# KivuWatt

## Impact Evaluation study

December 2022

# Authors & acknowledgments

Enea Consulting is a strategy consultancy that maximises energy transition opportunities for public and private organisations globally. Through dedicated consulting services and pro bono support to NGOs and social entrepreneurs, Enea is also committed to improving energy access, especially in developing countries.

As part of this KivuWatt Impact Evaluation Study, FMO managed and commissioned Enea Consulting and its partners to conduct this evaluation from feasibility study to endline results. This evaluation was conducted with the support of Rwanda institutions, KivuWatt project team and local experts.

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Photo credits: Enea Consulting, ContourGlobal

# Executive summary

## CONTEXT

Before 2016, Rwanda's electric system was short of generation capacity to meet its energy demands, and the energy supply was expensive and unreliable.

Therefore, it was critical to develop the KivuWatt power plant to increase the supply of affordable and reliable electricity, and ultimately contribute to the improvement of the country's energy security and economic development opportunities.

### KIVUWATT POWER PLANT - HELPING RWANDA'S ENERGY NEEDS

**The KivuWatt project is a 26 MWe ongrid power plant project located in Kibuye (West of Rwanda), which uses methane gas extracted from Lake Kivu's deep waters** and represents 12% of Rwanda's total installed capacity. The plant has been running in commercial operation since January 2016 and operates baseload on a 24-hour basis with a yearly target for electricity production of 220 GWh.

**The KivuWatt project was the first Rwandan Independent Power Producer (IPP) project.** The 25-year Power Purchase Agreement (PPA) agreement was signed between KivuWatt Ltd, a 100% owned Rwandan Special Purpose Vehicle (SPV) controlled by ContourGlobal (USA), and the Government of Rwanda's (GoR) national electricity utility company Rwanda Energy Group (REG), the project's electricity offtaker.

The KivuWatt project is also governed by a 25-year Gas Concession Agreement (GCA) with the REG, under which it must comply with the Management Prescriptions (MP), a set of requirements set by experts and the REG to ensure sustainable methane extraction and lake stability. The Kivu Lake is a stratified lake with different layers having different biochemistry characteristics, which if disturbed, through for instance methane extraction from its deep layers, can increase the risk of biodiversity disappearance or lake saturation, therefore explosion.

### PROJECT FUNDING

The level of risk for the KivuWatt project combined with lack of finance in the local market have drove FMO, the Netherlands Entrepreneurial Development Bank, into supporting financially ContourGlobal.

The total project investment was USD $211.25 million, of which ContourGlobal contributed USD $120 million equity investment. ContourGlobal sought debt of USD $91.25 million to close the financing of this capex-intense project.

FMO's investment logic relied on three criteria based on an agreement with the Dutch Government:

1. **Sustainable development:** FMO's strategy is aligned with the Sustainable Development Goals (SDGs), building on increased focus and impact in its activities. FMO steers its contributions to the SDGs in general, and in three in particular: decent work and economic growth (SDG8), reduced inequalities (SDG10) and climate action (SDG13).
2. **Financial additionality:** FMO's financing should mitigate risks through the financing product offered which is not readily available from commercial parties on workable terms.
3. **ESG additionality:** FMO's financing should add value in the field of Environmental, Social and Governance standards. Hereby, ensuring that outcome / returns to society will be higher than would otherwise be the case with other parties. ESG additionality is considered as an element in a financing package that cannot be easily obtained from other market parties.

# IMPACT EVALUATION

FMO commissioned Enea Consulting[1] andits partner DataStorm[2] to conduct a full socio-economic and environmental impact evaluation study of the KivuWatt project.

## IMPACT EVALUATION GOALS

The goals of FMO in mandating this study was to assess the:

1. Impacts of the investment in KivuWatt power plant on the Rwandan energy sector.
2. Socio-economic impacts linked to the improvement of energy availability and reliability on households, health centres, schools and businesses at national level.
3. Local impacts of KivuWatt project through Corporate Social Responsibility (CSR) activities.

The baseline for this study was conducted in March 2015 and the endline in October 2019. The impacts on the Rwandan energy sector was assessed from government institutions data and in-field interviews, the socio-economic impacts were assessed through a national survey with a statistical approach seeking to be representative of populations at household levels and at health centres, schools and businesses levels, and the local impact of KivuWatt were assessed though interviews and in-field visit to the KivuWatt plant.

1 Enea Consulting provides strategy consultancy services in the fields of energy transition, including energy access projects and programs. It is based in Paris, Melbourne, Hong Kong and Singapore.

2 DataStorm is a French company with statistics expertise providing support and analysis in the field of statistics and econometrics.

### NATIONAL SURVEY METHOD

The evaluation assessed changes in more than ten socio-economic indicators among 180 villages, 1789 households, 7497 individuals, 154 schools, 104 health centres and 123 businesses.

For the national survey, a full five-year quantitative evaluation design was implemented to assess the impact of KivuWatt on socio-economic development, poverty reduction, and environmental sustainability at electricity end-user level: households, health centres, schools, and businesses.

The classes of indicators used for this evaluation focused on causal chain between access to electricity and poverty: improved/increased access to electricity; energy uses; energy spending; job/activity creation and access to services. The timeframe between baseline in March 2015 and endline in October 2019 was decided because KivuWatt would be the only expected major generation capacity added to the grid over the period.

The target surveyed population consists of end-users of electricity that would benefit, in all provinces of Rwanda, from the additional generation capacity of the KivuWatt project. The population of end-users was stratified ex-ante (before the start of the evaluation) into three groups of villages following the REG electrification plan:

**1.** Villages that were already supplied[3] with electricity from the national grid in 2015.

**2.** Villages that became electrified and were supplied by the National Grid between 2015 and 2019.

**3.** Villages that remained off grid.

The endline survey involved collecting endline data on grid stability and socio-economic criteria among the same pool of end-users as in the baseline survey.

3 By "supplied", we mean here that the villages are both connected to the grid and supplied with electricity. In the Rwandan context, where rapid electrification is underway, a number of villages might indeed have a connection (e.g. an electrical pole has been installed in the village), but this connection is not supplied with electricity yet.

## IMPACT RESULTS

As the only major capacity that has entered the grid since 2016, KivuWatt has delivered multiple benefits to the national energy sector, households, health care centres, businesses, and local communities.

### NATIONAL ENERGY SECTOR

For the Rwandan energy sector, the KivuWatt project has delivered direct national impacts at the national level, in terms of improvement to grid stability, reduction of grid carbon content, energy independence.

KivuWatt, along with a reduction of grid electricity tariffs has contributed to the improvement to electricity access and quality over the period.

**KivuWatt played an important role on the improvement of grid electricity security and independence,** as it has been the only large capacity addition in Rwanda's power mix since 2015. It was commissioned after Rwanda experienced a large deficit in power between 2011 and 2013 that was directly remediated with costly and high-carbon diesel generation. KivuWatt has been used at 95% of its capacity since its commissioning and represents 25% of total grid electricity sales in Rwanda. This has greatly improved grid-wide security of supply, and reduced electricity imports.

**As baseload power, the introduction of KivuWatt contributed to improve grid stability nationwide since 2016** along with grid stability efforts implemented by the REG from 2017 onwards. Prior to the commissioning of KivuWatt, baseload generation was fundamentally intermittent. The socio-economic survey carried out by Enea confirms that households recognise the improvement in the quality of electricity supply.

**The KivuWatt project resulted in a significant reduction in greenhouse gas emissions in the Rwandan power mix.** The carbon content of Rwandan ongrid production has experienced a halving of greenhouse gas emissions, from 308 $gCO_2$ per kWh to 134 $gCO_2$ per kWh. This is attributed to KivuWatt's low-carbon share of production capacity based on methane gas, at the expense of carbon-intense diesel used previously.

**Electricity production from the KivuWatt plant is cheaper than former diesel-based electricity production** (13.5 USDcts/kWh vs 24 USDcts/kWh), and cheaper than imports. As a result, the cost of power fed to the grid has decreased by 3 USDcts/kWh and subsidies to the sector have been reduced.

**The impact of KivuWatt on access to electricity is tightly linked to the impacts from the government's electrification program.** Indeed, between 2015 and 2019, the electrification rate, in terms of grid connection densification, grid extension and offgrid connections, has increased by 27% across the country, with 14% offgrid and 13% ongrid generation. These increase in electrification rates were bolstered by the government's 2017 electrification program, through extending the grid and making electricity tariff connections more affordable[4], while availability and quality of electricity supply improved with added capacity.

4 The implementation of tariff reforms in 2017 increased affordability of electricity tariffs for small energy consumers, the provision of connections for free for industrial customers and the reduction in connection cost and the adoption of a flexible payment plan for non-industrial consumers.

## HOUSEHOLD SURVEY

> Improved access to electricity, in terms of connections, quantity and quality of electricity consumed by households led to longer lighting periods and at-home phone charging activities, reducing commuting time to charge phones.
>
> However, overall, there was a small increase in the use of appliances for craft and trade activities, and no real change in employment rates.

Household results of the national survey show that 86% of the households surveyed in the baseline could be successfully tracked and surveyed in the endline.

This confirms the robustness of the survey methodology and power computations for impact evaluation.

The results at the household level show an **increase of the electrification rate** between 2015 and 2019, **both in already supplied (up from 61% to 72%) and newly connected villages (from 0% to 41%), as well as a decrease in the use of diesel generator equipment** among newly connected households in newly connected villages. These results confirm a positive impact of the rural electrification government policies, in particular the 2017 connection subsidy reforms. The decrease in the use of diesel equipment suggests that the grid offers relatively more cost-or/ and quality-performant electricity.

The quantitative survey provided evidence of a **significant improvement in the quality of electricity supplied, as reductions of 39 percentage points of daily power outages, of 26 percentage points of monthly load shedding, and of 11 percentage points reduction of periods with limited capacity** were observed in already supplied villages. These results also confirm a positive impact of governmental grid strengthening policy efforts, but also the impact of the introduction of large KivuWatt baseload capacity on grid stability.

**Energy spending of households were significantly greater among households that were already connected to the grid** in the baseline compared to newly connected household groups. This is explained by their higher degree of socio-economic development compared to the newly connected households, and by electricity tariffs per kWh cut by half.

**Among connected households,** lighting is exclusively powered by the grid and **lighting time among newly connected households has increased significantly,** by up to 15 hours per day, with a striking difference relatively to offgrid households. Regarding lighting uses, **night-time studying time was shown to have significantly increased among school aged children** in newly electrified dwellings. Also, although schools have been electrified among connected villages, students are benefiting from lighting access at home to study during night-time. This indicates that electricity access fosters the time spent studying, and therefore could improve quality and quantity of education and associated effects.

Regarding electric appliances uses, **all newly connected households have adopted a new habit of charging their phones at home** instead of their usual trip to a village charging point, **reducing in turn their net time spent charging their phone by about 30 minutes down to an average of 2 minutes.** The use of the more expensive electric appliances (mostly TVs) has also increased to 9% among newly connected households. This may stem from the access to greater electricity capacities as well as the possible economic spill overs on purchasing capacities. However, the use of appliances by newly connected households remains lower than by those already connected households - reflecting the striking difference in dwelling socio-economic characteristics.

**At the household level, there is overall little use of electricity for craft and trade activities** (e.g., cooling, heating, electronic appliances, motion).

This highlights the general still-highly-rudimentary economic situation in the country rural areas, including the massive contribution of informal activities to the Rwandan economy. However, **in newly connected households of higher income villages** already supplied by the grid in the baseline, access to a grid connection **enabled the newly connected households to engage more in some craft and trade activities,** because of their relatively higher degree of economic development.

**While employment rates have not significantly changed, a structural shift in occupation types among individuals in newly electrified households has been observed.** Villages that already had access to electricity had a smaller share of farming jobs. Meanwhile, the newly electrified villages decreased the share of farming jobs and an increase in better paid jobs. In addition, working time has increased among individuals in newly electrified households in higher income villages, already supplied by the grid in 2015. This also underscores the role of the village socio-economic dynamics on the labour supply behaviour of individuals.

## FACILITY SURVEYS: HEALTH CENTRES, SCHOOLS, AND BUSINESSES

> Improved access to electricity for facilities was mainly observed in the form of improved quality and reliability of electricity supply, leading to a sharp decrease in the use of diesel generators, and to an increase in operating hours.

Facility-level results of the national survey show that both 100% of the health centres and 87% of the schools were surveyed at the baseline were tracked at the endline. However, the attrition rate of businesses was over 50% due to businesses that failed or that shifted their focus in the meantime.

Compared to households, **facilities already had a high electricity access rate in the baseline, which slightly increased in the endline.** This depicts the priority access to an electricity connection granted to establishments as to guarantee education, health and amenity services in villages in line with the development measures put in place by the Rwandan government.

**A significant improvement in electricity supply quality has been observed across all connected facilities** and is similar to that of households, which reflects extensive governmental efforts.

**The use of diesel generators across facilities also decreased sharply** to the extent that they are currently kept for backup, **showing that the grid proved more reliable.** Indeed, diesel generators have traditionally been the main off grid power-generation source for facilities (compared to solar generation), because of their reliability.

**Electricity hours used per week increased significantly for health centres (18 additional hours per week), and slightly for schools (5 additional hours per week), and meanwhile remained stagnant for businesses in 2015-2019.** Health centres consumption comes hand in hand with the increase in night-time operation and the use of additional electricity-driven equipment, and with an increase of the average consumption of electricity from the grid.

Health centres and schools' lighting time and total weekly opening hours have increased to 128 hours and 79 hours on average in 2019 respectively.

Regarding appliances used by health and school facilities, **light bulbs were the predominant lighting device for health facilities and schools (90% in 2019). Equipment ownership among connected health centres in the baseline has doubled since 2016, driven particularly by computer ownership.** This proves the effectiveness of the government's national measures in increasing digital access among Rwandan businesses. Similarly, almost all schools surveyed had computers available to students. Moreover, **the average number of computers per school increased by 65.3%** between the baseline (75 computers on average) and endline (124 computers on average). This proves the effectiveness of the government's digitalisation policies.[5]

**The average annual revenues of businesses almost doubled and weekly hours of operations increased by 11.3%** between the baseline and the endline. This stems partially from the longer opening hours of businesses, also likely from electricity quality and quantity spinoffs.

5 Information and Communication Technology has been introduced in the national competence-based curriculum. See Government of Rwanda's Education Sector Strategic Plan "One Laptop Per Child policy" and the "smart school" initiatives

## LOCAL COMMUNITY

For local impacts, KivuWatt has generated several benefits contributing to regional, social, environmental and economic development. Significantly, KivuWatt's positive impacts are extensive and additional to both the local community and employers.

**KivuWatt is the first major infrastructure project that came into light in the Kibuye region, into which it has funnelled economic, social and environment spinoff benefits.** The construction and operation of the project created local employment and attracted investments and spending in the region. Combined with improved access to reliable and cheaper electricity, the regional and local economy has developed substantially since 2010. Kibuye residents and KivuWatt employees have experienced improved social conditions and livelihood.

**KivuWatt is actively engaged in Corporate Social Responsibility (CSR) activities** as consequence of commitments made to its lenders. KivuWatt spends on average USD 200,000 per year in its CSR program. Its 15 CSR projects that have been implemented have had a positive impact on the region.

**KivuWatt has a strong employment and retention performance** driven by robust recruitment, human resource and health and safety strategies, **which provides an example for other infrastructure development companies in Rwanda.** As for its employees, its recruitment strategy allowed the recruitment of more than 50% of Rwandan employees and around 20% of women employees.

## FMO FINANCING

FMO financing has successfully brought sustainable development and additionality to Rwanda.

At approval, KivuWatt was expected to contribute to the SDG 7: affordable and clean energy, the SDG 8: decent work and economic growth, and to the SDG 13: climate action. This study has also found that KivuWatt also contributed to four additional SDGs: (i) SDG 5 gender equality; (ii) SDG 9 industry, innovation, and infrastructure; (iii) SDG 10 reduced inequalities; and (iv) SDG 17 partnerships for the goals.

FMO has also brought two main sources of additionality:

1. **Financial additionality:**
FMO's financing mitigated financial risks for the client and for other financiers and investors. This is because a commercial financier would not do in the following ways: gap in the amount and tenor (due date) of debt; mobilizing / catalysing; political risk cover; and stamp of approval.

2. **ESG additionality:**
FMO was instrumental in imposing strict adherence to the management standards of the lake-water methane extraction, as well as air pollution and GHG emission, waste, fire and health and safety.

# RECOMMENDATIONS

## CONTEXTUAL FACTORS AND ROLE OF FMO AND OTHER DEVELOPMENT BANKS

Deep understanding of the contextual factors around the project contributed to the achievement of positive impacts. For future projects, FMO should try to replicate factors of success observed through the KivuWatt project:

- **A1. Assess the country's macro-economic and legal framework:** Its assessment early in the project development phase helped to ensure alignment of expectations of all stakeholders with project outcomes, as well as to maximize the financial, socio-economic, and environmental impacts of the project.
- **A2. Ensure the adequacy of the technology to the setting:** The project developed an integrated technology solution for the exploitation of methane gas located in Lake Kivu, which is one of the three lakes in the world that holds large commercially exploitable methane resources.
- **A3. Align with the energy framework in place:** The grid extension / interconnections and tariff subsidies played an impactful role in the development of the Rwanda's electricity system. KivuWatt added generation capacity that contributed to stabilizing the grid, reducing energy costs, and driving electrification. All things considered, the subsidies enabled a swift development of Rwanda's energy sector from 2015 to 2019.

- **A4. Ensure strength of investors' support and robustness of financing structure:** In the case of KivuWatt, this led to successful project development and operational / financial performance.
  _ **Financing structure:** ContourGlobal had a strong risk appetite backed with a significant equity investment, and FMO mobilized debt financing from other development banks, to overcome the significant project risks and lack of available financing
  _ **Investors' support:** ContourGlobal fully absorbed the cost overrun associated with construction delays. Project lenders restructured the senior debt including a new flexible repayment schedule (without changing the overall debt maturity of the project)
  _ **Non-financial support:** ContourGlobal provided training, exchange programs, and career progression opportunities to employees; KivuWatt developed CSR projects for the local communities; FMO and the Dutch government financed, committed, and managed an impact evaluation study of the project.
- **A5. Nurture and partner with a private investor with the right expertise and risk appetite:** This was in terms of the technology used, the business development approach, the availability of financial resources and the country knowledge required to successfully implement the project.
- **A6. Contribute to create buy-in from the government, the private sector, and other stakeholders:** This created the conditions for establishing the necessary enabling environment and the legislation / regulation reform indispensable for the private sector to implement a sustainable project.
- **A7. Provide investment and advisory services to the borrower which in turn would contribute to the increase of the competitiveness of the electricity market, and to the broadening the access to electricity to people and businesses / services.** Services to ContourGlobal led to positive development impacts and contributed to the commitments to the Sustainable Development Goals by the country.

# Contents

# Abbreviations

**ABAKIR**
Authority for Lake Kivu and the Ruzizi. River Basin

**AEF**
Access to Energy Fund

**AfDB**
African Development Bank

**BDR**
Rwanda Development Bank

**BIO**
Belgian Investment Company for Developing Countries

**BPS**
Basis points

**CCR**
Client Credit Review

**CEO**
Chief Executive Officer

**$CH_4$**
Methane

**CO**
Carbon Monoxide

**$CO_2$**
Carbon Dioxide

**CSR**
Corporate Social Responsibility

**DiD**
Differences-in-differences

**FMO**
Financierings-Maatschappij voor Ontwikkelingslanden

**GCA**
Gas Concession Agreement

**GCP**
Gas Capacity Payment

**GDP**
Gross Domestic Product

**GEF**
Gas Extraction Facility

**GFC**
Gas Fixed Costs

**GHG**
Greenhouse Gas

**GiZ**
Deutsche Gesellschaft für Internationale Zusammenarbeit

**GoR**
Government of Rwanda

**DiD**
Difference in Difference

**DPO**
Development Policy Operations

**DRC**
Democratic Republic of Congo

**DSCR**
Debt-Service Coverage Ratio

**E4I**
Energy4Impact

**EAIF**
Emerging Africa Infrastructure Fund

**EFOR**
Equivalent Forced Outage Rate

**EDCL**
Energy Development Corporation Limited

**EDPRS**
Economic Development and Poverty Reduction Strategies

**ELSA**
Emergency Life Support Apparatus

**Enabel**
Belgium Development Agency

**EnDev**
Energizing Development

**EPC**
Engineering Procurement Construction

**ESAP**
Environment Social Action Plan

**ESG**
Environment, Social, Governance and Corporate

**ESSP**
Energy Sector Strategy Plan

**EU**
European Union

**EUCL**
Energy Utility Corporation Limited

**HR**
Human Resources

**HSE**
Health Safety and Environment

**HV**
High-Voltage

**ICOT**
Internal Control Oversight Team

**IDF**
Investment Development Fund

**IEAG**
International Expert Advisory Group

**IPP**
Independent Power Producer

**JADF**
Joint Action Development Forum

**LCGP**
Least Cost Generation Plan

**LCPDP**
Least Cost Production Development Plan

**LIBOR**
London Interbank Offered Rate

**LKMU**
Lake Monitoring Unit

**LV**
Low Voltage

**MINECOFIN**
Ministry of Economics and Finance

**MININFRA**
Ministry of Infrastructure

**MoU**
Memorandum of Understandings

**MP**
Management Prescriptions

**MTV**
Medium-term fiscal framework

**MV**
Medium Voltage

**MW**
Megawatt

**MWel**
Megawatt of electricity

**NDC**
Nationally Determined Contribution

**NEBOSH**
National Examination Board in Occupational Safety and Health

**NEP**
National Energy Plan

**NISR**
National Institute of Statistics Rwanda

**NOx**
Nitric Oxides

**NST1**
National Strategies for Transformation

**PCP**
Power Capacity Payment

**PMS**
Power Management System

**pp**
percentage point

**PP.**
Power Plant

**PPA**
Power Purchase Agreement

**PPP**
Public Private Partnership

**PTW**
Permit to Work

**PVC**
Power Variable Costs

**PSU**
Primary sample units

**RBF**
Result-based Financing

**RE**
Renewable Energy

**REG**
Rwandan Energy Group

**REF**
Rwanda Renewable Energy Fund

**RESSP**
Rwanda Electricity Sector Strengthening Project

**RWF**
Rwandan Francs

**RURA**
Rwanda Utilities Regulatory Authority

**SACCOs**
Savings and Credit Co-Operative Society

**SAIDI**
System Average Interruption Duration Index

**SAIFI**
System Average Interruption Frequency Index

**SDG**
Sustainable Development Goal

**SHS**
Solar Home Systems

**SOGER**
Scaling up Offgrid Energy in Rwanda

**SOx**
Sulphur Oxides

**SPV**
Special Purpose Vehicle

**SREP**
Scaling-Up Renewable Energy Fund Project

**SSA**
Sub-Saharan Africa

**T&D**
Transmission and distribution

**USAID**
United States Agency for International Development

**USD**
United States Dollars

**WB**
World Bank

**WEP**
Work Exchange Programs

**WHO**
World Health Organisation

# Tables

# Figures

# 1

# Introduction

## 1.1

# Context of the KivuWatt evaluation

KivuWatt is a 26 MWe ongrid power plant project located in Kibuye (West of Rwanda) which uses methane gas extracted from Lake Kivu's deep waters, on the Rwandan side of the lake. Lake Kivu is located on the East African Rift Valley and is shared by both Rwanda and the DRC. This stable and stratified lake holds a high concentration equivalent to 55% of biogenic methane gas in its deepest layers. Therefore, an increase in the concentration of methane to 100% or a disturbance of the stratification of water layer can result in a lake saturation. FMO invested funds provided by the Dutch government and mobilized financial resources from the African Development Bank (AfDB), the Emerging Africa Infrastructure Fund (EAIF) and the Belgian Investment Company for Developing Countries (BIO) in support of Contour Global (USA) as developer and owner of the plant.

The plant has been running in commercial operation since January 2016. It is Rwanda's first bilateral 25-year Power Purchase Agreement signed with the Rwanda Energy Group (REG), the national electricity utility and the project's electricity off-taker. The plant runs baseload on a 24h basis with a yearly target for electricity production of 220 GWh and an installed capacity of 26 MW.

The KivuWatt project is also governed by a 25-year Gas Concession Agreement (GCA) with the REG, under which it must comply with the Management Prescriptions (MP), a set of requirements set by experts and the REG to ensure sustainable methane extraction and lake stability.

The construction of the project experienced a costly 3-year construction delay due to the underperformance of the EPC contractor and technical challenges throughout the construction of the project, delaying operating cash flows (commissioning was originally planned in January 2013, as displayed on Figure 1). The cost overruns have been fully absorbed by ContourGlobal who injected an extra USD $65 million equity into the project, and the project lenders offered flexibility to the client by restructuring the senior debt and approving a new repayment schedule without changing the overall debt maturity of the project. Despite the delay, the project is now is generating enough cash for lenders, allowing KivuWatt Ltd – ContourGlobal's 100% owned Rwandan SPV – to service its debt to its lenders in due time along with the new repayment schedule.

Contour Global had a Phase 2 expansion plan that would consist in installing 3 additional floating gas extraction facilities of 25 MW each, which would increase the peak power delivered to 100 MW. Additionally, a smaller expansion of 7 MW was under consideration in the short term to use of the gas extracted in excess to what is needed to power the 26 MW power plant – which is instead currently being flared[6].

6 Although the most ideal scenario would be to utilise all of the extracted gas, flaring of this excess gas remains less impactful in terms of GHG emissions than keeping this share of gas unprocessed in the lake: methane emitted by the lake is greater than methane released when flaring the extracted gas.

However, under the recently revised Least Cost Generation Plan, the Government of Rwanda (GoR) has foregone the development of the additional capacity as there is already sufficient capacity on the grid to meet a slowly increasing demand. Thus, additional capacity would lead to substantial unused electricity and result in heavy stranded costs for the already-indebted GoR. Aside from the KivuWatt project, the GoR signed a deal with Symbion Power to develop a 56 MW power plant on the Lake Kivu, which is believed to be favored by the GoR as a result of a lower negotiated cost of electricity than KivuWatt's planned small expansion project.

FMO is interested in evaluating the actual impact of the client on socio-economic development, poverty reduction and environmental sustainability from local to national levels. Therefore, FMO hired Enea Consulting[7] to assess the evaluability of KivuWatt's socio-economic impacts in 2014[8] (c.f. **Appendix**), as well as later engaged Enea Consulting and its partner DataStorm[9] to conduct a full socio-economic and environmental impact evaluation study of the KivuWatt.

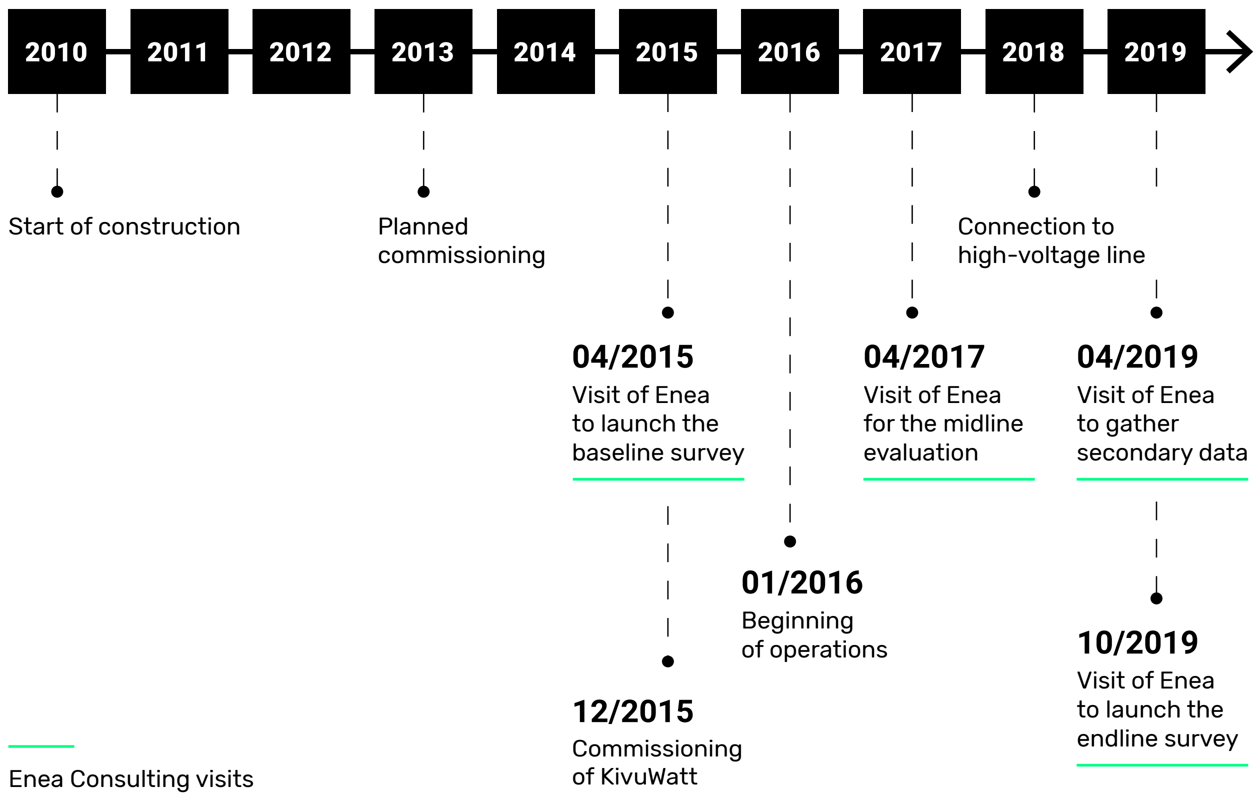
7 Enea Consulting provides consultancy services in the fields of energy, including energy access projects and programs. It is based in Paris, Melbourne and Hong Kong.

8 See Enea's report for FMO Evaluability assessment of KivuWatt Project in Rwanda, September 2014.

9 DataStorm is a French company with statistics expertise providing support and analysis in the field of statistics and econometrics.

**FIGURE 1**

CONSTRUCTION, O&M, AND ENEA FILED VISIT TIMELINE



## 1.2

# Evaluation methodology

The methodology of the socio-economic and environmental impact evaluation study conducted by Enea and FMO includes:

## 1. A QUALITATIVE ASSESSMENT

**A qualitative assessment** of, on the one hand, the project's socio-economic and environmental performance at the local-level, and, on the other hand, its impact on the national Rwandan electricity sector development. These assessments are based on an analysis of **secondary data** from the project developer and electricity sector governmental bodies, and **interviews** conducted by Enea during two field visits in March and October 2019. The list of interviewed stakeholders can be found in Appendix 1, and pertain to four categories:

**1.** Rwandan electricity sector governmental bodies: the Rwanda Energy Group (REG), Rwanda Utilities Regulatory Authority (RURA), the Ministry of Infrastructure (MININFRA).

**2.** International development institutions and private companies active in Rwanda's energy landscape: the Belgium Development Agency (Enabel), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GiZ)), USAID, BBOXX and Energy4Impact (E4I).

**3.** KivuWatt Ltd stakeholders: seven Rwandan employees, the Corporate Social Responsibility (CSR) manager, the Lake Monitoring manager, the Chief Operating Officer.

**4.** Local (Kibuye) stakeholders: the Western Province Governor[10], villagers directly benefiting of 5 selected CSR projects.

10 Provinces are the largest administrative entities in Rwanda, and count 5 (the Northern, Eastern, Southern, Western provinces and Kigali).

## 2. A QUANTITATIVE ASSESSMENT

**A quantitative assessment** of the socio-economic impacts of national grid electricity access and grid stability for Rwandan grid electricity end-users. It is conducted between two points in time; just before and 4 years after the commissioning of KivuWatt, for which improvements can be attributed as it is the only major capacity added over this period.

As such, the assessment was conducted in three phases, along the timeline on Figure 1:

**1. Phase 1, the baseline evaluation** in March 2015: A quantitative survey was launched among 180 villages, targeting in each 10 households, 2 formal businesses, 1 health facility and 1 school to provide an overview of their electrification and their socio-economic status prior to the commissioning of KivuWatt's power plant in December 2015.

**2. Phase 2, the midline evaluation:** Conducted in early 2017, its tasks were threefold:

- Monitoring the grid connection status of the sample villages surveyed in the baseline evaluation

- Evaluating first impacts of KivuWatt on local communities
- Setting a date for the endline study in such a way to be conducted after a long enough period to have a chance to detect changes and prior to the commissioning of the planned additional grid capacity as to not negatively affect the measurability of the impacts of the KivuWatt 1 project on end users and grid stability.

**3. Phase 3, the end-line evaluation** conducted in October 2019: It involved collecting endline data on grid stability and socio-economic criteria among the same pool of end-users as in the baseline.

## 1.3 Evaluation objective

**The objective of this evaluation is to fathom the impact of KivuWatt on the Rwanda's socio-economic development between 2015 and 2019 both at local and national levels.** The appendices include complementary and detailed information, and the methodology and statistical analysis of the quantitative survey (cf. **Section 7**).

The balance of the report is structured along two core chapters.

### CHAPTER 2 SETS OUT THE CONTEXT OF THE PROJECT.

- **Section 2.1** discusses the context and rationale behind the FMO investment in the project.
- **Section 2.3** presents the technologies used in the KivuWatt project and its financial, operational and environmental performances to date. It also assesses qualitatively its impact on local employment and communities.

### CHAPTER 3 DEPICTS THE IMPACT ASSESSMENT STUDY OF THE KIVUWATT PROJECT.

- **Section 3.1** discusses the findings from the qualitative assessment of the impact of KivuWatt in the Rwandan electricity sector, namely on electrification, generation, economy and decarbonization, amidst other direct and indirect development drivers.
- **Section 3.2** presents the findings from the quantitative assessment of the impacts of KivuWatt on the electricity consumers in the country.
- **Section 3.3** describes the impacts of KivuWatt at the local level.

**The quantitative assessment focuses on these four consumer categories: households, businesses, health facilities, and schools:**

- Change is measured with a before-after design for consumers in the villages with access to the grid at the time baseline information was collected
- A differences-in-differences (DiD) designed is used for consumers in the villages with no access to the grid at the time the baseline was collected.

The classes of indicators used for this evaluation focus on causal links between poverty and access to electricity: improved/ increased access to electricity; energy uses; energy spending; job/activity creation and access to services.

# 2

# Project context

2.1

# Macroeconomic context of Rwanda[11]

## MACROECONOMIC DYNAMICS IN RWANDA

**Rwanda has one of the fastest growing economies in Africa. It experienced an average economic growth of 7.5% a year over the past decade,** bolstered by two five-year Economic Development and Poverty Reduction Strategies—EDPRS (2008-12) and EDPRS-2 (2013-18). Whilst the service sector, particularly construction and tourism, contributed most to the overall growth, Rwanda's economy remains overwhelmingly rural and heavily dependent on agriculture [8].

**Low inflation, fiscal and administrative decentralisation, political stability, and a reputation for low corruption are the key factors supporting the country's inclusive growth.** It became a leader reformer in the World Bank's 2019 Ease of Doing Business indicators: it grew from a global rank of 148 in 2008 to 29 in 2019- second-best in sub-Saharan Africa behind Mauritius [12]. It also has the world's highest number of women in politics.

**Although Rwanda's poverty levels significantly reduced from 57% in 2006 to 39% living under poverty line and 16% under extreme poverty in 2018, it remains one of the world's poorest countries,** ranking 175th in terms of GDP per capita, which stood at USD $847 in 2019 [8].

In this respect, the Government aspires to making Rwanda a middle-income country by 2035 and a high-income country in 2050, a vision which will be put in effect through the first seven-year-long National Strategies for Transformation (NST1: 2017 - 2024) aimed towards the achievement of the SDGs. Among priorities for the NST1, a strong focus is placed on accelerating private sector led economic growth and increased productivity [13].

## ENERGY CONTEXT

Rwanda has emerged as exemplar in energy access in Africa. The country experienced substantial electrification over the past decade, outpacing most of its Sub-Sahara African (SSA) neighbours and ranking it 11th globally and 3rd in Africa in terms of its progress in electrification over 2010-2016. At 10% in 2010, combined ongrid and offgrid connections quintupled in 8 years reaching 51% in February 2019 (Figure 2).

Backed by the World Bank, since 2015, ongrid electrification has been greatly driven by government support and subsidies.

11 The Rwandan macroeconomic context is comprehensively depicted in the **Appendix section**, in terms of the country's macroeconomic dynamics, the energy sector's main stakeholders, its evolution and development with regard to regulation, electrification (offgrid/ongrid), system-wide capacity increase. Please refer to this section for a detailed contextual understanding of the electricity dynamics in Rwanda.

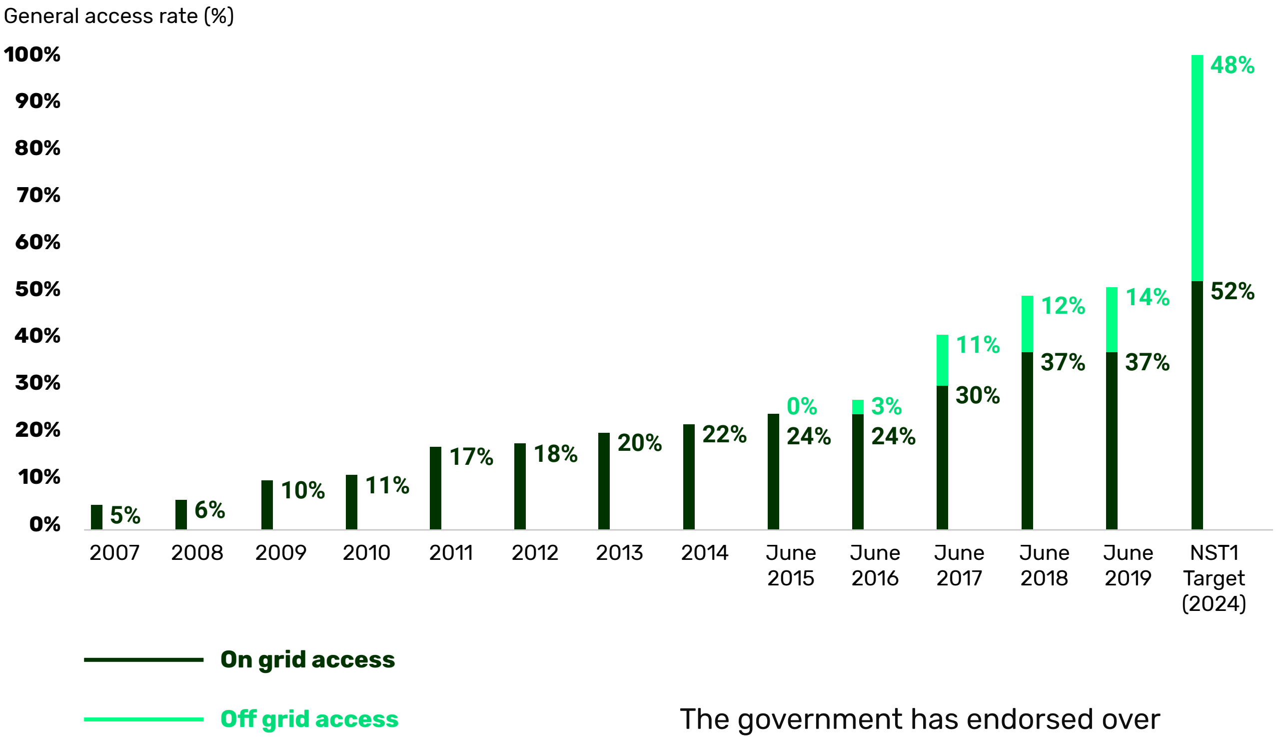



**FIGURE 2**

EVOLUTION OF RWANDA'S ELECTRIFICATION RATE [7]

Connection cost reduction measures have increased affordability and accessibility to grid-electricity[12]. Aside from its extension and densification in connections, the National Grid has also been at the heart of an extensive loss reduction program aiming at improving grid stability and reliability[13].

Offgrid electrification has been mainly driven by the private sector and is led by Solar Home Systems (SHS) adoption. However, considerable regulatory instability has been impeding and halting offgrid electrification growth rate, particularly for mini-grids. The government aims to become an actor of offgrid electrification backed by a recent approval of a subsidy mechanism to support SHS development.

