults do occur, they should be fixed quickly. This can be achieved through investment in monitoring technologies, which support troubleshooting, analysis of

power flows, so that faults can be anticipated, and appropriately resourced and trained teams in place to fix faults.

Table 21 sets out the international benchmarks that will be monitored through the ESSP and NST-1.

Table 21 Electricity quality of supply indicators

Performance Indicator	Description	Baseline	Target
System Average Interruption Frequency Index (SAIFI)	**Total Customer Outages / Total Customers** The number of times per year the average customer experiences an outage.	229 times/per year	**91.7 times/ per year**
System Average Interruption Duration Index (SAIDI)	**Total Customer Minutes out / Total Customers** The number of minutes per year that the average customer is without power.	36 hours/ per year	**14.1 hours/ per year**

A detailed programme of network upgrades and initiatives has been developed and will be implemented by REG. The total estimated cost to deliver this target is $240million.

3	**Priority**	Improve the health, well-being and economic opportunities available to Rwandans through increased household access to electricity.
	HLTO	Household access to electricity increased to 100%.

Electricity is a clean, safe and reliable source of lighting and power for households. Eliminating the use of kerosene and expensive batteries will give households greater economic freedom, security and opportunities. As of June 2017, 34.5% of Rwandan households have access to electricity. By the end of this ESSP period, this will be expanded to 100%, with 52% connected via the grid and 48% connected via off-grid technologies.

In the new ESSP period, around 1,036,000 households will be connected to the grid. This is equivalent to 170,000 new connections per year. Around 1,500,000 households will be electrified through off-grid solutions, equivalent to 250,000 connections per year. Given forecast population increases, 3.72 million households (100%) will have access to electricity by 2024. Table 22 outlines connection increases to 2024.

Table 22 Electricity access projections to households

Connections	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
New on-grid connections	163,914	148,201	160,466	173,624	187,472	202,734
On-grid access	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 access	17%	23%	30%	36%	42%	48%
Households connected (m)	1.5	1.8	2.3	2.7	3.2	3.7
Households connected (%)	51.5%	61%	71.5%	81%	90.5%	100%

REG is finalising a National Electrification Plan which will set out exactly how the access targets will be achieved. The EARP will continue to drive grid connections. Given the high cost per on-grid new connection, at roughly $700, development partners' support will be leveraged. Further, gird connections give social benefits not captured in a cost/benefit analysis. However, this presents a considerable technical and financial challenge.

To support increased access, it is planned that 5,600 km of medium voltage lines and 8,050 km of low voltage lines will be constructed during the period.

The growth in off-grid access, which has been one of the most important changes in electricity access over recent years, will increase rapidly. Off-grid access provides timely, affordable electricity, with per-connection cost estimated at $100. Combining it with grid expansion reduces the financial burden on the utility, offers access to remote households or productive users who would otherwise have to wait years for the grid. Off-grid access will be delivered through the RES and the private sector.

Delivering access to 100% of the population will require significant investment, with costs estimated at $510 million for on-grid and $78 million for off-grid.

4	**Priority**	Improve public service provision and support economic development through increased productive user access to electricity.
	HLTO	Productive user access to electricity increased to 100%.

REG analysis has identified 2,421 productive users across Rwanda that currently have no electricity connection. These are summarised by user category in Table 23. Connecting these productive users will support economic development and the provision of key services such as health and education.

Table 23 Productive users to be connected by type

User category	Number	User category	Number
Beverages and Tobacco	14	Mining facility	80
Cell Office	843	Pre-primary school	214
Coffee Washing Station	109	Primary school	700
Food Processing	41	Secondary school	281
Health Facility	104	Sector office	25
IDP Model Villages	35	Tea factory	2
Industry park	1	Technical school	14
Irrigation pumping facility	13	Telecom tower	97
Market	111	University and Institutes	1
Milk Collection centre	15	Water pumping facility	33
Total			**2,733**

REG has designed and will implement a plan to connect all of these users by 2021. Productive users within 800 metres of a distribution transformer will be directly connected to the grid as the connection cost is relatively low. Those further away from the grid will be connected via either on- or off-grid solutions based on analysis of their consumption patterns and exact location.

REG will deliver access to these users through eight phases. These are planned sequentially and deliver high-priority grid connections and off-grid connections in areas where solar suitability is high. For each case, the investment required in terms of line extensions, substations and solar infrastructure is identified.

For new connections, a regulatory framework will be established to make sure that all new productive use facilities provide an electrification plan as prerequisite for establishment.

A summary of each case is included in Table 24.

Table 24 Summary of productive user access cases

Phase	Grid	Included	Rationale	Requirement
1	On	**EARP planned 2017-18** Mixture of users across all districts; potential for 36 additional users to be added	Identified in EARP planning	Included in EARP
2		**EARP planned 2018-19** Mixture of users across all districts	Identified in EARP planning	Included in EARP
3		**Medium-voltage extension** Health centers; milk collection centers; irrigation pumping; water pumping stations; sector offices	Significant contribution to national development and well-being of Rwandans, through food security and health service provision	143 km of MV line; 82 transformers; 1.6 km of LV service connection
4		**Low-voltage extension** Productive users within 800m of existing transformer	Close to existing network so cost of electrification is low	170 km of LV line; 15 km of LV service
5		**Concentrated location of productive use** All productive users in north west of Rwanda, where 52% of the total non-electrified productive users are located	Low suitability for solar Development of location	547 km of MV line; 256 LV service connections 210 transformers 28.4 km of LV service connection
6		**6.1: Eastern Province - productive users close to trade centres** 19 productive users located close to trade centres	Connected to grid as close to existing users	18 km of MV line; 16km of LV line; 7 transformers; 0.7 km of service connection
	Off	**6.2: Eastern Province – all productive users** 370 productive users located far from trade centers	Located within high solar suitability area	Solar and storage capacity
7		**Off-grid, North East** Range of productive users	Grid connection will require medium-voltage line extension; located within high solar suitability area	Solar and storage capacity
8		**Off-grid, South and West**	Grid connection will require medium-voltage line extension; located within high solar suitability area	Solar and storage capacity

Each case connects a specified number of productive users, has an associated budget and contributes to achieving 100% connection for productive users by 2023. This information is presented in Table 25. New productive users will be connected according to requirements over the implementation period.

Table 25 Summary of productive user electrification plan

CASE	Year	Number	Budget (USD)	Progress (%)
N/A	now	6,122	N/A	69%
1	2017-2018	276	EARP Budget	72%
	2017-2018	36	Potential to be added	72%
2	2018-2019	309	EARP Budget	76%
3	2018-2019	82	4,776,753	76.80%
4	2018-2019	416	1,992,530	81%
5	2019-2020	842	20,465,355	91%
6	2020-2021	389	1,655,511	95%
7	2021-2022	151	684,900	97%
8	2022-2023	232	608,500	100%
New productive users		1. 100 p/y	2. 7,537,528	
TOTAL		**8,855**	**30,183,549**	

The total cost for connecting all existing productive users is $30 million.

5	**Priority**	Increase safety of communities and support 24-hour service delivery through expansion of street lighting.
	HLTO	Street lighting expanded to all populated areas and main roads.

The Government of Rwanda has introduced a 24-hours working strategy to expand service delivery along major roads outside of daylight hours. The quality, consistency and efficiency of night lighting in streets and public spaces will be improved and roads with no street lights will be covered in the period of this ESSP.

A plan is being developed to equip all main roads with street lighting. Three initial categories have been identified: (1) existing national roads (2) Main roads in Kigali City and urban areas; (3) New main national roads and roads under construction. It is expected that street lighting will be rolled out by 2024. Initial estimates give a total length of 1,810 km to be covered and a required budget estimated at $**123.1**million.

The lighting technology used in the programme will be high-quality LEDs or efficient CFLs. This will reduce the level of electricity required, the occurrence of faults and the requirement for replacements.

REG, with the support of the Rwanda Transport Development Agency (RTDA), will lead the design and implementation of the plan. REG will investigate and assess funding options and ensure that the plan and its implementation is delivered efficiently.

6	**Priority**	Reduce sector costs and environmental impacts through improved efficiency in the use of resources.
	HLTO	Losses in the transmission and distribution networks reduced to 15%.

Transmission and distribution losses in Rwanda are around 22%, significantly higher than the international benchmark of 6% to 8%. Of this total, 17% is estimated to be technical losses and 5% commercial. Reducing losses is an objective of the Energy Efficiency Strategy and by 2024, losses will be reduced to 15%.

A thorough review of losses is being carried out by an international consultant. Initial analysis by REG suggests that technical losses are being caused by a range of issues, including poor planning, poor workmanship and old and overloaded equipment. Reduction in losses will be achieved through targeted investments, improvements in operations and processes and capacity building. REG will implement the required changes based on detailed assessment of the causes of losses. The highest standards of maintenance and operational excellence will be embedded within REG, with employees at all level given the training and support required to work effectively.