The government has endorsed over the past decade the development of substantial energy capacity on the grid, regardless of demand evolution (Figure 8). However, as countrywide demand growth has been stagnant because of the inability of the residential sector to afford costs of electricity connections and supply, the country is already confronted with a costly supply demand imbalance. This recent realization led the government to aggressively cut planned capacity and adopt least-cost generation principles as to prevent this gap from aggravating.

12 The new connection policy set in June 2017 made new connections free for industries. For all residential consumer categories, it also made new connections more affordable, at RWF 56,000 or USD $60, as well as more accessible through new payment options for the connection fee. Households can from now on avoid large lump-sum up-front payment for the connection and pay-back the cost gradually together with the electricity bill. Indeed, at each purchase of power, 50% of the paid amount is used to repay the balance of the connection fee. See the **Appendix section** for more details.

13 Investments in grid extension have increased ongrid connections from 6% in 2008 to 37% in 2018, which is equivalent to 811,000 connections by end of June 2018. See the **Appendix section** for more details.

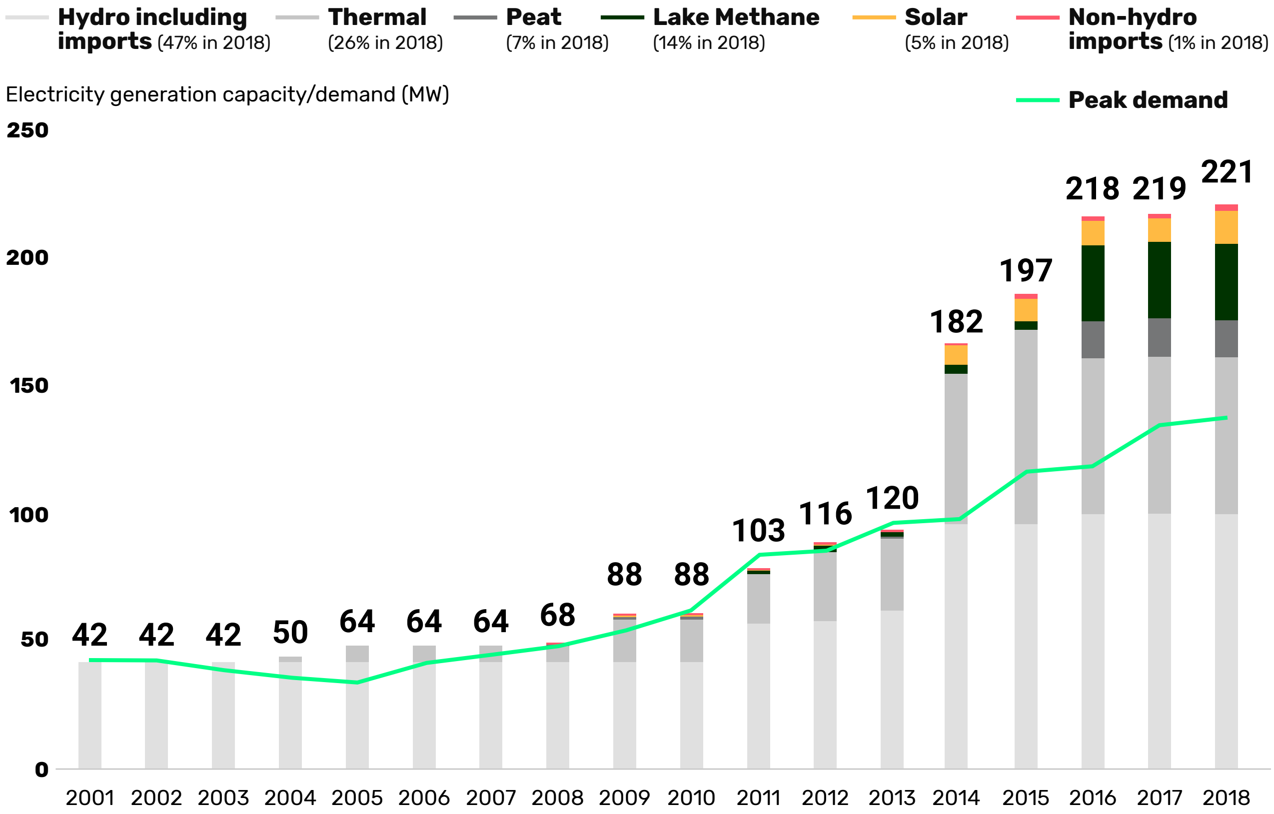



**FIGURE 3**

GROWTH IN INSTALLED ELECTRICITY GENERATION CAPACITY [8]

The Rwandan government has established reforms to promote the business environment and attract private sector investments across all sectors. Rwanda has demonstrated electricity off-taker creditability and succeeded in creating an attractive investment climate in power generation and offgrid electrification. Indeed, as of 2018, it has attracted the direct investment of more than 15 independent power producers (IPP), leaving 52% of capacity under private ownership - one of the highest shares in Sub-Saharan Africa – of which 14% represents KivuWatt's capacity – Rwanda's first-ever PPA, setting the learning ground for other PPAs.

## 2.2

# The KivuWatt investment

### CONTEXT AND INVESTMENT RATIONALE

Before 2016, Rwanda's electric system was short of generation capacity to meet the energy demands, and the energy supply was expensive and unreliable. Therefore, it was critical to develop the KivuWatt power plant to increase the supply of affordable and reliable electricity, and ultimately contribute to the improvement of the country's energy security and economic development opportunities.

The KivuWatt project was the first Rwandan Independent Power Producer (IPP) project. The Power Purchase Agreement (PPA) agreement was signed between the following two parties:

- KivuWatt Ltd, a 100% owned Rwandan Special Purpose Vehicle (SPV) controlled by ContourGlobal (USA)
- The Government of Rwanda's (GoR) national electricity utility company Rwanda Energy Group (REG).

The total project investment was to USD $211 million, of which ContourGlobal contributed with a USD $120 million equity investment. Therefore, ContourGlobal sought from the market debt for USD $91 million to close the financing of this capex-intense project (Table 3-1). The high-risk profile of the project and the banks' low risk-taking capacity / appetite limited the availability of commercial sources of debt financing. Therefore, FMO lent to ContourGlobal a total of USD $31 million from two funds that it managed: USD $11 million from the Access to Energy Fund (AEF), and USD $20 million from the Investment Development Fund (IDF)[14] (Table 3-1). Additionally, FMO catalyzed USD $60 million in debt financing from three impact investors: (i) BIO (USD $10 million) within a cooperation agreement with FMO where BIO's funding is managed by FMO; (ii) AfDB (USD $25 million); and (iii) EAIF (USD $25 million).

The investment led to significant impact as summarized in Table 3-1. FMO aims with its interventions to "pursue investments that are expected to produce strong economic, social and/or environmental returns to a society, but whose risks and expected returns are such that they attract insufficient private investment interest" [3].

| FMO FACILITIES | LOAN PRODUCT TYPE | VALUE (USD $ MILLION) |
|---|---|---|
| **AEF** | AEF – Series A | 8 |
| **IDF** | IDF – Series A | 13 |
| **IDF** | IDF – Series B | 7 |
| **AEF** | AEF – Series B | 4 |
| **TOTAL FMO** | | **32** |
| **BIO** | BIO – Series A | 7 |
| **BIO** | BIO – Series B | 3 |
| **AfDB** | Series A | 25 |
| **EAIF** | Series A | 25 |
| **TOTAL funding** | | **92** |

**TABLE 3-1**

LOAN FACILITIES UNDER THE KIVUWATT PROJECT[15] [4]

14 A mix investment between AEF and IDF has been sought as the level of investment needed was not possible solely with AEF.

15 The outstanding amount yet to be paid by ContourGlobal for the FMO by Q1 2019 is USD $26.5 million. Debt servicing for FMO is semiannual with a 15-year tenor. Interest follows a LIBOR /Fixed rate of 5% or L+ 500 basis points (bps).

| IMPACTS | DESCRIPTION |
|---|---|
| **Safety** | Mitigation of lake saturation risk as the like of Cameroon's 1986 Lake Nyos's explosion from oversaturation in $CO_2$ killing around 2,000 people, by reducing methane concentrations over time and preventing the mixing of the lake's stratified stable layers through monitoring efforts |
| **Environment** | Avoidance of higher carbon, more expensive, and less reliable peaking diesel generation |
| **Energy independence** | Increase in countrywide energy security through provision of 1/3 of Rwanda's total energy demand |
| **Energy Reliability** | Improvement of national grid stability with the provision of dispatchable baseload power |
| **Energy Affordability** | Reduction in generation cost and thus reduce subsidies to the sector |
| **Socio-economic growth** | Concentration of substantial economic spin-offs within the country by exploiting a natural resource to generate power. Catalysis of local and national socio-economic development through improved and increased access to lighting and productive power |
| **Energy Access** | Indirect impact: Extension of National Grid and densification in connections in both poorly electrified Kibuye region and in Rwanda, as planned by the REG relatively to the commissioning of KivuWatt |
| **Energy Market** | Setting the grounds for increased PPA adoption, therefore paving the way for a competitive Rwandan electricity sector |
| **Demonstration effect** | Setting grounds for increased gas extraction process for eventual energy uses and lake monitoring process for the concerned Rwandan and DRC lake monitoring responsible bodies |

**TABLE 3-2**

FORESEEN IMPACTS OF THE KIVUWATT PROJECT

## DUTCH GOVERNMENT AND FMO INVESTMENT OBJECTIVES

FMO's strategy is aligned with the Sustainable Development Goals (SDGs), building on increased focus and impact in its activities. Since 2017, FMO steers its contributions to the SDGs in general, and in three core SDGs in particular: decent work and economic growth (SDG8), reduced inequalities (SDG10) and climate action (SDG13).

Additionally, FMO received government support to *"only provide financial services which the market does not provide or does not provide on an adequate scale or on reasonable/workable terms".* This concept has been enshrined as a principle of operational policy in the Criteria Memo, Agreement FMO – State of the Netherlands.

Accordingly, FMO defines the two main sources of additionality as:

- **Financial additionality:** risk mitigation through the financing product offered which is not readily available from commercial parties on workable terms
- **ESG additionality:** derived from value addition in the field of Environmental, Social and Governance standards. Hereby, ensuring that outcome / returns to society will be higher than would otherwise be the case with other parties. ESG additionality is considered as an element in a financing package that cannot be easily obtained from other market parties.

## SUSTAINABLE DEVELOPMENT GOALS

**FMO's investment rationale implies meeting a set of Sustainability Development Goals (SDGs).**

As summarized in Table 3-2, KivuWatt contributed to the SDGs through positive impacts in terms of economic growth, as well as in terms of social, environmental and financial sustainability. KivuWatt was the largest generation capacity added to the electric system since its commissioning in December 2015 and contributed to meet the energy demands of the Rwandan economy thereafter[16].

According to the latest FMO supervision reports, KivuWatt was expected to contribute to the SDG 7 affordable and clean energy, the SDG 8 decent work and economic growth, and to the SDG 13 climate action. This study has also found that KivuWatt also contributed to four additional SDGs: (i) SDG 5 gender equality; (ii) SDG 9 industry, innovation, and infrastructure; (iii) SDG 10 reduced inequalities; and (iv) SDG 17 partnerships for the goals. Table 3-3 describes the KivuWatt's contributions to these seven SDGs.

16 cf. **Section Electricity [...] and outcomes** for a full picture of the capacities introduced in the grid

## IMPACT GENERATED BY KIVUWATT

**TABLE 3-3** DIRECT AND INDIRECT IMPACT GENERATED BY KIVUWATT

| SDGs | IMPACT DESCRIPTION | IMPACT VALUE |
|---|---|---|
| **SOCIO-ECONOMIC IMPACTS** | | |
| 8 DECENT WORK AND ECONOMIC GROWTH | Contribution to **national GDP increase** | GDP from USD $8 bln in 2014 to **$9.5 bln in 2018 [1]** |
| | | Reduction of balance of payment from USD $-1,562 in 2015 to **$-986 mln in 2017 [2]** through reduction of costly imported diesel generation |
| | **Employment creation** for the operation and maintenance of the KivuWatt plant and through **Corporate Social Responsibility (CSR)** projects for the local community undertaken by KivuWatt (cf. **Section 3.3**) | **64 local direct jobs created** or equivalent to €1.5 million invested by lenders per person |
| | | **15 CSR projects** undertaken by KivuWatt for Kibuye since 2016, **equivalent to USD $600k invested into the socio-economic development of the region** |
| 5 GENDER EQUALITY | **Employment creation for women** for the operation and maintenance of the KivuWatt plant | **22 female employees** having access to equal corporate opportunities and wages (as stated via interviews and exemplified through career paths (e.g. from secretary to HSE Manager, and not found on consolidated data) |
| 7 AFFORDABLE AND CLEAN ENERGY | Increased **access to energy** | **26 MW of cheaper and cleaner capacity** added to the grid increased the capacity of the government to reduce connection costs, therefore densify and expand grid |
| | | **Increase in grid connections** from 61,000 in 2015 to **154,000 in 2019** |
| | | **Increase in lighting access** improving livelihood of households and education for pupils |

| | | |
|---|---|---|
| | Improvement of **energy security** | **Reduction of 26 MW of diesel generation** since 2016 thanks to KivuWatt |
| | Improvement of **energy reliability** and **grid stability** | **Connected households and businesses** in Kibuye stated they were able to produce more volumes and generate **higher economic yields** with catalytic macroeconomic effect |
| 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE | Substantial **sector learning effect** stemming from the 'pilot' nature of the project | **Methane/water extraction** on Lake Kivu |
| | | **Biodiversity and lake stability** monitoring |
| | | **First PPA** in Rwanda as learning ground for REG for future PPAs |
| | **Symbolic project** | Generates a senwse of pride and attachment to Rwandans as it is a one-of-a-kind project |
| 10 REDUCED INEQUALITIES | **Reduced income gap inequality** across the country | The quantitative survey proved that electricity access enabled poverty reduction through allowing greater access to employment, education, healthcare, and business operations |
| | Reduced gender and local employment inequality in the KivuWatt/ Contour Global working space | KivuWatt's employee profile meets soundly local employment and gender inclusivity criteria. The company currently comprises 111 employees, 58% of which are Rwandan and 20% of which are female |
| 17 PARTNERSHIPS FOR THE GOALS | **Financing partnership with the AfDB, EIAF and BIO** | Financing partnership among lending banks catalysed by the FMO enabled access to the amount of financing required for the construction and commissioning of the project |
| **ENVIRONMENTAL IMPACT** | | |
| 13 CLIMATE ACTION | **Annually avoided GHG** relatively to its closest diesel alternative | **114,600 $CO_2$eq/year** avoided eq. to €798 million invested by lenders per tCO2eq avoided |
| | Increase of **renewable energy share** in Rwanda's energy mix | From 55% to **71% renewable energy** penetration |
| | **Low lifecycle GHG emissions** of the plant | **i. Methane is sourced locally.** Transport and storage of imported fossil fuel is avoided |
| | | **ii. Water is sourced locally** to separate methane from other gases |
| | | **iii. KivuWatt supplies onsite power demand** at a far lower tariff than the national grid with minimal use of alternative diesel backup power |
| | | **iv. PPA with REG paves way for controlled dispatches,** which reduces the probability of extracting methane in excess or burning methane extracted in excess (cf. description of technology in **Section 2.1**) |
| | | **v. Flaring of excess extracted gas :** Although the most ideal scenario would be to utilise all of the extracted gas, flaring of this excess gas, besides being necessary for safety reasons, remains less impactful in terms of GHG emissions than keeping this share of gas unprocessed in the lake: methane emitted by the lake is greater in amplitudes than that released when flaring the extracted gas |

# FMO'S ADDITIONALITY

## FINANCIAL ADDITIONALITY

**FMO's financing mitigated financial risks for the client and for other financiers and investors (which a commercial financier would not do) in the following ways: tenor and financing gap; mobilizing / catalyzing; political risk cover; and stamp of approval.**

**Tenor and financing gap:** Debt in the amount and tenor (15 years) provided by FMO was not available at the time the financing of KivuWatt was structured (cf. **Section 2.2**). This financing was needed because the equity investment made by ContourGlobal needed to be leveraged with long-term debt to be repaid with the cash flows generated by the KivuWatt in the long run.

**Mobilizing / catalyzing:** FMO mobilized financing from BIO, AfDB and EAIF who had no prior exposure to Rwanda. FMO's unsecured loan of USD $31.25 million was instrumental in mobilizing the consortium's debt of USD $91.25 million, which is equivalent to 43% of total investment cost. It raised confidence of investors that FMO conducted its due diligences and was confident about its investment thesis. FMO investments did, however, not attract investment from local investors.

**Stamp of approval:** FMO's engagement with ContourGlobal signaled the market that it was a sound project that met international standards. Among other developments, KivuWatt was groundbreaking in terms of lake monitoring, technology operation, and PPA agreement. This provided comfort to other parties that would otherwise not invest in this type of power generation projects in Rwanda.

For example, Gasmeth Energy Limited is planning the construction of methane gas extraction plant for cooking end-uses that is expected to be operational by 2021 [5] probably financed by American, Nigerian and Rwandan investors. Moreover, Symbion power signed a concession agreement to build a 56 MW plant by the Lake Kivu to be commissioned in 2023. Additionally, and beyond lake Kivu, 15 PPAs have been signed in Rwanda since 2016.

## ENVIRONMENTAL SOCIAL GOVERNANCE (ESG) ADDITIONALITY

**FMO offered unique value-adding services in ESG in the way of E&S risk management.**

**E&S risk management:** FMO was instrumental for the KivuWatt ESAP to include strict adherence to the Management Prescriptions (MP) to manage the lake-water methane extraction, as well as air pollution and GHG emission, waste, fire and health and safety management standards (cf. Apprendix 2). For example, FMO identified the following risks related to the methane extraction operation: (i) The uncontrolled release of methane gas; (ii) The mixing of water layers of lake Kivu, affecting lake water stability and biodiversity; and (iii) the KivuWatt plant operation and its effect on the national grid stability.

## 2.3
# The KivuWatt project

## PROJECT'S DESCRIPTION AND TECHNOLOGY[17]

### TECHNOLOGY

The KivuWatt project is a first-of-a-kind integrated power generation project. It exploits the unique geophysical characteristics of Lake Kivu, a lake containing high concentrations of biogenic methane and carbon dioxide gases trapped in the resource zone - a stable layer at 270 m to 500 m deep. The project combines both a gas extraction facility (GEF) on Lake Kivu and an associated 26 MW power plant in Kibuye. Once extracted, washed, and dried, the methane gas is then transported through a 13 km long semi-submerged pipeline to the power plant onshore of the lake. The KivuWatt power plant operates baseload on a 24h basis, with a yearly target for electricity production of this plant is 220 GWh, which is equivalent to 25% of the country total electricity generation. The plant is connected to a high-voltage line (220 kV) that transmits the electricity to Kigali.

17 Cf. **Appendix** for further information on the biophysical characteristics of Lake Kivu, the GES and KivuWatt power plant technologies.

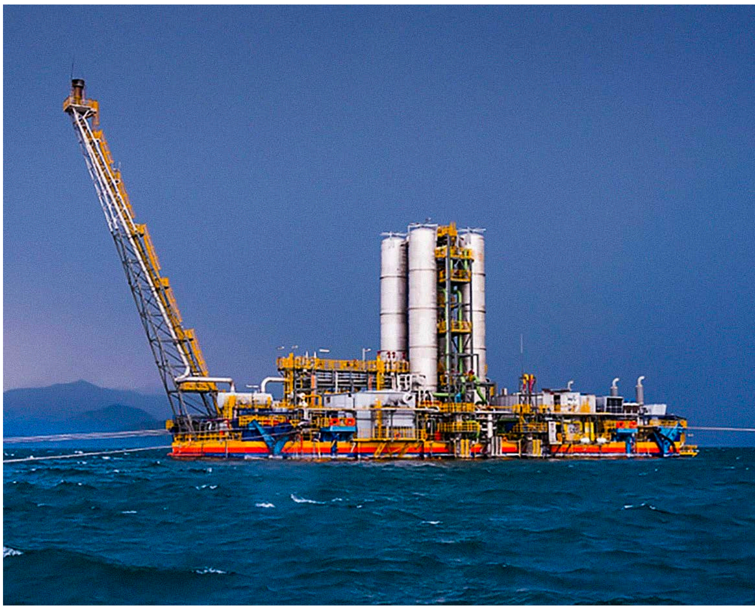


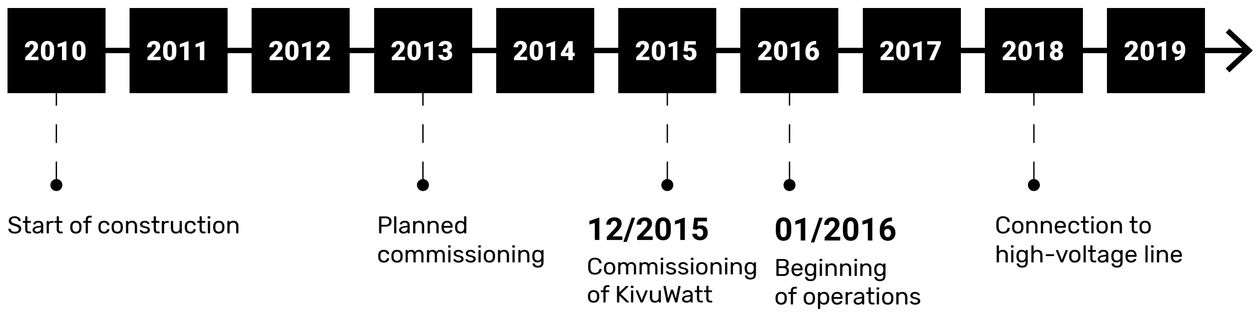
**FIGURE 4**

KIVUWATT'S GAS EXTRACTION FACILITY (GEF) FLOATING ON LAKE KIVU (SOURCE: CONTOURGLOBAL)

### PROJECT CONSTRUCTION TIMELINE

**The construction of the KivuWatt project took approximately five years (Figure 5).** The construction of the KivuWatt 1 project began in 2010, and its commissioning was initially planned for 2013. However, construction delays as a result of the underperformance of the initial engineering contractor, deferred commissioning by 3 years. The KivuWatt was consequently commissioned by the end of 2015 and operations started in January 2016.

FIGURE 5 KIVUWATT - CONSTRUCTION AND OPERATIONS TIMELINE




## PROJECT CONCESSIONS

The KivuWatt project is governed by a 25-year Power Purchase Agreement (PPA) signed between KivuWatt (project developer, owned by ContourGlobal Group[18]) and the off-taker the Rwanda Energy Group (REG—government owned), and a 25-year Gas Concession Agreement (GCA) signed between the KivuWatt and the Government of Rwanda (Figure 6).

## PROJECT EXPANSION PLANS

**The KivuWatt initial project's plan included two phases, the first one being the al-ready completed 26 MW power plant and the GEF.** The second phase would consist of 3 additional barges of 25 MW capacity each, which would have increased the total capacity to 100 MW. However, the second phase was recently foregone by the GoR in its last revision of the country's National Energy Plan (NEP) and Least Cost Generation Plan (LCGP). Because demand is merely increasing in Rwanda, there was no apparent need according to the GoR for additional generation capacity.

There was also a smaller capacity expansion (7 MW) under consideration to use of the excess gas extracted by the GEF that is currently being flared. This expansion would increase profitability of project (increasing power capacity with no added capex investment). However, this plan is currently on hold.

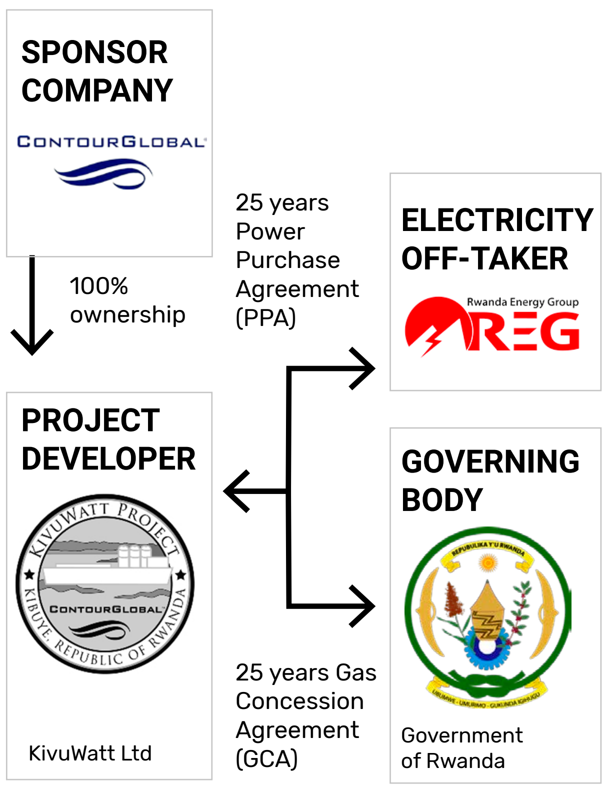
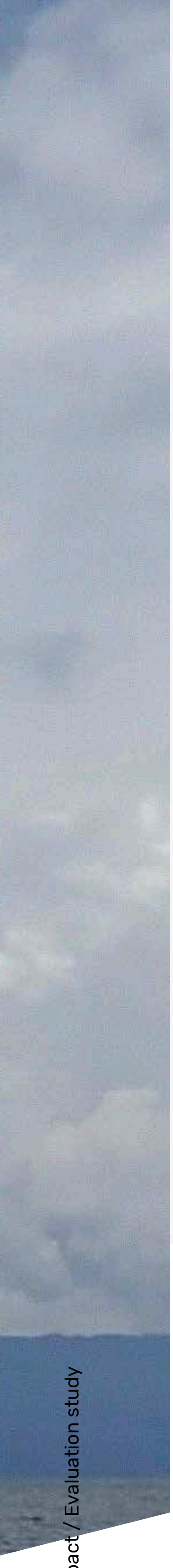



FIGURE 6 BILATERAL AGREEMENTS GOVERNING THE KIVUWATT PROJECT

18 Contour Global currently owns over 37 power generation plants in 20 countries around the world, totalling 3.9 GW of gross installed capacity of thermal (lignite, gas, oil, coal) and renewable energy (biogas, hydro, wind, solar plants).

# 3



# Development Impact of KivuWatt

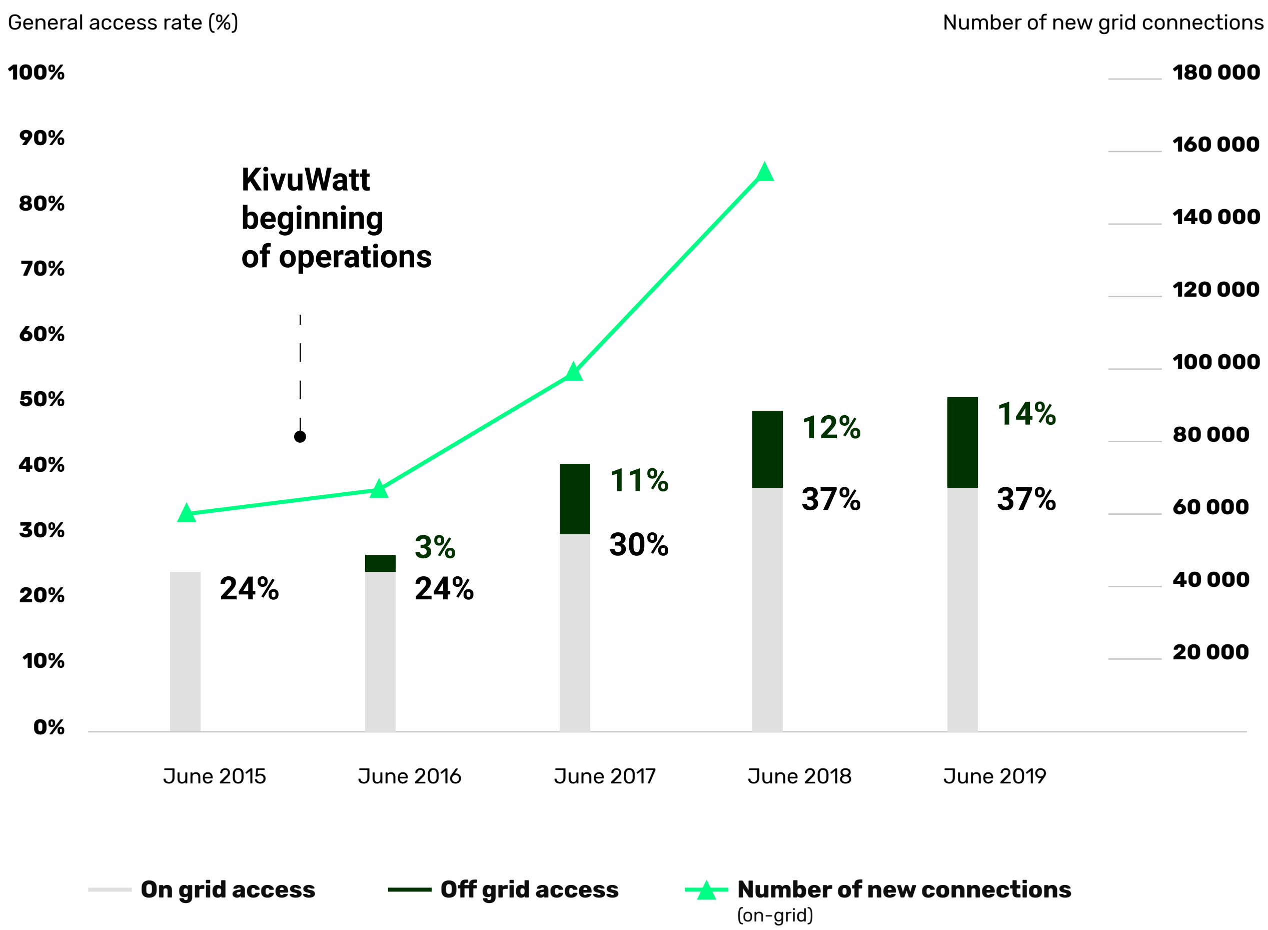
## 3.1

# KivuWatt's impact on the energy sector

**FIGURE 7**

KIVUWATT RELATIVELY TO ELECTRIFICATION GROWTH IN RWANDA [7]

The KivuWatt project is the only major capacity that has entered the grid since its commissioning in 2016 and has driven visible direct impact at the national level, in terms of improvement of grid stability, reduction of grid carbon content, energy independence. It is worth noting that the extent to which KivuWatt has contributed to a rise in electrification and a reduction of grid electricity tariffs is not straightforward to measure qualitatively as several other electrification drivers have emerged during the past 5 years. The following sections explore these impacts relative to access to electricity, grid stability, energy independence, energy cost and energy sector decarbonization.



## ACCESS TO ELECTRICITY

**Between 2015 and 2019, access to electricity grew from 24% to 51% (by 27 percentage points). About 73% of the connections are currently on grid, and the balance 27% off grid. It is not clear the extent to which this increase can be attributed to KivuWatt, because other factors have also influenced access to electricity over the period.**

In the Kibuye region, KivuWatt had a positive impact on ongrid electrification. The construction, operation and maintenance of the plant also had a positive impact on employment and economic growth, which led to increased access and electricity demand. It also helped neighboring villages which were connected with transmission lines to KivuWatt.

**Concurrently with KivuWatt, sector regulation reform has also stimulated grid densification and access to electricity expansion.** KivuWatt has been the major contributor in terms of generation capacity addition, which facilitated the effectiveness of the reforms enforced by the GoR:

- Tariff reforms in 2017 which strongly increased affordability for small energy consumers.
- Free connections for industrial customers
- Connection cost reduction and adoption of a flexible payment plan for non-industrial consumers.
- Grid investment program supported by a Development Policy Operation project of the World Bank.

## GRID STABILITY

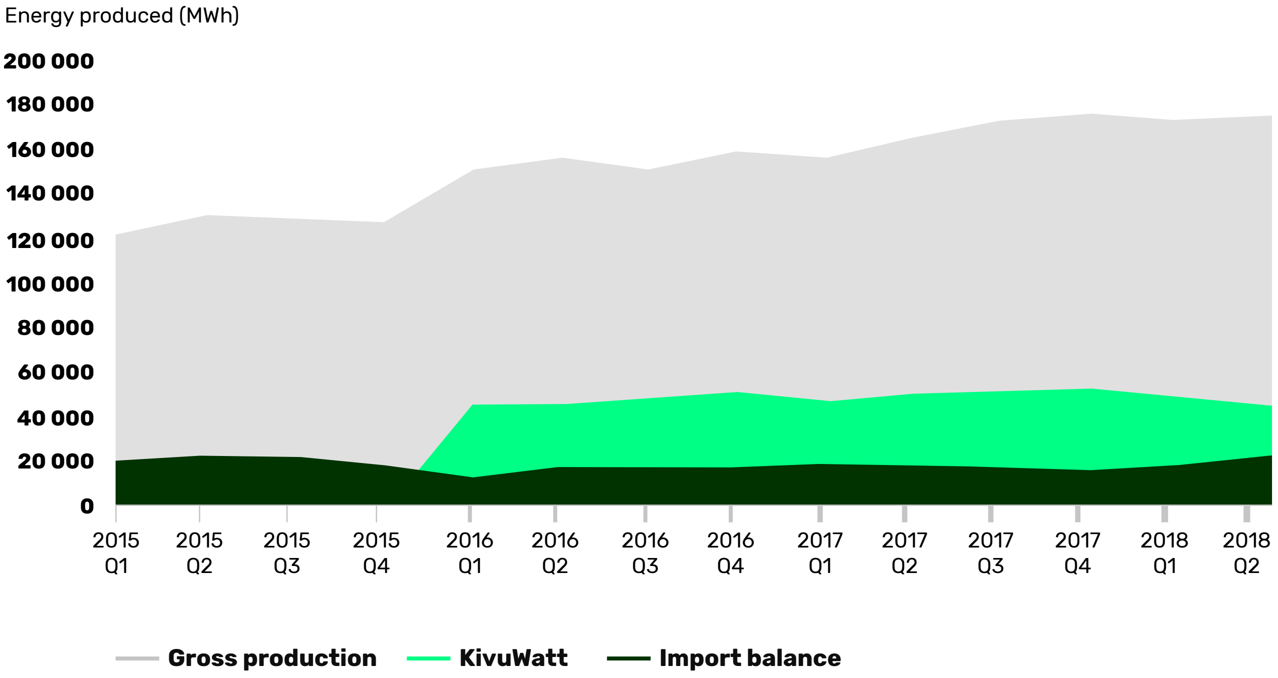
**Prior to the commissioning of KivuWatt, baseload generation was fundamentally intermittent, comprised of a matrix of hydropower and costly diesel generation.** As baseload power, the introduction of KivuWatt undoubtedly improved grid stability. According to the RURA, since the commissioning of KivuWatt, voltage fluctuations and planned load shedding decreased significantly. Indeed, KivuWatt installed dispatching measures to render the grid more stable although they are not required to do so under the PPA but did so to overcome the large grid voltage fluctuations that pose a risk to grid power suppliers.

**The addition of KivuWatt contributed to the success of concurrent efforts implemented by the REG to stabilize the electric system, despite grid stability is hard to measure ex-post because its indicators have been recently implemented and they are not fully reliable: the average frequency of interruption (SAIFI), and the average duration of interruption (SAIDI).**

## ENERGY INDEPENDENCE

Between 2011 and 2013, Rwanda experienced substantial power generation deficits, which was mitigated by increasing the generation capacity with costly diesel fuel generation. Since 2015, KivuWatt has been the only large capacity addition to the electricity system representing roughly 25% of the electricity produced (Figure 8). KivuWatt also contributed to the increase in the share of local generation capacity and the phase-out of costly and carbon intensive diesel generation.

**FIGURE 8** SHARE OF KIVUWATT PRODUCTION AND IMPORT BALANCE WITHIN THE EVOLUTION IN ENERGY GENERATION IN RWANDA (MWh)




## ENERGY COST

**KivuWatt contributed to the decrease in generation costs in the electricity system. The cost of the energy paid by the REG was reduced to USDc 21 per kWh (from USDc 24 per kWh before KivuWatt) [3]. This led to a reduction in energy subsidies (see Appendix 3) and a reduction in the deficit of the national budget due to lower diesel fuel imports.**

The biggest challenge for REG and the energy market going forward would be to handle overcapacity in the electric system by the time the Hakan Mining and Generation Industry & Trade Inc. (a Turkish IPP) commissions its 80 MW peat-fired power plant in Gisagara District, Southern Rwanda in 2021. REG has also signed a 25-year PPA with Hakam Mining.

## ENERGY SECTOR DECARBONIZATION

**Rwanda has committed to decarbonizing its electricity sector in its Nationally Determined Contribution (NDC) under the 2015 Paris Agreement.** These are its three priorities:

1. Increasing the share of new grid-connected renewable capacity as alternative to fossil fuels.

2. Increasing access to solar-based power in rural communities.

3. Increasing grid-level energy efficiency through demand-side measures, generation management and grid-loss reduction efforts.

**The energy generated by KivuWatt led to the reduction from 45% to 20% (25 percentage points) of the baseload generation fired by diesel oil. This significant shift enabled Rwanda to reduce the greenhouse gas (GHG) emissions of the energy sector by roughly 44%, from 308 $gCO_2$ per kWh to 134 $gCO_2$ per kWh (Figure 9).**

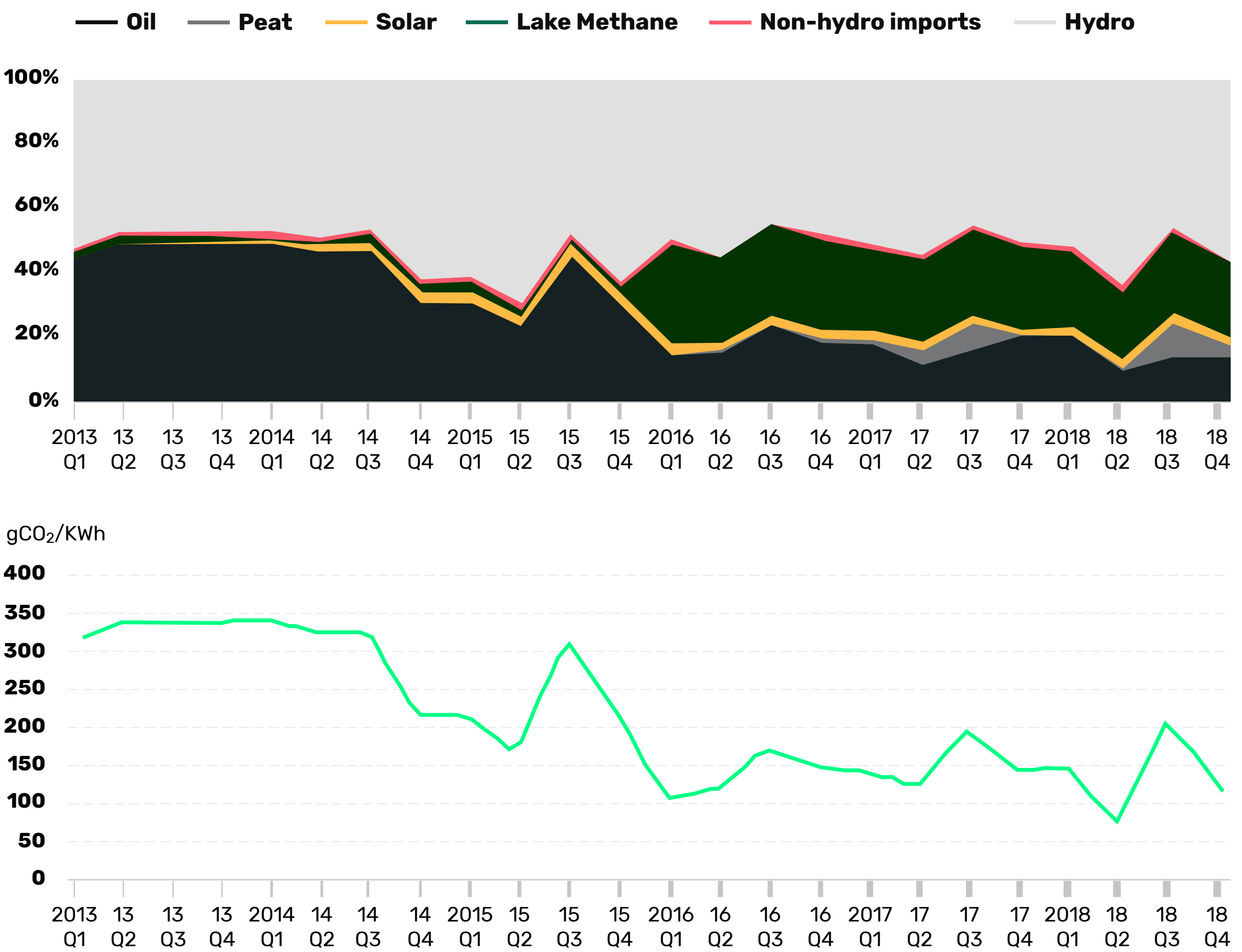
Additionally, KivuWatt leads to unequivocal reduction of GHG emissions even when considering the global life cycle of the fuel and the technology used to generate KivuWatt's equivalent power, namely the localized methane extraction as compared to the import of diesel fuel oil from another corner of the world.