Reducing non-technical losses requires a very different approach. In particular, awareness campaigns and the appropriate legal framework are required to change consumer behaviour. Training, investment and operational improvements are required to ensure metering and payment collection is carried out efficiently by the utility.

REG is already implementing initiatives to reduce losses. Significant distribution network investments are being made and an initiative is underway to replace post-paid metres with pre-paid metres for a number of large consumers.

Table 26 outlines the loss reductions to 2023/24.

Table 26 Electricity losses reduction up to 2024

	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
Electricity losses (%)	22	20	19	18	17	16	15

Total costs to deliver this HLTO are $48 million.

7	**Priority**	Improve the health of Rwandans and promote the efficient use of forests through reduced reliance on inefficient cooking fuels and technologies.
	HLTO	Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass through promotion of most energy efficient technologies

Biomass represents by far the largest share of energy consumption in Rwanda (85%). Nearly all of this comes from the use of firewood as a fuel for cooking. Firewood is cheap if bought

and free if collected in rural areas. However, demand for firewood is currently greater than supply and so the level of use is not sustainable. Further, it is often burned on inefficient stoves, which causes serious health problems – disproportionately suffered by women and children.

The use of firewood as the main source of energy for cooking has reduced to 83.3% from 86.3% in 2011, but the speed of reduction must be increased. This slow rate of change is not unique to Rwanda, with similarly limited progress seen internationally. This ESSP sets a new target to reduce the use of firewood to 42% of households.

The following principles set out how the target will be achieved:

- Increased use of analysis
  Studies will be completed to establish the current status of supply and demand of biomass. This will enable accurate forecasting and impact assessment and cost/benefit analysis of proposed interventions. The BEST process has built capacity in MININFRA and MINIRENA to carry out this analysis and modelling will be updated annually to ensure continued accuracy.
- Multi-strategy approach
  The biomass deficit will be closed through supply-side improvements, such as increasing the yield of designated forests and efficiency of charcoal processing, and through demand-side improvements, such as reducing the amount of biomass consumed. Although the HLTO focuses on switching households from firewood to other fuels, where this is not possible initiatives will be undertaken to increase the use of efficient cookstoves. This will ensure that low-income and rural households contribute to the overall reduction of biomass consumption and benefit from the health and economic effects of efficient cookstoves.
- Improved institutional context
  Biomass is a wide-ranging subsector, involving a number of ministries with diverse mandates. When the definition is expanded to cooking fuels and technologies more generally, this increases further. Roles and responsibilities will be clarified and optimised and cooperation will be supported through data sharing and regular cross-institutional meetings and working groups (including the TWGs). Further, the strategies and objectives developed in biomass will be mainstreamed into key environmental, energy and forestry programmes, projects and activities.
- Focus on behavioural change
  Experience in Rwanda and internationally has shown that ingrained behaviours can result in efficient technologies and alternative fuels being rejected or used improperly. Awareness campaigns will play a vital role in overcoming this. Demonstrations of operation and clear explanations of the benefits of change will be required. However, to ensure take-up of new technologies and fuels, efforts will go beyond this, with behavioural change to be made central to the design of all programmes and interventions.
- Market development
  Following the successful model of rural electrification, the private sector will play a prominent role in delivering access to clean cooking technologies. Government will engage with the private sector and promote investment through establishing an appropriate enabling environment. Barriers to entry and bottlenecks will be

identified and reduced or removed, resulting in competition and innovation in both technologies and business models.

- Targeted use of Government resources
  Government resources will be used to de-risk investments, subsidise access for low-income households, unlock further financing from the private sector and development partners and deliver the required supporting infrastructure.
- Diversification
  Further modelling will demonstrate the impact of different fuel-mix scenarios for cooking. However, it is expected that a combination of LPG, pellets, charcoal, biogas and electricity will be used to replace firewood. Stoves used will be efficient, reducing the cost and negative health impacts on users. The process of urbanisation is expected to contribute to achieving this target, with 35% of Rwandans expected to be living in cities by 2024.
- Supply chain expansion
  Moving large numbers of households from firewood onto pellets, LPG and other technologies will require the expansion of and improvements to supply chains. This will include developing import routes, building storage/collection and processing points around the country and linking these to rural households. Government is already working with private companies to assess capacity and needs and will ensure appropriate support is in place.

- Holistic approach and clearly-defined initiatives
  Ad-hoc initiatives have made little impact to consumption of firewood in Rwanda. As such, a holistic approach will be taken to ensure that initiatives are complementary and directly contribute to objectives. The understanding and definition of biomass in this context will be expanded to cooking technologies more generally. Under this approach, specific, complementary initiatives and programmes will be designed, costed, implemented and monitored.

Table 27 Targets for modern cooking technologies uptake by households

	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
Households using firewood	83%	74.80%	66.60%	58.40%	50.20%	42.0%
Households using alternative fuels	542,177	835,368	1,150,858	1,489,985	1,854,094	2,244,642
Households moved off firewood	137,219	293,191	315,490	339,127	364,109	390,548

Significant resources ($185 million) will be required to meet this ambitious target. Over $300 million of this is expected to come from the private sector.

8	**Priority**	Safeguard continued economic development through the security of supply of petroleum.
	HLTO	Petroleum strategic reserves increased to cover three months' supply.

The REP and ESSP aim to ensure the safe, sufficient, reliable, sustainable and affordable

supply of petroleum and gas reserves. This will entail expanding domestic exploration and production, boosting investments in supply and storage infrastructure, and promoting sound management of downstream petroleum resources.

Petroleum Reserves: The HLTO to be monitored through the ESSP and NST-1 is the increase of petroleum reserves to cover three months' supply (at forecast demand for 2024). Storage facilities have been increased to 74 million litres, up from 31 million litres in 2012. Completion of the SP storage development, which is underway, will take storage to 112 million litres. Current monthly consumption is around 38,490 million litres and demand is expected to increase to 65,965 million litres per month by 2024. As such, 198 million litres will be required.

Data collection and usage will be improved to ensure that consumption levels and trends are known. The storage level (in litres) will be revised based on regular reviews to ensure it is in line with demand.

Reserves are currently split between Government and private sector-owned. This approach will continue, with further private sector investment encouraged. Assessments of demand and requirements will be made based on location and fuel type before any new project is commenced.

Expected costs for this HLTO are based on past costs of building fuel storage. Project size and location will impact costs, but it is anticipated that $101 million will be spent.

Gas Reserves: The target to be monitored in the ESSP will be the increase of gas reserves to cover at least three months. Currently there are a few storage facilities with uncertain reserves managed by private importers. The demand for LPG has increased tremendously since 2016 years with the demand stands at more 10,000 tonnes of LPG per annum and this is expected to increase to more than 240,000 tonnes by 2024`.

There is an urgent need to set up reserves to mitigate future risks and ensure steady supply of LPG as demand will be increasing with increasing urban population. The current required strategic reserves is 2600 tonnes and is expected to increase to more than 60,000 tonnes by 2024.

The total required cost for the strategic reserves is estimated at $106millions

Contribution to National Strategy for Transformation Pillars

NST-1 identifies three pillars: Economic Transformation, Social Transformation and Transformational Governance. The role of energy in delivering these is now presented.

3.2.1 Economic Transformation Pillar

This ESSP strongly supports the Economic Transformation Pillar of NST-1. Energy underpins the continued economic growth of Rwanda. Ensuring all households and productive users have access to electricity will boost economic activity across all sectors and all provinces. Further, the electricity supply will be of high quality, something especially important to commercial and industrial consumers. Therefore, combined with the January 2017 tariff review, which lowered the price of electricity for industrial users, this ESSP will ensure the availability of reliable, competitively priced electricity. This will help attract investment into Rwanda and therefore increase employment and industrialisation – and therefore exports.

Provision of electricity will support the acceleration of urbanisation as well as the Made in Rwanda programme, which seeks to build up Rwanda's manufacturing base.

Further, the sector contributes directly to economic development. New generation projects, construction and rehabilitation of transmission and distribution infrastructures and other planned programmes will provide jobs and economic stimulation.

Reducing the number of households relying on firewood as a cooking fuel will contribute significantly to the sustainable management of natural resources and moving Rwanda towards a carbon neutral economy. Further it will significantly reduce the time spent collecting firewood each year, thus freeing people to pursue more productive endeavours.

Many services and businesses rely on petroleum products. Ensuring three months of reserves are in place will reduce the likelihood of supply gaps, help to smooth out price fluctuations and allow Rwanda to re-export petroleum to neighbouring countries when beneficial to do so.

3.2.2 Social Transformation Pillar

Energy's central contribution to this pillar will be the delivery of 100% energy access for households and productive users. On and off-grid access will be delivered across the country. Low-income, rural households will be supported in accessing off-grid solutions such as solar home systems. Productive users include health centres and education facilities. Connecting these to electricity will ensure that modern, high quality services can be offered. In the case of education, electricity access will allow the uptake of ICT use, a pre-requisite to Rwanda becoming a knowledge-based economy.