## RWANDA ENERGY CONTEXT

**In the broader context of the Rwandan electrification policy (both on-grid and offgrid), other competing power plants and sources and the role of other private sector energy investors, and especially since the introduction in 2017 of the Least Cost Power Development Plan (LCPDP), Rwanda's electricity mix is shifting towards a low-carbon mix.**

**FIGURE 9**

POWER GENERATION MIX (UP) AND GREENHOUSE GAS INTENSITY OF POWER GENERATION IN RWANDA (BOTTOM) (2013-18) [8]



However, the Rwandan decarbonization strategy and Paris Agreement commitments do not seem to be applied consistently in the light of the huge investments in peat-fired power plants by a Turkish PPI. The least cost energy mix could indeed be synonymous with shifting towards a low-carbon energy mix, given Rwandan's abundant low-cost indigenous hydro, methane and solar resources and opportunities for cheap imported electricity but would not follow this path if peat-fired plant development will be carried out as planned[19].

**Efficient co-implementation of the NDC and LCPDP can further allow for emission reduction in the power sector.** The last version of the LCPDP highlighted the impact of adhering to least cost principles on global power sector emission reduction. In Rwanda, transitioning to a least cost energy mix is synonymous with shifting towards a low-carbon energy mix, given its abundant low-cost indigenous hydro, methane and solar resources. Thus, exploiting these renewable resources at the expense of costly fossil fuel and high-carbon peat-based generation can significantly reduce generation cost and drive down GHG emissions by 8% between 2018 and 2030 (or an equivalent of a cumulative 800,000 $tCO_2eq$ between 2018 and 2030).

19 The development of this plant has not been confirmed yet, due to the oversupply problems that Rwanda's energy system is currently facing.

3.2

# KivuWatt's socio-economic impact

## OVERVIEW OF THE QUANTITATIVE DESIGN[20]

A full five-year quantitative evaluation design was implemented to assess the impact of KivuWatt on socio-economic development, poverty reduction, and environmental sustainability at electricity end-user level. The evaluation exercise was considerable in size and rich in results. It evaluated changes in more than ten socio-economic indicators among 180 villages, 1789 households, 7497 individuals[21], 154 schools, 104 health centers and 123 businesses.

The evaluation design involved a baseline and an endline survey based on quantitative data collected via two national surveys:

- **A baseline survey (March 2015)** was conducted to provide an overview of the electrification and socio-economic status of pools of end-users of electricity prior the commissioning of KivuWatt's power plant in December 2015

20 Refer to **Appendix 5** for more detailed information on the methodology used to construct and conduct the national survey.

21 Individuals refer to all adults in the house.

- **An endline survey (October 2019)**[22] was conducted 4 years after the commissioning of the plant. It involved collecting endline data on grid stability and socio-economic criteria among the same pool of end-users as in the baseline.

This timeframe was decided because over it KivuWatt would be the only expected major generation capacity added to the grid, and thus changes measured between these two points could be mainly attributed to[23]:

- Grid extension in rural areas as planned by the REG
- The increasing penetration of offgrid solutions in the country
- The new government policy measures on connection cost reduction and tariff reforms (from 2016)
- KivuWatt's additional capacity compared to base power produced on the grid at the baseline.

The target surveyed population consists of end-users of electricity that would benefit, in all provinces of Rwanda, from the additional generation capacity of the KivuWatt project. In this regard, the evaluation focused on **four types of electricity end-users: households, businesses, health facilities and schools.**

At the baseline time, the population of end-users was stratified ex-ante into three mutually exclusive groups of villages following the REG electrification plan named G1, G2 and G3 (Table 4-1):

- G1: villages that were already supplied[24] with electricity from the national grid in 2015
- G2: villages that became electrified and were supplied by the National Grid between 2015 and 2019
- G3: villages that remained off grid.

**TABLE 4-1**

EVOLUTION OF CONNECTION STATUS OF GROUPS AT VILLAGE-LEVEL

| VILLAGE GROUPS | VILLAGE ELECTRIFICATION STATUS | |
|---|---|---|
| | BASELINE (Q1 2015) | ENDLINE (Q4 2019) |
| G1 | Supplied by the grid | Supplied by the grid |
| G2 | Not connected | Supplied by the grid |
| G3 | Not connected | Not connected |

22 An intermediate analysis, the midline evaluation, was carried out in 2017 right between these two milestones to set a date for the endline study in such a way to be conducted after a long enough period to have a chance to measure changes and prior to the commissioning of the planned additional grid capacity and to not negatively affect the measurability of the impacts of KivuWatt on end users and grid stability. Refer to the 6.5 for more information.

23 The contribution of KivuWatt's to socio-economic development relatively to other major socio-economic factors cannot be directly distinguished at outcome level. However, it is worth noting that half of the new connections occurred between 2015 and 2017 that is before the introduction of the newly tariff policy subsidizing upfront connection fees and solar systems installation remain marginal among households.

24 By "supplied", we mean here that the villages are both connected to the grid and supplied with electricity. In the Rwandan context, where rapid electrification is underway, several villages might indeed have a connection (e.g. an electrical pole has been installed in the village), but this connection is not supplied with electricity yet.

**However, not every household living in each village supplied by the grid was connected to the grid.** For various socio-economic reasons, some households remained offgrid in villages supplied by the grid (Table 4-2).

**TABLE 4-2**

CATEGORIZATION OF THE POPULATION WITH REGARDS TO THE CONNECTION STATUS OVER TIME

| VILLAGE GROUPS | END-USER GROUP | BASELINE CONNECTION STATUS | ENDLINE CONNECTION STATUS | GROUP EVALUATION STATUS |
|---|---|---|---|---|
| G1 | **G1c** (G1 connected) | Supplied by the grid | Supplied by the grid | Control group |
| | **G1nc** (G1 newly connected) | Not connected | Supplied by the grid | Treated group |
| | **G1off** (G1 offgrid) | Not connected | Not connected | Control group |
| G2 | **G2nc** (G2 newly connected) | Not connected | Supplied by the grid | Treated group |
| | **G2off** (G2 offgrid) | Not connected | Not connected | Control group |
| G3 | **G3off** (G3 offgrid) | Not connected | Not connected | Control group |

Treatment groups are beneficiaries connected and supplied by the grid between the baseline and endline, namely G1nc and G2nc beneficiaries, thus assumed to be impacted by KivuWatt. Control groups are beneficiaries for which the connection status has not changed over this 5-year period, namely G1c, for which the impact of added capacity on improved grid quality can be evaluated, and offgrid G1 off, G2off and G3off groups, not directly impacted by KivuWatt. The indicators focused on causal links between poverty and access to electricity along a causal chain as shown on the Theory of Change graph on Figure 10:

1. **Development impact indicators are directly impacted by the new production capacity (KivuWatt):** improved/increased access to electricity (connection rates and quality of supply)[25].

2. **Electricity consumption and outcomes indicators are avenues created or impacted by electricity access at the end-user level:** domestic and productive energy uses, economic activity, jobs/activity creation, electricity spending, access to public services, time studying. Impact for these indicators are more diluted and harder to detect precisely.

25 Revenue inequality could not be directly measured as surveyed end-users were not willing to disclose such information in the baseline survey.

FIGURE 10 CAUSAL CHAIN AND CLASSES OF INDICATORS USED FOR THE IMPACT EVALUATION OF KIVUWATT PROJECT

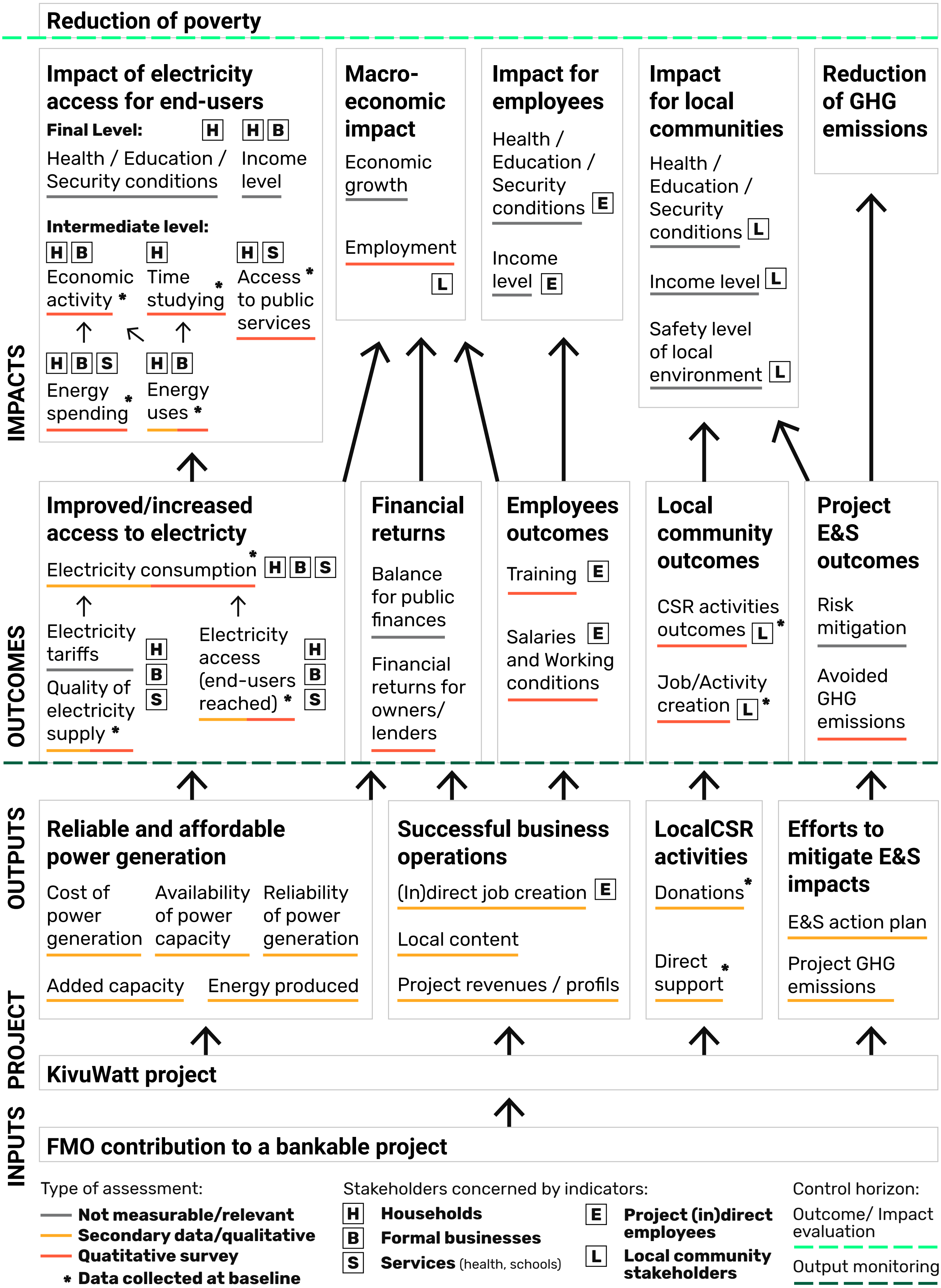


**TABLE 4-3** EVOLUTION OF ELECTRIFICATION RATE AMONG SURVEYED TREATMENT GROUPS BETWEEN BASELINE AND ENDLINE

| VILLAGE GROUPS | G1 | G2 | G3 |
|---|---|---|---|
| **Attributed villages at baseline** | 62 villages | 59 villages | 59 villages |
| **Electrification status at endline** | 62 villages electrified | 38 villages electrified | 19 villages electrified |
| **Final village distribution at endline** | 62 villages | 57 villages | 61 villages |

In each of the 180 surveyed villages, 10 households, 2 formal businesses, 1 health facility, and 1 school[26] were surveyed. The final distribution of villages surveyed for the baseline and endline was: G1, 62 villages; G2, 59 villages; and G3, 59 villages.

**At the endline time, 19 electrified villages attributed ex-ante to G3, and 21 non-electrified villages ex-ante attributed to G2 had to be reassigned to G2 and G3, respectively.** Between 2015 and 2019, 57 villages were electrified and were included in G2, and 61 villages remained non-connected to the grid which were included in G3 (Table 4-3).

**Eighty-six percent of the households surveyed in the baseline could be successfully tracked and surveyed in the endline. This confirms the robustness of the survey methodology and power computations for impact evaluation of our main outcomes.**

**The attrition average rate at household level was 14% well below the expected 20% according to the design (Table 4-4).**

Lower attrition rates were found in G3 and G2, which could be attributed to their agrarian household profile – thus more attached to the land and less prone to move - as these groups were located further away from dynamic and unsteady city economies.

Between baseline and endline, the major change was an increase in the number of household members (Table 4-5).

26 The implementation of both the baseline and endline surveys considered targeted methods for data collection, training of enumerators and supervisors, questionnaire testing, survey monitoring and data cleaning, and the selection of the survey management team. These methods were flexibly designed to incorporate any changes that arose during the survey testing period on the field. A more detailed description of each component of the survey implementation process can be found in the **Appendix 5**.

**TABLE 4-4** NUMBER OF SURVEYED VILLAGES, HOUSEHOLDS, AND INDIVIDUALS SURVEYED AT BASELINE AND ENDLINE

| VILLAGE GROUPS | VILLAGES | HOUSEHOLDS | | | INDIVIDUALS[18] | | |
|---|---|---|---|---|---|---|---|
| | # of villages | $T_0$ # in Baseline | $T_1$ # in Endline | Attrition rate[19] | $T_0$ # in Baseline | $T_1$ # in Endline | Attrition rate |
| G1 | 62 | 605 | 471 | 0.22 | 2424 | 1909 | 0.21 |
| G2 | 57 | 650 | 526 | 0.19 | 2489 | 2044 | 0.18 |
| G3 | 61 | 543 | 542 | 0.00 | 2584 | 2148 | 0.17 |
| **Total** | 180 | 1,789 | 1,539 | 0.14 | 7497 | 6101 | 0.19 |

**TABLE 4-5** HOUSEHOLDS CHARACTERISTICS AT BASELINE AND ENDLINE

| | BASELINE CHARACTERISTICS | ENDLINE CHARACTERISTICS |
|---|---|---|
| **Households** | Households surveyed are composed of an average of 4.7 members, including around 1.6 children below 16 years old | Households surveyed are composed of an average of 4.9 members, including around 1.3 children below 16 years old |
| | The household head is 45 years old in average | The household head is 50 years old in average |
| **Individuals** | 20% of household heads were women | 20% of household heads were women |
| | Dwellings count an average of 4 rooms | Dwellings count an average of 4 rooms |
| | Connected households are significantly wealthier and have a household head with a higher education level | As in the baseline connected households are wealthier and have a household head with a higher education level |

27 Individuals refer to all adults in the house.

28 A measure of the number of individuals moving out of each collective treatment group between the baseline and endline surveys.

# DEVELOPMENT IMPACTS AT HOUSEHOLD LEVEL FROM THE QUANTITATIVE DESIGN

**Nota Bene:** Performance indicators were compared through several combinations of treated/control groups e.g., newly connected vs off grid groups, or newly connected vs connected at baseline groups (G1nc/G1c). However, only the statistically significant impact results are presented in this report.

## ELECTRICITY ACCESS AND QUALITY

### CONNECTION RATE TO THE GRID

The results of this study show a significant increase in the share of connected households from 2015 to 2019 (Figure 11). The share of connected households in G1 increased from 60.7% to 71.8% (11.1 percentage points). Moreover, the connection rate shot up to 41% in the newly connected G2 (Figure 11). The increase in electrification was 13 percentage points for the entire sample, which is similar to the increase at the national level (Figure 7).

**These results confirm a positive impact of the rural electrification government policies, in particular the 2017 connection subsidy reforms**[29]. For example, among the non-connected households those stating that the cost of connections was high significantly decreased between the baseline and endline. Among the non-connected households in 2019, 53% in G1 and 42% in G2 declared that the cost of electricity (connection fee or electricity tariff[30]) was the reason for non-connection. However, the share of G1 offgrid households having stated this reason in 2015 was 14 percentage points higher. Also, an overall 9% of newly connected G1nc and 18% of newly connected G2nc households state that they received connection subsidies.

[29] New connection and tariff reforms implemented in 2017 in Rwanda made new connections more affordable for residential segments, at RWF 56,000 or USD $60 [20], as well as more accessible through new payment options for the connection fee (refer to **Appendix 3**).

[30] Connection fee and electricity tariff are given in **Appendix 3**.

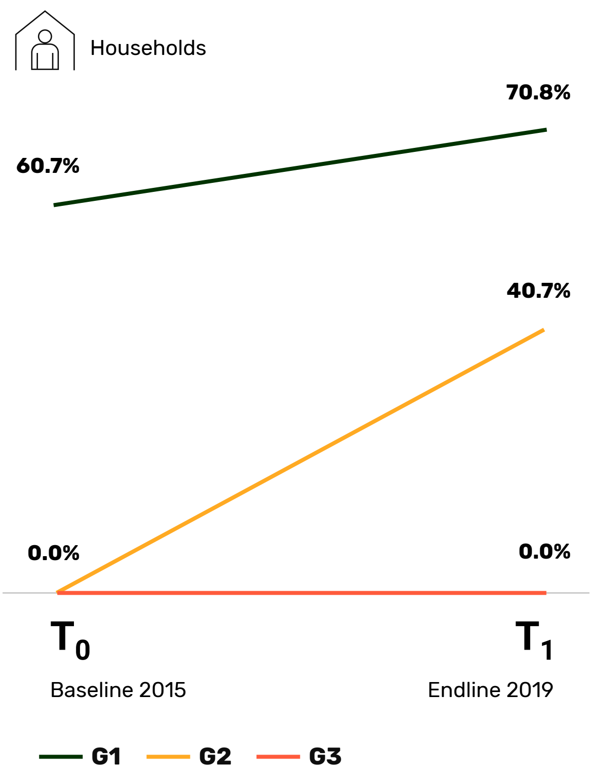



**FIGURE 11**

EVOLUTION OF GRID ELECTRIFICATION RATES (%)

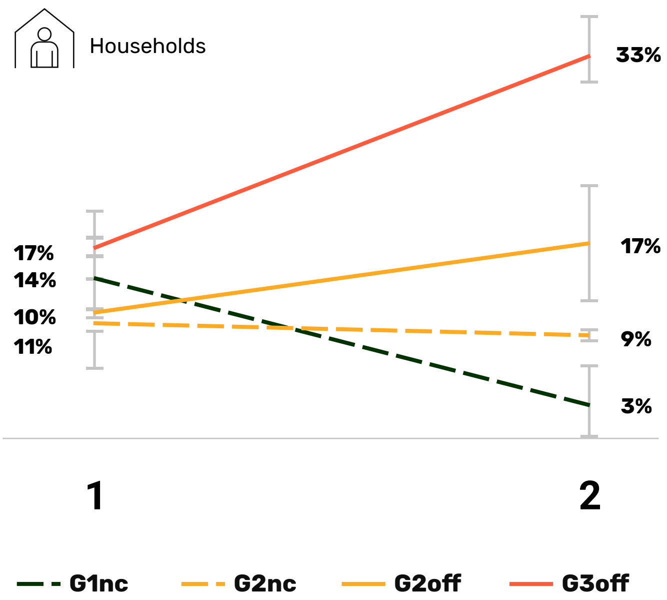
## USE OF ELECTRICITY GENERATORS

**The survey provided evidence of a significant reduction of electricity generators by households in the newly connected areas.** The use of an electricity generation equipment has significantly reduced among households that gained access to grid electricity over the 2015-2019 period (Figure 12): respectively -11 pp. and 1 pp. in G1nc and G2nc groups.

**Offgrid access to electricity through electricity generators has almost doubled, showing that overall electricity access among surveyed villages has increased over the past 5 years.** Offgrid generation has almost doubled in G3off and G2off areas (Figure 12) respectively by 16 pp. and 7 pp.

FIGURE 12

PERCENTAGE OF HOUSEHOLDS USING A GENERATOR[31]



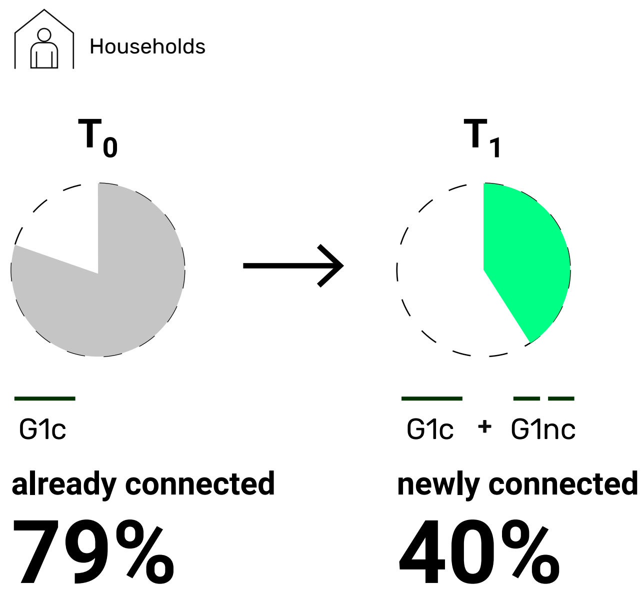

## TYPE OF ELECTRICITY GENERATION EQUIPMENT

**Use of solar technologies has significantly increased and, at the endline, it largely prevails among offgrid generation equipment.**

The use of solar technologies as offgrid generation represents 80% of G2off and G3off users use of generation equipment, which has significantly gained popularity since 2015 (respectively 26.6% and 54.2% for G2off and G3off users).

FIGURE 13

SHARE OF GRID END-USERS WITH AT LEAST ONE POWER OUTAGE PER DAY




31 Standard errors are computed taking into account spatial and serial correlation of observations across households and within villages.

## QUALITY OF ELECTRICITY SUPPLY

The quantitative survey provided evidence of a significant improvement in the quality of electricity supplied in the G1 areas that were connected. The quality of electricity supply by the grid was measured with three indicators: (i) power outages; (ii) load shedding; and (iii) low voltage supply.

### SHARE OF GRID END-USERS WITH AT LEAST ONE POWER OUTAGE PER DAY

Power outages per day are much less frequent (-1.4 a day) than in 2015, and equal to around 0.7 a day across G1 connected areas in 2019, representing a 39 pp. reduction between T0 and T1 (Figure 13).

### SHARE OF GRID END-USERS WITH AT LEAST ONE LOAD SHEDDING PER MONTH

By 2019, only 13% declare experiencing at least one power cut a month, which is 26% less than in 2015. Households in 2019 experience on average almost one less power cut a month relatively to 2015: from 1.5 in 2015 to an average of 0.5 across G1 connected areas in 2019, representing a 26 pp. reduction (Figure 14).

### SHARE OF GRID END-USERS FACING LOW VOLTAGE SUPPLY

The share of grid end-users facing low voltage supply decreased by 11 pp. between T0 and T1 (Figure 15). Though less frequent, when it occurs low voltage supply lasted on average longer at endline (+1.6 hours) than at the baseline. It lasted around 3.5 hours in G1 connected villages in 2019. Grid quality improvement measures may have indeed eliminated the smaller and more frequent limited capacity periods, thus leaving out the less frequent and longer capacity periods bound to occur.

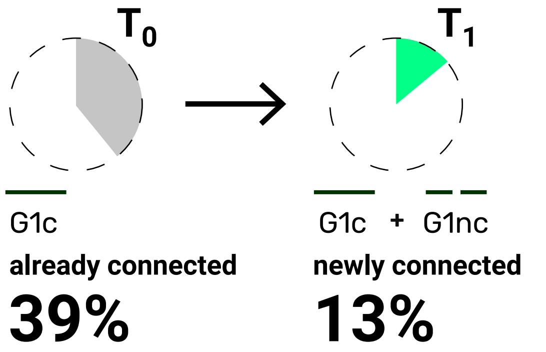



**FIGURE 14**

SHARE OF GRID END-USERS WITH AT LEAST ONE LOAD SHEDDING PER MONTH

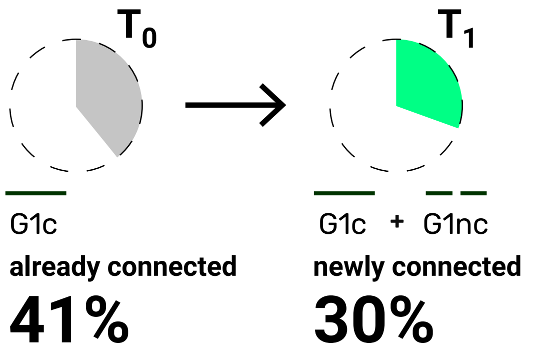



**FIGURE 15**

SHARE OF GRID END-USERS SUPPLIED WITH PERIODS OF LIMITED CAPACITY

## ELECTRICITY CONSUMPTION PATTERNS AND OUTCOMES

### HOUSEHOLD SPENDS

**Household spend on energy was significantly greater in G1c (at baseline) relatively to newly connected groups (G1nc and G2nc). This is explained by their higher degree of socio-economic development driven compared to the newly connected households, and that electricity tariff per kWh had been cut by half (Figure 16).**

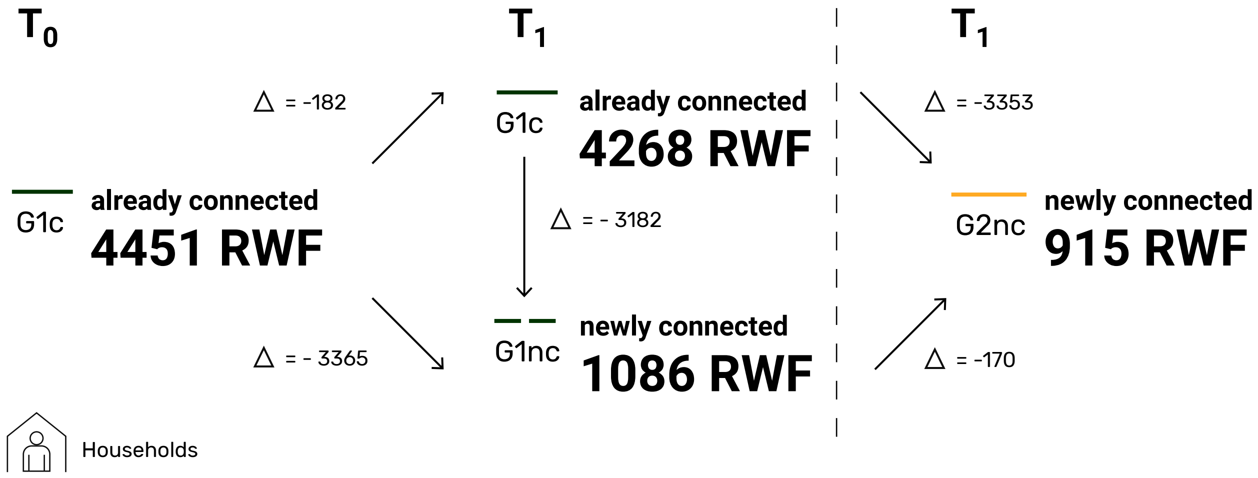



**FIGURE 16**

EVOLUTION OF HOUSEHOLDS' MONTHLY GRID ELECTRICITY SPEND (RWF)

Overall, G1c already connected groups spent around 3300 RWF more on energy per month than the G1nc and G2nc newly connected groups. On the one hand, this reflected longer and more established consumption habits of G1c (grid T0) households and that they were better off. On the other hand, it depicted that the low electricity spending of newly connected households stemmed from their lower electricity consumptions, combined with reduced tariffs for lower consuming segments stemming from the new electricity tariff reform's floating tariffs. Stagnant electricity spends among already connected G1c (grid T0) reflected the existence of a threshold in electricity consumption, which may be a result of the number of e.g., rooms in the dwelling, the number of electronic equipment, and the fact that households were making very little use of electric appliances beyond lighting (see **Section Lighting**).

## HOUSEHOLDS' USE OF ELECTRICITY

### Lighting

**Nearly all the G1 and G2 households surveyed and connected to the grid used electricity mainly for lighting purposes[32].**

**Lighting time has increased significantly among the newly connected households depicting a positive impact of access to electricity.** Total lighting time increased by approximately 9 hours and 15 hours per day, respectively, for newly connected groups G1nc and G2nc compared to control groups G1c and G3 (Figure 17, right)[33].

**Lighting time per day was significantly greater for grid connected households than for off grid households.** Households connected to the grid enjoyed 6 to 9 times more cumulative hours of lighting per day than non-connected households. The lighting use of households in grid proximity areas G1off and G2off was comparable to households in villages without any access to the grid G3 (Figure 17, left).

32 The use of lighting energy at household level is measured as the cumulated sum of hours of the use of lighting devices across of the rooms of the dwelling per day.

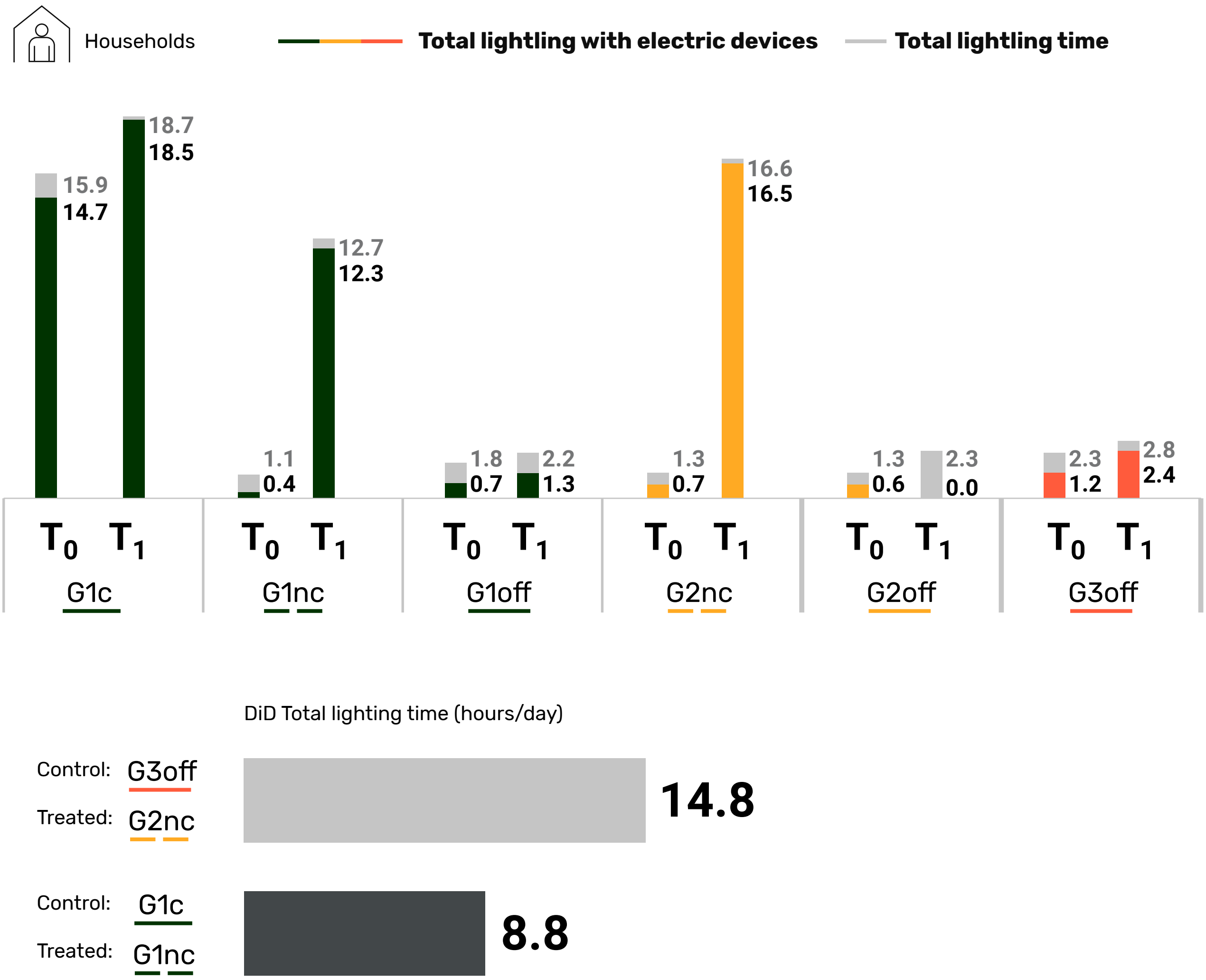
33 Half of this additional lighting time is accounted by outdoor lighting, it is very common in Rwanda, and even sometimes compulsory, to light outdoor all night long.

**The household survey suggests the existence of an upper bound of lighting time per households.** Indeed, G1c households already connected to the grid have experienced a small rise in lighting time. It is likely limited by the number of rooms in a dwelling, and by the capacity of their lighting appliances (Figure 17, Top).

**The household survey also found evidence of a small but statistically significant difference in lighting electricity consumption between connected households possibly due to their diverse socio-economic characteristics.** G1c's cumulative daily lighting time was 5 hours greater than that of G1nc, and this is likely due to e.g., better income, more established lighting habits (Figure 17, Top).

**FIGURE 17**

TOP: LIGHTING TIME IN HOURS/DAY, TOTAL AND ELECTRICITY DRIVEN; BOTTOM: IMPACT OF GRID ELECTRICITY CONNECTION ON LIGHTING TIME (HOURS/DAY) IN NEWLY CONNECTED HOUSEHOLDS



## Cooking or boiling

**Less than 10% of G1 households and nearly none of G2 households used electricity for cooking or water boiling purposes.** Liquified petroleum gas (LPG) is the prevalent cooking fuel in urban areas, and charcoal and woodfire are the prevalent cooking fuel in rural areas [9].

## Phone Charging

**All newly connected households switched to charging their own phones at home, instead of the usual trip that they used to do before to a village charging point. This has significantly reduced the net time that they spend charging their phones.**

99% of G2nc households charged their phones at home that represents an increase of 74 percentage points over the G3off households in T0-T1 (Figure 18, left), reducing significantly the time spent previously spent commuting from their home to the charging point (Figure 18, right).

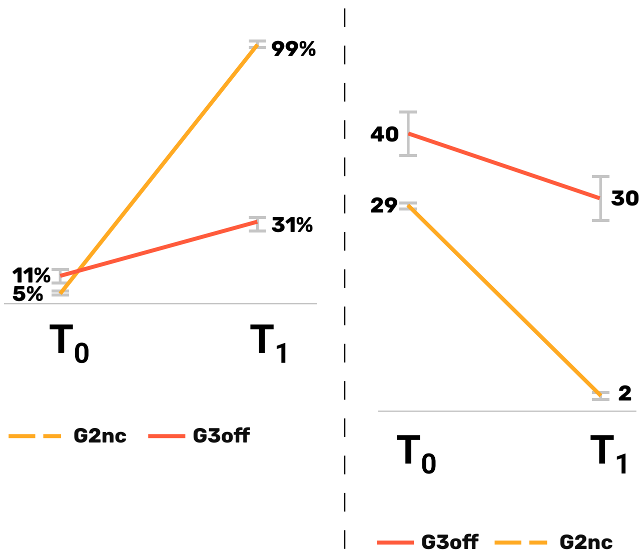



**FIGURE 18**

LEFT: SHARE OF HOUSEHOLDS THAT CHARGE THE PHONE AT HOME (%); RIGHT: TIME SPENT TO REACH A PHONE CHARGING POINT (MINUTES)

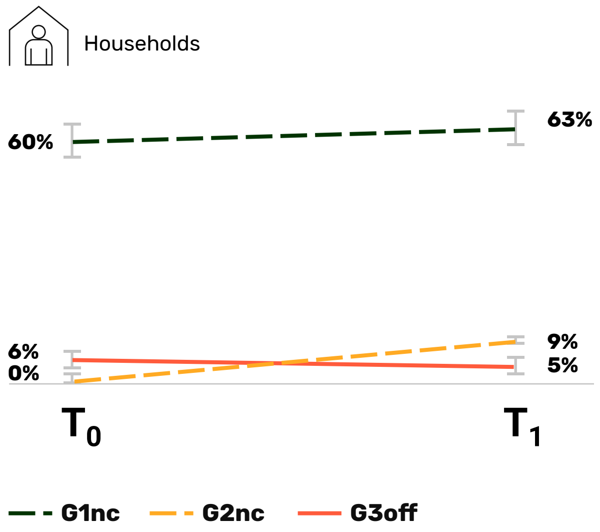



**FIGURE 19**

SHARE OF HOUSEHOLDS USING AT LEAST ONE APPLIANCE EXCLUDING CELL PHONES (%)

## Use of other appliances (beyond phones e.g., computer, TV, refrigerator)

**Access to electricity between T0 and T1 led to the use by households of more expensive appliances (mostly TVs).** Between T0 and T1, the use of such appliances by G1nc and G2nc households increased respectively by 3 and 9 percentage points. Compared with G3off households, its use by G2nc increased by 10 percentage points over the same period (Figure 18).

**However, the use of appliances by newly connected households remains lower than by those already connected G1c households - reflecting the striking difference in dwelling socio-economic characteristics.** Households in the G1c group use electric appliances (excluding cell phones) 54 percentage points more than the newly connected households in G2nc (Figure 19).

They probably can afford the use of more appliances because they have had access to electricity for longer which led to higher purchasing power. Moreover, only 5% of G3 offgrid households use of electric appliances because of their cost and energy consumption.

## PRODUCTIVE USE OF ELECTRICITY

### Craft and trade activities

**There is overall little use of electricity for craft and trade activities given the degree of under development in the surveyed areas (e.g., cooling, heating, electronic appliances, motion).** Although the use of electricity for craft and trade activities increased slightly in the newly electrified G1nc and G2nc households, their share at T1 remained low (3% and 7%, respectively) compared to off grid households G1off, G2off and G3off. These low rates among G2 and G3 villages reflect the socio-economic characteristics of these villages, where farming occupations prevail, and which are less energy intensive. Although low (25%), use of productive energy remains significantly greater among already connected G1c households, which reflects the higher share of non-farming jobs as well as the impact of longer electricity access on occupation types (Figure 20, left).

**Access to a grid connection enabled the newly connected G1nc households to engage more in craft and trade activities. This effect evident only in the newly connected households of higher income G1 villages, because of their relatively higher degree of economic development.** The connection to the grid contributed to an increase of 3 to 4 percentage points in the use of electronic of G1nc and G2nc, respectively. G1nc increased the use of cooling (3 pp.) and motion (2 pp.) relatively to already connected households (Figure 20 right).