Investment in, and promotion of, clean, renewable technologies, such as off-grid electrification, solar water heaters, biogas and energy efficiency will improve the quality of Rwandans' health. This will reduce premature deaths and improve the quality of life enjoyed by all Rwandans.

3.2.3 Transformation Governance Pillar

Achieving 100% electricity access for social infrastructures such as health centres, schools, sectors offices and street lights will ease service delivery and enable the use of ICT. This will improve service delivery in, and the efficiency of, Government institutions. Delivering electricity access to all Rwandans will support peace, unity and the engagement of all citizens in society.

3.3 Mainstreaming of Cross-cutting Areas

3.3.1 Capacity building

A range of traditional and new skills are required if the sector's objectives are to be met. Traditional skills such as planning, project management and commercial, as well as specific mechanical and electrical engineering knowledge, are required at operational and management levels. Further, there is a requirement to build up capacity in newer areas, such as off-grid electrification and energy efficiency. Qualified staff must be put in place through hiring and training at MININFRA, REG and related institutions. Further, capacity building must equip the private sector with skilled employees. For example, a recent study

found that 53% of private sector off-grid organisations do not have critical skills for off-grid energy[21].

Human resource development: Capacity gaps identified among energy sector staff include planning, procurement, project management, and contract management skills. Further, these is the ongoing need to train staff in core technical skills, such as working with high-voltage lines. In addition, there are specific gaps in non-traditional energy areas, such as efficiency and off-grid. In response to this, capacity will be enhanced through knowledge transfer from long-term experts to local counterparts.

Institutional capacity development: Institutional reforms are underway in MNIINFRA to ensure capacity to deliver on responsibilities and the NST-1 objectives. The Energy Division team will be strengthened and an institutional development program will ensure the team functions as required.

Additional guidelines to support capacity building and skills development include:

- Each institution in the energy sector shall have a clear responsible focal point with the mandate to deliver on specific objectives and targets related to capacity building.
- Senior management and administrative personnel of all energy-related agencies shall develop clear policies on training needs and priorities to address key bottlenecks and capacity gaps. Attendance at these training courses shall be incorporated into performance contracts and annual reviews.
- Opportunities for peering and short-term staff exchanges or rotations shall be developed as a way to rapidly build capacities.
- Senior management and administrative personnel of all energy-related agencies shall develop clear guidelines and policies for internships reflecting selection criteria and expected outputs so that they are effectively utilised.

[Include capacity plan when complete]

3.3.2 Regional integration

The energy sector will play a key role in developing regional integration. This ESSP fully supports the deepening of regional cooperation and integration in the energy sector and the sector vision foresees a fully integrated regional exchange of power resources in the long-term. In particular, Rwanda is committed to participating actively in regional initiatives such as:

- regional master plans and energy planning;
- regional strategies for efficient procurement, transportation and storage of petroleum products;
- regional electrical power projects, including Rusumo and Rusizi III hydro projects;
- regional bodies such as EAPP and NELSAP, which falls under the NBI; and
- joint development with the DRC of Lake Kivu methane gas and petroleum exploration.

[21] Skills Audit In Off-Grid Energy Sub-Sector In Rwanda, 2017

3.3.3 Gender and Family

Gender equality promotion is a key aim of Government. It has been prioritised in national documents, such as Vision 2020 and EDPRS 2, and the National Gender Policy was published in 2010. MININFRA developed the Infrastructure Gender Mainstreaming Strategy in 2017. This recognises gender mainstreaming as a pathway to poverty reduction and sets out five strategic objectives:

1. Enhance institutional and human resource capacity for gender equality promotion in the infrastructure sector.
2. Enhance gender responsiveness in the delivery of infrastructure services.
3. Promote the participation of women in decision making processes in the infrastructure sector.
4. Improve access to job opportunities for, and increase the earning potential of, women through infrastructure investments.
5. Develop and coordinate partnerships and collaborative mechanisms amongst Government institutions, civil society organizations, the private sector and development partners.

Within energy, the biggest gender issue is the time women and girls spend collecting firewood and plant residues necessary for household activities. This reduces the time available for other purposes, including income generation and education. Absenteeism, especially for girls, at school age is another consequence resulting from the time used for firewood collection.

The Multi-Tier Framework (MTF) Survey conducted between November and December 2016 found that women spend more time collecting and preparing fuel for cooking spending between 42 and 80 minutes per day collecting firewood in urban and rural areas, respectively. Data results also show that women spend twice as much time as men preparing fuel for cooking. This is shown in Figure 15.

As a result, women are disproportionately affected by diseases and health problems associated with collecting and burning firewood. The MTF survey found that 13% of female household members (15 years or older) experienced a cough in the last 12 days, compared to only 3% of males. In addition, 5% and 3% of females (15 or older) in rural and urban areas reported suffering from back or neck issues due to demanding wood collection work.

Reducing the use of firewood, as set out in the HLTOs, will have a significant positive impact on the lives of women and girls across Rwanda.

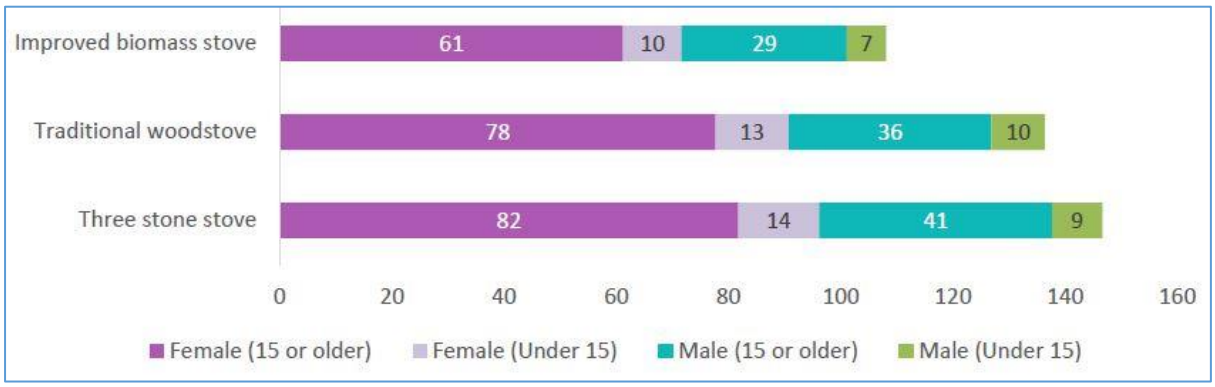


Figure 15 Fuel collection and preparation time by gender

Increasing access to electricity will provide further benefits to women and children. Increased lighting will allow children to study into the evening and improve safety on roads and in public spaces, and the use of basic appliances, such as radios, will reduce isolation.

3.3.4 Environment and climate change

Rwanda is embarking on a low-carbon development pathway as reflected in its National Strategy on Green Growth and Climate Resilience. Further, Rwanda hosted the update to the Montreal Protocol in 2016. Globally, energy is one of the most environmentally impactful sectors. The ESSP prioritises improved efficiency through the reduction of losses and the Energy Efficiency Strategy will deliver significant improvements to generation and end-user efficiency. This will be increasingly important as Rwanda's economy grows and consumption increases.

The ESSP prioritises renewables. Up to 52% of the electricity mix will be renewable in 2024, far ahead of the international average and ahead of SE4ALL targets. Also, around 48% of households will have access to electricity from renewable energy sources.

Reducing reliance on traditional biomass energy is a priority of the Biomass Energy Strategy. A pathway to reducing the use of biomass – and the negative environmental effects, including deforestation – will be implemented. Efficient fuels and technologies will be promoted.

3.3.5 Disaster management

MININFRA is responsible for mainstreaming disaster prevention guidelines into its operational policies as well as environment, health, and safety (EHS) guidelines to be followed by its implementation agents. International EHS standards shall be applied in all energy infrastructures both public and private owned so as to ensure the safety of both personnel and equipment as well as the conservation of the environment. This shall be especially applicable in tendering of PPPs and IPPs and in the activities of REG.

Elaboration of these plans shall involve all relevant stakeholders and peer review by disaster management experts. Plans including clear protocols to be followed in the event of a "catastrophic" event or "system failure", such as a total power grid blackout, will delegate clear responsibility for alerting and providing emergency response measures. Fire outbreaks and oil spills, which are the main EHS risks in the petroleum industry, can be mitigated by ensuring strict compliance and enforcement of regulations and the adoption of international best practices in handling safety concerns. Other concerns associated with hazardous materials will be addressed through use of high standard equipment and use of personal protective equipment.

3.3.6 Disability and social inclusion

Achieving 100% access to electricity will improve the lives of all citizens, including those with disabilities. This will apply to the provision of clean cooking technologies. Connecting all productive users to electricity will ensure that health centres and other social buildings can operate outside of daylight hours and provide modern services.

3.3.7 HIV/AIDS and non-communicable diseases

Achieving 100% access to electricity will improve the lives of all citizens, including those with HIV/AIDS and non-communicable diseases.