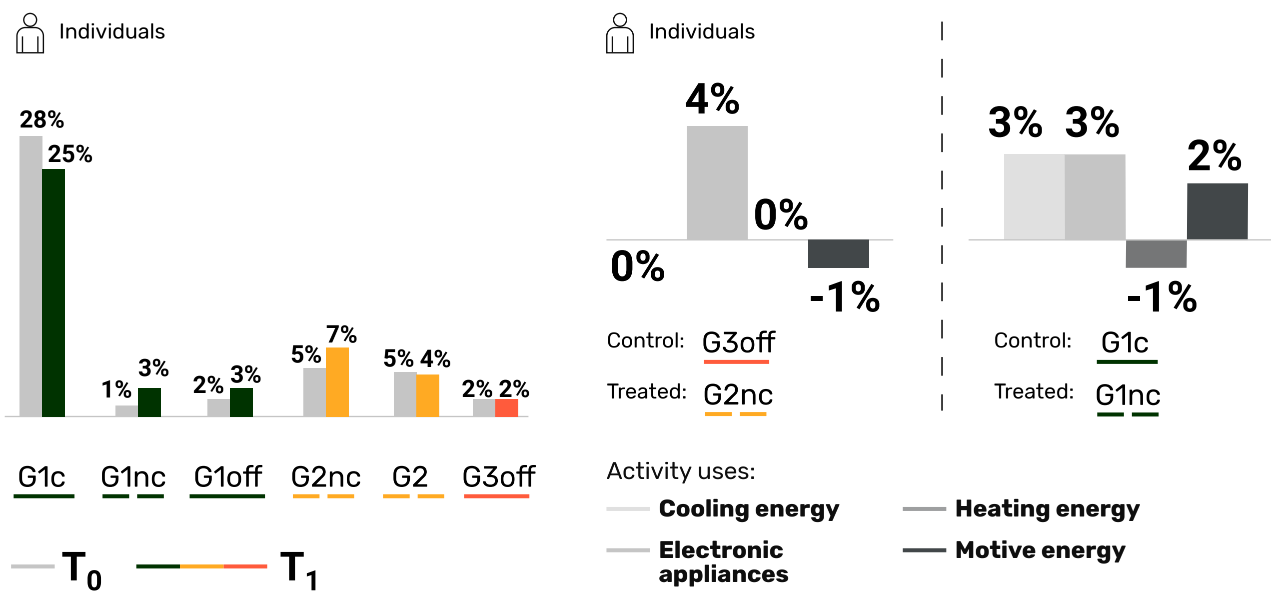



FIGURE 20 LEFT: PROPORTION OF SURVEYED INDIVIDUALS USING ELECTRICITY FOR CRAFT AND TRADE (%); RIGHT: IMPACT OF ELECTRICITY ACCESS ON THE NUMBER OF HOUSEHOLDS ENGAGED IN CRAFT AND TRADE ACTIVITIES (PERCENTAGE POINTS)

## Employment

**The employment rate increased in G1nc (8 percentage points) and in G2nc (5 percentage points) between the baseline and the endline (Figure 21, Top).** Over the same period, G1nc employment rate increased 2 percentage points and 6 percentage points compared to the treatment groups (G1c and G1off, respectively), and G2nc employment rate increased 3 percentage points compared to the treatment group (G3off) (Figure 21, Bottom).

**FIGURE 21**

TOP: EMPLOYMENT RATE AT T0 AND T1 (%); BOTTOM: IMPACT OF ELECTRICITY CONNECTION ON EMPLOYMENT RATE (PERCENTAGE POINTS)

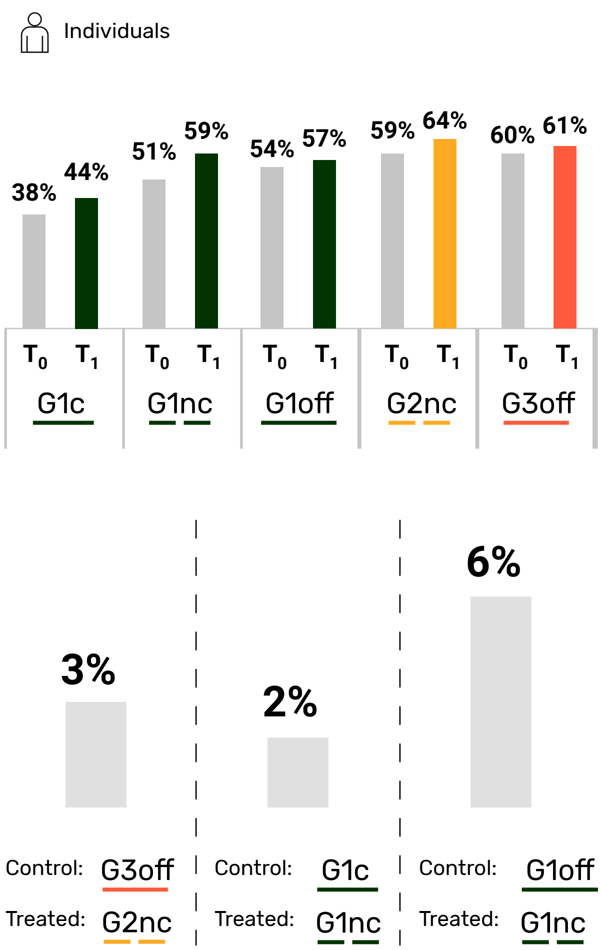
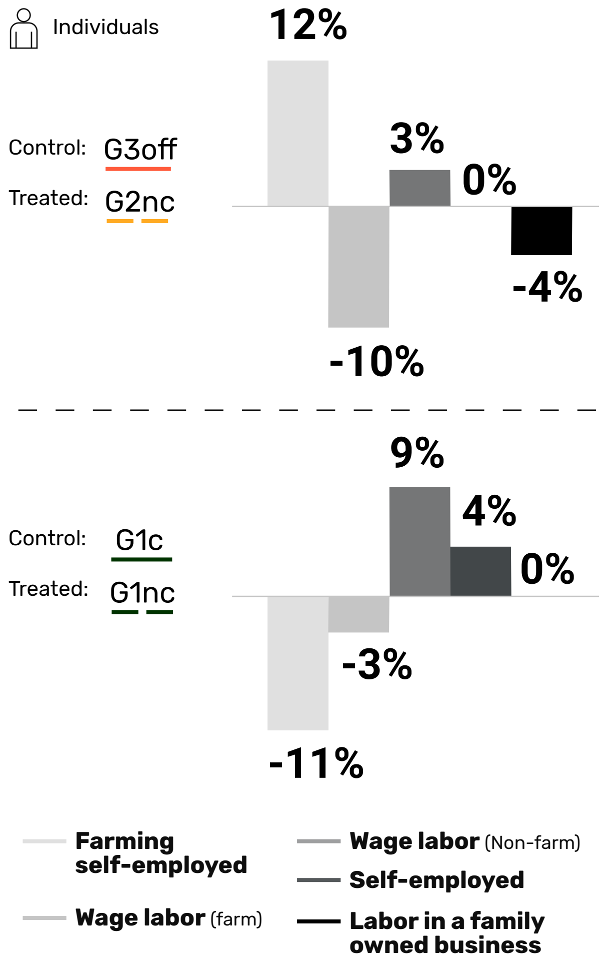



**FIGURE 22**

IMPACT OF ELECTRICITY ACCESS ON THE EMPLOYMENT TYPE (PAID WORK) OF INDIVIDUALS IN A HOUSEHOLD (PERCENTAGE POINTS)




## Employment Type

**G1 villages that already had access to electricity had a smaller share of farming jobs, meanwhile, the newly electrified villages in G2 had a change in occupation types within the farming sector toward better paid jobs.** For example, in G1nc there is evidence of a reduction in farming jobs (11 percentage points), and an increase in both self-employment (4 percentage points) and non-farming wage labor (9 percentage points). Similarly, G2nc households presented a reduction in the share of wage labor of 10 percentage points, and an increase in self-employment of 12 percentage points (Figure 22). This reflects the higher growing economies in G1 catchments and reveals the greater diversity in job opportunities in G1 villages compared to G2 villages. Furthermore, small employment shifts were found in control groups (G1c, G1off and G3off), suggesting that the employment effect was driven by the socio-economic effects associated to electricity access.

## Work hours

**New access to electricity led to a significant increase in work hours in G1 villages, which underscores that the level of socio-economic development is a factor that catalyzes the impact of electricity access.**

Between baseline and endline, the newly connected individuals in G1nc increased work hours by 21 hours per month. Compared to the control groups, the impact of the new electricity access was an increase of about 44 hours per month (compared to G1c) and 17 hours per month (compared to G1off). Meanwhile, individuals in G2nc increased work hours by only 8 hours per month between baseline and endline. Compared to the control group, the impact of this change was a decrease in work hours of about 8 hours per month compared to G3off (Figure 23). This is likely to be a result of the switch from wage farming to self-employed farming.

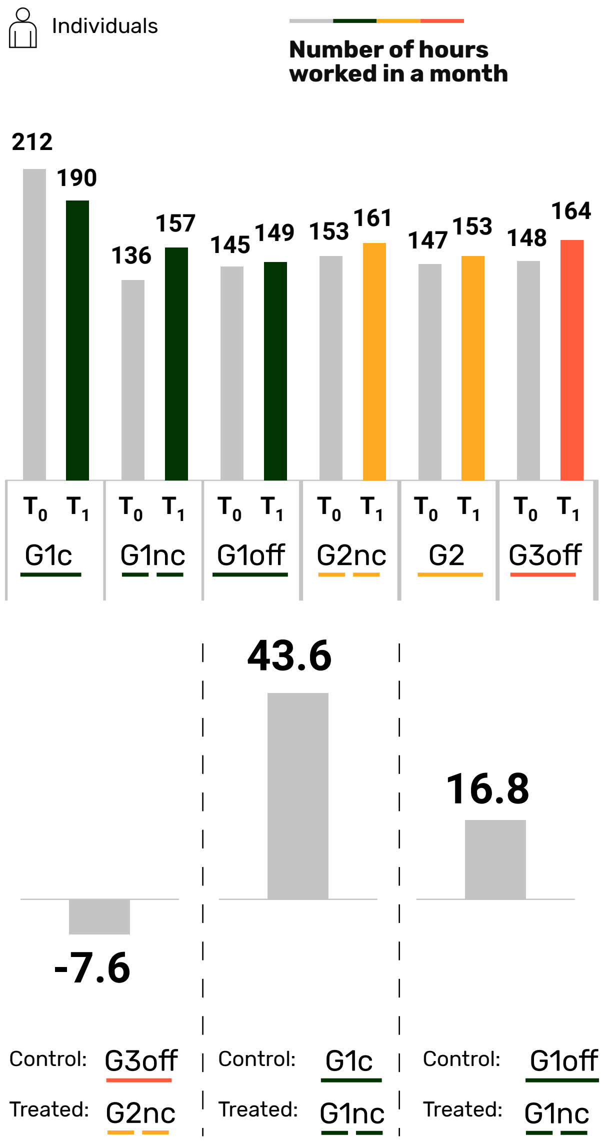



**FIGURE 23**

TOP: WORK HOURS (HOURS/MONTH); BOTTOM: IMPACT OF ELECTRICITY ACCESS (WORK HOURS/MONTH)

## STUDY TIME

### At home

Study time at home after sunset increased 0.41 hours/day in G1nc villages and 0.13 hours/day in G2nc villages since 2015 (Figure 24, Top). The impact of the connection effect is 0.65 hours in G1c villages compared with control G1c villages, and 0.52 hours in G2nc hours compared with control G3off (Figure 24, Bottom). This additional study time after sunset did not replace study in daylight time, therefore it represented a net increase in study time.

**FIGURE 24**

TOP: STUDY TIME IN DAYLIGHT HOURS AND AFTER SUNSET (HOURS/DAY); BOTTOM: IMPACT OF ELECTRICITY ACCESS ON STUDY TIME (HOURS/DAY)

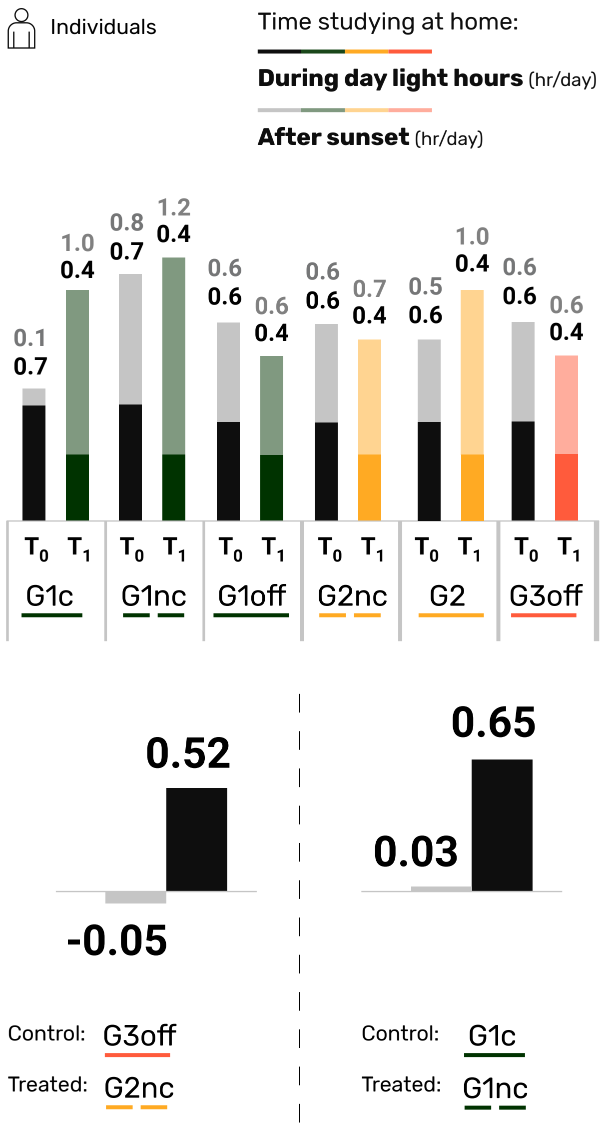
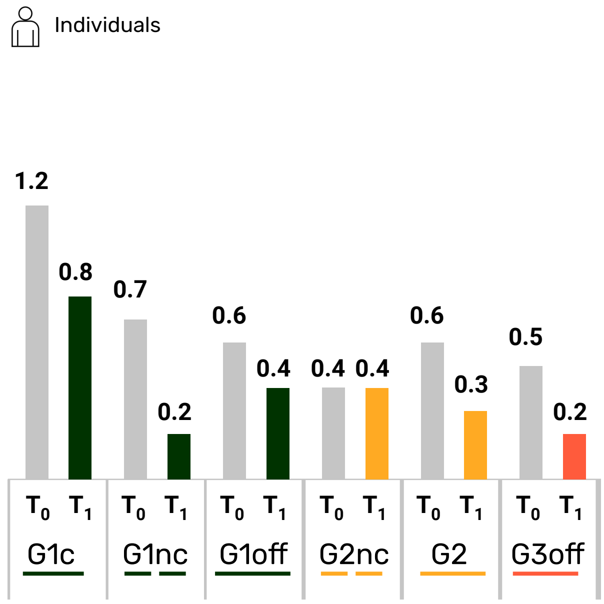



**FIGURE 25**

EVOLUTION OF STUDYING TIME AT SCHOOL AFTER SUNSET (HOUR/DAY)




## At school

Although schools have access to electricity in the connected villages, its students may be benefiting from lighting access at home (either ongrid or offgrid) for studying during night-time. As seen on Figure 25, studying time at school after sunset has decreased among almost all group types.

# OVERVIEW OF THE QUANTITATIVE DESIGN FOR HEALTH FACILITIES, SCHOOLS, AND BUSINESSES

## OVERVIEW

Both 100% of the health centers and 87% of the schools were surveyed at the baseline and at the endline. However, the attrition rate of business was over 50% driven by businesses that failed or that shifted their focus (Table 4-6).

Their main characteristics are described in Table 4-7.

| | HEALTH CENTERS | | | BUSINESSES | | | SCHOOLS | | |
|---|---|---|---|---|---|---|---|---|---|
| Types of end-user facilities | $T_0$ # in Baseline | $T_1$ # in Endline | Attrition rate | $T_0$ # in Baseline | $T_1$ # in Endline | Attrition rate | $T_0$ # in Baseline | $T_1$ # in Endline | Attrition rate |
| Number of surveyed end-users | 123 | 123 | 0 | 104 | 53 | 0.49 | 154 | 134 | 0.13 |

| | MAIN CHARACTERISTICS |
|---|---|
| **Health facilities**[34] | Most of health facilities surveyed were health centers |
| | One fourth of health facilities surveyed were built between 2010 and 2014 |
| | This is clearly the mark of a growing expansion of health services across the country, and towards more remote and rural areas that were not yet connected to the grid |
| **Formal businesses**[35] | The businesses surveyed were mainly in the trade sector, in particular for connected firms |
| | Non-connected businesses were more likely to operate in the manufacturing sector |
| | Only 15% of the businesses are affiliated to a mother company |
| **Schools**[36] | Connected and non-connected schools surveyed were of similar type, half of them being primary schools exclusively |
| | Very few schools surveyed were built recently |
| | Connected schools were slightly larger and employed a higher number of teachers per student |

**TABLE 4-6** HEALTH CENTERS, BUSINESSES, AND SCHOOLS SURVEYED AT BASELINE AND ENDLINE

**TABLE 4-7** OVERALL GENERAL CHARACTERISTICS OF HEALTH FACILITIES, BUSINESSES, AND SCHOOLS SURVEYED

34 Health facilities considered in the survey are small village dispensaries and larger district hospitals.

35 Formal businesses are defined as establishments comprising at least 5 employees or reporting an official accounting.

36 Schools considered in the survey are primary or secondary schools or both within the same establishment.

## DEVELOPMENT IMPACTS AT HEALTH FACILITY, BUSINESS, AND SCHOOL LEVEL FROM THE QUANTITATIVE DESIGN

**Nota Bene 1:**
Measuring the impact of KivuWatt-driven electricity access on performance indicators would lead to statistically insignificant results, as grid electricity access among facilities was already considerably high in the baseline.
Therefore, only the impact stemming from KivuWatt-driven electricity quality improvement will be measured, and, in view of statistical coherence, solely among facilities that were already connected to the grid in the baseline (if not mentioned otherwise).

**Nota Bene 2:**

— Despite both dispensaries and health centers were surveyed, the pool of health centers is evaluated hereafter because only their sample size allowed for statistically significant results. The dispensaries or the small village level health centers were the 20% of the sample, and the health centers were 80% of the sample.

— For businesses, only the sample of 47 connected businesses among the 53 businesses successfully tracked in the endline provided consistent data on performance indicators.

— The entire sample of schools was evaluated.

## ELECTRICITY ACCESS

### Connection rate[37]

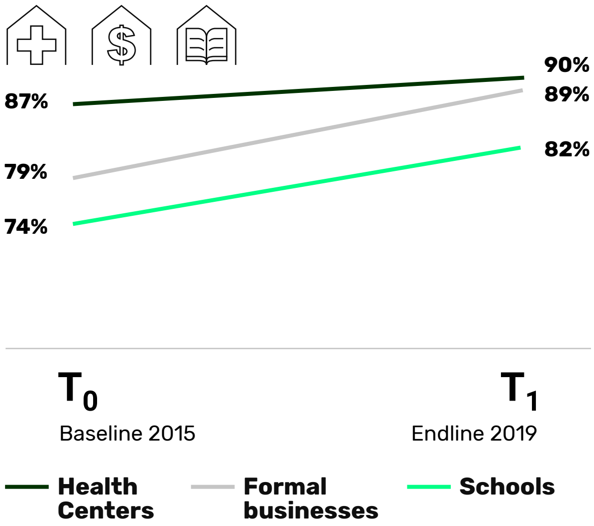
Relatively to households, facilities already had a high electricity access rate in the baseline, which slightly increased in the endline (Figure 26). This depicts the priority access to an electricity connection granted to establishments as to guarantee education, health, and amenity services in villages in line with the development measures put in place by the Rwandan government.

The connection rate of health facilities increased by 3%, from an already 87% high rate in 2016, and that of formal businesses increased to 89%, and that of schools to 82% (Figure 26).

37 For this indicator, the evolution of electricity access has been measured on the full sample of facilities.

**FIGURE 26**

CONNECTION RATE OF HEALTH CENTERS, BUSINESSES, AND SCHOOLS (%)




### Electricity hours (hours/week)

**Electricity hours used per week increased substantially for health centers and slightly for schools; meanwhile, electricity hours per week remained stagnant for businesses in 2015-2019.**

— Electricity hours used per week increased substantially in health centers. Compared with 2016, health centers used in 2019 18 additional hours of electricity per week (up to a total of 161 hours), as well as one additional month of electricity (up to 12 months per year).

— Electricity consumption of businesses remained unchanged over the period and stands at around 93 hours a week. This reflects the threshold in power loads used typically among businesses.

— Schools increased the use of electricity by 5 hours per week up to 92 hours per week, which may be a result of longer hours of operation into the evening. They are also used with 11.5 months of electricity per year in 2019, an increase of 1.4 months relative to 2016.

## Diesel generators

**The use of diesel generators across facilities decreased sharply to the extent that currently they are kept for backup purposes. Diesel generators have traditionally been the main off grid power-generation source for facilities, because of their reliability (compared to solar generation).**

**Though most health centers own diesel generators for backup given the unreliability of the electricity-grid supply, their overall use decreased by 20% between baseline and endline due to the positive impact on the newly grid connected health centers (Figure 27).**

- **Electricity consumed from diesel generators:** When considering the pool of health centers using generators (representing 42% of total health centers), only 14% of the total electricity consumed was sourced from gensets in 2019, which represents a sharp 20% decline relatively to genset consumers in 2015
- **Hours of operation of the diesel generators:** At the endline, diesel generators were used on average 12.6 hours per week, which represents a decline of 18 hours per week compared to the baseline
- **Purpose of the diesel generators:** At the endline, diesel generators were used for backup in 83% of health centers surveyed. About 57% of the health centers surveyed responded that they kept them as backup because of low-quality grid supply.

**Though the share of businesses connected to the grid that have diesel generators available increased by 14 percentage points, their use decreased between the baseline and the endline. The unreliability of the electricity supply led these businesses to increasingly keep diesel generators as backup.**

- **Electricity consumed from diesel generators:** Out of the businesses surveyed in 2019, 54% had diesel generators available onsite, and only 7.6% of the electricity that they consumed from was produced by the diesel generators (down from xx% in 2015)
- **Hours of operation of the diesel generators:** Diesel generators were run on average 4.4 hours per week in 2019, which represented a decline of 9 hours per week compared to 2015. **Purpose of the diesel generators:** In 2019, 97% of the businesses surveyed responded that they kept diesel generators for backup, and 80% informed that this was because of the low-quality electricity grid supply.

**Both the share of the schools connected to the grid that had diesel generators available onsite and the energy that they generated decreased in 2015-2019. However, their use was significantly higher than the use of diesel generators by health centers and businesses, possibly because diesel generators were to a larger extent for schools a source of electricity (Figure 27).**

- Electricity consumed from diesel generators: About 19% of the schools surveyed had diesel generators available onsite, and they used those generators to meet 27% of their electricity demand in 2019 (down 16 percentage points from 2015)
- Hours of operation of the diesel generators: Diesel generators were used on average 20 hours a week in 2019, which represented a decline of 3 hours per week compared to 2015
- Purpose of the diesel generators: 50% of the schools surveyed in 2019 responded that they kept the diesel generators onsite for backup. 40% of them responded that this was because of the low quality of the electricity grid supply (a decline of 17 percentage points compared to 2015), and 40% because they already owned the diesel generators before they were connected to the grid.

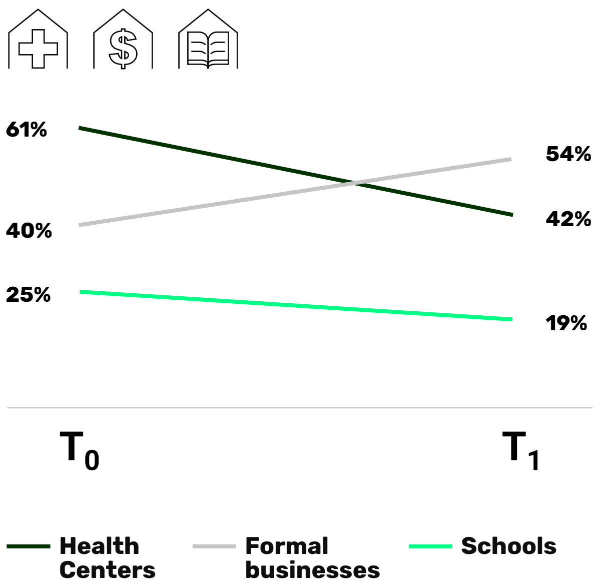



**FIGURE 27**

SHARE OF FACILITIES USING DIESEL GENERATORS (%)

## QUALITY OF THE ELECTRICITY SUPPLY

**The quality of the electricity supply increased in 2015-2019 as measured by two indicators: (i) power outages; and (ii) low voltage supply.**

### Power outages

In 2019, health centers experienced on average .7 power outages per day, businesses experienced 1.3 per day, and schools experienced .8 per day; compared to 2015, they represented a decrease of 1.1 outages per day for health centers, 1.8 per day for businesses, and 1.4 per day for schools (Figure 28).

Consequently, the output loss suffered by businesses due to power outages dropped from 16% in 2015 to 5.4% in 2019.

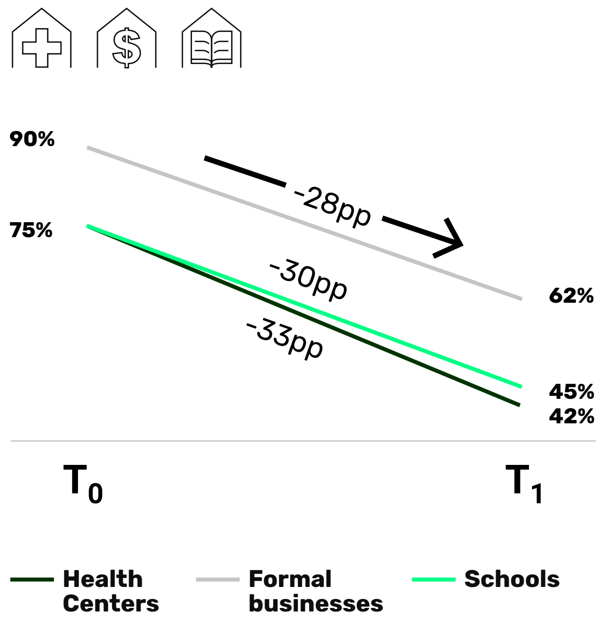



**FIGURE 28**

HEALTH CENTERS, BUSINESSES, AND SCHOOLS EXPERIENCING AT LEAST ONE POWER OUTAGE PER DAY

## Low voltage supply

Low voltage supply incidents for health centers were not only less frequent in 2019 than in 2015 (a drop of 2.5 incidents per week-Figure 29), but also they were on average shorter by 2.5 hours in 2019 than in 2015 (on average an incident lasted 6.4 hours in 2019).

Similarly, schools experienced less frequent incidents of low voltage supply in 2019 (a drop of .9 incidents per week compared to 2015), and they lasted on average 1.3 hours per incident in 2019 (a drop of 7 hours per incident compared to 2015).

Businesses experienced slightly more frequent low voltage supply incidents (an increase of .3 incidents per week in 2015-2019) and they lasted for longer in 2019 than in 2015 (on average up 2.7 hours per incident from 2015, for an average of 4 hours per incident in 2019). These are similar values to the ones measured with households, probably because they were served by the same low voltage distribution network.

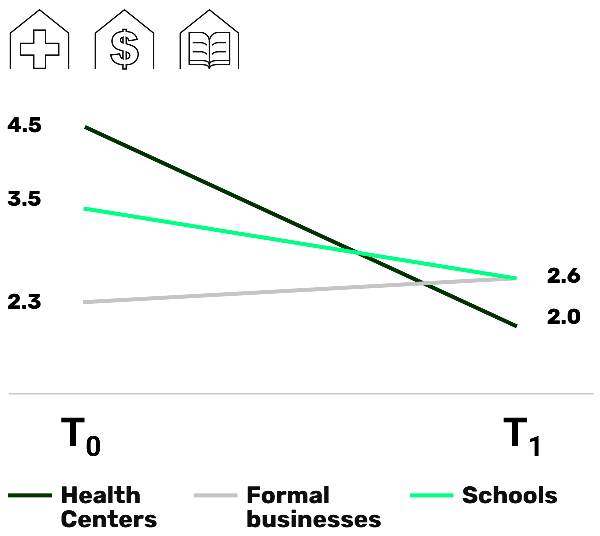



**FIGURE 29**

FREQUENCY OF LOW VOLTAGE SUPPLY INCIDENTS (# PER WEEK)

## ELECTRICITY CONSUMPTION

### Grid electricity consumption (kWh per year, and kWh per employee)

In 2015-2019, health centers were the only facilities that increased on average their consumption of electricity from the grid. Factors related to under development may explain the stagnant consumption by schools and businesses.

— The electricity from the grid consumed per health centers annually on average has increased by 40% in 2015-2019 (up to 4,900 kWh per health center in 2019), which also led to an average increase of 73 kWh per employee year over the same period (up to 243 kWh per employee year in 2019). The latter might point to an increase in employee productivity over time.

— The electricity from the grid consumed per school annually on average remained stable at 930 kWh in 2015-2019, which also led to a stable average of 2 kWh per student year over the same period. The latter might point to a focus on classes during the daylight hours.

— The electricity from the grid consumed per business annually on average remained stable at 1,400 kWh in 2015-2019. The latter might point to the under economic development of the region.

**NB:** Some discrepancy in stated electricity consumption levels by surveyed participants were observed and this may be due to a possible confusion in consumption units in the communicated numbers (i.e. kW or kV instead of kWh). These outliers were disregarded.

## OUTCOMES FROM GRID-ELECTRICITY USE

### ELECTRICAL LIGHTING, LOADS, AND EQUIPMENT

Electrical lighting

Light bulbs were the predominant lighting device for health facilities and schools (90%, 2019). The balance is distributed among other lighting devices including integrated solar lamps, rechargeable lamps, kerosene lamps, and other devices (Figure 30) (Figure 31).

**FIGURE 30**

HEALTH FACILITIES, CONNECTED AT BASELINE - DISTRIBUTION OF LIGHTING DEVICES USED, 2015 AND 2019 (%)

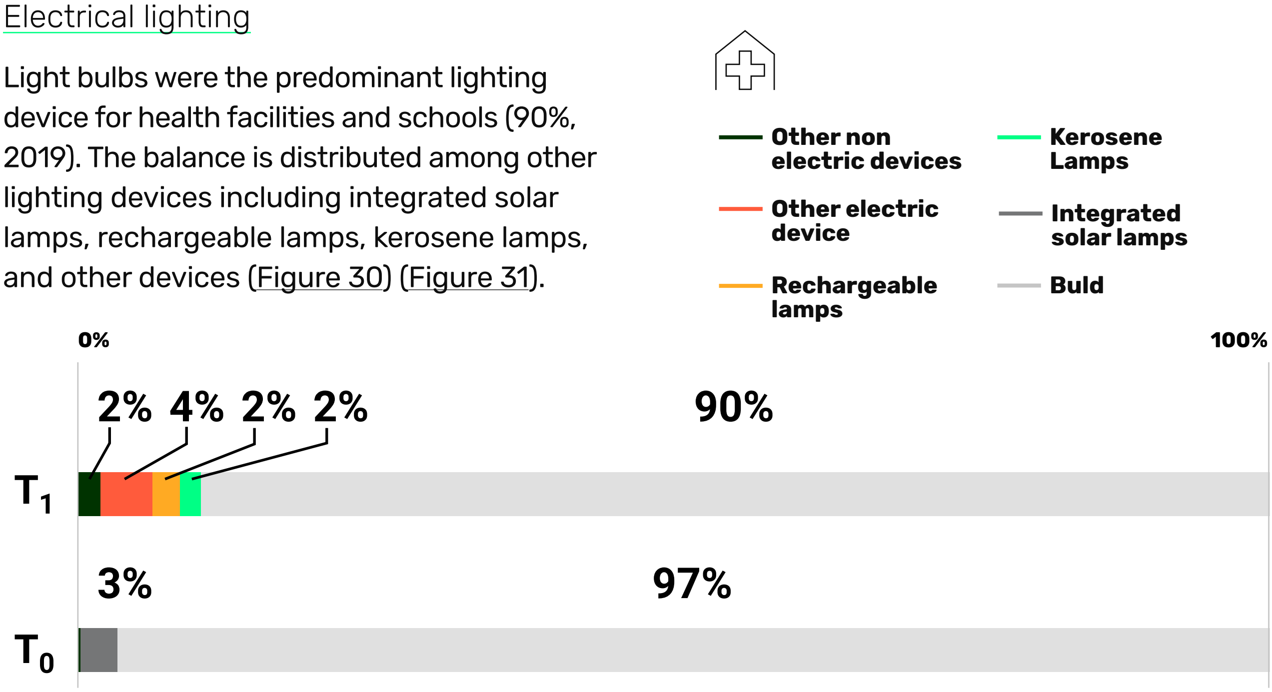
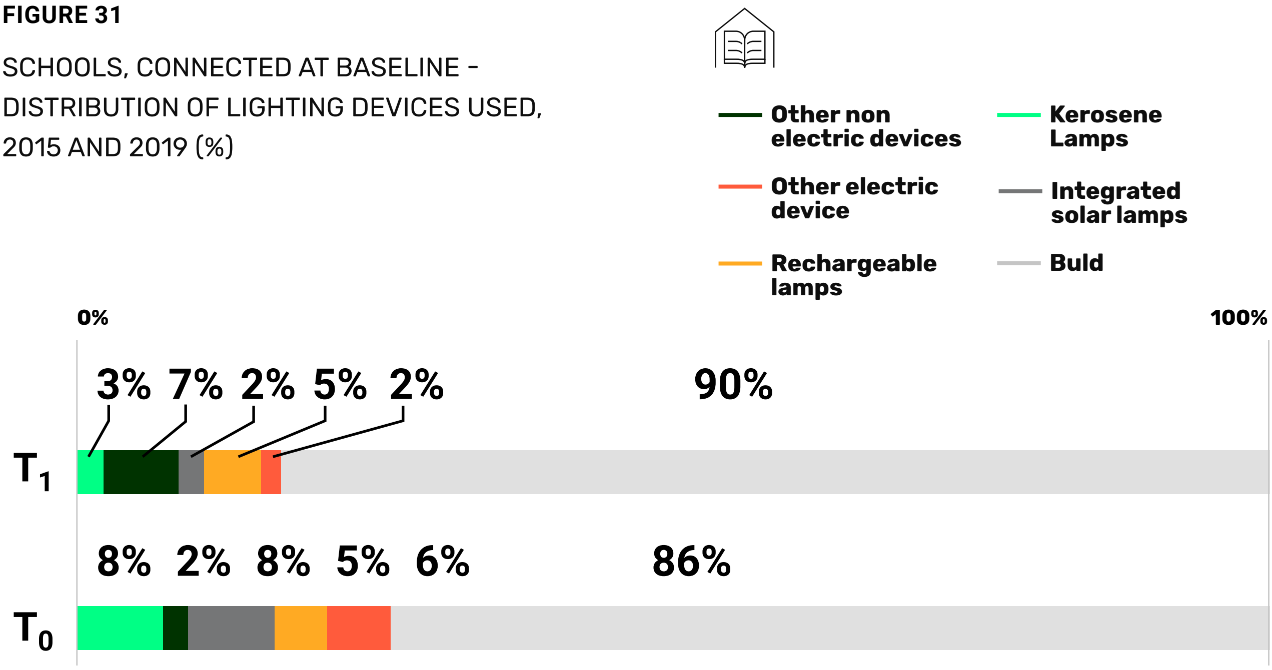



**FIGURE 31**

SCHOOLS, CONNECTED AT BASELINE - DISTRIBUTION OF LIGHTING DEVICES USED, 2015 AND 2019 (%)

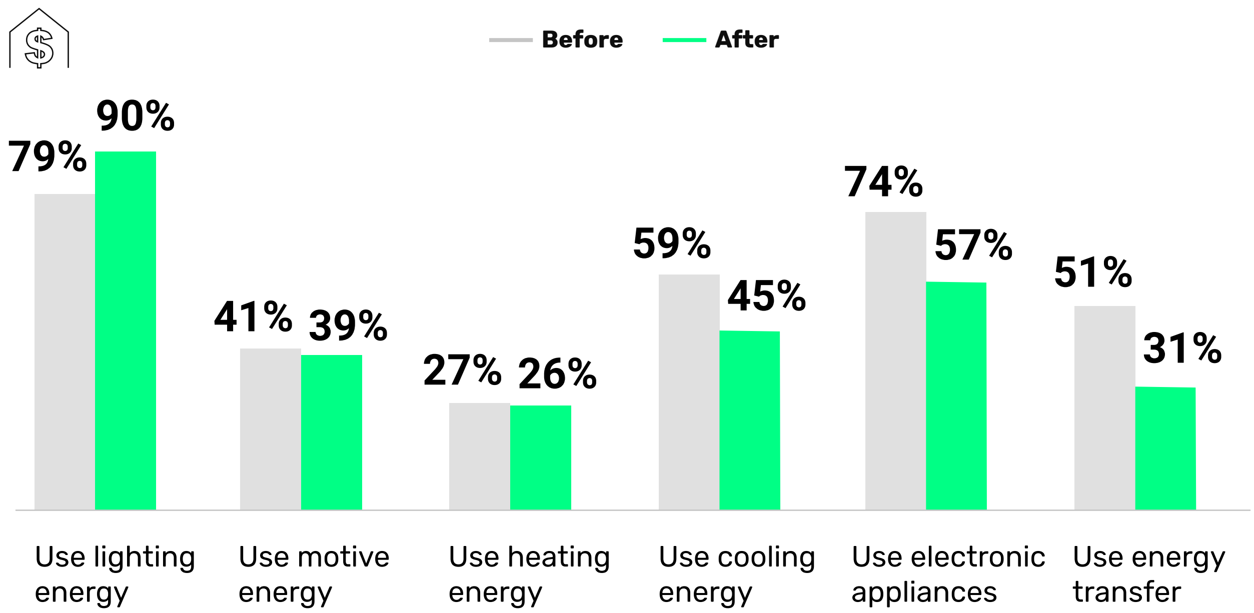


## Electrical loads

The business surveyed responded that the use of all electrical loads decreased except for lighting in 2015-2019. This includes motion, heating, cooling, electronic appliances, and transfers. This is possibly due to the switch to more energy efficient technologies (Figure 32).

**FIGURE 32**

SHARE OF BUSINESSES CONNECTED AT BASELINE USING ELECTRICAL LOADS BETWEEN 2015 AND 2019 AMONG BUSINESS CONNECTED AT BASELINE (%)




## Health-facility equipment

Equipment ownership among health centers increased on average by 17% between baseline (12.8 pieces of equipment on average) and endline (15 pieces of equipment on average) (Figure 33). The average number of computers increased the most (43.6%, from 5.5 in 2015 to 7.9 in 2019).

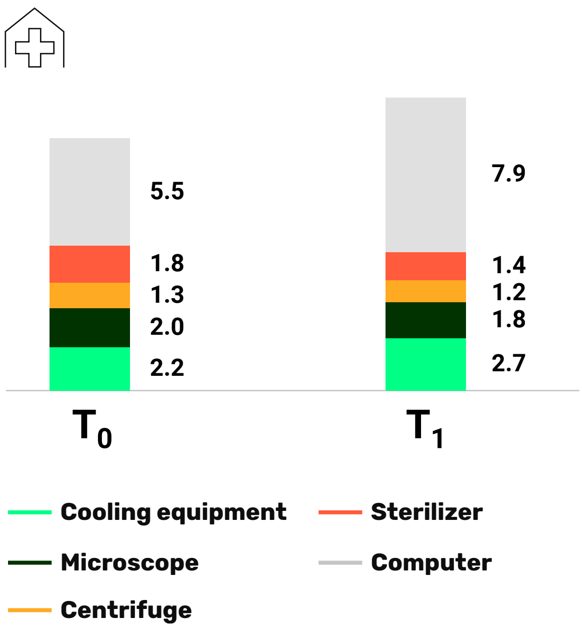



**FIGURE 33**

HEALTH CENTERS, CONNECTED AT BASELINE – EQUIPMENT TYPE (AVERAGE #, PER CENTER)

### School equipment

Almost all schools surveyed had computers available to students; moreover, the average number of computers per school increased by 65.3% between the baseline (75 computers on average) and endline (124 computers on average) (Figure 34). This is possibly due to the availability of grid electricity and active government policies focused on digitalization[38].

38 Information and Communication Technology has been introduced in the national competence-based curriculum. See Government of Rwanda's Education Sector Strategic Plan "One Laptop per Child policy" and the "smart school" initiatives

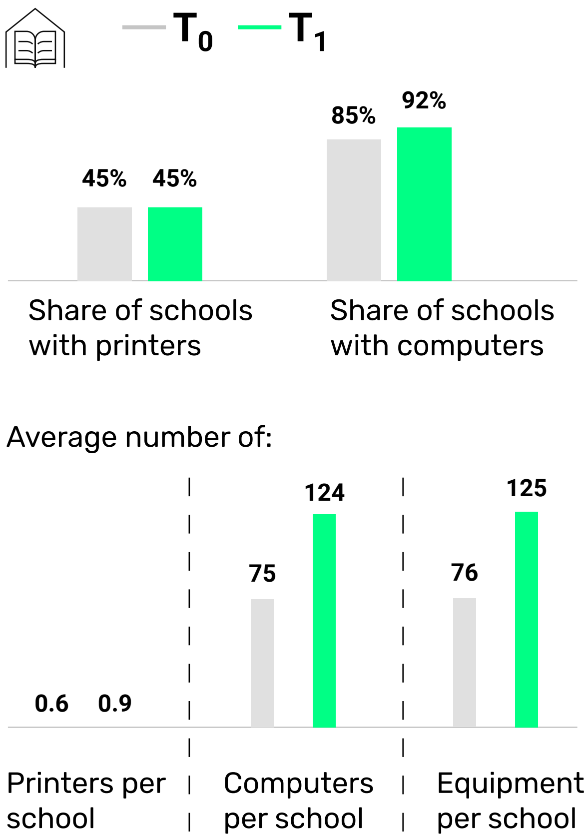



**FIGURE 34**

TOP: SHARE OF SCHOOLS OWNING PRINTER / COMPUTER; BOTTOM: AVERAGE NUMBER OF PRINTER / COMPUTERS PER SCHOOL

## PERFORMANCE OF HEALTH CENTERS, SCHOOLS, AND BUSINESSES

### Health centers

**The average number of hours of electrical lighting per week increased by a 16.4% between the baseline (110 hours on average) and the endline (128 hours on average) (Figure 35).** This led to a significant average increase in the total number of hours of operation per week across all health centers.

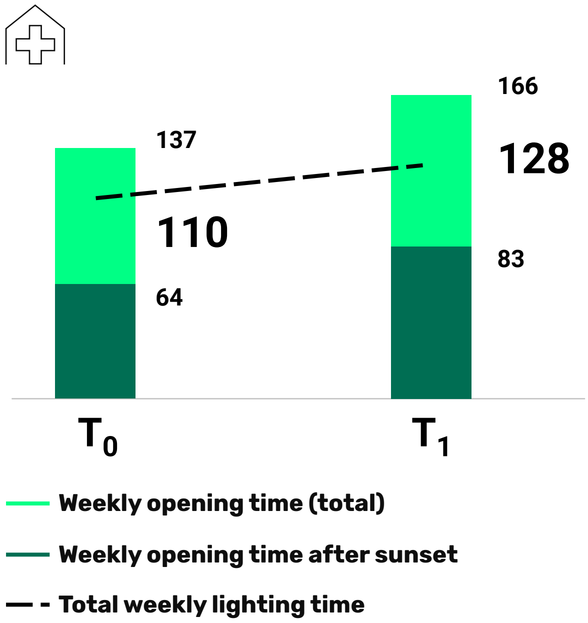



**FIGURE 35**

HEALTH CENTERS – HOURS OF OPERATION, OF OPERATION AFTER SUNSET, AND OF ELECTRICAL LIGHTING (PER WEEK)

## Schools

**The average number of hours of electrical lighting per week increased by a 17.9% between the baseline (67 hours on average) and the endline (79 hours on average) (Figure 36).** This led to a significant average increase in the total number of hours of op-eration per week across all health centers (probably, earlier in the morning).

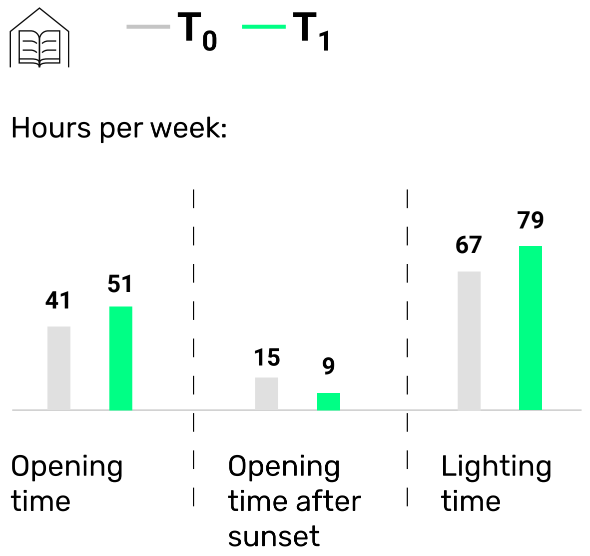



**FIGURE 36**

SCHOOLS - HOURS OF OPERATION, OPERATION AFTER SUNSET, AND OF ELECTRICAL LIGHTING (PER WEEK)

## Businesses

**Average annual revenues almost doubled and weekly hours of operations increased by 11.3% between the baseline and the endline (Figure 37).** This is probably the consequence of improved access to electricity and the general economic improvements in the country.

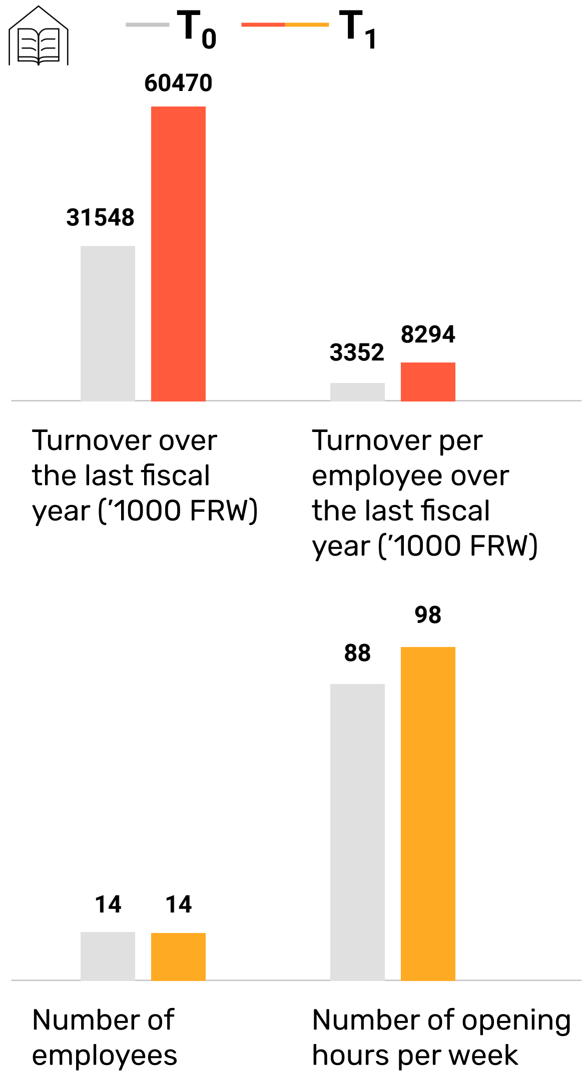



**FIGURE 37**

BUSINESSES – TOP: REVENUE (AVERAGE ANNUAL, '1,000 FRW); BOTTOM: EMPLOYEES AND HOURS OF OPERATION (AVERAGE # PER WEEK)

## 3.3

# KivuWatt's local impact

## DIRECT EMPLOYMENT

### EMPLOYEE PROFILE

**In 2019, the company employed 111 staff of which 58% were Rwandan and 20% were women (Figure 38).**

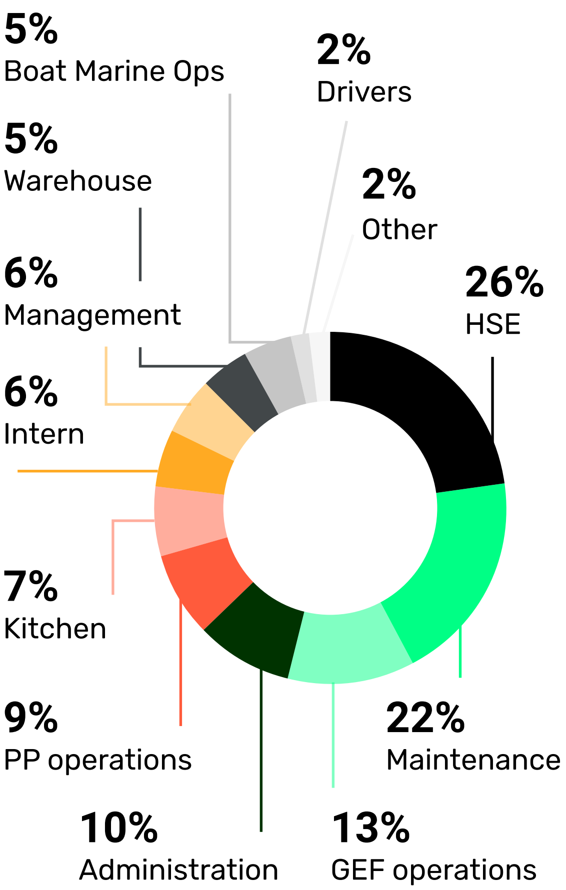



**FIGURE 38**

KIVUWATT – EMPLOYEE DISTRIBUTION

### HUMAN RESOURCES STRATEGY

**KivuWatt supports the development of its staff by: (i) coordinating a mentoring program from the first day of employment; (ii) providing training nationally and internationally; and (iii) facilitating month-long work exchange programs (WEP) of its employees with other subsidiaries of ContourGlobal.** There are no limits on the number of training courses an employee can receive, and courses are selected based on top-down identified needs and bottom-up aspired career development.

More than 80 certified trainings were offered to KivuWatt employees in 2018 which span technical to transversal themes. For example, Permit to Work (PTW), ELSA Inspection, Used/Waste oil management, Chemical handling, Hot Work, PPE Awareness Presentation, Slip, Trip and Fall, Spill Control and Prevention, and Biodiversity. Additionally, employees were given access to the following courses: Advanced Excel, Supply chain management, NEBOSH[39] process safety management, Personality testing, Procedure to pay process, Internal Control Oversight Team (ICOT) and Internal controls, Leadership and Management, Visible Felt Leadership training[40], and HSE audit training.

39 The National Examination Board in Occupational Safety and Health is a UK-based independent examination board delivering vocational qualifications in health, safety and environmental practice and management.

40 Visible Felt leadership is a concept made famous by the DuPont organisation in the field of safety.

### OPERATIONAL HEALTH AND SAFETY STRATEGY

All new employees and visitors attend a first and intensive health and safety training session. Employees also attend weekly health and safety meetings.

Each employee is responsible for its own and for its team safety, and failure to comply with safety practices may lead to dismissal. For example, all employees must wear the relevant safety onsite including boots, jackets, earplugs, life vest, helmet, gloves, and glasses. Safety equipment and signals are visible onsite including fire extinguishers, exit points, oxygen tanks, water pipelines, and first aid kits.

### OUTCOME OF 6 IN-DEPTH STAFF INTERVIEWS

**Six in-depth interviews of KivuWatt staff purposively sampled were conducted to learn about their experiences in the company (cf. names in Table 7-2 in Appendix). Overall, they were satisfied with working in the company and recognized its strong ethics, and equal opportunities provided to men and women, with examples of significant career advancements for women. More specifically:**

- Ernest, an employee from Kibuye, highlighted how KivuWatt has not only provided him with security and a sustainable life, but has also improved the village's economy
- Emmanuel specifically described the differences between his work experience at KivuWatt relatively to his previous experience at a Chinese construction firm, in terms of guaranteed safety, strong management support geared towards personal and professional development, flexibility in terms of aspiration for career development
- Liliane, who started as secretary, she is now the company's HSE manager, thanks to training courses, trust from the management, and professional support
- Nsabimana, who started as gardener, is now a member of the maintenance team; he stated that thanks to KivuWatt he had been able to buy a house and send his children to school
- Musa stated that KivuWatt demonstrated high professional standards which other local companies do not support. This professional environment equipped its employees with the certification and experience to seek high-standard jobs internationally. He also voiced his gratefulness towards KivuWatt's pre-primary school refurbishment initiative that allowed him to reunite and live with his wife and kids.

## CORPORATE SOCIAL RESPONSIBILITY (CSR)

As part of its commitment to lenders and the strategy of its mother company, KivuWatt ensures its social impact is extensive and additional on both the local community and its employees. It implements Corporate Social Responsibility projects along a yearly budget which it selects, implements and manages in strong interaction with the local community.

## CSR PROGRAM

**KivuWatt is engaged in Corporate Social Responsibility (CSR) activities as consequence of commitments made to its lenders. KivuWatt spends on average USD 200,000 per year in its CSR program [10], and the 15 CSR projects that it implemented so far.**

The CSR projects are chosen working closely with the local community and the Rwandan Government's Joint Action Development Forum[41] (JADF). Four projects were visited by Enea during the evaluation mission in October 2019 (Table 4-8). Six villagers – all men – were interviewed in the context of this task. The villagers showed appreciation for the outcomes of these projects (a comprehensive sample of CSR projects can be found in Appendix 1.).

**TABLE 4-8**

CSR PROJECTS VISITED DURING THE EVALUATION MISSION (OCTOBER 2019)

| CSR PROJECT VISITED | DESCRIPTION | FEEDBACK FROM BENEFICIARIES |
|---|---|---|
| **Pre-primary school refurbishment project** | KivuWatt refurbished Kibuye's only pre-primary school in 2017, with the aim to bring pupils access to education. Under this same project, the school is currently being extended (Figure 39) | Kibuye lacked primary schools with proper amenities, which led to the separation of several KivuWatt employees from their kids during weekdays to send them to schools in Kigali. The project has allowed these parents to stay close to their kids whilst ensuring they received proper school care |
| **The cow donation project** | KivuWatt donated 43 high breed cattle as a way of eradicating poverty through milk production and organic manure for subsistence farming Figure 40) | KivuWatt appointed two vets to sustain the cows' healthcare. The interviewed villager strengthened on how the cows as well as KivuWatt in general have changed his and the village's livelihood and wellbeing. Particularly stemming from the cow donation program, through revenue generated by selling the milk or calves, he was able to buy his kids schoolbooks, send them to school and provide them with light at night to study |
| **The fishing project** | Large Isambaza and Tilapia fish are being harvested in ground ponds and underwater cages in Lake Kivu to increase production intensity (Figure 41) | The fish farmers are looking forward to the project. As harvested fish would be sold by the village's fish cooperatives, the localized and stable harvest of larger fish will increase revenue of fish farmers which would come hand in hand with economic spinoffs in the region |
| **The water accessibility project** | KivuWatt built 5 water collection points across KivuWatt to improve accessibility to clean water | Villagers avoid walking long distances to fetch clean water, which has notably improved their wellbeing |

41 The Joint Action Development Forum (JADF) is a national-scale Rwandese platform that was put in place to facilitate full participation of citizens in the decentralised governance and improve service provision processes with representatives from the public sector, private sector and civil society [25]. KivuWatt is one of the 125 members of Kirungi's JADF, which goal is to coordinate community developments within the district, identify community needs and align KivuWatt's CSR projects and the agenda of the GoR during a general annual meeting with the Western Province Governor [7].


**FIGURE 39**

PRE-PRIMARY SCHOOL REFURBISHMENT PROJECT[42]

42 Top left: school kids having lunch; Top right: refurbished class in the school; Bottom left: Enea and school principal in front of the school; Bottom right: ongoing school extension project.

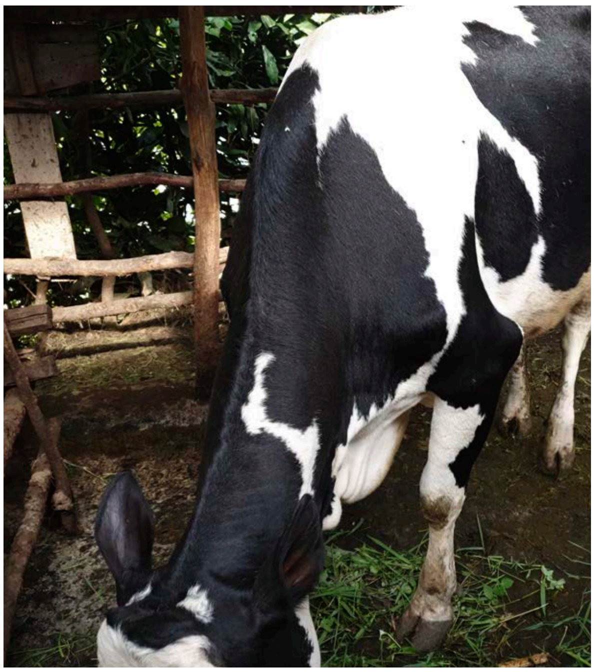


**FIGURE 40**

A COW DONATED TO A VILLAGER

**FIGURE 41**

FISH FARMING PROJECT[43]

43 Left: Fish larvae harvesting pond; Right: Fishers overseeing fish harvesting cages.

**KivuWatt also undertook two stakeholder engagement activities to increase its interactions with the local community and to create a positive footprint in the village:**

- Six Aside Basketball tournament: in Kibuye, for students, teachers, and staff to promote wellbeing and collaboration
- Tutsi genocide commemoration: provided 10 genocide survivor families with food supplies, provided counseling services to vulnerable groups, and contributed to the preservation of cultural practices.

**In 2015, KivuWatt implemented a grievance mechanism to allow villagers to voice specific grievances, complaints, or incidents where KivuWatt may have a degree of responsibility.**

**The Rwanda's Western Province Governor, Munyantwari Alphonse was also interviewed during evaluation mission.** He shared his view that KivuWatt has contributed to the improvement of the Kibuye the region and the country's economy. This is because of the enhanced electrification of the region, but also because of the CSR projects which focused on the community needs. Economic spin-offs are substantial at all levels of the country's economic development.

## ASSESSMENT OF THE CSR PROGRAM

The CSR program has had a positive impact on the region because of the:

**Project selection:** KivuWatt selected the projects via a bottom-up approach that engaged the local community. Moreover, through this mechanism, KivuWatt co-selected projects with long-term lifespan and catalyzing effects (i.e. the cow donation project), which led to positive impacts in the region including demonstration effects.

**Project implementation and management:** It was carried out to ensures a long-term sustainability of each project.

- Firstly, it engaged communities in the project implementation and management. It did not simply deliver turnkey solutions to the villagers; therefore, it increased the proactivity and transparency to villagers
- Secondly, KivuWatt maintained a foothold in the project through frequent visits and check-ups, to ensure that operation was sound
- Thirdly, throughout the construction and operation of each project, KivuWatt enforced its "Safety and Quality First" principles, even for people not directly touched by the project.

# 4


# Recommendations

**This comprehensive impact evaluation distilled findings that are not only valuable to KivuWatt, FMO and the Dutch government, but also to a wide range of stakeholders including policy makers, the National Institute of Statistics of Rwanda (NISR), impact investors, development banks, thinktanks, and academia.**

**Therefore, based on the findings, the evaluation formulates the following recommendations based on contextual factors and role of FMO and other development banks.**

Deep understanding of the contextual factors around the project contributed to the achievement of positive impacts. For future projects, FMO should try to replicate factors of success observed through the KivuWatt project:

### A1.

Assess the country's macro-economic and legal framework: Its assessment early in the project development phase helped to ensure alignment of expectations of all stakeholders with project outcomes, as well as to maximize the financial, socio-economic, and environmental impacts of the project.

### A2.

Ensure the adequacy of the technology to the setting: The project developed an integrated technology solution for the exploitation of methane gas located in Lake Kivu, which is one of the three lakes in the world that holds large commercially exploitable methane resources.

### A3.

Align with the energy framework in place: The grid extension / interconnections and tariff subsidies played an impactful role in the development of the Rwanda's electricity system. KivuWatt added generation capacity that contributed to stabilizing the grid, reducing energy costs, and driving electrification. All things considered, the subsidies enabled a swift development of Rwanda's energy sector from 2015 to 2019.

### A4.

Ensure strength of investors' support and robustness of financing structure: In the case of KivuWatt, this led to successful project development and operational / financial performance.

_ Financing structure: ContourGlobal had a strong risk appetite backed with a significant equity investment, and FMO mobilized debt financing from other development banks, to overcome the significant project risks and lack of available financing

_ Investors' support: ContourGlobal fully absorbed the cost overrun associated with construction delays. Project lenders restructured the senior debt including a new flexible repayment schedule (without changing the overall debt maturity of the project)

_ Non-financial support: ContourGlobal provided training, exchange programs, and career progression opportunities to employees; KivuWatt developed CSR projects for the local communities; FMO and the Dutch government financed, committed, and managed an impact evaluation study of the project.

### A5.

Nurture and partner with a private investor with the right expertise and risk appetite: This was in terms of the technology used, the business development approach, the availability of financial resources and the country knowledge required to successfully implement the project.

### A6.

Contribute to create buy-in from the government, the private sector, and other stakeholders: This created the conditions for establishing the necessary enabling environment and the legislation / regulation reform indispensable for the private sector to implement a sustainable project.

### A7.

Provide investment and advisory services to the borrower which in turn would contribute to the increase of the competitiveness of the electricity market, and to the broadening the access to electricity to people and businesses / services. Services to ContourGlobal led to positive development impacts and contributed to the commitments to the Sustainable Development Goals by the country.

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# Appendices

# 1 LIST OF INTERVIEWS AND SECONDARY DATA COLLECTED

**TABLE 7-1**

SECONDARY DATA COLLECTED BY GOVERNMENTAL BODIES DURING THE FIELD VISIT IN MARCH 2019

| SOURCE | FREQUENCY | TITLE | INFORMATION | PERIOD | LINK |
|---|---|---|---|---|---|
| RURA | Quarterly | Statistic in Electricity Subsector | Domestic generation and imported electricity | 2015–2018 | → |
| RURA | Quarterly | Statistic in Electricity Subsector | Electricity generation mix | 2015–2018 | → |
| RURA | Quarterly | Statistic in Electricity Subsector | System peak demand | 2015–2018 | → |
| RURA | Quarterly | Statistic in Electricity Subsector | Exported Electricity | 2015–2018 | → |
| RURA | Quarterly | Statistic in Electricity Subsector | Electricity supplied | 2015–2018 | → |
| RURA | Quarterly | Statistic in Electricity Subsector | Electricity Sold | 2015–2018 | → |
| RURA | Quarterly | Statistic in Electricity Subsector | Applicable electricity end user tariffs | 2015–2018 | → |
| RURA | Quarterly | Statistic in Electricity Subsector | Licensed IPP + installed capacity | 2015–2018 | → |
| RURA | Annually | Annual Report | Access to electricity | 2015–2018 | → |
| RURA | Annually | Annual Report | Aggregated data from the quarterly report: 'Statistics in the electricity sector | 2015–2018 | → |
| RURA | Annually | Annual Report | Power interruption and their duration | 2015–2018 | → |
| REG | One-time | Power outage | Outages (frequency and duration for each substation post) | 2018 | → |
| REG | One-time | Transmission Master plan for Rwanda | Transmission infrastructure | 2018 | → |
| RURA | Annually | Annual Report | Losses | 2015–2018 | → |
| RURA | Annually | Annual Report | Size of the network | 2015–2018 | → |
| RURA | Annually | Annual Report | Number of customers ongrid and offgrid | 2015–2018 | → |
| REG | One-time | Ongrid | Electricity access rate per district | 2019 | → |
| REG | One-time | National Electrification plan | Map of the national electrification plan | 2018 | → |
| REG | One-time | Offgrid | Electricity offgrid access rate per district | 2019 | → |
| REG | One-time | Projects | Information regarding all completed and planned projects from the REG | 2015–2018 | → |
| REG | One Time | Energy Sector Stractegic Plan | General context + aggregated numbers | 2018 | → |
| REG | One Time | Rural Electrification strategy | General context + aggregated numbers | 2016 | → |
| MININFRA | Annually | Annual Report | General context + aggregated numbers | 2015–2018 | → |

**TABLE 7-2** INTERVIEWS CONDUCTED FOR THE QUALITATIVE ANALYSIS DURING THE TWO FIELD VISITS IN MARCH AND OCTOBER 2019

| TYPE OF STAKEHOLDERS | PERSON INTERVIEWED | ORGANISATION | ROLE | DATE | OBJECTIVE |
|---|---|---|---|---|---|
| Rwandan electricity sector governmental bodies | | Rwanda Energy Group (REG) | | March 2019 | Collection of secondary data and overview of the Rwandan energy landscape |
| | | Rwanda Utilities Regulatory Authority (RURA) | | March 2019 | Collection of secondary data and overview of the Rwandan energy landscape |
| | | Ministry of Infrastructure (MININFRA) | | March 2019 | Collection of secondary data and overview of the Rwandan energy landscape |
| International institutions or private energy companies | Julien JOMAUX | Belgium Development Agency (Enabel) | Power Networks expert | 10 October 2019 | Overview of the Rwandan energy landscape |
| | Andrea REIKAT | Deutsche Gesellschaft für Internationale Zusammenarbeit (GiZ) | Component manager | 11 October 2019 | Overview of the Rwandan energy landscape |
| | Claire NELSON | USAID | Rwanda Power Africa Lead | 16 October 2019 | Overview of the Rwandan energy landscape |
| | Iwona BISAGA | BBOXX | Group Research Manager | 14 October 2019 | Overview of the Rwandan offgrid energy landscape |
| | Herbert NJIRU NYAGA | Energy for Impact (E4I) | Country Manager | 22 October 2019 | Overview of the Rwandan mini-grid energy landscape |
| KivuWatt stakeholders | Liliane NIWEMWIZA | KivuWatt Ltd | HSE Officer | 17 October 2019 | Feedback on professional experience at KivuWatt |
| | Emmanuel NSENGIYUMVA | KivuWatt Ltd | C&I Snr Technician | 17 October 2019 | Feedback on professional experience at KivuWatt |
| | Nsabimana EMILLE | KivuWatt Ltd | Scaffolder | 17 October 2019 | Feedback on professional experience at KivuWatt |
| | Metuschelah IRAKOMEYE | KivuWatt Ltd | Snr. Electrical Technician | 17 October 2019 | Feedback on professional experience at KivuWatt |
| | Musa SYLVERIEN | KivuWatt Ltd | Mechanical Engineer | 17 October 2019 | Feedback on professional experience at KivuWatt |
| | Ntirandekura ERNEST | KivuWatt Ltd | Housekeeping | 17 October 2019 | Feedback on professional experience at KivuWatt |
| | Placide NKUSI | KivuWatt Ltd | Environmental coordinator | 17 October 2019 | Overview of Lake Monitoring process |
| | Vedastine MUTONI | KivuWatt Ltd | HR Officer | 18 October 2019 | Overview of HR management |
| | Dan MUNYAKAZI | KivuWatt Ltd | Corporate Social Responsibility (CSR) coordinator | 17 October 2019 | Overview of CSR management |
| | François DARCHAMBEAU | KivuWatt Ltd | Lake Monitoring expert | 18 October 2019 | Overview of Lake Monitoring process and outstanding issues with the REG |
| | Priysham NUNDAH | KivuWatt Ltd | KivuWatt Facilities Manager | 18 October 2019 | Overview of KivuWatt management |
| Local (Kibuye) stakeholders | Munyantwari ALPHONSE | Province Governor | Western Province Governor | 17 October 2019 | Feedback on KivuWatt impact in Kibuye and Rwanda |
| | Villagers directly benefiting of 5 selected CSR projects | | | 17-18 October 2019 | Feedback on CSR projects |

# 2 THE KIVUWATT PROJECT

## DESCRIPTION OF THE KIVUWATT PROJECT

The Kivu Lake

**The KivuWatt 1 project is a first-of-a-kind integrated power generation project.** It exploits the unique geophysical characteristics of Lake Kivu, a lake containing high concentrations of biogenic methane and carbon dioxide gases trapped in the resource zone - a stable layer at 270 m to 500 m deep.

The gases remain sequestered because the lake waters are stratified along stable density layers. Due to its stratification and the fact that deeper levels of the lake lack oxygen, the lake produces methane through the anaerobic digestion of organic nutrients. These gases also stem from nearby volcanic activities.

**The upper surface of the lake, to a depth of 60 m, is referred to as the biozone. The biozone is the lake's only oxygenated layer thus the only layer that offers living conditions for organisms**[44]. Lake Kivu is currently estimated to contain 300 billion m³ of carbon dioxide and 60 billion m³ of methane in its lower density layers. The current saturation level of the gases is at 55%[45].

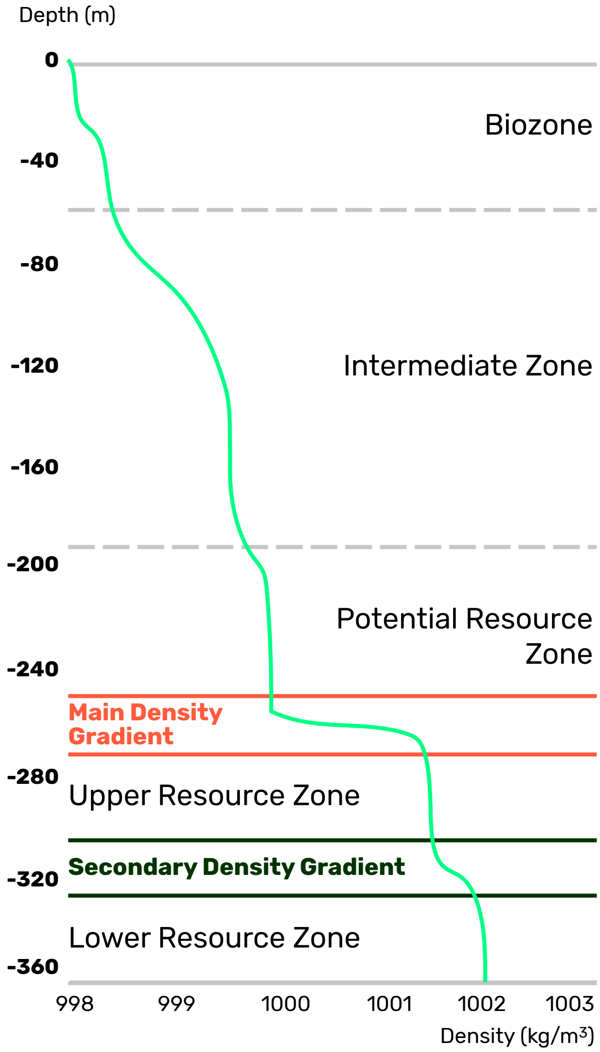



**FIGURE 42**

VERTICAL DENSITY PROFILE AND STRUCTURE OF LAKE KIVU[46] [11]

44 As a result of the limited concentration of oxygen in this layer, small-sized fish are the largest living organisms found in Lake Kivu.

45 If this level reaches 100%, it can produce a cataclysmic gas release within a range of 50 to 200 km. However, there is currently no scientific agreement on whether the gas concentration in the lake is increasing and on the real risks related to lake saturation.

46 The density structure of the lake is a series of relatively homogeneous mixed zones separated by density gradient layers. The major mixed zones, beginning at the surface, are referred to as the Biozone, Intermediate Zone, Potential Resource Zone, Upper Resource Zone, and Lower Resource Zone.

## The KivuWatt project

The project combines both a gas extraction facility (GEF) on Lake Kivu and an associated 26 MW power plant in Kibuye (Figure 43).

The rationale behind the location of the project near Kibuye is twofold. First, the area which was most practical, and which had the highest potential to exploit the gas resource on the Rwandan side of the lake, was closest to Kibuye. Second, Kibuye was the city located on the shore of the lake with the highest availability of labour and an inhabitable location to displace future KivuWatt labour.


**FIGURE 43**

KIVUWATT POWER PLANT AND GAS EXTRACTION FACILITY LOCATION IN LAKE KIVU

## Technology

**The GEF is a platform floating on Lake Kivu that extracts methane gas at a 350 m depth in the lake.** The water/gas extraction technology is not technically innovative but based on a commonly used industrial process – it is a well-established technology that has been used in Oil & Gas and Chemical industries for decades.

However, the GEF is innovative with regards to:

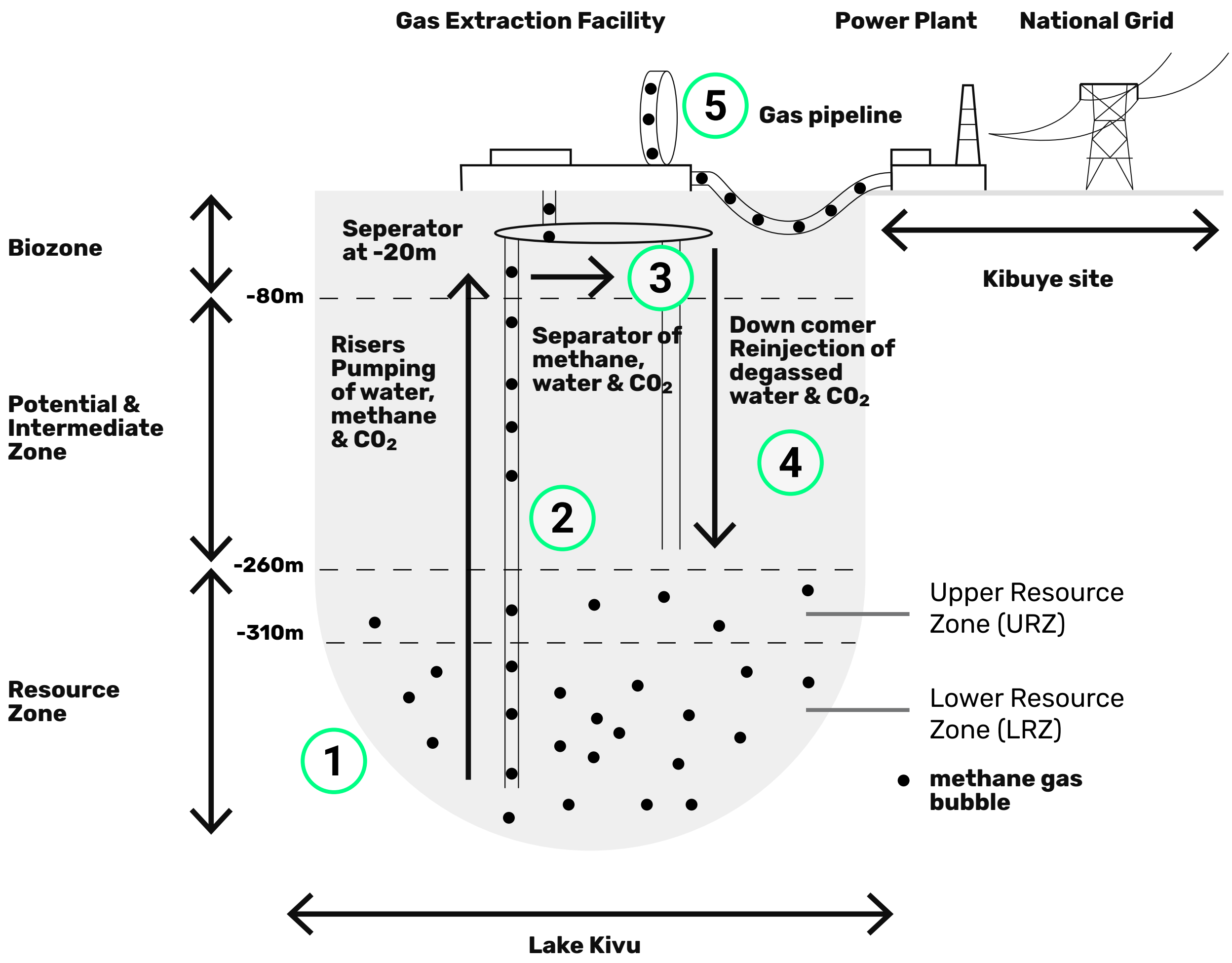
1. **Its geographic context – it is the world's first floating gas extraction platform on a lake.** Offshore gas extraction facilities are commonly found on deeper ocean or sea waters.

2. **The end-use of the extracted gas –** the uncommonly abundant methane gas is extracted from the lake's bottom layers to generate grid-scale power.

The gas extraction process is described in Figure 44. Once extracted, washed, and dried, the methane gas is then transported through a 13 km long semi-submerged pipeline to the 26 MW power plant onshore of the lake.

The KivuWatt power plant uses three simple cycle gas engines (3 x 8.5 MW) supplied by Wärtsilä (Finland). The plant operates baseload on a 24h basis, with a yearly target for electricity production of this plant is 220 GWh, which is equivalent to 25% of countrywide total electricity generation.

The plant used to be connected to the former 110 kV electric line that was primarily used to supply the district of Karongi. However, the line was relatively unstable with a lot of dispatches to Burundi. A high-voltage line (220 kV) has been constructed and connected the plant in 2018, in addition to the former line, to secure power for Kigali. According to KivuWatt, this line is used at half of its capacity due to technical problems, with no major impact on transmissions.




1. The gas-rich water is extracted from a depth of 350m and separated into gas and water through decompression in the underwater separator, which process creates upward flow to collect water.

2. Degassed water is released back into the lake at 240m depth, where its physiochemistry is in harmony with that of the layer's water body.

3. The gas is then further washed in the scrubber with water pumped from 40m to separate $CH_4$ from $CO_2$ and $H_2S$.

4. Wash water is then re-injected into the water at a depth of 60m. This is to avoid impacts on the ecosystem since the depth of 50m is the limit of habitation for living organisms

5. The $CH_4$ is sent to the dryer, and a volume in line with REG's dispatch need is piped to the power plant. Another part of the $CH_4$ is used directly to generate onsite power needs. If excess $CH_4$ is extracted, it is burnt and released through a gas chimney.

**FIGURE 44**

LEFT: OVERVIEW OF THE METHANE EXTRACTION PROCESS.
RIGHT: TECHNICAL CONFIGURATION OF THE GEF [3]

## ENVIRONMENTAL PERFORMANCE OF THE KIVUWATT PROJECT

### Lake monitoring program

**A lake monitoring program for GEF methane gas extraction is conducted by KivuWatt to preserve lake stability and biodiversity and is regulated by the Management Prescriptions (MPs).** MPs are a set of rules set by a group of International Lake Experts coordinated by the Netherlands Commission for Environmental Assessment MER and by the Lake Monitoring Unit. The rules are set to ensure safe and sustainable methane gas extraction.

The lake monitoring program's objectives are fourfold:

1. Monitoring of the spatial behaviour and stratification of injected wash water at 60 m.

2. Monitoring of the behaviour and stratification of injected degassed water at 240 m.

3. Monitoring the entire water column to ensure lake stability.

4. Monitoring of the impact of GEF operations on fish behaviour in the lake's biozone (Figure 45).

### Lake monitoring bodies

**The Lake Monitoring Unit (LKMU) is a Rwandan national authority responsible for monitoring KivuWatt's compliance with the MPs and managed by the REG.** The establishment of a joint authority between the governments of Burundi, DRC and Rwanda to take on LKMU governance for Lake Kivu MPs compliance has been long planned, to no avail. Indeed, this authority is not yet operational, leaving the integrity of lake monitoring work managed by KivuWatt and governed by the GoR.

### Lake monitoring process

A 360-degree profile of the lake water is taken several times per week with 35 stations at 500 m from the barge to profile the lake water using a multi-parameter probe. The pH levels of wash water discharge plume stratification is monitored to ensure it is not close to acidic as to not destabilise the above biozone. The conductivity level of degassed water discharge plumes are monitored to ensure their density is high enough to maintain stratification and stability of the lake (Figure 45).