Table 28 ESSP performance indicator and monitoring matrix

N		Indicator	Baseline	Targets Across the years						Means of verification
			17	18-19	19-20	20-21	21-22	22-23	23-24	
1	Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained	Reserve margin	10%	15%	15%	15%	15%	15%	15%	Installed capacity on power system
2	Reliability of electricity supply improved: average number of power interruptions per year reduced to 16 and average number of hours without power to 9	SAIFI (avg no of interruptions)	229.3	206.4	183.4	160.5	137.6	114.6	91.7	REG Annual Reports
		SAIDI (avg hrs without power)	36	32	28	24.7	21.2	17.7	14.2	
3	Losses in the transmission and distribution networks reduced to 15%	% losses on system	22%	20%	19%	18%	17%	16%	15%	RURA assessment
4	Household access to electricity increased to 100%	% HHs connected to grid	32.7 %	34.50%	38%	41.50%	45%	48.50%	52%	REG electrification report
		% HHs off-grid	7.80%	17%	23%	30%	36%	42%	48%	REG electrification report
5	Productive user access to electricity increased to 100%	% productive users connected	72.60%	77.80%	88.90%	100%	100%	100%	100%	REG electrification report
7	Street lighting expanded to all populated areas and main roads.	% of national and district roads with lighting	50%	70%	80%	90%	100%	100%	100%	REG and RTDA status reports
8	Halving the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of Biomass	% of HHs depending on firewood	83.30%	83%	74.80%	66.60%	58.40%	50.20%	42%	MININFRA reporting
9	Petroleum strategic reserves increased to cover three months' supply	Millions of liters of fuel storage	74	135	145	157	170	183	198	MININFRA reporting

4 Implementation of the ESSP

Chapter outline

The chapter provides an overview of key implementation considerations as well as a high-level implementation plan for the ESSP.

4.1 Background and implementation plan

Past experience has shown that policies and strategies must be followed by timely, effective implementation. A high-level plan is in place to ensure the targets of the ESSP are met and the key initiatives delivered. More detailed plans will be drawn up by the implementing agencies for specific initiatives as required. Further, the implementation of the ESSP will retain some flexibility. The energy sector is complex and it interacts with a range of other sectors and the economic growth of Rwanda more generally. In particular, growth in demand for electricity is directly linked to growth in GDP and access rates are influenced by wider urbanisation and resettlement policies. The successful implementation of the ESSP will require cooperation with a number of Government ministries and institutions, development partners and the private sector.

The significant financing requirements in energy mean that cost-efficiency will be a priority of ESSP implementation. Cost/benefit analysis will be carried out ahead of significant investments and private sector capital will be leveraged where possible.

4.2 Communication plan

Clear communication between lead and supporting stakeholders will be important in ensuring effective implementation. Issues and challenges will be dealt with as they arise and new opportunities will be identified and, where appropriate, adopted. MININFRA will lead communication. Regular progress reports will be provided on specific projects and the sector more generally. The SWG will provide a forum to discuss progress and raise concerns. REG will provide updates on all areas of its work, including electrification, capacity installed and demand projections. RURA will monitor and report on the performance of implementing agencies and ensure that tariffs are clear, including the methodology and assumptions behind them. Specifically, communication will be maintained through:

- **Regular meetings** will be held with the Energy SWG, which will participate in Joint Sector Review meetings to assess the performance of the sector. TWGs will cover more specific areas, organise research and projects and provide analysis and recommendations to the SWG.
- **MININFRA website** will be updated quarterly, with significant information about the Strategy and key sector achievements, opportunities as well as plans in pipeline, accessible to the public.

- **Local media** (newspapers, radio and television) will be used to communicate the status of projects and key developments. This will be particularly useful in raising awareness of end-user initiatives such as efficiency and off-grid technologies.
- Through MINALOC, the OGS and MINAFFET, MININFRA shall arrange and organise **UMUGANDA** purposely to address the citizens on both strategy and policy both within the country and outside through our Embassies.

4.3 Data Sharing

An energy sector database will be developed and implemented. This will be scaled up over time, eventually connecting all sector stakeholders and acting as a repository for data and documents. Data will be required across all subsectors and areas. This data will be shared effectively between MININFRA and REG and across Government and the NIS, in particular. The SWG, TWGs and Energy Steering Committee will facilitate data sharing. Appropriate investment will be made in IT hardware and software, and training, to ensure that data is stored and made available. Transparency will become central to the energy sector, with all stakeholders able to access accurate, up-to-date information. MININFRA will also develop the capacity to carry out regular reporting, bulletins and policy briefs.

4.4 Risk Analysis

The Rwanda energy sector is exposed to significant risks. There is therefore a need to integrate risk screening into planning, particularly at the sectorial level. Some especially critical risks worth highlighting include:

Import Dependency: Diversifying the portfolio of energy sources both domestically and externally through imports from neighbouring countries can increase energy security. In electricity, the proportion of hydro in the domestic supply is being reduced and regional integration is being pursued. Rwanda will support the EAPP in establishing the appropriate physical assets and regulatory, commercial and legal structures required to ensure reliable trading and wheeling of power between countries. Increasing petroleum storage will reduce the risk of supply shortages. Increasing the number of households using LPG will require the supply chain to be improved and storage facilities to be expanded. Short and medium-term planning, based on observed consumption levels and trends, and cooperation with the private sector will minimise risks.

Environmental and climatic shocks: These pose a significant challenge. Extraordinary events such as volcanic eruptions could destroy energy investments and disrupt service provision. Oils spills or methane gas explosions can be catastrophic to humanity and the surroundings. The long-term impact of climate change on rainfall and available hydropower generation capacity could also be detrimental to meeting the country's long-term energy plans. A Disaster Recovery Plan therefore needs to be integrated into energy sector planning.

Insufficient and un-integrated planning: All Government stakeholders have an obligation to contribute to electricity planning processes in an accurate and timely manner by providing realistic plans.

Urbanisation rates: Urbanisation, with an NST-1 target of 35% by 2024, is a key risk factor to the successful achievement of the electricity access targets. Reducing the marginal cost of new grid connections can be achieved indirectly through greater densification and growth of

settlements. Reducing the reliance on firewood for cooking is also directly linked to increasing urban populations. Cross-Government cooperation is required to ensure forecasts are aligned and accurate data shared. This will allow energy sector investments to be made effectively.

Table 29 ESSP implementation plan

Target		Strategic Action	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	Responsible Institution
1	Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained	Implement LCDP	Update LCDP assumptions annually						REG, MININFRA
			Implement LCDP generation build programme						
		Maintenance	Collect data on generation efficiency	Carry out routine maintenance and efficiency improvements					
		Generation studies	Continue to assess opportunities for further generation projects, to ensure demand beyond 2024 can be met						
		Demand stimulation	Finalise cross-Government demand stimulation plan	Implement plan and ensure continued coordination and alignment of demand expectations					
		Regional integration	Continue to construct transmission lines				Assess potential for expansion/upgrade		REG, MININFRA
			Develop commercial and operational frameworks		Design and implement regional trading agreements as required				
2	Reliability of electricity supply improved: average number of power interruptions per year reduced to 91.7 and average number of hours without power to 14.2.	Infrastructure expansion and upgrade	Continue ongoing and implement planned investments and activities						REG
		Data-driven interventions	Establish data collection and analysis	Monitor performance and design interventions and initiatives as required					REG, MININFRA
		Best practice processes	Design and implement capacity building and process improvement programmes	Carry out all operational processes according to international best practice					REG
3	Losses in the transmission and distribution networks reduced to 15%	Reduce Commercial losses	Implementation of Smart metering and DMS, analyze results and implement corrective measures.		Maintain measures for energy management systems. Analyze information and do corrective measures				REG
		Reduce Technical losses	Continue to reduce long MV feeders, upgrade single phase lines, and reduce length of long LV lines						
4	Household access to electricity	National Electrification	Complete NEP	Update NEP as required					REG

Target		Strategic Action	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	Responsible Institution
	increased to 100%.	Plan							
		On-grid	Continue EARP	Align EARP with NEP and regularly review connection policy					
			Build required MV and LV lines						
		Off-grid	Support SHS market development						REG, MININFRA
			Monitor disbursement of (RES P2) SREP						
			Support development of mini-grids where technically and economically feasible						
5	Productive user access to electricity increased to 100%.	Data gathering	Finalise data collection	Update mapping					REG, MININFRA, MINICOM
		Implement connection plan	Implement connection plan, with regular review of impact and sustainability						
		Intensive-user connection	Coordinate delivery of infrastructure to connect new intensive users (e.g. extractive, industrial parks)						
6	Street lighting expanded to all populated areas and main roads.	Deliver street lighting	Design and issue tender(s) according to plan	Monitor progress and evaluate impact					REG, RTDA
		Upgrade existing lighting	Upgrade existing street lighting with LED and high-quality CFL where required						REG
		Maintenance	Expand maintenance programme to cover new street lighting						
7	Losses in the transmission and distribution networks reduced to 15%.	Data gathering	Finalise data collection	Continually update network performance data					REG, MININFRA
		Infrastructure expansion and upgrade	Continue ongoing and implement planned investments and activities						
		Awareness and enforcement	Run awareness campaign and develop appropriate enforcement mechanisms		Enforce legal and regulatory environment				REG, MININFRA, RURA
		Metering upgrade	Assess impact of initial smart and post-paid metering distribution	Roll-out smart and post-paid metering as required					REG
		Implement other efficiency	Implement end-user efficiency initiatives						REG, MININFRA,