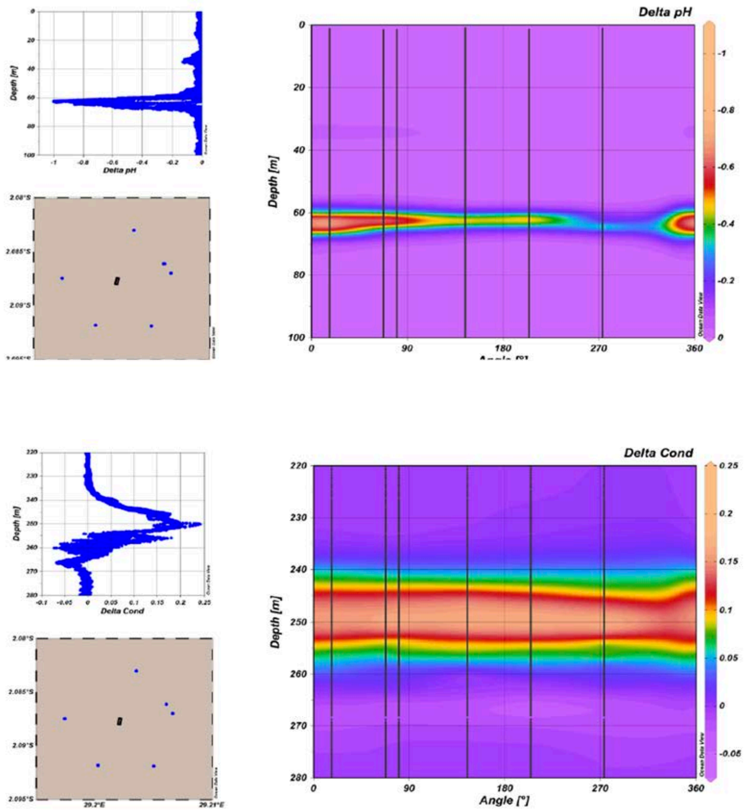



**FIGURE 45**

LEFT – EXAMPLE OF WASH WATER DISCHARGE PLUME STRATIFICATION (15/03/3019). RIGHT – EXAMPLE OF DEGASSED WATER DISCHARGE PLUME STRATIFICATION (15/03/2019)

## Lake stability performance

**Lake stability performance since the existence of KivuWatt has been relatively sound. KivuWatt has proactively taken the necessary actions to improve MPs and maintain lake stability. This includes changing methods of GEF operations or proposing modifications to MPs.**

- In initial operations, the wash water plume entered the biozone, which could be noticed by somewhat increased pH levels, which was not in line with the MPs. **KivuWatt made various changes in operation,** reducing the dissolved air content of the reject wash water and subsequent plume uplifting, and ensuring compliance
- However, notwithstanding pH compliance, discharging wash water at 60 m still does not leave any safety depth margin from the biozone. **Its extension was recommended** by both Independent Lake Experts (International Expert Advisory Group IEAG) together with the LKMU in June 2019. Approval from the GoR is currently being sought.

## Fish monitoring program

**As part of the Lake monitoring program, KivuWatt provides technical support to LKMP-led fish monitoring campaigns conducted twice a year across the entire lake area. KivuWatt also conducts its own fish survey campaigns in the Kibuye basin since 2018 for result comparison.** These monitoring campaigns aim to estimate the stock of pelagic fish populations using hydro-acoustic methods.

Figure 46 shows an echogram of the sardine fish from the surface to 30 m depth in January 2019, which demonstrates that the fish schools have been unharmed. Enea did not identify any flaws or shortcomings in the program's operations, based on discussions held with the head of the fish-monitoring program, and evaluation of its ESMA reports.

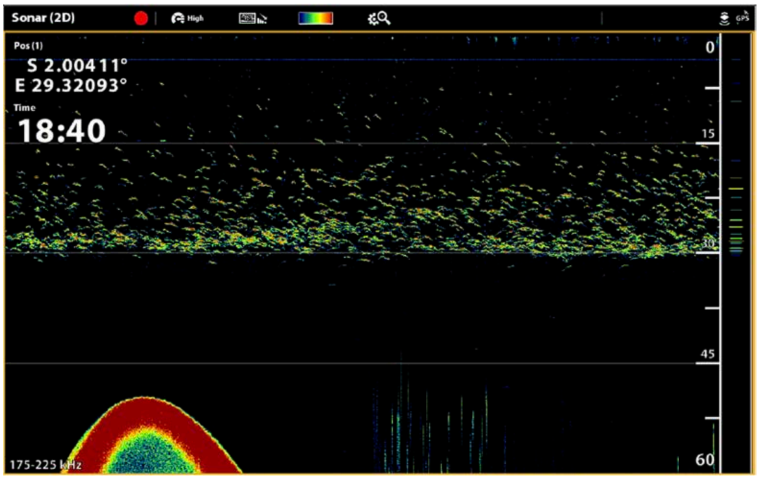



**FIGURE 46**

ECHOGRAM SHOWING THE SARDINE FISH REPARTITION IN LAKE KIVU IN THE VICINITY OF THE GEF[47]

## Air pollution monitoring program

KivuWatt is also required to monitor air pollution emissions from its power plant's three engines, namely NOx, SOx and CO emissions and ensure they meet with United States Environmental Protection Agency standards.

For the ESPA, KivuWatt should ensure that air emissions are in line with United States air pollutant standards and noise emissions with World Health Organisation and World Bank standards. Since the start of operations, NOx, SOx and CO emissions have always been compliant with standards and MPs.

47 The bump visible on the echogram is a rock.

# 3 RWANDAN MACROECONOMIC CONTEXT

## MACROECONOMIC DYNAMICS IN RWANDA

**Rwanda is one of the fastest growing economies in Africa. It experienced an average economic growth of 7.5% per year over the past decade,** bolstered by two five-year Economic Development and Poverty Reduction Strategies—EDPRS (2008-12) and EDPRS-2 (2013-18). Whilst the service sector, particularly construction and tourism, contributed most to overall growth, Rwanda's economy remains overwhelmingly rural and heavily dependent on agriculture [8].

**Low inflation, fiscal and administrative decentralisation, political stability, and a reputation for low corruption are the key factors supporting the country's inclusive growth.** It became a leading reformer in the World Bank's 2019 Ease of Doing Business indicators: it grew from a global rank of 148 in 2008 to 29 in 2019 – second-best in sub-Saharan Africa behind Mauritius [12]. Rwanda also has the world's highest number of women in politics.

**Although Rwanda's poverty levels significantly reduced from 57% in 2006 to 39% living under poverty line in 2018, it remains one of the world's poorest countries.** Rwanda ranks 175$^{th}$ in terms of GDP per capita, which stood at USD $847 in 2019 [8]. In this respect, the Government aspires to make Rwanda a middle-income country by 2035 and a high-income country in 2050. This vision will be put into effect through the first seven-year-long National Strategies for Transformation (NST1: 2017 - 2024) aimed towards the achievement of the Sustainable Development Goals (SDGs). Among priorities for the NST1, a strong focus is placed on accelerating private sector led economic growth and increased productivity [13].

## OVERVIEW OF RWANDA'S ENERGY SECTOR

### STAKEHOLDERS

#### Rwandan electricity sector governmental bodies

The GoR has undergone structural reforms in line with its last 5-year plan, the Second Economic Development and Poverty Reduction Strategy program (EDPRS), which has resulted in major electricity sector restructuring efforts [14]. In 2014, the previously merged water and electricity utility was split into two separate bodies: the Water and Sanitation Corporation (WASAC) and the Rwanda Energy Group (REG).

**The ensuing national electricity utility, the REG,** holds the responsibility of expanding, maintaining and operating the electricity infrastructure in the country through its two 100% owned subsidiaries (Figure 47).

- **The Energy Utility Corporation Limited (EUCL)** is responsible of enhancing efficiency in utility operations (including electricity import, export, generation, and electricity purchase from IPPs)
- **The Energy Development Corporation Limited (EDCL),** is responsible of ensuring more timely and cost-efficient construction and implementation of development projects.

This new structure allows for better transparency, accountability, and governance of revenue-generating services (EUCL) and investment-requiring activities (EDCL). **According to the World Bank [14], important work is however still to be undertaken to reach fully functional electricity companies with streamlined business procedures, operational policies and information technology solutions.**

**The Ministry of Infrastructure (MININFRA)** acts as the governing ministry in overseeing REG operations and investments. Both entities work closely together to establish national energy plans and monitor set objectives. **The Rwanda Utilities Regulatory Authority (RURA)** is the country's independent regulator. It evaluates the revenue requirements of REG and approves tariff structures (including power purchase agreements, subsidies, cross-subsidies, and feed-in tariffs). **Although RURA has developed its capacity since its creation in 2001, it still requires strong technical support to efficiently handle arising regulatory issues from the emerging competitive sector structure.**

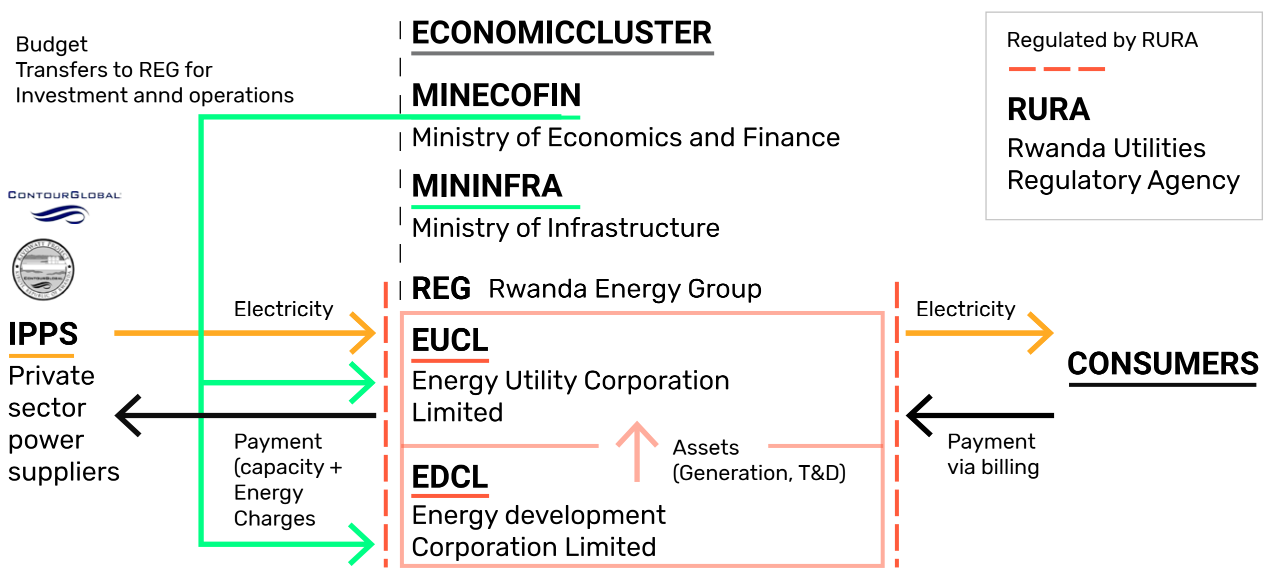
Namely, in issuing licenses to independent power producers (IPPs) and offgrid sectoral players and ensuring energy prices that are simultaneously affordable to end-users and able to recover costs of energy supply, operation and maintenance and capital costs [15].

**The Ministry of Economics and Finance (MINECOFIN) provides subsidies to the REG to finance EDCL investments and EUCL operations,** and monitors power sector performance in line with EDPRS targets relatively to two indicators: the increase in electricity generation capacity (in MW) and the increase in number of connections.

**The Economic Cluster of the Government of is a subgroup of the Cabinet of Ministers formed for the effective implementation and monitoring of EDPRS and NST1 priorities.** It includes the Ministers of Natural Resources; Agriculture and Animal Resources; Trade, Industry; Finance and Economic Planning; Infrastructure; and Employment Promotion.

**FIGURE 47**

INTERACTIONS BETWEEN THE MAJOR ENERGY SECTOR PLAYERS IN RWANDA [13]



International organisations

**Several bilateral and multinational institutions play a pivotal role in the development of the country's energy sector.**

- **The European Union** is Rwanda's largest development partner. In line with its National Indicative Program [16], it holds a €200M budget for 2014 – 2020 allocated for operations in energy access, loss reduction and power generation, as well as sector budget and organisational support. The EU also attempts to influence policy making when perceived unsustainable
- **The World Bank Group** has been promoting the sustainable development of the Rwandan electricity sector. Through its **International Development Association (IDA)** it has recently awarded to the GoR the Third Energy Sector Development Policy Operation (DPO) $125M loan. The objective of the loan is to enable a fiscally sustainable expansion of the electricity services in Rwanda. The series of DPOs is built around two pillars: (a) containing the fiscal impact of electricity sector; and (b) improving the operational efficiency, affordability, and accountability of electricity service
- Rwanda is among the three largest beneficiaries of the **Belgium Development Agency** (a.k.a. Enabel). With a budget of €39M spread over 2014 to 2020, its energy arm has been providing on-the-ground technical consulting and project monitoring services to the REG
- Through its 2009-2019 **EnDev program, the GIZ** has been supporting rural energy access through funding provision and the setup of innovation financing mechanisms for private offgrid companies
- Through its Power Africa program, the **USAID has been strongly influencing** energy policy development and implementation through the provision of transaction advisory services, as well as technical assistance and capacity building for energy sector institutions.

Private sector involvement

**Private sector energy investments have bolstered faster, cheaper, more efficient and sustainable countrywide electrification.** Positive outcomes have increased government lenience towards private sector support towards meeting national energy agendas and improving country development.

The Rwandan government has established reforms to promote the business environment and attract private sector investments across all sectors. **Together with the energy sector's 2014 reforms, Rwanda has demonstrated electricity off-taker creditability** and succeeded in creating an attractive investment climate in power generation and offgrid electrification. Indeed, as of 2018, it had attracted the direct investment by more than 15 IPPs, leaving 52% of capacity under private ownership - one of the highest shares in Sub-Saharan Africa – of which 14% represents KivuWatt's capacity. **As for the offgrid sector, electrification has been almost entirely driven by a dozen of private companies -** through the distribution of a range of solar products across the country. The private sector has also been supporting the REG in grid efficiency improvement, namely through strengthening the grid, reducing losses and electricity theft and implementing grid performance monitoring indexes.

## ENERGY SECTOR EVOLUTION AND DEVELOPMENT OBJECTIVES

Rwanda has increased substantially ongrid and offgrid electrification since the beginning of the decade.

Ongrid electrification has been greatly driven by governmental support (backed by the World Bank). Connection cost reduction measures have increased affordability and accessibility to grid-electricity. Aside from its extension and densification in connections, the National Grid has also been at the heart of an extensive loss reduction program aiming at improving grid stability and reliability.

Offgrid electrification has been mainly driven by the private sector and is led by Solar Home Systems (SHS) adoption. However, considerable regulatory instability has been impeding and halting offgrid electrification growth rate, particularly for mini-grids. The government aims to become an actor of offgrid electrification backed by a recent approval of a subsidy mechanism to support SHS development.

The government has endorsed over the past decade the development of substantial energy capacity on the grid, regardless of demand evolution. However, as countrywide demand growth has been stagnant due to the inability of the residential sector to afford costs of electricity connections and supply, the country is already confronted with a costly supply demand imbalance. This recent realization led the government to aggressively cut planned capacity and adopt least-cost generation principles to prevent this gap worsening.

## RWANDA'S ENERGY REGULATORY FRAMEWORKS

The development of Rwanda's electricity sector is governed by five major regulatory frameworks within a 2017-2024 timeframe. Combined, they aim to achieve universal access to electricity by 2024, whilst reducing costs to the sector.

- **The National Strategy for Transformation (NST1)** (2017-2024) sets grounds for Rwanda's economic development. It aims for social transformation of the entire economy, through increase of accessibility to affordable services across all economic sectors, including electricity
- **The Energy Sector Strategy Plan (ESSP) (2017-2024)** defines national energy electrification and production targets along priorities defined in the NST1
- **The National Energy Plan (NEP) (2017-2014)** translates ESSP targets into a more concrete spatial spread of electrification and production targets
- **The Third Development Policy Operations (DPO) (2019-2024)** is a program subsidised by the World Bank to support the Government towards reducing fiscal transfers to the energy sector as well as improving its long-term sustainability
- **The Least Cost Power Development Plan (LCPDP) (2017-2014)** is the ESSP's framework for the development of new generation assets, based on least cost principles.

### National Strategy for Transformation

The Government of Rwanda (GoR) has set very ambitious targets regarding electrification. Its National Strategy for Transformation (NST1) (2017-2024) aims for social transformations towards improving country income status, which implies achieving **universal access by 2024 for the electricity sector** with provision of quality, reliable, and affordable electricity to consumers. Electricity expansion is set to follow least-cost principles and competitive procurement and prioritise energy-intensive industries and productive uses of electricity as measures to reduce the cost of doing business in Rwanda.

### Energy Sector Strategy Plan

As laid out in 2017 in the NST1's Energy Sector Strategy Plan (ESSP), the GoR adopted both **ongrid and offgrid supply options to reach sustainable countrywide electrification and defined a split of 52% for the former and 49% for the latter.** Such a high offgrid target is unprecedented in world-wide national electrification plans and is mainly aimed at Rwanda's low-income households with small electricity needs, hence those with limited ability to afford connection costs or even subsidized electricity from the grid.

Offgrid technologies are recognised by the GoR as the only affordable solutions for customers in remote regions that are at a distance from the grid, within an unreachable terrain and/or with power demand that does not justify the investment in grid connection or expansion. The government's financing capacities have undoubtedly been limited in the extension of the network, explaining the widely acknowledged rationale in the industry behind this ambitious offgrid target.

**Under the ESSP, 100% of productive users, namely facilities that are critical for social and rural development, are expected to have access to electricity, up from the current level of 69%.** Connecting productive users in rural regions are expected to support rural economic development and improve the sustainability of the energy sector, as they have a higher ability to pay for energy services than households. By 2024, 91% of productive users are expected to be connected to the national grid, with the remaining 9% connected via offgrid solutions. The ESSP also set the national grid efficiency improvement strategy, whereby grid losses are to be reduced to 15% by 2024.

### National Energy Plan

**The National Energy Plan (NEP) paves the way for universal access by 2024 by translating ESSP targets into the GoR's perceived most cost-efficient and feasible geographic split between National Grid extension and offgrid solution deployment.** On top of providing a clear electrification framework, such micro-planning aims to provide certainty and mobilize private sector investment for electricity expansion, on which the GoR is particularly dependant to accelerate and reach affordable electricity expansion.

**A first version of the NEP validated by the Energy Sector Working Group in October 2018,** was devised by consultants from the MIT-COMILLAS UEA Lab and TATA POWER DDL with the use of power system planning and geospatial tools, factoring in topographical restrictions, distance of loads to the grid, quality of grid service, concentration of households and productive uses and socio-economic status. It was directly criticised by international energy institutions, such as the European Union and the World Bank, as an unfounded strategy, that substantially overestimated the costs of electricity cables as well as generation capacity requirements for the period. These would have resulted in implementation costs of the grid expansion and thus would be far from reaching affordability for connected customers. It was also rebuked by private offgrid actors who believed the segmentation between offgrid and grid electrification and between mini-grid and SHS was unclear and with no visibility.

**A revised map institutionalizing least-cost principles into electricity access and generation planning had consequently been approved by the GoR in June 2019 (Figure 48).** Generation capacities were reduced to 300 MW, but according to interviewed institutional stakeholders, the NEP is predominantly ongrid and far from reflective of the 48% and 52% targets outlined in the Energy Sector Strategic Plan (ESSP). It leaves strong and not yet tackled uncertainties for offgrid electrification. Mini-grid developers now have far fewer sites to explore in scattered places in between grid crossovers and where the lowest-income households live for offgrid solutions. Also, the year-delayed publication of the NEP map not only caused uncertainty among private offgrid actors but also halted mini-grid development during this period as developers were left unable to obtain project permission during this mapping period. A third revision of the NEP is currently ongoing.

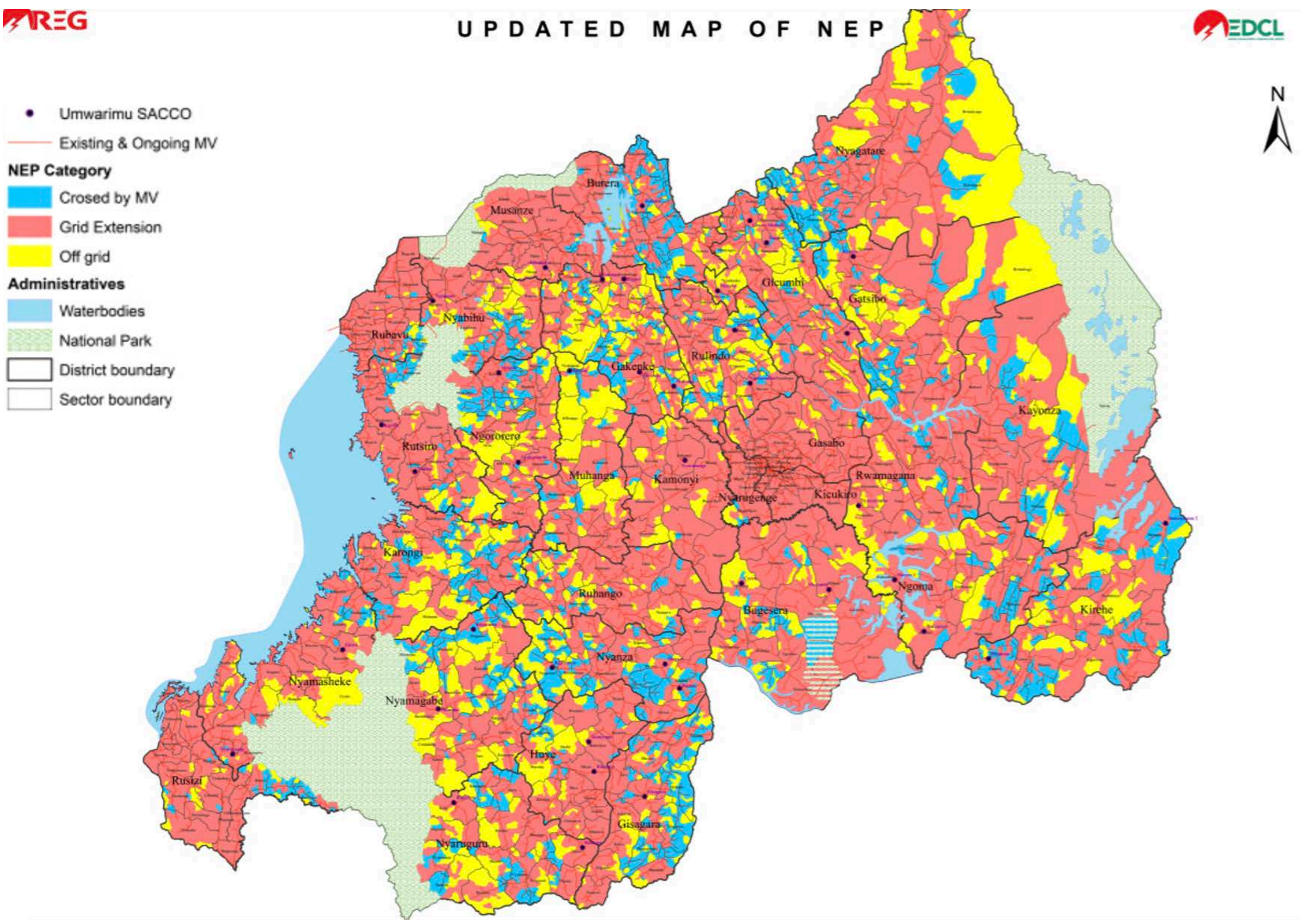



**FIGURE 48** VERSION 2 OF THE NATIONAL ELECTRIFICATION PLAN

On top of uncertain technical specificities of the NEP, the main challenge for the coming years is the funding deficit to implement the NEP. Indeed, REG is estimating a budget need of USD $600 million for ongrid and USD $150 million for offgrid electrification. Moreover, substantial investments have also to be made in the transmission network and in the operation and maintenance of the electrical grid. All combined, the CEO of REG stated that the financing need (in terms of investment only) is around USD $1.8 billion by 2024, which is not yet covered fully by the GoR and the development partners.

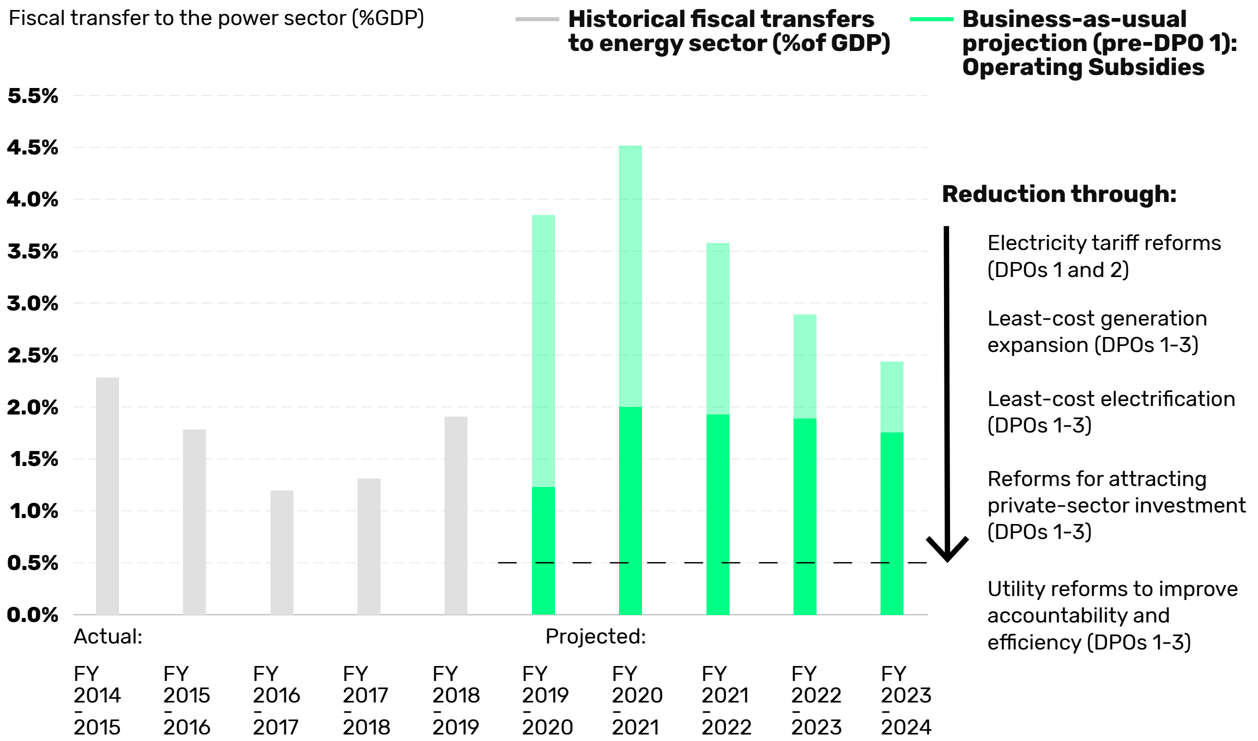
IDA's Energy Sector Development Policy Operation (DPO) Loans

**Economies of scale and profitability of the electricity sector investments have been difficult to reach in Rwanda as a result of the small and stagnating national power demand combined with the highest share of the population's small ability to pay.**

**The shortage of cash flow from operations have made REG dependent upon subsidies to cover the deficit in operations and finance investments.** Even though they have dropped over the past years, subsidies transferred to the electricity sector remain substantially high to fill in the gap between the high cost of electricity and the limited affordability. Indeed, consumer tariffs are not yet cost reflective (unit cost of USDc 32 per kWh vs unit revenue USDc 20 per kWh), which leaves REG struggling with profitability. These subsidies, comprising operating subsidies and public investment, made up around 1.35% of the country's GDP in 2018 (Figure 49).

**FIGURE 49**

FISCAL TRANSFERS TO THE POWER SECTOR AS A PERCENTAGE OF THE GDP; ACTUAL: FY2014/15–FY2018/19 AND BUSINESS-AS-USUAL CASE FOR FY2019/20–FY2023/24 [13]



**The GoR's draft medium-term fiscal framework (MTF) for FY2018/19 to FY2020/21, as laid out by MINECOFIN, includes budget allocations for the power sector in the order of 1-1.5% of GDP per year. However, subsidy requirements are expected to rise again to recover the anticipated cost escalations of the sector, which have been foregone in the medium-term fiscal budget. Arising costs come hand in hand with:**

- The planned large-scale investments in grid expansion and densification to meet the electrification targets
- The excess installed capacity with take-or-pay contracts as a result of excessive generation planning that hasn't followed least cost planning nor has incorporated demand estimates
- The limited capacity to increase electricity tariffs to offset costs as the electricity is already barely affordable for the majority of the population.

The World Bank estimates that these unaccounted fiscal risks may drive fiscal transfers up to 4% of GDP in 2022/2023, which may strongly threaten the sustainability of the sector (Figure 49).

**In view of this risk, the World Bank's International Development Association (IDA) is closely supporting the Government to reduce transfers to the electricity sector through a series of three Energy Sector Development Policy Operation (DPO)[48] loans.** Measures taken are expected to reduce the GoR's cost-revenues gap for the energy sector, drive down fiscal risk and consequently improve the long-term sustainability of the power sector.

48 Each DPO consists of a concessional loan of 125 M$ used to enforce operations built around two pillars: 1) containing the fiscal impact of the electricity sector and 2) improving the operational efficiency, affordability, and accountability of electricity service.

They include:

1. **The approval of the 2019 revision of the LCPDP** to reduce the high cost of electricity supply.
2. **The revision of tariff levels** to become reflective of consumption levels and more affordable to the lowest-income households.
3. **The revision of the NEP** to deploy least-cost electrification across the country.
4. **The import cheaper electricity** from neighbours to phase out fossil fuel imports.
5. **The improvement of grid efficiency and accountability** of utility operation through the Rwanda Electricity Sector Strengthening Project (RESSP) to reduce incurred losses.

**REG has implemented the RESSP in May 2016.** It is a utility operational improvement plan to 2021 financed by the **IDA's** DPO [13]. The RESSP has an objective to **improve the quality of electricity supply** through loss reductions, increased access to electricity, as well as strengthened electricity sector capacity. These are expected to reduce the quantity of unbilled electricity and stimulate demand, therefore **contribute positively to REG's revenues.**

## Least Cost Power Development Plan (LCPDP)

**The Least Cost Production Development Plan (LCPDP)** is the ESSP's framework for new generation assets. Completed in October 2017, it was updated in October 2018 and May 2019 [14]. It aims to optimize the expansion of electricity generation in Rwanda by prioritizing least-cost generation options and aligning increase in generation capacity with demand.

Its latest revision aims to substantially reduce planned grid capacity to be in harmony with projected country demand, as well as improve the competitivity of the electricity system with more transparent and non-bilateral PPAs.

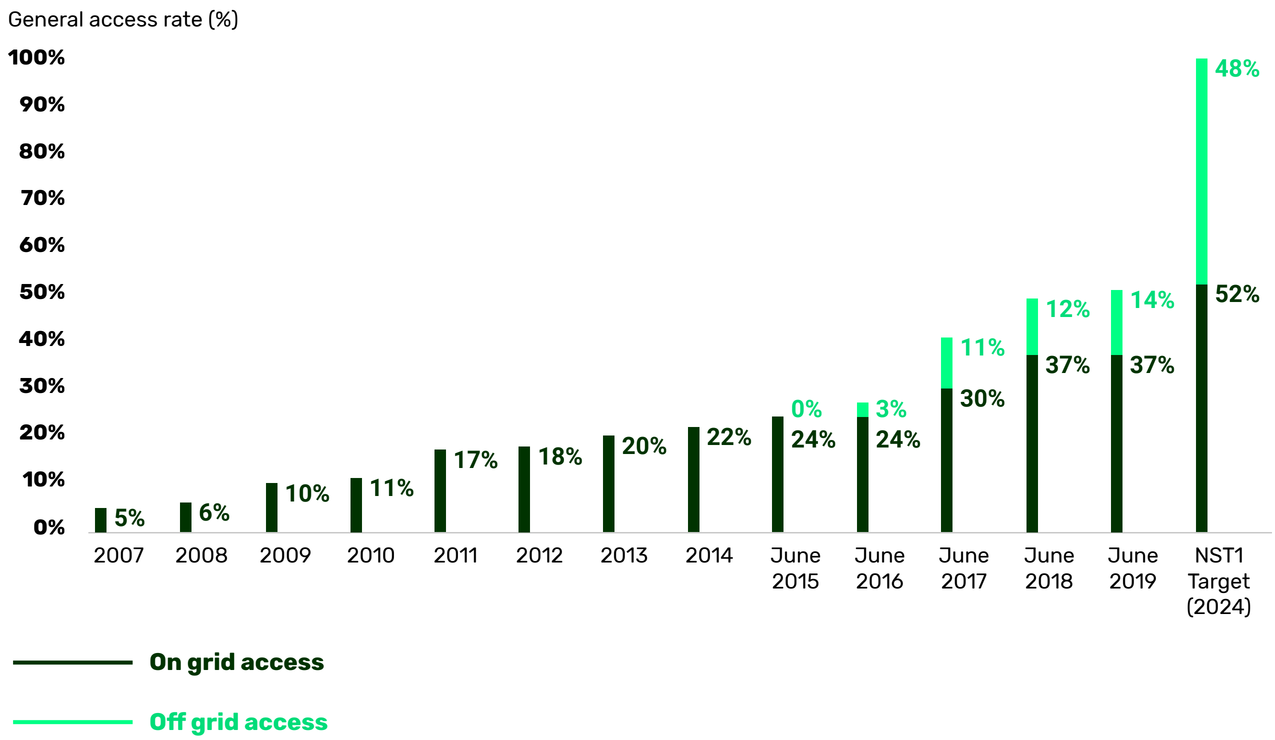
**According to the LCPDP, in face of stagnating trends in demand, no additional generation or transmission projects are envisioned nor welcomed in the short-term. This excepts the replacement of diesel generation with power trading with neighbouring countries.** All oil-fired power will be discontinued by 2020. The medium-to-long term awaits a shift towards generation based on indigenous renewable resources (hydropower, solar and lake methane). The revised LCPDP is expected to reduce the cost of supply of electricity and as such reducing revenue requirement thus fiscal transfers to the sector.

## ELECTRIFICATION DEVELOPMENT IN RWANDA

**Rwanda has emerged as exemplary in terms of energy access in Africa. The country experienced substantial electrification over the past decade, outpacing most of its Sub-Sahara African (SSA) neighbours. Rwanda ranked 11th globally and 3rd in Africa in terms of its progress in electrification over 2010-2016. At 10% in 2010, combined ongrid and offgrid connections quintupled in 8 years reaching 51% in February 2019 (Figure 50).**

**FIGURE 50**

EVOLUTION OF RWANDA'S ELECTRIFICATION RATE [7]



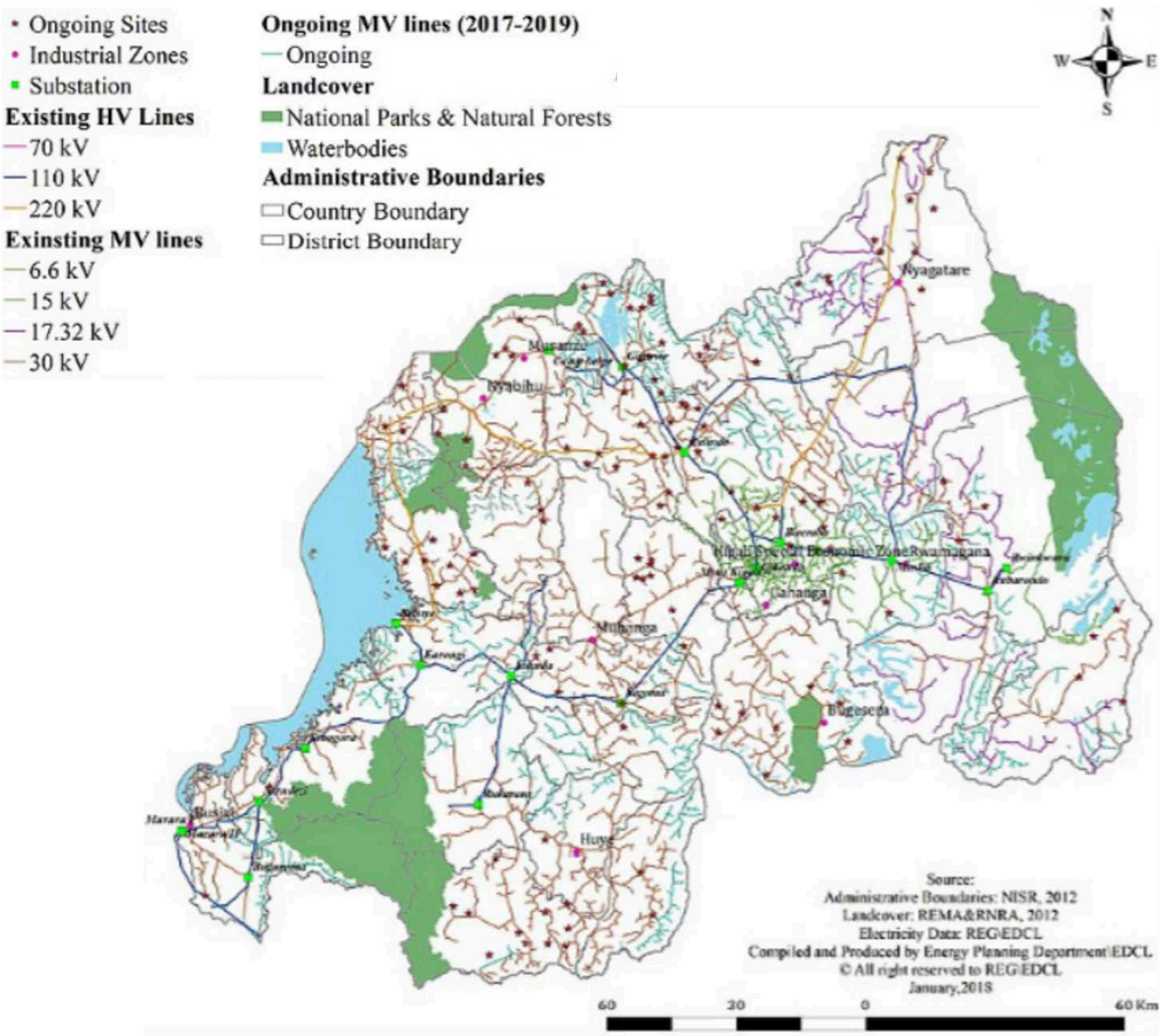
Grid extension

**Investments in grid extension have increased ongrid connections from 6% in 2008 to 37% in 2018 (Figure 51), which is equivalent to 811,000 connections by end of June 2018 [17].** The transmission and distribution (T&D) networks extend almost across the entire country surface area of 26,338 km² (Figure 51). As of 2019, the high-voltage (HV) transmission network is equivalent to 1,300 km, whilst the medium-voltage (MV) and low-voltage (LV) distribution network amount to 16,162 km (35% are MV and 65% LV) [17].

**This network extends to all of Rwanda's hospitals, 93% of its health centres (versus an average 30% in SSA), and 80% of primary and secondary schools (versus an average 25% for SSA) [8].**

**FIGURE 51**

RWANDA'S DISTRIBUTION NETWORK (MEDIUM VOLTAGE LINES)



**As for households, access to grid electricity remains largely concentrated in the three highest** Ubudehe categories[49], but has been recently reaching the lowest Ubudehe categories (Figure 52). This can be mainly attributed to the voluntary government policy supported by the World Bank, to finance connections all the way to households (cost evolution of connections, tariff reforms etc.).

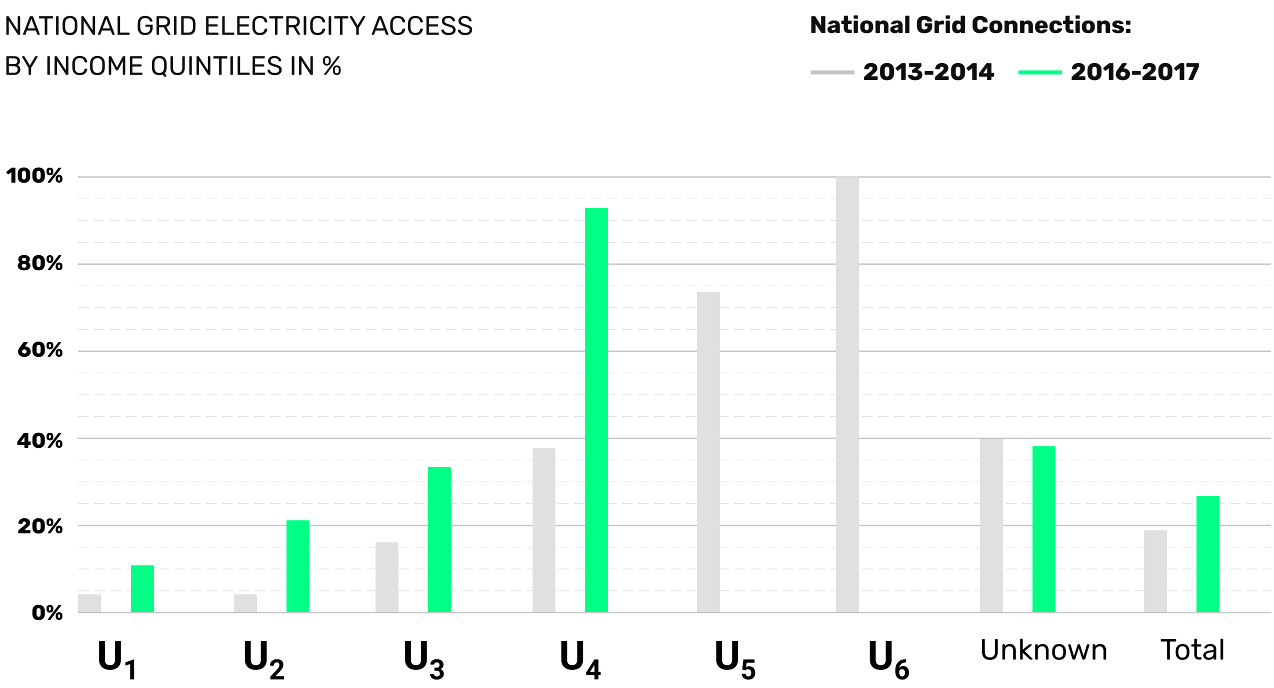
49 In Rwanda, households are classified into six socio-economic classes known as 'Ubudehe categories'. This classification is based on subjective perceptions of people. There are 6 categories defined by a set of criteria, from the poorest category U1 (without land, facing difficulties to have food) to the richer people U6.

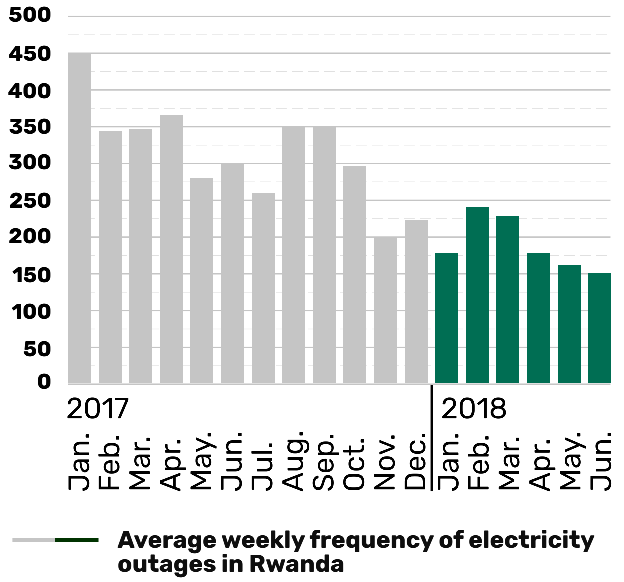
## Evolution of National Grid efficiency and losses

**Rwanda's power sector has experienced fewer, shorter and less impactful outages over the past years but their occurrence is far from being erased (**Figure 53**).** Grid outages combined with overall system losses have been creating high cost burdens for the REG and contributing to the country's high cost of electricity supply. Losses mainly arise from the ageing T&D infrastructure and from little informal electricity theft. They fell from 22% in 2017 to 19.8% as of March 2019 following a period of higher losses due to LV and MV line expansion project.

**FIGURE 52**

NATIONAL GRID ELECTRICITY ACCESS BY INCOME QUINTILES IN %





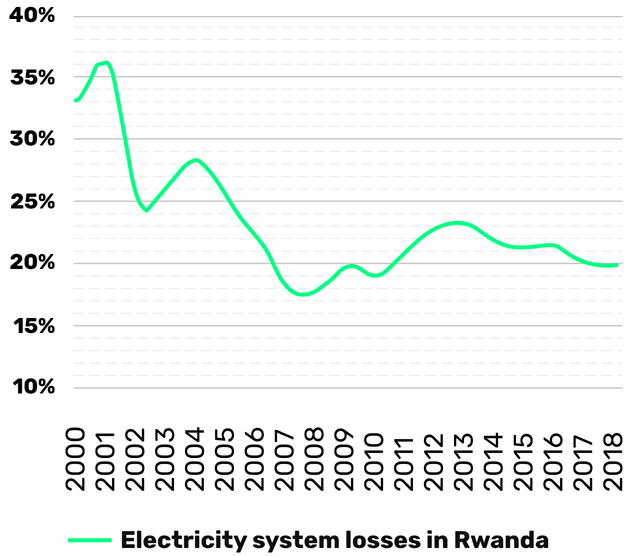




**FIGURE 53**

AVERAGE WEEKLY FREQUENCY OF ELECTRICITY OUTAGES IN RWANDA (LEFT) AND ELECTRICITY SYSTEM LOSSES IN RWANDA IN % (RIGHT) [7]

## Drivers of ongrid electricity development

Strong measures, in line with the RESSP plan, have been undertaken by the REG since 2017 to strengthen the grid, further reduce losses and electricity theft, as to lead to EUCL financial operation improvement and reduced cost of electricity supply. These measures are in line with the ambition of REG's new CEO, Ron Weiss[50], to rapidly improve grid performance prior to investing in grid extension efforts.

- **As part the RESSP, the EU funded a grid loss reduction project** with USD $23million from 2016 to 2018, as part of the "Kigali Ring" project [18]. This project contributed both to an increase in electricity access as well as loss monitoring and reduction measures. This project has emerged as a bedrock for more efficient management and deployment of the Rwandan grid infrastructure
- **The GoR adopted two international grid performance monitoring indexes to identify network assets requiring maintenance and upgrade actions to improve their serviceability. These two indexes** are the average duration of interruptions (SAIDI[51]) and the average frequency of interruptions (SAIFI[52]), which are being regularly measured and monitored by the REG. **Although their measurement methodology remains uncertain, their implementation demonstrates the willingness of the GoR to reach international standards in terms of grid performance monitoring.**

50 Prior to joining REG, Ron Weiss served as the Senior VP, Engineering Projects and Business Development Group for the Israel Electric Corporation (IEC).

51 System Average Interruption Duration Index

52 System Average Interruption Frequency Index

**Notwithstanding the need and objectives to reduce electricity system costs and fiscal transfers to the sector, the GoR deployed connection subsidies in keeping with electrification as key sector priority. The new connection policy has already had an impact and is expected to further increase access to electricity supply for the bottom 40%.**

- The new connection policy set in June 2017 made new connections free for industries, which is expected to spur baseline demand, and in turn result in positive economic spin-offs at local and national levels
- For all residential consumer categories, it also made new connections more affordable, at RWF 56,000 or USD $60 [20], as well as more accessible through new payment options for the connection fee. **Households can now avoid large lump-sum up-front payment for the connection and pay-back the cost gradually together with the electricity bill. Indeed, at each purchase of power,** 50% of the paid amount is used to repay the balance of the connection fee
- This measure has resulted in several new connections, as the cost of connection had been the main electrification impediment in connected villages[53].

Offgrid Solar Home Systems (SHS)

**Adoption of offgrid solutions for energy use surfaced around 2016 and has since grown rapidly, reaching 14% at the end of February 2019, which mainly comprises low-income households. This rise is principally owed to the increased market penetration of private distributors of standalone solar offgrid products.**

Offgrid electrification has been mainly driven by the adoption of SHS solutions at the expense of mini-grids. The private sector supported this growth, in particular 21 private distributors of solar solutions.

Low-income households in unelectrified rural areas of Rwanda have been the main target and adopters of solar products. However, over the past year, market players have also seen an increasing number of peri-urban customers purchasing SHS to meet grid blackout demand, which have recently increased in frequency around Kigali due to grid restoration works. Such sales remain marginal but demonstrate the interest generated for SHS beyond the initially targeted low-income offgrid customers.

Although SHS adoption has been positive, their default rates remain strikingly high. They stand between 4% and 8% according to BBOXX, a large offgrid SHS firm. These rates have not experienced any reduction as the main target end-users have low ability to pay (low-income households), or irregular incomes (i.e. farmers), therefore difficulty to pay back due fees for the systems. Market players, such as BBOXX, are testing different payment systems to evaluate impact on default rates. These include energy loans, whereby end-users are offered extra days on credit to defer payment.

53 The baseline survey conducted by Enea in 2015 showed that in several grid-connected villages, half of the population was not connected to the grid due to the high cost of connections (cf. **Section 3.2**).

### Drivers of SHS development

**The GoR partnered and signed a Memorandum of Understandings (MoUs) with 21 companies selling standalone solar products ranging from solar lamps all the way to large Solar Home Systems [17].**

Up to mid-2019, partnership prerequisite was having Lighting Global certified products[54] to ensure quality and reliability, as well as longevity of the systems. Government-endorsed companies would enjoy:

- A tax exemption on their imported products
- An opportunity to voice their opinion and influence decision-making in a Governmental working group - the Rural Electrification Campaign.

Tax exemptions have driven the development of the market in Rwanda and attracted a competitive environment of market players, which have together been successful in improving affordability of SHS products and reaching the poorer segment of the population.

The well-integrated countrywide **mobile money infrastructure,** together with the **prevalence of mobile money utilisation** among the Rwandan population, have also been favourable development factors for Pay-as-you-go[55] enabled solar systems. These make up more than 98% of sold solar systems to date.

BBOXX has also noticed the **power of "Word-of-Mouth"** for awareness raising and the swelling impact on sales created by a simple positive feedback communicated to a neighbour [19].

### SHS market players

Four key SHS players are leading the market, namely Mobisol, BBOXX, Ignite Power and Zola Electric, and all products sold are manufactured and imported from abroad.

However, NOTS Solar Lamps, a Dutch company has just recently entered the market with a new business model. It announced in July 2019, in collaboration with the GoR, an investment of USD $70 million in a Solar Home Systems factory in Rwanda, a first in Africa. Through local manufacturing, the aim of this project is to drastically cut costs down to USD $1 a week (vs a minimum of USD $3.96 for other SHS products) and render their 10 W systems affordable for the poorest households. Such a project is aimed to increase electricity access of the lowest income households that cannot afford basic SHS systems in the market. However, they will impose a down payment of USD $10 per system, which, based on experience in the market, would lead to high default rates[56]. Also, capacity of systems remains are very small, therefore limited to consumers with little non-productive electricity consumptions. The technical viability of their business model is yet to be proven.

### SHS policy framework for NEP implementation

**In order to presumably provide clarity and certainty for offgrid developers with regards to the NEP (National Energy Plan) implementation, the GoR has established a policy and regulatory framework for implementation of the NEP.**

54 Lighting global certification is the prevalent quality assurance framework serving the offgrid sector with quality-verified products.

55 Pay-as-you-go solar systems are increasingly used in the offgrid energy access sector as they remove the initial financial burden of solar energy access. Instead of paying a high upfront cost, customers pay a set fee per kWh consumed per month until repossession of the system.

56 Down payments frequently result in discrimination of clients.

This includes guidelines and technical specifications for mini-grids and offgrid solar products, and REG has approved an incentive scheme to make these electrification options affordable.

**Ministerial guidelines on minimum standards requirements for solar home systems (SHS)** have also been recently adopted by the GoR, together with a public tool able to verify the suitability of a product with the new standard [20]. On top of the aforementioned Lighting-Global certification criteria for Government endorsement, SHS systems should now meet a strict minimum service level requirement[57]. According to sector actors, this standard has been implemented in line with the government ambition to increase profitability and reduce government costs, and less in harmony with NST1 priorities. Not only does this standard disqualify 60% of SHS systems in the Rwandan market – the SunKing Greenlight Planet 60 SHS is the most sold SHS products in Rwanda and does not meet the new standards – it also contradicts the NST1 vision of providing universal access to all Rwandans including those at the bottom of the pyramid. It therefore puts the future of SHS development in peril and hampers low-income household access to affordable electricity.

**SHSs and mini-grid technologies remain beyond the paying capacity of many Rwandans residing in the regions with planned offgrid electrification, especially in the lowest-income "Ubudehe 1" households.** These offgrid technologies thus require additional incentives to address this affordability issue and reach electrification target. In the past, a large pool of customers benefited from free giveaways of solar products through Government-held tenders at national and district levels. These have indeed provided much needed support to the poor but have created a market distortion effect whereby sales have decreased in concerned areas as customers delayed SHS purchases in anticipation of free systems or governmental support. Not only have they threatened the long-term sustainability of offgrid electrification but also, they left numerous systems stranded stemming from a lack of ownership.

**To address this issue and provide support to the sector, the GoR has approved at the end of April 2019 a national Pro-Poor Result-Based Finance (RBF) scheme for offgrid electrification through SHS,** whereby SHS companies will, through a market-oriented approach, benefit from targeted subsidies to improve affordability of their solutions to Ubudehe 1 and Ubudehe 2 end-users whilst ensuring the sustainability of their business model. This programme will be implemented together by EnDev and the EDCL and financed by USAID's PowerAfrica. Although the GoR approved the idea, nothing concrete has been yet put in place. Also, private actors in the sector still ignore the bridge between the new ministerial standards for SHS and this new subsidy scheme, and the impact of one on the other, thus further strengthening sectorial uncertainty.

**Another financial support mechanism is set to stimulate offgrid electrification across the country through private sector participation. The Rwanda Renewable Energy Fund (REF)** is a World Bank-funded

57 The systems should include 3 lamps of at least 120 lumens each able to operate at least 4 hours per day, a mobile phone charge supply for at least two hours per day, a radio charge supply for at least 5 hours per night. The systems should also be able to supply the above loads for at least one day without input from the solar module.

USD $50 million fund established in 2017 under the Scaling-Up Renewable Energy Fund Project (SREP) [21]. The REF is implemented by the Rwanda Development Bank (BDR) and provides local-currency financing through four financing windows until the end of the programme in 2023: 1) on-lending through SACCOs to households and microenterprises, 2) on-lending through banks (commercial and microfinance) to households and small to medium-sized enterprises, 3) direct financing to mini-grid developers, 4) direct financing of locally registered offgrid solar companies supporting Tier 1 or higher solar systems. **As of March 2019, just around 315 SHS have been sold through Window 1, which have resulted in slower sales than expected, mainly due to more attractive PAYG model. No funds have been yet disbursed and no agreements undertaken for the three last windows, which are believed to be caused by the widely acknowledged sector uncertainty.**

**In view of NEP uncertainties and its lack of harmony with the specificities of the Rwandan energy ecosystem, actors of the sector, namely, the UE, the World Bank, Enabel, and private SHS companies, are wary of the potential of Rwanda to reach universal access in 2024,** particularly in terms the offgrid ambitions. For mini-grids, connections and subsidized grid tariffs remain largely cheaper than the cost of electricity of mini-grids – projects that do not benefit as of 2019 from new subsidy schemes. When looking at the current NEP map, the current grid is already extensive across the country, with the greatest distance between a grid and an offgrid region not exceeding 5 to 10km. In that extent and in light of 1) the foreseen rapid grid extension rate beyond 2024 relatively to Rwanda's small surface area, 2) the high cost of unsubsidized mini-grid electricity, 3) uncertainty with regards to mini-grid status with long take-or-pay agreements in presence of the grid, the economic viability and sustainability of implementing mini grids in the country remains largely questionable. As for SHS systems, they can provide affordable energy to the poor and meet 2024 electrification targets if greater visibility on regulations are provided.

### Mini-grids

The mini-grid sector in Rwanda is relatively small. As of 2019, 4 mini-grids (between 11 and 50 kW) and 58 micro-grids (1 to 4 kW) connect a total of 3,236 customers and are operated across the country by 6 private developers. Most are solar-power mini-grids, with only a couple powered by hydraulic energy.

**This mini-grid landscape has been unchanged since 2017, as no investments or deployment of mini-grids were made during the period of 2017 to 2019. The sector has been suffering from the lack of a favourable supportive environment with regards to the three following factors, all putting the future of the industry at stake:**

- The lack of competitiveness of the mini-grid sector
- A weak mini-grid policy framework
- An uncertain mini-grid sustainability potential.

### Lack of competitiveness of the mini-grid sector

Notwithstanding international support, the mini-grid sector still suffers from a lack of competitiveness.

Two programmes, which have concluded, attempted to improve affordability of mini-grid development through subsidy provision:

- **EnDeV's Result-Based Financing scheme [22]** has attempted to render mini-grid electricity costs more affordable. 3 companies or 2 mini-grids and 57 nano-grids benefited from a financial incentive that typically covered up to 70% of capital expenditure, as well as a top up of for every customer successfully connected to a mini grid. Post-subsidy tariffs ranged between USD $0.35 and USD $0.70 per kWh, depending on the consumer group, subsidy amount, tariff structure, geographic location, and business model
- **Energy 4 Impact (E4I), through the Scaling up Offgrid Energy in Rwanda (SOGER) programme,** supported several mini-grid projects through upfront grants as well as providing technical assistance support to project developers.

However, these programs failed in sustainably developing the sector. Even with the RBF subsidy, the cost of electricity generated by mini grids remain expensive and higher than national grid tariffs (USD $0.15 to USD $0.24 per kWh), therefore unattractive to the target low-income end-users.

Also, both EnDev and E4I launched projects to stimulate productive use hence the necessary energy demand to render mini-grids more sustainable. These programs were also ineffective, as productive demand barely emanated as a result of the lack of cost-competitive cost of mini-grid electricity.

### Weak mini-Grid Policy Framework

**Developers were unable to obtain permission by the GoR to implement projects between 2017 and 2019, putting the sector at a standstill.** This was due to an uncertain policy and regulatory frameworks governing the mini-grid sector during this period. The GoR's vision for the sector was undecided and contributed to the year delay in the validation of the new NEP electrification plan.

**In June 2019, the MININFRA developed and validated ministerial guidelines and RURA licensing frameworks for the development of mini grids [23].** Off-taker agreement with the public sector are henceforth not required and tariffs should be negotiated before obtaining a licence and after approval by RURA.

**Detailed requirements are still unclear, and even more mini-grid tariff structures, maintaining an uncertain and unattractive environment for mini-grid development.** Although not explicitly stated, it is widely believed among actors that mini-grid tariffs should aim to be as competitive as grid tariffs to be granted a permit.

### Uncertain Mini-Grid Sustainability Potential

**The GoR has not yet defined a status for mini grids when the National Grid arrives in the set location.** This undefined policy is seen as a hindrance for developers or off-takers as they are left with no sign on the sustainability potential of their investments. Indeed, as mini-grid take-or-pay agreements last 20 years, they would avoid off-taker engagement.

Actors of the sector are left wary of the extent to which cost of energy and mini-grid investment can be made sustainable in front of low demand, lack of regulatory visibility, absence of strong subsidies and limited opportunity for mini-grid in the NEP. All combined, they pose a threat to the sector and ESSP target attainment.

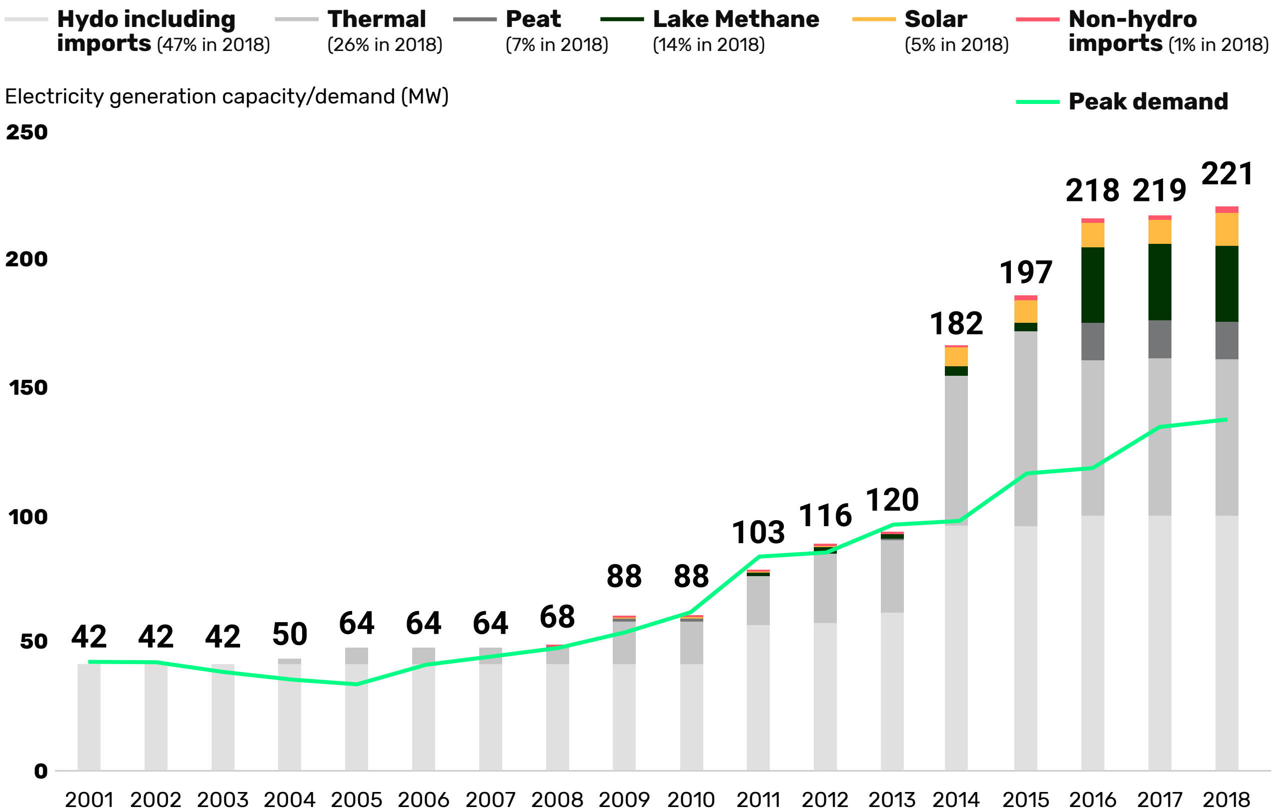
## ELECTRICITY SUPPLY - DEMAND BALANCE

### Evolution of the supply demand balance in Rwanda

**Rwanda's generation capacity has grown rapidly throughout the past decade. It tripled from 76 MW in 2010 to 222 MW in June 2019 and increased 1.5 times since the commissioning of KivuWatt in 2015.**

**FIGURE 54**

GROWTH IN INSTALLED ELECTRICITY GENERATION CAPACITY [8]




Since then, electricity supply has diversified from solely hydropower and diesel-thermal power until 2011 to a mix of 47% hydropower including imports (82 MW), 26% oil-thermal power (heavy fuel oil and diesel) (51 MW), 14% of methane, 5% solar power (5 MW), and 1% of non-hydro imports from Kenya (Figure 54).

The 222 MW are not available steadily in the country. The KivuWatt and hydropower plants are the country's baseload generation. However, hydropower availability lowers significantly (around 50%) during the dry season and, with the impact of climate change, the reduction of water levels has been even more substantial over the past years. Solar capacity is not significantly available during evening peak hours. Diesel is used to meet peak demand and reserve during peak (Jabana II, Jabana I and SO Energy).

**Electricity sales rose from 286 GWh in 2010 to 654 GWh in 2018 [16].** 17.6% of electricity was sold to residential customers, 27.3% to industries, 32.8% to non-residential customers and the remaining 22.5% were sold to water pumping station, water treatment plan, telecom towers, health facilities, broadcasters, and hotels.

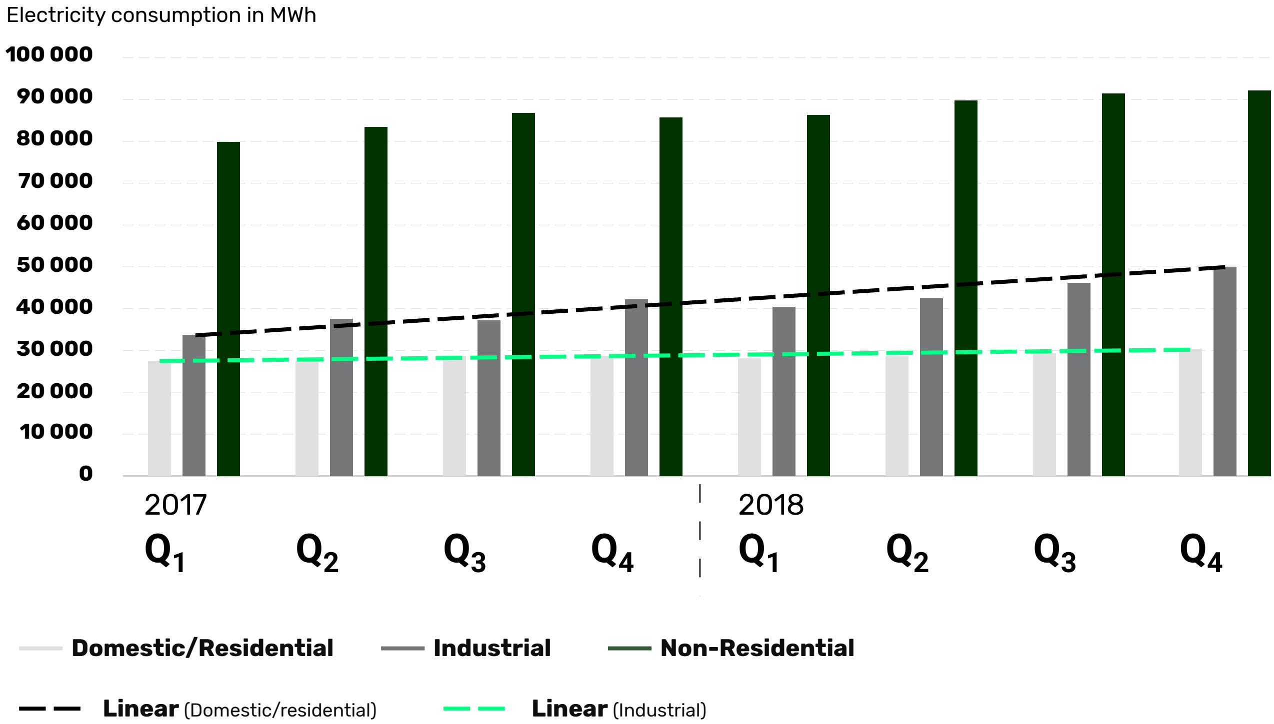
The evolution in electricity demand has been mainly driven by industrial and non-residential tertiary demand, as the residential sector remains less able to consume and pay for electricity today (Figure 55).

The KivuWatt power plant is the country's first ever PPA agreement signed bilaterally with the REG. But since, a lot of PPA agreements have been made. Rwanda counts a total of 17 independent power producers (IPPs) that supply power to REG, which makes 52% of the country's generation capacity under private ownership. According to the World Bank, Rwanda is a pioneer in the Maximising Financing for Development agenda[58] in the energy sector in Africa.

58 Maximising Finance for Development (MFD) is the World Bank Group's approach to systematically leverage all sources of finance, expertise, and solutions to support developing countries' sustainable growth.

**FIGURE 55**

ELECTRICITY CONSUMPTION PER CATEGORY IN MWH PER QUARTER (2017 AND 2018)



## Rwandan electricity production plan

INITIAL ELECTRICITY PRODUCTION PLAN
**In its initial energy plan devised in 2015, the GoR planned the construction of four major thermal power plants that would have added 230 MW capacity between 2018 and 2024.** These plants include a 120 MW peat power plant (80 MW and 40 MW) and 150 MW of lake methane power plants, half of which would be developed by Symbion in two phases (50 MW and 25 MW) and half under the next phase of KivuWatt (75 MW).

As a result of the newly adopted generation planning tools, the GoR recognised that the relatively stagnant countrywide electricity needs were not considered. Thus, as illustrated in Figure 54, the implementation of its entire pipeline of new generation capacities on their originally proposed date would lead to substantial unused electricity and result in heavy stranded costs for the already-indebted REG.

REVISED ELECTRICITY PRODUCTION PLAN
**In response to such supply-driven and costly planning, the GoR committed to improving sector planning whereby all new generation will follow least-cost and low-carbon principles whilst factoring in appropriate demand assumptions. Four actions have unfolded:**

- The reduction in planned capacity production to avoid costly stranded assets
- The update of the 2016 PPA law to improve competitivity of the electricity system
- The development of interconnections to exploit lower cost energy from neighbouring countries
- The adoption of tariff reforms to render electricity more affordable.

## Solving for overcapacity planning

**The Least Cost Production Development Plan (LCPDP) –** the ESSP's framework for new generation assets - was revised in June 2019 [14] to substantially reduce planned grid capacity to be in harmony with projected country demand.

As a result of its implementation, the planned pipeline's two major power plants were foregone: the planned second 40 MW peat power plant as well as the 75 MW extension of the KivuWatt Plant. Several small hydropower purchasing contracts were renegotiated, significantly lowering the expected excess costs. Also, considering the environmental risk of peat plants, the revised LCPDP reduced the size of the already planned peat power plant Hakan I from 80 MW to 72 MW. Although its size remains significant equalling 1/3 of the present generation capacity of the country.

The revised list of planned power plants is summarised in the table 7-3 below and illustrated on Figure 56.

| | POWER STATION | INSTALLED CAPACITY (MW) | TECHNOLOGY TYPE | PLANNED COMMISSIONING |
|---|---|---|---|---|
| **1** | Hakan | 72 | Peat | 2020 |
| **2** | Nyabarongo II | 43 | Hydro | 2024 |
| **3** | Rusumo | 26.7 | Hydro | 2021 |
| **4** | Rusizi III | 48.33 | Hydro | 2026 |
| **5** | Symbion I | 50 | Methane | 2023 |
| | **Total** | **464.4** | | |

**TABLE 7-3** PLANNED GENERATION ASSETS (2019 - 2026) [14]

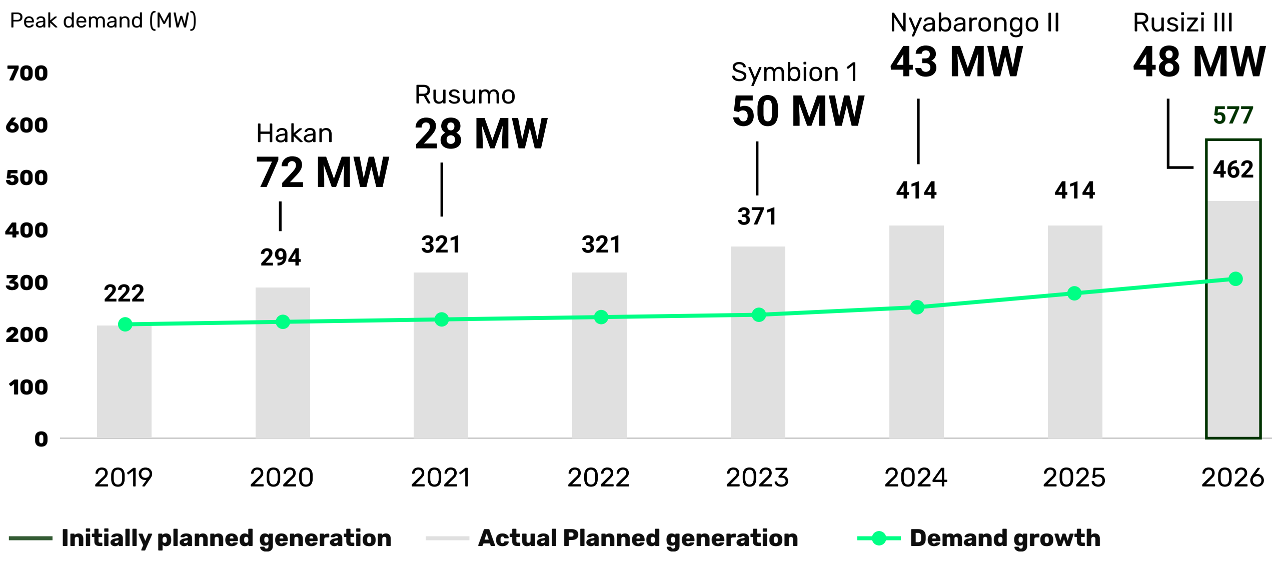



**FIGURE 56** EVOLUTION OF PLANNED SUPPLY AND FORECASTED DEMAND IN RWANDA UNTIL 2026 (MW) [24]

## A more competitive Public-Private Partnership (PPP) Law

**The GoR also committed to ensure no more bilaterally negotiated agreements are undertaken. Rather, only transparent competitive procurement of private sector-owned electricity infrastructure as specified under the PPP Law of 2016 will be undertaken.** Additionally, as of 2019, it has committed to signing new PPAs only for least-cost plants as informed by the LCPDP[59]. Implementing the PPP Law follows LCPDP and least-cost principles and guarantees value-for-money when the GoR procures new generation capacity. The last 12 months saw a successful implementation of the PPP law as no bilateral agreement or MoUs were signed.

## Exploiting lower cost energy sources in neighbouring countries

**The revised LCPDP also includes ambitions to benefit from the low-cost regional hydropower and geothermal resources as well as developing regional interconnections with East African countries and exploit economies of scale and regional trade.**

Although energy self-reliance has been a steering policy in Rwanda, regional electricity trade is advocated at the expense of costly fossil fuel imports as to supply low-cost and low-carbon electricity to meet its demand in the short to medium term.

An interconnection to Kenya through Uganda is under construction and a bilateral agreement for up to 30 MW of imports at US$0.14 per kWh was signed with Kenya in 2014. An 80 MW regional Rusumo Falls hydropower plant, that will be shared equally by Rwanda, Tanzania, and Burundi is currently under construction and is expected to be operational at the end of 2020 and a 147 MW regional Ruzizi III hydropower plant project, to be shared equally by Rwanda, the Democratic Republic of Congo, and Burundi is currently planned for 2025 (Figure 56 and Table 7-3).

59 The only exceptions to that PPP law are mini-grid projects that do not require an off-taker agreement with the public sector.

More affordable electricity tariffs

The new series of tariff reforms (the latest in August 2018) have already impacted and are expected to further increase affordability to electricity supply for the bottom 40%.

Since 2015, a series of tariff reforms have been implemented by RURA to recover the cost of electricity for REG whilst protecting the poor (Figure 57). Indeed, 2017 saw a major change in grid tariff structure, which shifted from one of the highest flat rates in Africa - USD $0.24 per kWh - to a block structure per consumer category.

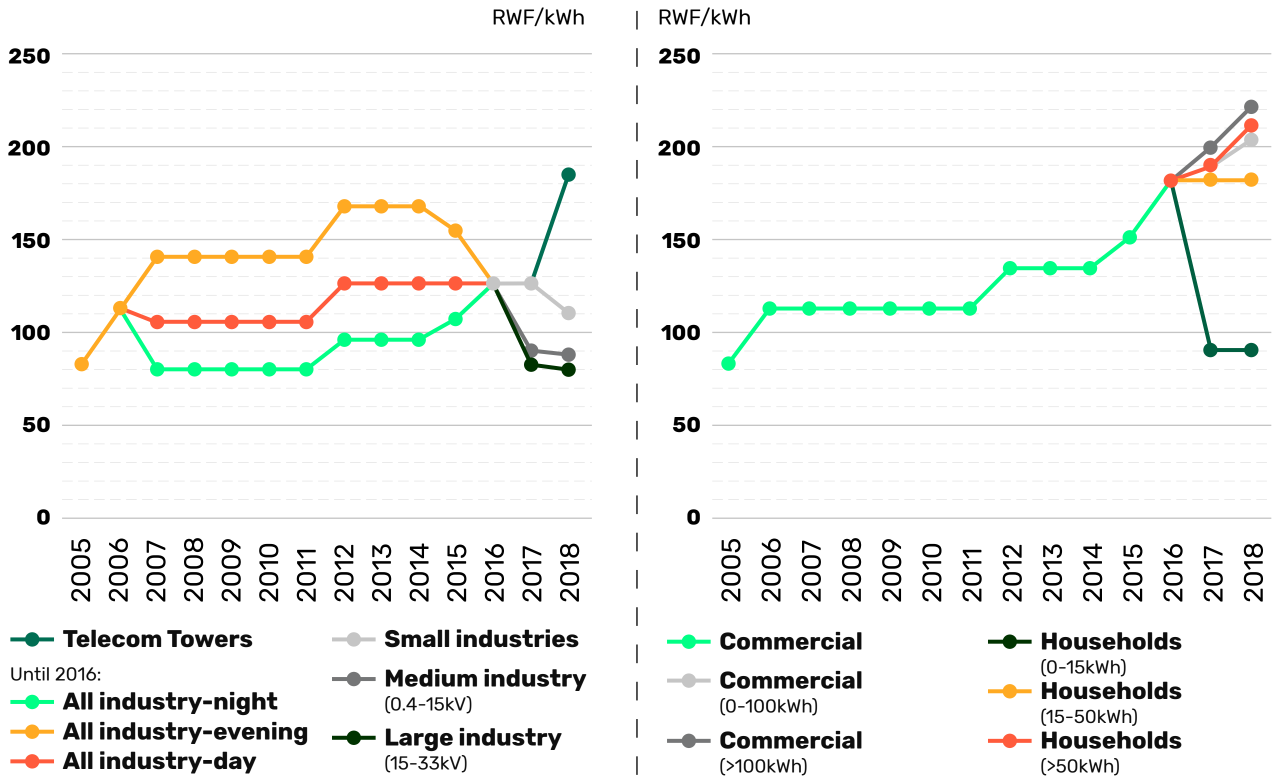
- A lifeline tariff for electricity consumers below 15 kWh per month has been implemented, for which a reduced rate to USD $0.12 per kWh decreased the cost of electricity by 51% for those households (the average monthly consumption of households in Rwanda was an estimated 35 kWh per month in 2016/17)
- Two other blocks of residential consumers have emerged with assigned tariffs reflective of their average energy consumptions (USD $0.22 per kWh for 15-50 kWh and USD$0.24 per kWh for >50 kWh).

**Although this reform raised average tariffs, it reduced rates for most households bearing in mind that 93% of households lie within the first two lowest blocks (consumptions up to 50 kWh). As estimated by the World Bank [13], this reform will result in strong poverty reduction while maintaining revenue base for the REG.**

However, tariffs remain higher than the average and median electricity tariffs among 39 other Sub-Saharan African countries, respectively at USD$0.08 per kWh and USD $0.15 per kWh, and impact mostly residential, commercial and industrial electricity consumers with consumptions greater than 50 kWh, and therefore still strongly hinder the scale-up of private investment flows and growth.