Target		Strategic Action	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	Responsible Institution
		strategies							RSB
8	Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass through promotion of most energy efficient technologies	Data and modelling	Collect cooking technology and supply and demand data and model forecast surplus/deficit						MINIRENA, MININFRA
		BEST and NBP	Continually review and update BEST and NBP initiatives						MININFRA, REG
		Awareness campaigns	Run demonstration workshops and distribute literature						MININFRA, MINALOC
		Institutional development	Align roles, responsibilities and accountability	Ensure continuing cross-Government cooperation					MININFRA
		ICS	Support ICS market development						MININFRA,
			Implement Government support according to NBP						
		Alternative fuels	Analyse current supply chains	Expand and improve supply chains			Monitor performance		MININFRA, MINIRENA
			Assess potential of alternative fuels/technologies	Continually review impact of fuels/technologies and update initiatives					
			Design Government support	Implement and monitor impact of support					
9	Petroleum strategic reserves increased to cover three months' supply.	Data gathering	Establish processes to collect and centralise data	Continually review and assess consumption, forecast demand, prices, etc.					RURA, MINICOM
		Storage requirement	Deliver final stages of SP project			Build new storage as required			MININFRA

Table 30 Risk register

Target		Risk	Mitigation
1	Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained	Projects are delayed resulting in insufficient generation to meet demand.	Ensure planning allows for reasonable delays and is updated based on latest expected CODs. Use standard project management templates and tools and escalate problems and bottlenecks for quick resolution.
		Misalignment between planning and forecasts of REG/MININFRA and supply-side stakeholders resulting in misalignment of supply and demand, and infrastructure.	Ensure ongoing cooperation between all relevant Government institutions and wider stakeholders. Establish formal, regular reporting and monitoring of all projects.
		Misalignment between generation and network roll-out results in congestion charges.	Use standard project management templates and tools and escalate problems and bottlenecks for quick resolution. Where appropriate/possible include transmission build in PPA requirements.
2	Reliability of electricity supply improved: average number of power interruptions per year reduced to 91.7 and average number of hours without power to 14.2.	Lack of finance results in project delays or cancellation.	Develop clear, medium-term plan of projects and explore all possible funding sources. Prepare project outlines to share with development partners, private sector and Government.
		Work carried out results in temporary increase in interruptions to supply.	Raise awareness of improvements, plan work to reduce inconvenience to customers and provide appropriate warning. Relevant institutions to recognise requirement for work and measure appropriately.
		Investment and work carried out does not improve reliability resulting in wasted resources and continued high level of interruptions.	Base all work on detailed analysis of network, monitor impact of interventions and review approach as required.
3	Losses in the transmission and distribution networks reduced to 15%	Analysis of information must be interpreted and action taken to investigate reported anomalies. Lack of finance may result in project delays or cancellation.	Monthly targets for follow-up actions must be set and reported Medium-term budget coordination with Minicofin must be established

Target		Risk	Mitigation
4	Household access to electricity increased to 100%.	Uptake of off-grid technologies by consumers is lower than forecast.	Ensure benefits of off-grid technologies are understood and financing options are in place and understood.
		Uncertainty around grid expansion results in reduced investment in mini-grids and other non-grid solutions.	Share publicly the NEP and ensure it is based on sound analysis and planning. Implement the NEP as published.
		Poor quality SHS result in failures and reduce real off-grid access rate.	Enforce standards for all private sector companies and Government tenders.
		Lack of financing for EARP results in slower than forecast on-grid access growth.	Ensure access plans and clearly presented to all relevant stakeholders. Explore all potential sources of funding. Raise gaps early within Government.
5	Productive user access to electricity increased to 100%.	Productive users not included in initial mapping resulting in failure to achieve 100% access or inefficient implementation changes.	Review and update mapping regularly to ensure accuracy of information. Ensure new productive users are included in planning and retain appropriate flexibility in implementation.
		Provision of on and off-grid technologies is misaligned to requirements resulting in inefficient allocation of resources or insufficient electricity supply to customers.	Enforce clear criteria for connection types based on sound analysis of current and future consumption levels and exact location.
6	Street lighting expanded to all populated areas and main roads.	Plans are misaligned with road building and urbanisation resulting in reduced effectiveness and/or higher costs.	Ensure all plans are agreed and coordinated with relevant stakeholders.
		Street lighting adds additional cost to REG resulting in reduced financial performance.	Explore innovative financing methods and funding sources for all projects.
		Installed lighting requires regular replacement and servicing.	Establish and enforce minimum technical standards for all lighting installed.
7	Losses in the transmission and distribution networks reduced to 15%.	Investment and work carried out does not reduce losses resulting in wasted resources and continued high level of interruptions.	Base all work on detailed analysis of network, monitor impact of interventions and review approach as required.
		Lack of finance results in project delays or	Develop clear, medium-term plan of projects and

Target		Risk	Mitigation
		cancellation.	explore all possible funding sources. Prepare project outlines to share with development partners, private sector and Government.
		Lack of awareness and appropriate enforcement limits progress on reducing commercial losses.	Work with relevant Government stakeholders to deliver awareness campaigns and build appropriate enforcement environment.
8	Halving the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass	Uptake and correct use of new technologies by consumers is lower than forecast resulting in reduced progress.	Ensure benefits of new technologies are understood and financing options are in place and understood. Run demonstrations to ensure technologies are understood and used correctly.
		Alternatives such as LPG, biogas and electricity cannot be implemented at sufficient scale resulting in continued reliance on firewood.	Explore all options and develop detailed assessments of availability, cost and likely demand. Identify and resolve bottlenecks in supply chains.
		Actual urbanisation rates are lower than forecast resulting in reduced opportunity to promote alternative technologies.	Coordinate with relevant Government stakeholders to ensure alignment on urbanisation rates. Review and update strategies and initiatives as appropriate.
		Underlying supply and demand data is inaccurate resulting in continued deficit or inefficient allocation of resources.	Ensure analysis is based on sound assumptions and regularly updated with accurate data. Review regularly and update forecasts based on implemented initiatives.
9	Petroleum strategic reserves increased to cover three months' supply.	Three month reserve supply is not aligned to actual consumption resulting in reserves being too large/small.	Improve consumption analysis and demand planning as a priority and review reserve requirements at appropriate intervals.
		Current and additional storage infrastructure does not meet requirements resulting in supply gaps despite three month reserve.	Ensure developments in cooking, economic activity and wider activity are considered so that the correct mix of fuels are stored in accessible locations.

5 Monitoring and Evaluation

Chapter outline

This chapter provides an overview of how implementation of the ESSP will be monitored and evaluated to ensure transparency and the timely resolution of issues.

5.1 M&E Approach

Monitoring and evaluation will be vital in supporting the effective implementation of the ESSP. Further, effective M&E contributes to a variety of core principles outlined in the REP, including: increased accountability and transparency to the Treasury and DPs on the use of public funds; enabling a timely resolution of implementation issues that can build investor confidence, and uncovering lessons on the effectiveness of activities so as to justify scaling-up and alternative procurement mechanisms or market-based approaches.

One of MININFRA's core responsibilities is to carry out monitoring and evaluation of strategic projects, programs, and strategies that are required to deliver national polices. High level monitoring of energy sector performance in line with NST-1 targets will be jointly done by MININFRA and MINECOFIN. Regular updates and briefs will be required from REG, which will be responsible for the implementation of many of the initiatives presented in this ESSP. Procedurally, to ensure rigour, MININFRA will monitor and evaluate performance through results-based management frameworks.

5.2 Targeted Areas

The HLTOs presented in this ESSP represent the key indicators to be measured. These cover vital sector issues such as generation capacity, access, efficiency and security of supply. These are not new metrics. Many of these targets have been developed from the previous ESSP and other sector policies and strategies. However, monitoring and evaluation has not previously been sufficient and so improvement is required. This will involve the development of new systems and significant improvements to existing systems.

5.3 Monitoring and reporting systems

The Sector Working Group acts as the main coordination forum for the sector, providing information and evaluating progress against targets set during the bi-annual Joint Sector Reviews. Below this, Technical Working Groups exist to deal with specific sub-sectors/issues. Recently, TWGs have developed approaches to off-grid access implementation and energy efficiency. The Sector-Wide Approach (SWAP) team within MININFRA lead on disseminating information to stakeholders. REG and MININFRA are improving Management Information Systems to ensure that accurate data is collected, stored and accessed to support project management and planning.

5.4 Evaluation

Beyond project tracking, all activities will need to be evaluated. This will allow lessons to be learnt to improve strategy formation and project delivery, and also increase the accountability of MININFRA. Led by MININFRA, standard evaluation and reporting formats will be drawn up and agreed upon between Districts and central Government. Regular sector reviews will be organized internally and with other partners, particularly in the NST-1 Pillar working groups to evaluate sector performance in line with commitments reflected herein. The expansion of the M&E unit in the Ministry will receive the required external expertise and training in various evaluation methodologies to be able to carry out internal evaluation projects. Additionally, the ministry will explore how best to engage with external evaluators, when final evaluations are not part of project packages, and seek support to do so.

In terms of monitoring the ESSP, this will be carried out on a quarterly basis in addition to regular monitoring activities. This will result in quarterly briefs to highlight successes and make suggestions to improve any areas where little progress is being made. Mid-year evaluation exercises will be carried out to better inform the Sector Working Group Joint Sector Reviews. The M&E Unit within the Ministry will assist in this exercise.

6 Cost and Financing

Chapter outline

This chapter presents a breakdown of the costs of implementing the ESSP, along with a financing plan to ensure that these costs can be met.

6.1 Costing

6.1.1 Total financing:

The total cost of implementing the ESSP between 2018 and 2024 is estimated at $3.12 billion. This is the total for the three subsectors, electricity, biomass and petroleum, as summarised in Table 31.

- **Electricity ($2.73 billion)**
  Electricity expenditure is largely driven by building new power stations and transmission lines. The costs for these are largely known. On-grid connection costs are also significant and are based on known per-household connection costs and forecast connection rates.
- **Biomass ($184 million)**
  Biomass costs are not certain. Clear initiatives to deliver the HLTO will be developed and costed. Current estimates are based on delivering ICS to the 42% who will continue to use firewood and new technologies to those who will switch.
- **Petroleum and Gas ($207 million)**
  Storage costs are based on past costs for similar projects and current demand forecasts.

Table 31 SSP costs and financing requirement ($m)

	HLTO	Initiative	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	Total
1	Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained	MW added	38.7	37.5	398.9	202.7	321.2	452.2	**1,451.56**
2	Reliability of electricity supply improved: average number of power interruptions per year reduced to 91.7 and average number of hours without power to 14.2 and network reinforcement to reduce network losses.	Network investment Distribution	62.02	7.27	3.27	7.15	5.50	0.70	86.16
		Network Investment Transmission	54.64	39.03	7.20	54.42	23.16	22.00	207.36
3	Household access to electricity increased to 100%.	On-grid	106.5	96.3	104.3	112.8	121.9	131.7	**673.8**
		Off-grid	28.3	22	27.1	25.5	27.4	29.4	**159.8**
4	Productive user access to electricity increased to 100%.	Productive users connected	5	10	10	1.1	1.1	1.1	**30**
5	Street lighting expanded to all main national roads and urban roads.	No of Km of street lighting added	3.2	27.4	30.6	30.7	15.5	15.5	**123.1**
6	Losses in the transmission and distribution networks reduced to 15%. This was combined with (2) above	Network investment							
7	Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass	ICS	13.7	29.3	31.5	33.9	36.4	39.1	**184**
8	Petroleum strategic reserves increased to cover three months' supply.	Build infrastructure	16.9	16.9	16.9	16.9	16.9	16.9	**101.3**
	Gas strategic Reserves increased to cover three months	Build infrastructure	28.6	13.4	14.4	15.5	16,6	17,8	**106.3**
	Capacity building(To be determined by Action Plan)		3. X	4. X	5. X	6. X	7. X	8. X	**x**
	Total								**$ 3,123.38**

6.2 Financing strategy

The significant capital requirements in energy mean that all financing sources will be utilised. As a principle, all investment by Government and development partners will seek to encourage further investment by the private sector, for example through guarantees or to support access to finance. This approach has successfully driven investment in large-scale generation by IPPs and in off-grid solutions by a number of companies. More directly, Government will support private investment where possible through funding initial feasibility studies and competitive tender processes. IPPs will be funded through a combination of debt and equity, with EUCL purchasing the generated electricity under a long-term PPA. Development partner loans are supporting the development of regional hydro power plants in Rusumo and Rusizi.

A combination of Government, development partner and private investment will be used to fund transmission and distribution lines. Regional interconnections will be supported by multilateral and development banks.

The EARP will continue to lead on-grid access. It is financed through a basket of funds from Government and development partners. Most of the non-Government funds are supplied in the form of grants or loans from donors with minimal interest.

Off-grid electrification will continue to be driven by the private sector, with companies operating in Rwanda and selling directly to households. The REF, coordinated by the World Bank with funding from a number of development partners, will reduce access costs. Government will provide support to low-income households who would otherwise be unable to purchase a system. MININFRA and REG will seek to encourage the development of mini-grids where technically and economically feasible and will use appropriate financing arrangements.

Government and development partners will provide the necessary funds to support the establishment of energy efficiency. Studies, investments and subsidies will be required initially. However, a key principle of the Energy Efficiency Strategy is that initiatives will become self-sustainable, with energy savings paying for initial expenditure. The electricity tariff structure will also play an important role in creating incentives to undertake projects in this area. The January 2017 review set incentives for large-scale electricity users to reduce and flatten consumption. Efficiency will be considered through future updates to the tariff.

Reducing the proportion of households using firewood as a fuel for cooking will be achieved through a combination of Government, development partner and private sector funding. As with off-grid electrification, for higher-income households, the private sector will be able to operate commercially. However, lower-income households will require support.

Storage will continue to be split between Government and private sector-owned facilities. Government facilities will still involve the private sector through lease contracts, whereby private investors will build and operate the storage facilities and receive an annual payment in exchange for the services.

6.2.1 Ongoing review

All expenditure will be rigorously assessed to ensure that investments give the greatest possible return. In the event of a continued major financing gap for the energy sector,

projects will be reprioritized and balanced according to demand and supply objectives, and further support asked of Government during the annual budget cycle.

7 Annexes

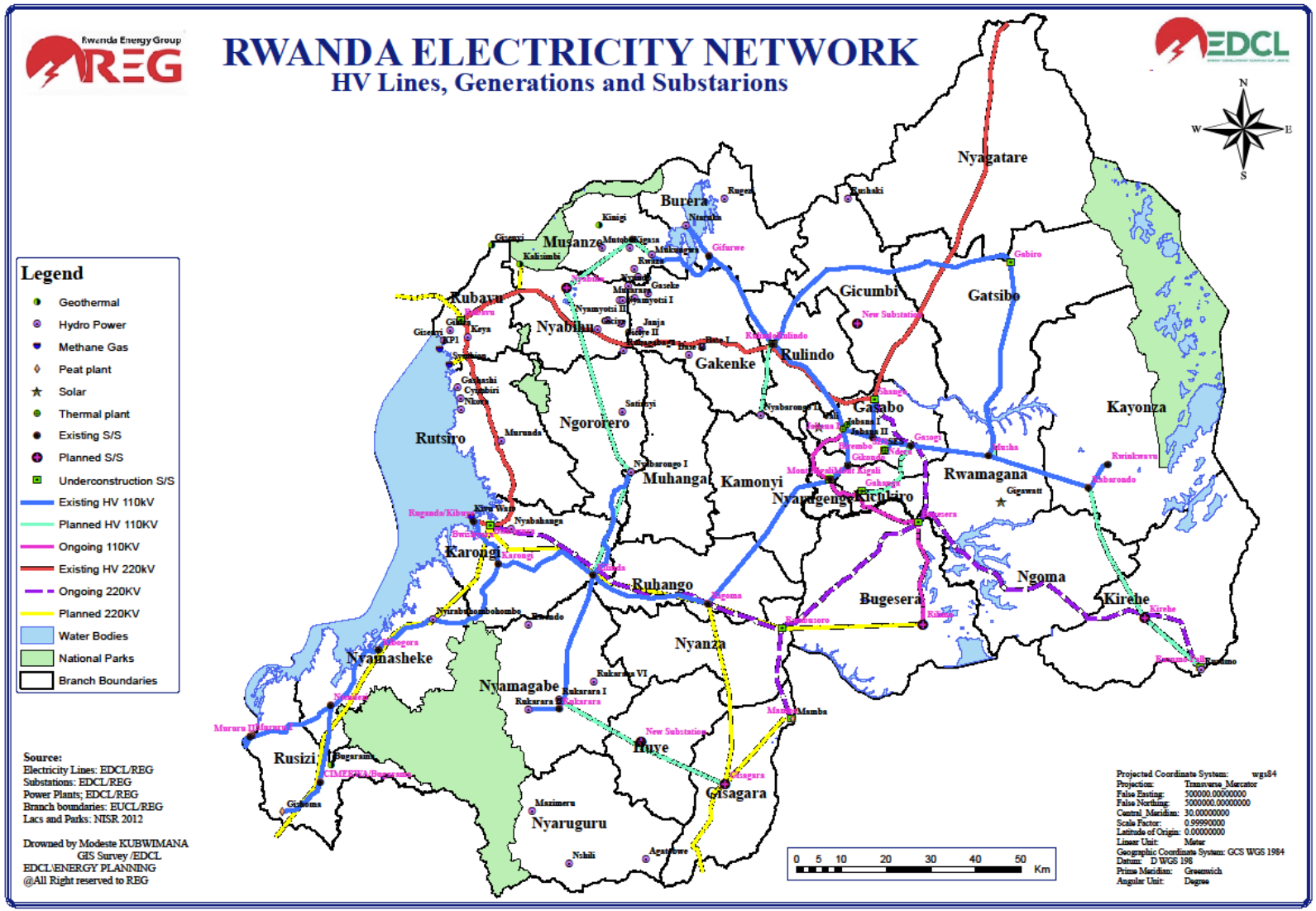
7.1 Transmission Expansion Plan

5.2 Energy Sector Priority Matrix

5.2 Transmission Projects List

5.3 Distribution List

Transmission expansion plan to 2024



Energy Sector Priority Action Matrix

Infrastructure Strategic Plan Priority Action /Output for the Period	Key Priority Actions Across the Period					
	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
Priority 1: Generation capacity increased to ensure that all demand is met and a 15% reserve margin is maintained.						
Power installed capacity increase by 228.763MW (Annex 1)	9.1MW Capacity added to the Grid	9.4MW Capacity added to the Grid	59.6MW Capacity added to the Grid	60.4MW Capacity added to the Grid	48.3MW Capacity added to the Grid	42MW Capacity added to the Grid
Priority 2 & 3: Reliability of electricity supply improve, Losses reduced to 15%						
747KM of High Voltage Transmission lines constructed	243Km High Voltage Lines constructed	24Km High Voltage Lines constructed	388Km High Voltage Lines constructed	35Km High Voltage Lines constructed	18Km High Voltage Lines constructed	40Km High Voltage Lines constructed
749Km of Distribution Network Constructed/Strengthened	231.7Km of Distribution Lines constructed/Strengthened/Rehabilitated	148.4 Km of Distribution Lines constructed/Strengthened/Rehabilitated	100.5 Km of Distribution Lines constructed/Strengthened/Rehabilitated	115 Km of Distribution Lines constructed/Strengthened/Rehabilitated	100 Km of Distribution Lines constructed/Strengthened/Rehabilitated	53.6 Km of Distribution Lines constructed/Strengthened/Rehabilitated
Priority 4: Household access to electricity increased to 100%.						

Infrastructure Strategic Plan Priority Action /Output for the Period	Key Priority Actions Across the Period					
	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
1,036,620 new households (HHs) will be connected to the grid.	163,914 New Households connected to the Grid	148,201 New Households connected to the Grid	160,466 New Households connected to the Grid	173,624 New Households connected to the Grid	187,680 New Households connected to the Grid	202,734 New Households connected to the Grid
1,598,965 new households (HHs) connected through Off-grid Solutions	283,507 New Households connected through off Grid Solutions	220,262 New Households connected through off Grid Solutions	271,266 New Households connected through off Grid Solutions	255,706 New Households connected through off Grid Solutions	274,286 New Households connected through off Grid Solutions	293,938 New Households connected through off Grid Solutions
Priority 5: Productive user access to electricity increased to 100%.						
2,421 existing productive use facilities connected to electricity	457 Existing Productive Users supplied with Electricity	982 Existing Productive Users supplied with Electricity	982 Existing Productive Users supplied with Electricity	100 New Productive Users supplied with Electricity	100 New Productive Users supplied with Electricity	100 New Productive Users supplied with Electricity
Priority 6: Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass						
1,839,684 ICS disseminated	137,219 ICS disseminated	293,191 ICS disseminated	315,490 ICS disseminated	339,127 ICS disseminated	364,112 ICS disseminated	390,544 ICS disseminated
Priority7: Street lighting expanded to all populated areas and main roads.						
Existing and New major national and urban roads Provided with street	48Km Provided with Street Lighting	403Km Provided with Street Lighting	451Km Provided with Street Lighting	452Km Provided with Street Lighting	228Km Provided with Street Lighting	228Km Provided with Street Lighting

Infrastructure Strategic Plan Priority Action /Output for the Period	Key Priority Actions Across the Period					
	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
lighting to a total length of 1,810 km						
Priority 8: Petroleum strategic reserves increased to cover three months' supply.						
Petroleum strategic reserves increased to cover three months' supply currently at 74 Million Liters of Oil storage capacity	Increase by commissioning additional capacity of 61 Million Liters of strategic Oil (petroleum) reserves.	Increase by commissioning additional capacity of 10 Million Liters of strategic Oil (petroleum) reserves.	Increase by commissioning additional capacity of 12 Million Liters of strategic Oil (petroleum) reserves.	Increase by commissioning additional capacity of 13 Million Liters of strategic Oil (petroleum) reserves.	Increase by commissioning additional capacity of 13 Million Liters of strategic Oil (petroleum) reserves.	Increase by commissioning additional capacity of 15 Million Liters of strategic Oil (petroleum) reserves.
Gas strategic reserves increased to cover three months' supply.	Capacity of 16 million Kgs of Strategic gas reserves required	Increase by commissioning of additional capacity of 7.6 million Kgs of Strategic gas reserves	Increase by commissioning of additional capacity of 8.2 million Kgs of Strategic gas reserves	Increase by commissioning of additional capacity of 8.8 million Kgs of Strategic gas reserves	Increase by commissioning of additional capacity of 9.5million Kgs of Strategic gas reserves	Increase by commissioning of additional capacity of 10million Kgs of Strategic gas reserves

List of transmission Projects 2018-2024							
S/N	**Project Name**	**Project Component**	**Length/ Capacity**	**Estimated Cost(USD)**	**Area to be served**	**Starting Period**	**End Year**
1	**Kigali Ring**	**Kigali Ring 110kV line Jabana - Mt Kigali - Gahanga and substations**	**27**	**17,000,000**	**Strengthening and loss reduction in Kigali area**	**2018**	**2019**
2	**110kV Gahanga-Bugesera**	**Construction of Transmission Line**	**17.5**	**3,150,000**	**Strengthning of Bugesera SS**	**2018**	**2019**
3	**110kV single circuit Bugesera-Rilima(Industrial Park)**	**1. Construction of Transmission Line**	**24**	**4,320,000**	**Supply of Bugesera network from Rwabusoro SS and N-1 for Bugesera Industrial Park**	**2018**	**2020**
4	**110kV single circuit Nyabarongo I-Nyabihu**	**1. Construction of Transmission line, 2. Extension of NyabarongoI s/s**	**55**	**16,900,000**	**To evacuate power from Nyabarongo I HPP**	**2019**	**2021**
5	**Nyamugari Substation**	**Construction of Nyamugari Substation**	**20/75MVA**	**12,000,000**	**Strengthening of Eastern Network and it will help to transmit 27MW from Rusumo to Nyamugari(220kV Line) then From Nyamugari to Bugesera(110kV Line)**	**2020**	**2021**
6	**110kV single circuit Rwinkwavu-Kirehe-Nyamugari (Rusumo)**	**1. Construction of Transmission line,**	**89.07**	**27,032,600**	**110kV Network renforcement & strengthening in Kirehe District**	**2020**	**2021**
		2. Upgrade of Rwinkwavu s/s,				**2020**	**2021**
		3. Construction of Kirehe s/s,				**2022**	**2023**
7	**110 kV single circuit Rwabusoro-Rilima**	**1. Construction of Transmission Line**	**32**	**5,760,000**	**Power Evacuation from Rwabusoro ss to Rilima (Industrial Park)**	**2019**	**2021**
8	**110/30 kV Rilima Substation(Industrial Park)**	**1. Construction of Substation**	**20**	**13,665,551**	**Supply Electricity in Bugesera Industry Park**	**2019**	**2021**
9	**Shango Control Center**	**1. Construction of control center**			**To assist existing control center**	**2019**	**2022**
10	**Nzove Substation**	**1. Construction of Substation**	**20MVA**	**7,000,000**	**Supply 30kV at proposed Skol and WASAC industries. Hence network reinforcement**	**2019**	**2019**
11	**Re-Conducting of 110 kV Tline from Ntaruka Ss to Rwinkwavu Ss**	**1. Rehabilitation of Transmission Line**	**191.72**	**11,311,480**	**Loss reduction and Netwok stability**	**2019**	**2021**
12	**220kV Symbion-Rubavu**	**1.Construction of Transmission line**	**10.5**	**19,890,000**	**Evacuation of power from Symbion MPP**	**2022**	**2022**

List of transmission Projects 2018-2024							
S/N	**Project Name**	**Project Component**	**Length/ Capacity**	**Estimated Cost(USD)**	**Area to be served**	**Starting Period**	**End Year**
		2.Construction of Symbion Substation					
13	**110kV single circuit Gahanga-Gasogi**	**1. Construction of Transmission line,** **2. Extension of Gahanga s/s,** **3. Extension of Gasogi s/s**	**17.8**	**15,204,000**	**110kV Network renforcement & strengthening in Kigali city**	**2022**	**2022**
14	**110kV single circuit Nyabihu-Rubavu**	**1. Construction of Transmission Line**	**40**	**7,200,000**	**Strengthening of the high voltage network in the Nyabihu and Rubavu areas**	**2021**	**2024**
15	**110kV single circuit Rukarara-Huye-Gisagara**	**1. Construction of Transmission line,** **2. Extension of Rukarara s/s,** **3. Construction of Huye s/s**	**40.71**	**19,327,800**	**To evacuate the power to be generated by Rukarara HPPs and network strengthening**	**2022**	**2023**
16	**110kV single circuit Nyabarongo II-Rulindo**	**1. Construction of Transmission line,** **2. Construction of NyabarongoII s/s** **3. Extension of Rulindo s/s**	**16.64**	**14,995,200**	**TL will evacuate Nyabarongo II to Rulindo substation**	**2024**	**2025**
17	**220kV single circuit Bwishyura-Kamanyora**	**1. Construction of Transmission Line**	**89.07**	**23,158,200**	**Regional power network interconnection towards power sharing amongest EAC countries**	**2023**	**2025**
18	**GICUMBI SS**	**1. Construction of Substation**	**20**	**7,000,000**	**Network renforcement & strengthening in Gicumbi District**	**2024**	**2025**
19	**Gifurwe s/s**	**Upgrade of Gifurwe Substation**	**10MVA**	**1,976,471**	**Network Reinforcement**	**2018**	**2018**
20	**Rulindo s/s**	**Rehabilitation of Rulinda Substation**	**20**	**4,941,176**	**Network Reinforcement and flexibility to construct new lines**	**2018**	**2018**
21	**110kV single circuit Mukungwa-Nyabihu**	**1.Construction of Transmission line, 2.Construction of Mukungwa s/s,**	**29**	**5,442,254**	**To evacuate 12MW from Mukungwa and Ntaruka once the old 110kV is faulty or under repair. It will help to connect the existing 110kV line with incoming 110kV line. Nyabihu substation will receive 3 main feeders; Gisenyi, Mukungwa and Nyabarongo1.**	**2018**	**2019**

List of transmission Projects 2018-2024							
S/N	**Project Name**	**Project Component**	**Length/ Capacity**	**Estimated Cost(USD)**	**Area to be served**	**Starting Period**	**End Year**
22	**110kV Single Circuit Musha-Gabiro Rulindo 110kV line and Gabiro Substation**	**1.Upgrade Musha Substation 2.Construction of Gabiro Substation 3.Construction of 110kV line**	**109.5**	**22,559,884**	**Network Reinforcement**	**2018**	**2019**
23	**220kV Double Circuit Mamba-Rwabusoro-Bugesera**	**1.Construction of Mamba, Rwabusoro and Bugesera Substations 2.Constructuion of Line**	**60**	**43,982,829**	**1.Evacuation of 80MW from Hakan 2.It will serve in Interconnection network**	**2018**	**2019**
				303,817,445			

Annex 5.3: List of Distribution Projects

SN.	Project name	Line Length	Cost Estimate (USD)	Starting Period	Category
1	Recon ducting the existing 70mm² conductor for 110kV Transmission lines Mukungwa - Camp Belge – Camp Belge with 120mm² .	13km	359,198	2019	Loss reduction
2	KKK Feeder extension to Gabiro switching station	27km	3,666,600	2019	Strengthening
3	Rwaza 30/30kV switching substation with 30kV distribution line connected to Janja Feeder.(Ongoing project).	5.2km	250,000	2018	Strengthening
4	Upgrade of Camp Belge substation		1.500,000.00	2019	Strengthening
5	Upgrade of Rubavu Network from 6.6kv to 30kV	11km	4,950,000	2019	Strengthening
6	KANAZI FEEDER – Load Transfer to Ntongwe feeder	OHL 1.7 km line	200,000	2019	Loss reduction
7	Reduce stress on Kigali (Jabana) short term solution using Base Feeder		721,000	2019	Loss reduction
8	30kV Double Circuit line Bugerera to Airport	OHL 7.5 km line	1,012,500	2019	Strengthening
9	Nasho 30kV Transmission line: Kabarondo Substation - Nasho Irrigation Scheme	28km 30kV line	4,000,000	2019	Loss reduction
10	Existing Kigali network upgrade (8 Cabins)		11,174,000	2019	Strengthening
11	Switching devices and Distribution Management Stystem (DMS)		25,000,000	2019	Loss reduction
12	Reconducting of the last section (35mm²) of Ngororero T-Off with 120mm² .	9km	248,675	2020	Strengthening
13	Reconducting Byumba – Kageyo line (35mm²) with 120mm²	4km	110,522	2019	Loss reduction
14	Reconducting Musasa main feeder with 120mm² .	20km	552,612	2020	Loss reduction
15	Interconnection of Byumba Feeder with Shango substation (30kV Distribution line)	7km	967,071	2020	Strengthening
16	Build a new feeder from Nyabarongo I substation and Load transfer from Gatumba r and Ngororero Feeders to the new feeders from Nyabarongo I	8.5km	1,174,300	2022	Strengthening
17	30kV distribution line to connect Muhanga	0.5km	69,076	2021	Strengthening

Annex 5.3: List of Distribution Projects					
SN.	Project name	Line Length	Cost Estimate (USD)	Starting Period	Category
	Industrial Park				
18	Feeder interconnection between Ntendezi & Mururu 1	1.2km	165,784	2019	Strengthening
19	30kV distribution line to connect Rusizi Feeder	0.05km	7,000	2019	Strengthening
20	Feeder interconnection between Kibogora & Karongi	3km	414,459	2019	Strengthening
21	Feeder interconnection between Karongi & Kigoma	6.2km	856,548	2019	Strengthening
22	Load transfer from Kibuye Feeder to Rubavu subatation		25,000	2019	Loss reduction
23	Upgrade of Mururu Transformer from 5MVA to 10MVA		300,000	2019	Strengthening
24	Replacement of Karongi YY transformer causing MV Harmonics in HV Line with DY Transformer.		300,000	2019	Strengthening
25	Upgrade of STEG Network	100km	3,000,000	2019	Loss reduction
26	Construction of a 15kV Double circuit line to supply industrial bulk loads at Rwamagana	3.4km	620,000	2019	Strengthening
27	Split Busbars in Kigali North and Kigali South for more flexibility in supply		60,000	2019	Strengthening
28	UTEXRWA (load transfer to DW)	OHL 1.7 km line	200,000	2019	Loss reduction
29	Upgrade of Gahanga-Gikondo distribution line	OHL-15kV - 120/20mm² - 7.2km	952,941	2019	Strengthening
30	Gikondo to Ministere feeders (underground 2x240mm²)	2.4 km	2,000,000	2019	Strengthening
31	Mont Kigali to Kigali south 120/20 ACSR	6.7 km	869,120	2019	Strengthening
32	30kV Airport to Nyamata (Back up line)	OHL 8.1 km line	1,057,191	2019	Strengthening
33	Upgrade of STEG Network	100km	3,000,000	2020	Loss reduction
34	Re-conduct the part of Kanazi Feeder from Nyamata to Nemba 70mm² with 120mm²	OHL 40km line	290,000	2020	Loss reduction
35	Interconnection of Ntongwe Feeder with Rwabusoro substation.	1.5km	207,229	2020	Loss reduction
36	Nzove to Abattoir 2 x 120/20 ACSR	5.5 km	750,000	2020	Strengthening

Annex 5.3: List of Distribution Projects					
SN.	Project name	Line Length	Cost Estimate (USD)	Starting Period	Category
37	Abattoir Upgrade		1,250,000	2020	Strengthening
38	Upgrade of network and single phase lines	100km	3,000,000	2021	Loss reduction
39	Reduce stress on Kigali (Jabana) using Nzove Substation		200,000	2021	Loss reduction
40	Upgrade of network and single phase lines	100km	3,000,000	2022	Loss reduction
41	Installation of a second Transformer 110/30kV at Mukungwa Substation for N-1 purpose.		800,000	2022	Strengthening
42	30kV distribution lines to connect the existing lines to new feeders from Huye Substation	15km	2,072,294	2022	Strengthening
43	Load Transfer of Gisenyi Feeder to Rubavu substation		100,000	2022	Loss reduction
44	Upgrade of network and single phase lines	100km	3,000,000	2023	Loss reduction
45	Upgrade Karongi Substation to 20MVA		2,500,000	2023	Strengthening
46	Interconnection of Kiyumba feeder with the new feeder in Nyabarongo II substation to create alternative source of supply.	3.5km	483,535	2024	Strengthening
47	Load Transfer of Musasa Feeder to Nyabarongo II 110/30kV Substation.	1.6km	221,045	2024	Loss reduction
Total Cost			**86,157,700**		