**FIGURE 57**

ELECTRICITY TARIFFS IN RWANDA, 2005-18 (IN RWF, NOMINAL) [8]



# 4 GENERATION PLANTS IN RWANDA

**TABLE 7-4**

POWER GENERATION PLANTS BY 2018 IN RWANDA [14]

| | NAME | TECHNOLOGY | CAPACITY (MW) |
|---|---|---|---|
| 1 | Ntaruka | Hydro | 11.3 |
| 2 | Mukungwa I | Hydro | 12 |
| 3 | Nyabarongo | Hydro | 28 |
| 4 | Gisenyi | Hydro | 1.2 |
| 5 | Gihira | Hydro | 1.8 |
| 6 | Murunda | Hydro | 0.1 |
| 7 | Rukarara I | Hydro | 9.5 |
| 8 | Rugezi | Hydro | 2.2 |
| 9 | Keya | Hydro | 2.2 |
| 10 | Nyamyotsi I | Hydro | 0.1 |
| 11 | Nyamyosti II | Hydro | 0.1 |
| 12 | Agatobwe | Hydro | 0.2 |
| 13 | Mutobo | Hydro | 0.2 |
| 14 | Nkora | Hydro | 0.7 |
| 15 | Cyimbili | Hydro | 0.3 |
| 16 | Gaseke | Hydro | 0.6 |
| 17 | Mazimeru | Hydro | 0.5 |
| 18 | Janja | Hydro | 0.2 |
| 19 | Gashashi | Hydro | 0.2 |
| 20 | Nyabahanga I | Hydro | 0.2 |
| 21 | Nshili I | Hydro | 0.4 |
| 22 | Musarara | Hydro | 0.5 |
| 23 | Mukungwa 2 | Hydro | 2.5 |
| 24 | Rukarara 2 | Hydro | 2.2 |
| 25 | Nyirabuhombohombo | Hydro | 0.5 |
| 26 | Giciye1 | Hydro | 4 |
| 27 | Ruzizi 2 | Hydro | 12 |
| 28 | Giciye2 | Hydro | 4 |
| 29 | Jali | Solar | 0.3 |
| 30 | GigaWatt/Rwamagana | Solar | 8.5 |
| 31 | Nyamata Solar | Solar | 0.03 |
| 32 | Nasho Solar PP | Solar | 3.3 |
| 33 | Ruziz 1 | Hydro | 3.5 |
| 34 | Jabana 1 | Diesel | 7.8 |
| 35 | Jabana 2 | Diesel | 20 |
| 36 | Mukungwa Thermal | Diesel | 10 |
| 37 | KSEZ Thermal | Diesel | 10 |
| 38 | Birembo Thermal | Diesel | 10 |
| 39 | Gishoma | Peat | 15 |
| 40 | Rice Husk | Biomass | 0.1 |
| 41 | KPI | Methane | 3.6 |
| 42 | Kibuye Gaz methane (Kivuwatt) | Methane | 26.4 |
| | **Total** | | **218** |

# 5 SURVEY METHODOLOGY

FMO engaged Enea Consulting to assess the evaluability of KivuWatt's socio-economic impacts in 2014[60]. This preliminary work was conducted through the development of a theory of change, describing causal links of the project from inputs to outputs, outcomes and final impacts (Figure 58). An assessment of the availability of data needed for such an impact evaluation was also performed. This led to the following conclusions:

- Impacts of electricity access cannot be evaluated at final level but at intermediate and outcome levels
- Such an evaluation can be conducted through a quantitative survey with a timeframe of not more than 3 to 5 years between the baseline and the end-line surveys in order to avoid the dilution effect of KivuWatt's impacts
- Existing national surveys in Rwanda (e.g. the Household Living Conditions Surveys – EICV) shall be used as an input and a complementary source of data for the study
- A quantitative survey to assess KivuWatt's impact on local employment[61] and local communities is vain since the construction phase was already well underway before the implementation of the baseline survey. However, a qualitative evaluation of both the impact on local employment and local communities can be done at outcome level
- The additionality of FMO's contribution to the project has been partly confirmed with interviews of project stakeholders but a rigorous ex-post evaluation is not feasible owing to the unavailability of tangible elements.

## Impact evaluation methodologies

Two strategies were proposed depending on the electrification status of beneficiaries at both the baseline and endline.

A simple before/after approach is selected for end users who already had access to electricity at the time of the baseline survey (G1c), since no counterfactual can be found within the country (i.e. electrified areas outside KivuWatt's area of influence). For this approach, KivuWatt's outcome is measured as the difference in outcomes before treatment (that is, KivuWatt's commissioning and operations) and after the treatment. Formally, the intervention impact is given by:

$$(1)\ Impact = x \cdot (Outcome_2^T - Outcome_1^T)$$

where, *x* is the percentage of the overall impact that can be attributed to KivuWatt, Outcome is the average outcome, subscripts 1 and 2 refer to the pre- and post-intervention period respectively and superscript T refers to the treatment group.

*x* is defined as the ratio between electricity generated by KivuWatt between the commissioning and the end-line survey over total additional electricity generated by new power plants installed on the grid during the period, including KivuWatt's plant.

$$(2)\ x = \frac{\sum_{i=1}^{4} E_i^{KivuWatt}}{\sum_{i=1}^{4} E_i^{Additional}}$$

where, *E* is the total electricity generated, subscript i refer to the years between KivuWatt's commissioning and the end-line survey, superscripts KivuWatt and Additional refer to KivuWatt's power plant and all additional electricity generation plants installed between baseline and end line respectively.

60 See Enea's report for FMO Evaluability assessment of KivuWatt Project in Rwanda, September 2014

61 This class of impacts was referred to as "Macroeconomic impacts" in the Evaluability assessment of KivuWatt Project in Rwanda, September 2014 (see Figure 58). The report however limited the scope of the impact assessment to local employment.

**A differences-in-differences approach** is selected for end users newly connected within the evaluation timeframe (G1nc, G2nc). The control group is chosen within the population who is not expected to get access to electricity within the project timeframe. For this approach, KivuWatt's outcome is measured as the difference in outcomes before treatment (that is, KivuWatt's commissioning) and after the treatment. Formally, the intervention impact is given by:

$$(3)\ I = x \cdot [(Outcome_2^T - Outcome_1^T) - (Outcome_2^C - Outcome_1^C)]$$

where, superscript *C* refers to the control group.

This strategy allows identifying the impact of the project controlling for non-time varying differences between treated and control units. Because treated and control units may also differ with respect to (observable) time varying characteristics, the above strategy is embedded within a multiple regression framework to control these additional effects. Indeed, one purpose of the questionnaires is, on top of offering endline level of indicators, to collect relevant information on household characteristics that may explain differences in outcomes that are not directly related to electricity.

Indicators measured

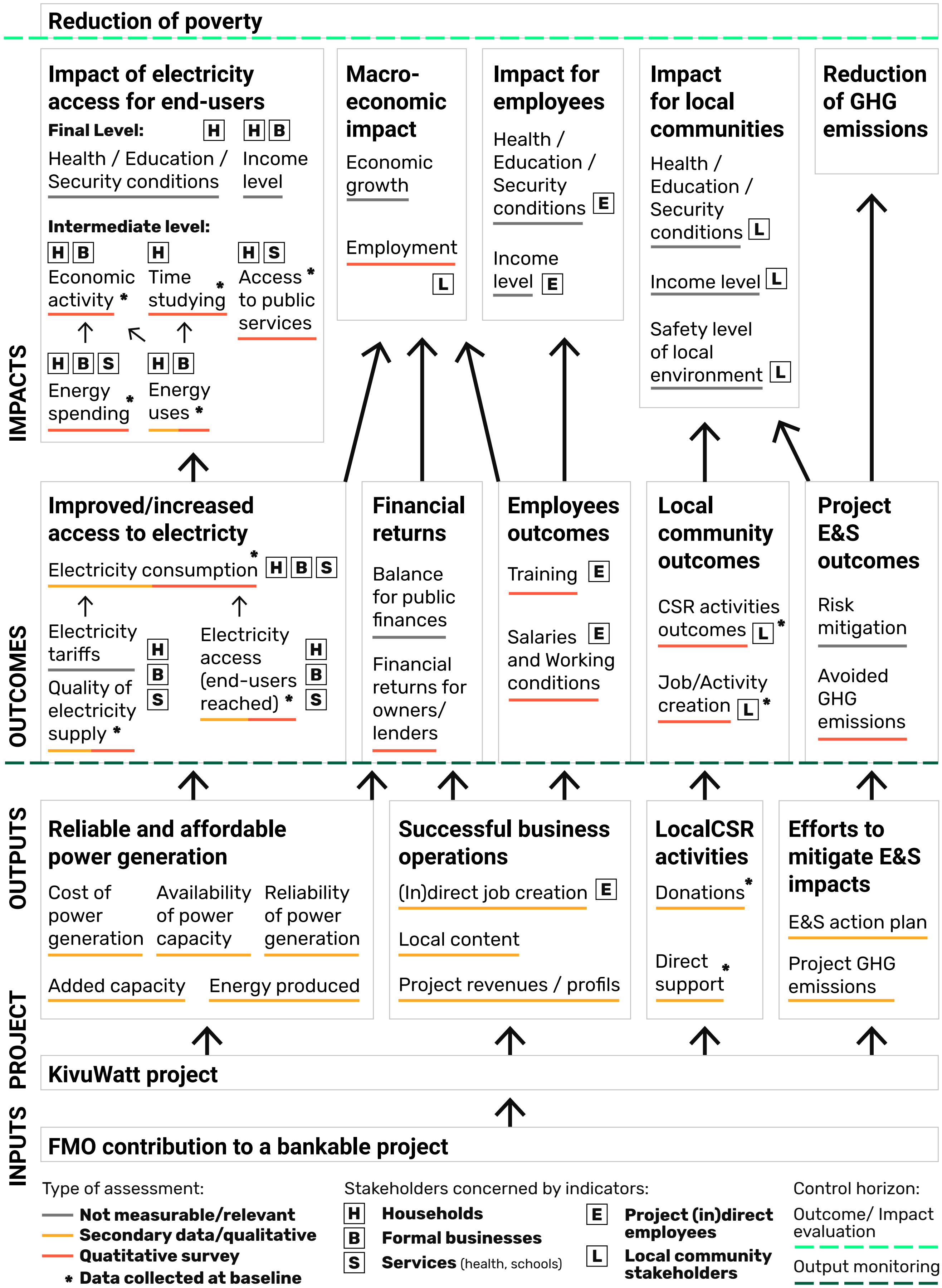
The relationship between KivuWatt's project outputs and intermediate outcomes and impacts are complex as shown in Figure 58. It is assumed that the project resulted in the increase in national grid-connected power generation capacity, as well as the reliability of the overall generation system and yearly produced electricity. The cost of electricity generation is assumed to have decreased due to the replacement of expensive rental diesel generators. These project outputs, in turn, produce short-term or immediate outcomes at an end user's level such as a potential reduction in electricity tariffs, an increased consumption of electricity, increased electricity supply reliability and an increased electricity access for new end users due to a generation capacity exceeding current demand.

Finally, impacts for end users emerge at two levels. The first intermediate level includes the emergence of new energy uses (lighting, refrigeration, productive motive power, etc.) for end users, decreased energy spending, the creation or improvement of activities and jobs relying on electricity and improved access to electrified public services such as health or education. Lastly, these contribute to better health, education and security conditions for the households, as well as an improved income level.

The impact evaluation measures the intermediate impacts of the project at an end user's level. The rationale for that is that final impacts are also influenced by external factors. Focusing on intermediate impacts thus offers the possibility to better capture direct project impacts and limits the bias related to external factors. Five questionnaires were developed to capture intermediate impacts, targeting the four types of end users as well as village representatives.

The final indicators used depend on the quality of information collected (number of observations, standard deviation, etc.) as listed in Table 7-5. All final impact indicators consider the share of KivuWatt in the measured outcome or impact. For instance, if connections have increased from 60 to 80% in some villages, KivuWatt will have contributed to this increase according to its contribution to the additional capacity (i.e. KivuWatt's capacity/total additional capacity 2015–2019). With respect to this, the chosen indicators were therefore weighted to consider KivuWatt's contribution to the evolution of these indicators.

**FIGURE 58** CAUSAL CHAIN AND CLASSES OF INDICATORS USED FOR THE IMPACT EVALUATION OF KIVUWATT PROJECT



| INDICATORS | HOUSEHOLDS | FORMAL BUSINESSES | SCHOOLS | HEALTH FACILITIES |
|---|---|---|---|---|
| **Electricity access** | | | | |
| Connection rate | x | x | x | x |
| Reason for not being connected to the grid | x | x | x | x |
| Share using an electricity generation equipment | x | x | x | x |
| Type of generation equipment | x | x | x | x |
| Type of use of electricity generation equipment | x | x | x | x |
| Reason for use of electricity generation equipment | x | x | x | x |
| **Quality of electricity supply** | | | | |
| Power outage frequency (#/day) | x | x | x | x |
| Share with at least 1 power outage a day | x | x | x | x |
| Selective power cut frequency (#/month) | x | x | x | x |
| Share with at least one load shedding per month | x | x | x | x |
| Share supplied with limited capacity by the grid (low voltage supply) | x | x | x | x |
| # of time/week electricity from grid supplied with low capacity | x | x | x | x |
| Duration of supplied with limited capacity (hours) | x | x | x | x |
| **Electricity consumption** | | | | |
| Average monthly grid electricity consumption (kWh/month) | x | x | x | x |
| **Energy spendings** | | | | |
| Monthly expenditures (last month) | x | | | |
| Share of electricity from grid in energy budget (electricity + fuel) | | x | x | x |
| **Domestic use of energy** | | | | |
| Total lighting time in dwelling (cumulated hours/day) | x | | | |
| Share of lighting devices used (based on lighting time) | x | | | |
| Number of cell phones in hh | x | | | |
| Phone is charged at home | x | | | |
| Time to reach phone charge place (minutes) | x | | | |
| Share using electricity for cooking or boiling | x | | | |
| Share using at least one TV | x | | | |
| Share using at least one fridge | x | | | |
| Share using at least one computer | x | | | |
| **Productive use of energy** | | | | |
| Use of energy in occupations | x | | | |
| Share of energy in occupations powered by electricity | x | | | |
| Use of energy in occupations (excl. farming) | x | | | |
| Share of energy in occupations (excl. farming) powered by electricity | x | | | |
| Use of lighting energy in occupations | x | | | |
| Use of motive energy in occupations | x | | | |
| Use of heating energy in occupations | x | | | |
| Use of cooling energy in occupations | x | | | |
| Use of electronic appliances in occupations | x | | | |
| Use of energy transfer (charging) in occupations | x | | | |

| | | | | |
|---|---|---|---|---|
| Use of lighting energy | | x | | |
| Use of motive energy | | x | | |
| Use of heating energy | | x | | |
| Use of cooling energy | | x | | |
| Use of electronic appliances | | x | | |
| Use of energy transfer (charging) | | x | | |
| **Economic activity** | | | | |
| Turnover | | x | | |
| Turnover evolution in last year | | x | | |
| New products/services introduced last year | | x | | |
| # of hours opening per week | | x | | |
| Number of employees | | x | | |
| Growth activity constrained by electricity | | x | | |
| Main reason of growth constraint | | x | | |
| Output loss due to power outages | | x | | |
| **Access to public services** | | | | |
| Establishment provided with lighting device | | | x | |
| Lighting device type | | | x | x |
| Main lighting device is bulb | | | x | x |
| Number of hours health facility lighted by week | | | x | x |
| # opening hours after sunset | | | x | x |
| # of hours opened per week | | | x | |
| Hold an X-ray machine | | | | x |
| # cooling equipment | | | | x |
| # microscope | | | | x |
| # centrifuge | | | | x |
| # steriliser | | | | x |
| # health equipment per employee | | | | x |
| Hold a copy machine | | | x | |
| # computer | | | x | |
| # computer per student | | | x | |
| Total # of equipment per student | | | x | |
| Total # of equipment per teacher | | | x | |
| Student/teacher ratio | | | x | |
| **Time studying** | x | | | |
| Time studying at home during day light hours (hr/day) | x | | | |
| Time studying at home after sunset (hr/day) | x | | | |
| Time studying at school after sunset (hr/day) | x | | | |

**TABLE 7-5**

LIST OF INDICATORS USED IN THE SURVEY

## SAMPLE DESIGN

### TARGET POPULATION, PRIMARY AND SECONDARY UNITS AND UNITS OF ANALYSIS

The target population, primary and secondary units of the analysis, have already been determined in the baseline survey and will act as the basis of the end-line analysis framework. The following is the strategy adopted for sample design.

The target population consists of end users of electricity that will benefit in all provinces of Rwanda, from the additional generation capacity of KivuWatt project, including households, businesses (formal and informal), health facilities and schools.

To keep costs at a manageable level and due to the lack of a full-population census frame, clusters are used. Clusters are defined at the level of treatment assignment. In our case, a village/ community level or any primary census enumerated areas (for which we also need to have a boundary map) representing our Primary Sampling Unit (PSU).

The Primary Sampling Units (PSU) of the present survey is a village. The secondary sample units comprise households (and their possible informal economic activity), health centres, schools, and formal businesses at establishments level. Units of analysis unit are both at household and village levels.

Health centres and schools are public services that directly impact households. The sample frame for these end users is therefore considered as a sample frame of households. Hence, in each village selected for household interviews, the closest school (primary and secondary schools) and closest health facility (dispensaries, health centres, and district hospitals) are taken as secondary sample units. Where no school or health facility are present in the village, the closest school or health facility outside the village is chosen as secondary sample units.

Formal businesses in the form of establishments as well as informal businesses are also considered as secondary sample units within our selected PSU. Without a dedicated sampling frame, formal and informal businesses from the same villages are sampled as households allowing the measurement of impacts on businesses with which households are more likely to interact (as a client or labour supply provider). As for schools and health facilities, in case no formal business is present within the village, the two closest formal businesses outside the village are chosen as secondary sample units.

The population was stratified into three groups. The groups named G1, G2 and G3 are mutually exclusive:

- G1 villages are villages that were already supplied[62] with electricity from the national grid in 2015
- G2 villages are villages that became electrified and were supplied by the National Grid between 2015 and 2019
- G3 villages are villages that remained offgrid.

We have assumed a status for G2 and G3 villages. However, it was observed that some G2 villages had not been supplied by the grid by the end line and have

62 By "supplied", we mean here that the villages are both connected to the grid and supplied with electricity. In the Rwandan context, where rapid electrification is underway, a number of villages might indeed have a connection (e.g. an electrical pole has been installed in the village), but this connection is not supplied with electricity yet.

therefore been considered as G3 villages. Conversely villages initially identified as G3 villages that have been supplied with grid electricity by the end line have thus been considered as G2 villages. Such a switch in the status of villages is not an issue for the quality of the measurement because all these villages had similar characteristics in the baseline. However, the volume of each sample (the number of G2 villages and the number of G3 villages) must be controlled to be as close as possible to 60 in each group (see next paragraph Sampling).

The survey is nation-wide because the impacts of KivuWatt are generated from electricity provided from the grid all over the country. The group G1 includes villages in all provinces of Rwanda because all of the 5 provinces are connected to the grid and all potentially include villages connected to the grid.

The group G2 does not include the province of Kigali because this province shows a very high rate of grid connection and too few villages are suitable with the G3 group. Similarly, the Eastern Province has been excluded from the perimeter of the groups G2 and G3 because this province is the focus of large development projects to increase the grid connection rate, and thus overcoming the risk of not having a sufficient G3 group size in this province at end-line survey.

## SAMPLING

Indicators measured in this study are directly linked with electricity consumption and use. A substantial change is expected between baseline and end line. In order to increase the accuracy of the measurement, the survey used a panel sample: the same end users were surveyed at baseline and end-line measurements as far as possible.

The sample size computation considers the complex design of our sample (two stage cluster sampling).

The generic formula used for sample size computation is:

$$n = D\left[\frac{(Z_a + Z_b)^2 \times P_1 \times (1 - P_1) + P_2 \times (1 - P_2)}{(P_2 - P_1)^2}\right]$$

With

$$D = 1 + \rho(m - 1)$$

Each term of the equations is described and its value for each sample is given in here after.

The sample size for households has been computed with the aim of being able to detect a change of at least 10 percentage points of a relevant impact indicator expressed as a percentage with a power of at least 80% and with 95% confidence level. Sample size of schools, health centres and formal businesses have been computed with the aim of being able to detect a change of at least 25 percentage points of a relevant impact indicator expressed as a percentage with a power of at least 80% and with 95% confidence level.

| TERM | DESCRIPTION | VALUE FOR HOUSEHOLDS | VALUE FOR SCHOOLS | VALUE FOR HEALTH FACILITIES | VALUE FOR FORMAL BUSINESSES |
|---|---|---|---|---|---|
| **D** | Design effect (to adjust for clustering effect) | 1.9 | 1.1 | 1.1 | 1.1 |
| **$Z_a$** | Degree of confidence, avoiding type I error (concluding there is an effect when indeed there is not)[63] | 1.645 | 1.645 | 1.645 | 1.645 |
| **$Z_b$** | Confidence with which we will be able to detect an effect of P2-P1 when it occurs[64]. | 0.84 | 0.84 | 0.84 | 0.84 |
| **$P_1$** | Level of the indicator at the baseline | 0.5 | 0.5 | 0.5 | 0.5 |
| **$P_2$** | Level such that P2-P1 can be detected | 0.6 | | | |
| **p** | Intraclass correlation on the outcome/indicator of interest | 0.1 | 0.1 | 0.1 | 0.1 |
| **m** | Number of units in each cluster | 10 | 1 | 1 | 1 |
| **n** | Size of the sample (number of secondary sample units) | 575 | 44 | 44 | 48 |

The number of villages surveyed for each group was thus set to 60 with a target of 10 households, 2 formal businesses, 1 health facility and 1 school surveyed per village. For each group (G1, G2 and G3), the sample included at least 575 households, 48 formal businesses, 44 health facilities and 44 schools.

**TABLE 7-6**

VALUES OF PARAMETERS USED FOR SAMPLE SIZE COMPUTATION

63 Za=1,645 for a 95% level of significance

64 For a power of 80% Zb=0.84; for a power of 90% Zb=1.28

| | NUMBER OF HOUSEHOLDS | NUMBER OF SCHOOLS | NUMBER OF HEALTH FACILITIES | NUMBER OF FORMAL BUSINESSES |
|---|---|---|---|---|
| G1: Connected villages (60) | 600 (= 60 x 10) | 60 (=60x1) | 60 (=60x1) | 120 (=60x2) |
| G2: Treatment villages (60) | 600 (= 60 x 10) | 60 (=60x1) | 60 (=60x1) | 120 (=60x2) |
| G3: Control villages (60) | 600 (= 60 x 10) | 60 (=60x1) | 60 (=60x1) | 120 (=60x2) |
| **Total** | **1 800** | **180** | **180** | **360** |

**TABLE 7-7**

SAMPLE SIZE

In addition to households, schools, health facilities and formal businesses, a questionnaire was administered to the village representative of each village. The questionnaire allowed collecting objective information on distance to public buildings or grid connected roads for instance.

The village sample frame consists of a list of all villages of Rwanda that belong to the groups G1, G2 or G3 with information on their location, measure of size (number of households in the village) and rural/urban status. This database was elaborated thanks to information provided by the REG and the National Institute of Statistics Rwanda (NISR).

The list of villages currently connected or planning to be connected was put together thanks to the locations (i.e. GPS coordinates) of existing transformers, infrastructures currently connected to the grid, existing electric lines and electric lines under construction communicated by the REG, along with the names of cells, sectors or districts included in the projects areas for grid extension.

Thanks to this information, villages are attributed to the different groups, with the following conditions:

- **Villages of group G1 are defined as any village for which at least one of the following conditions is true:**
  _ The central point of the village is located less than 500 metres from an existing grid transformer;
  _ A grid transformer is located in the village;
  _ An infrastructure connected to the grid has been identified in the village.
- **Villages of group G2 are defined as villages combining the following conditions:**
  _ The village is not in the group G1;
  _ An electric line under construction goes through the village;
  _The village is neither in the Eastern Province nor in the Kigali province[65].

65 Both Kigali and the Eastern Province are the focus of a large development projects to increase the grid connection rate [6]. Therefore they were excluded from G2 group based on the fact that no counterfactual could be found in the end-line.

- **Villages of the group G3 are defined as villages combining the following conditions:**
  _ The village is neither in the group G1 nor G2 nor 'planned areas';
  _ The village is in a province comprising at least one village of the group G2;
  _The central point of the village is located at more than 2 km from the central points of villages that are likely to be connected to the network in 2019 (villages of the groups G1, G2 and 'planned areas').

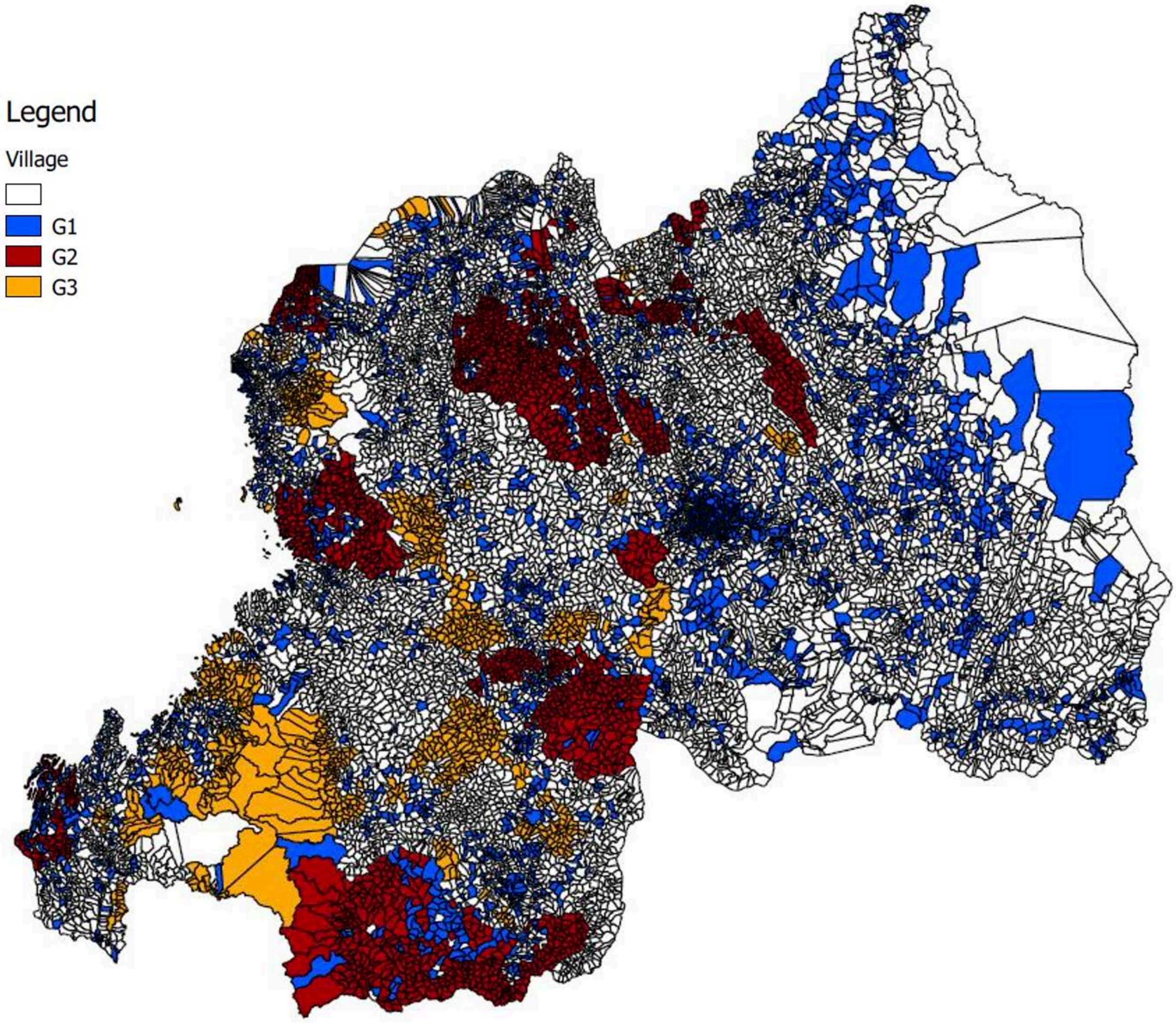
The sample frame is shown on Figure 59 in the form of a map of villages in groups G1, G2 and G3.

Villages of the groups G1 and G2 are sampled randomly according to the explicit stratification (G1 and G2), to the implicit stratification (rural/urban) and to a probability of being sampled proportional to village size. Villages of the group G3 are sampled as the closest to G2 villages in terms of size, within the same implicit stratum (province[66]).

[66] All villages of the group G3 are rural. Therefore, the urban/rural stratum has not been used for G3 selection within the sample frame.

**FIGURE 59**

MAP OF VILLAGES IN THE GROUPS G1, G2 AND G3 AS DEFINED IN THE SAMPLE FRAME



The chosen strategy is to perform the survey on a panel of stakeholders in order to reach a high accuracy of measurement with a limited number of stakeholders interviewed. It means that in the end line, the same respondents as in the baseline (households, business, schools, and health facilities) were to be interviewed again.

As for the sample sizes, in each village surveyed in the baseline, 10 households were randomly[67] selected among the household list held by the village leader. Formal businesses, health facilities and schools have been sampled to be representative of their effect on households (i.e. their coverage of the sampled villages).

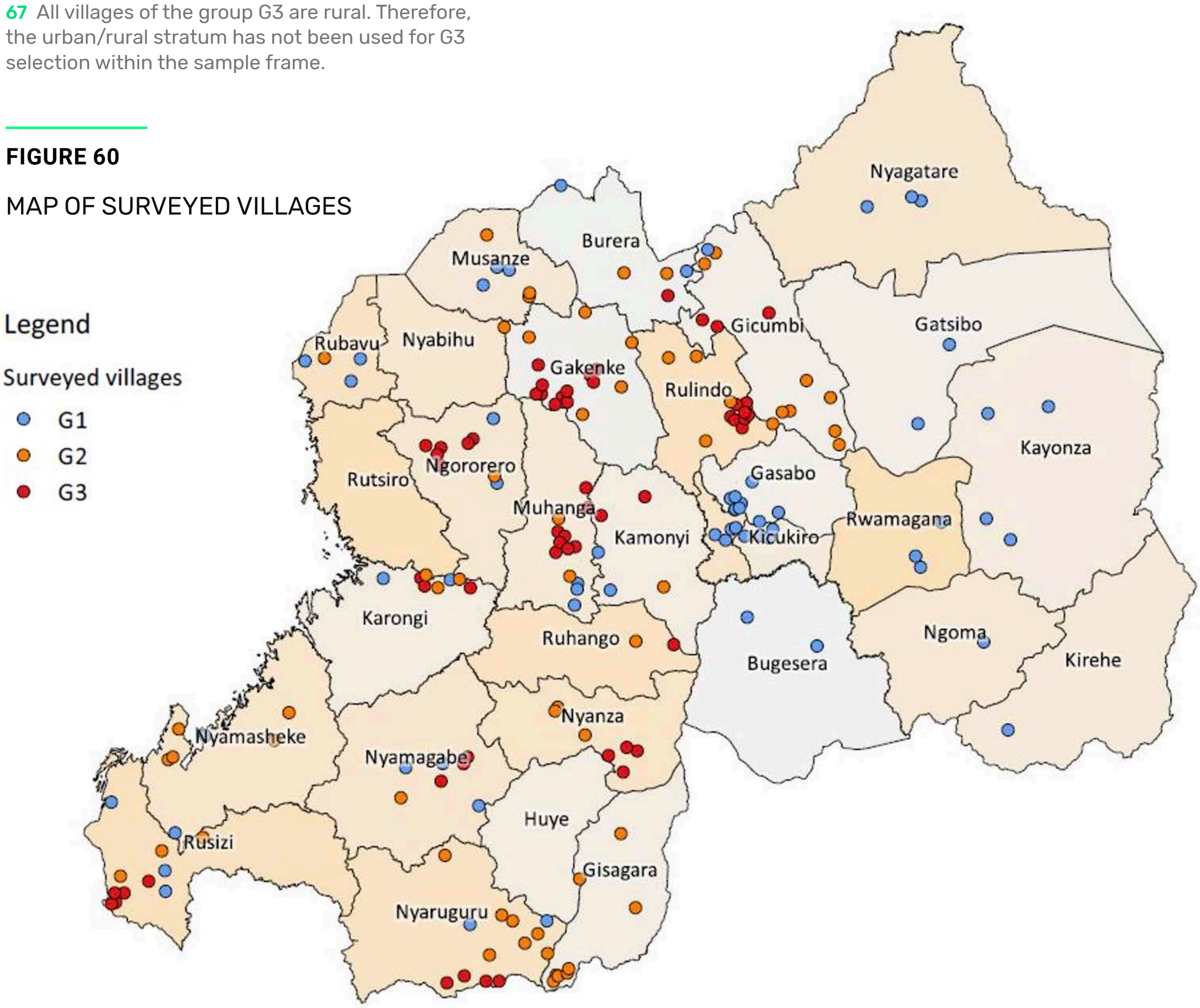
When the village accounted for more than 2 formal businesses, more than 1 health facility or more than 1 school, the concerned establishments were randomly selected. If no establishment was found in the village, the closest establishment outside the village and in the same sector was surveyed.

A before-after strategy on health centres and schools for the G2 villages is implemented as they were identified to be generally located in villages benefiting from a grid connection during the baseline survey. On the same line, as there were too few formal businesses in offgrid rural villages (G2 and G3) in the baseline survey, impacts on formal businesses are evaluated in G1 villages only.

67 All villages of the group G3 are rural. Therefore, the urban/rural stratum has not been used for G3 selection within the sample frame.

**FIGURE 60**

MAP OF SURVEYED VILLAGES



## SURVEY IMPLEMENTATION

### DATA COLLECTION

Two tools were used to ensure efficient data collection during each survey:

- An android-based mobile application for data collection and submissions to data server. This application was installed and used by all enumerators participating in the survey
- A data server to manage the questionnaires and collect and manage questionnaire submissions by enumerators. It is exclusively used by the survey team leader to monitor data entries by enumerators and for quality control purpose.

In the baseline survey, **ODKCollect** was used for data collection. ODKCollect is a user-friendly tool provided by a private company that offers a satisfactory level of confidentiality of data.

In the endline survey, **CSPro** was used as it offered additional functionalities than ODKCollect. CSPro is a public domain data processing software package, with applications that can be used for mobile sur-vey data collection (CSPro app). Whilst questionnaires are coded in excel on ODKCollect, the C++ lan-guage of CSPro allows for more flexibility, efficiency and accuracy for entering baseline data in each questionnaire/code. This is is a critical requirement for the endline survey which must be conducted on the same pool of population as that of the baseline. For example, identifying directly through logical links the name of the head of the household interviewed in 2016 without having to identify him man-ually elsewhere. The endline questionnaires were coded into the CSPro platform by JISECO Ltd, Enea's local partner responsible for the seeking enumerators, training, logistics, data collection and cleaning.

### TRAINING OF ENUMERATORS AND SUPERVISORS

Training of the survey team is the first step towards survey implementation. Training gives zone supervisors and enumerators an opportunity to become familiar with the questionnaires.

Training was thus conducted prior to launching both surveys. Each training programme included 4 full days of training and 2 days of testing. It covered the following activities:

- Equip all enumerators with the mobile-based data collection application and make them familiar with its use
- Make all enumerators thoroughly familiar with all questions in all questionnaires, including their purpose, range of potential answers, how to prompt if needed, sensitiveness if any, and so on. The teaching of questionnaires must be done in Kinyarwanda by an experienced local person
- Test all enumerators throughout the training session and test for their learning ability, knowledge, interviewing skills, and so on
- Decide to resolve confusing issues related to interviewing through consensus.

### QUESTIONNAIRE TESTING

Testing was done prior to the launch of both surveys with 50 stakeholders in a random village that is not concerned by the survey. The reason is to ensure that testing does not influence or biases the households during the actual interviews.

The survey team was equipped with all necessary materials as they would have been during the actual surveys, including the questionnaires, necessary authorization letters, mobile phones/tablets. Activities during the testing include:

- Carrying out the interviews entirely
- Timing each interview accurately, and making note of questions that take more than expected time
- Making note of questions that seem to confuse the respondents, make them hesitate or sensi-tive. In particular, all types of non-response was carefully noted and distinguished, such as 'Do not know', 'Refuse to answer', etc.
- Making notes of categorical questions where the responses are outside the range of listed re-sponses.

### COMPLETION OF SURVEY TOOLS

The team involved in survey design as well as survey team coordinators and Enea worked together to finalise the questionnaires before data collection for both surveys. After the finalisation of all questionnaires, and suggestions coming from the pilot survey, questionnaires were translated again into Kinyarwanda in order to facilitate the interviews which were all done in Kinyarwanda. Finally, final questionnaires were uploaded on ODK Aggregate platform/CSPro platform to make it available through ODK Collect/ CSPro app to all enumerators.

### LOGISTICS

The enumerators were equipped with a kit before the kick-off (umbrella, survey tools multiplied, cap & tee-shirt, etc.) and a fieldwork plan.

For the purpose of the surveys, a VISA was to be requested by the NISR, and a survey request made to MINALOC. Local authorities (sectors' secretary executives) were informed officially five days before the data collection staff deployment. The introduction kit for informing local authorities and interviewees comprised a copy of NISR VISA.

### SURVEY MONITORING

Enea's team stayed in Rwanda in the first days of each field survey to check that procedures were well suited and to solve the first issues encountered by the teams. Enea worked closely with the local partner, JISECO LTD, during these two days to be sure that they can manage the survey after the departure of Enea.

The local partner was in daily phone contact with every supervisor to follow the progress of the teams, identify issues encountered and find solutions/additional procedures to be communicated to all teams.

Enea was in close contact with the local partner to follow the progress and help the local partner to find solutions to issues encountered. Since all questionnaires filled in a day were uploaded at the end of each day of survey, Enea also followed the progress of the survey remotely and analysed the data collected by the teams in the first days of the survey in order to identify any bug in the questionnaires and mistakes made by enumerators before a large number of questionnaires is filled.

Also, the GPS location was recorded in front of every surveyed household, business, health facility and school, as well as at the location of each village representative and at the last asphalted road in each village, which allowed remote monitoring and mapping of conducted surveys.

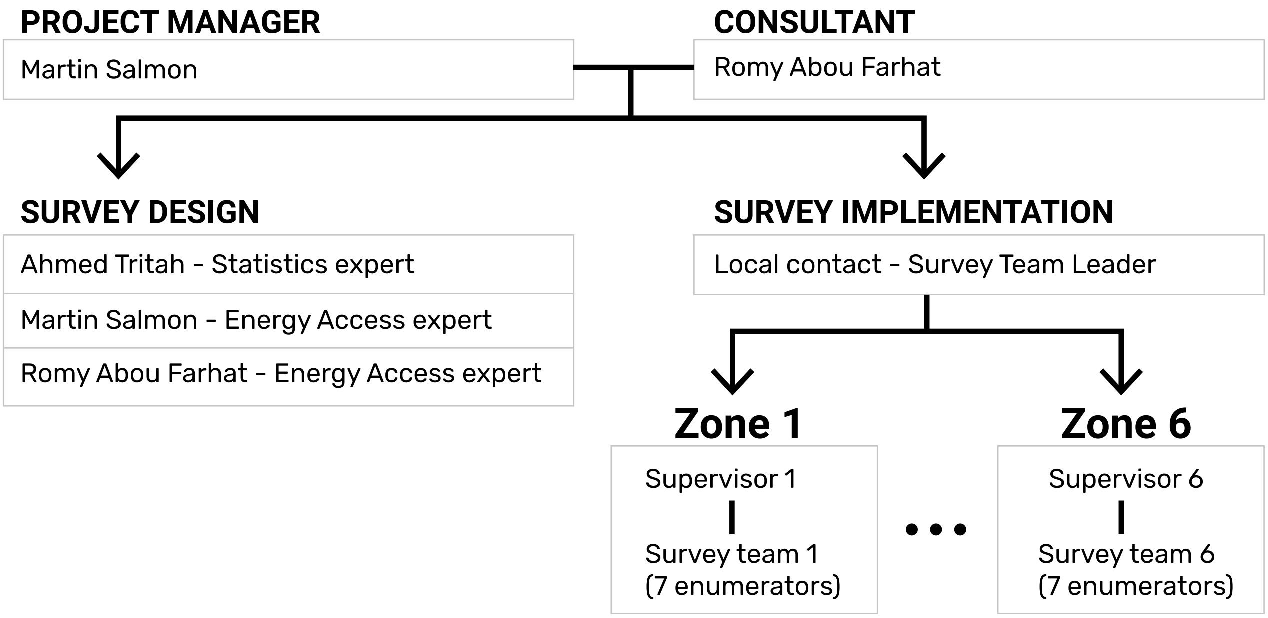
### DATA VERIFICATION AND CLEANING

Data entry was directly done via ODK Collect or CSPro by enumerators.

Data verification involved checking the accuracy and consistency of the collected data and preparing the data sets for analysis. The first step of data verification entailed a set of pre-specified checks, including range, outliers, and invalid values for categorical variables (codes for education level, type of fuels used, etc.). The list of invalid entries was examined for correction. At the second step, logical consistency skip patterns, missing values, and inapplicable answers were done.

**FIGURE 61**

SURVEY TEAM ORGANISATION CHART




## SURVEY TEAM ORGANISATION

The organisation chart of the survey team for the baseline and endline surveys are shown in Figure 61. Martin SALMON, Enea Consulting, had the overall responsibility of ensuring the success of survey activities. Survey design is under the responsibility of Ahmed Tritah, DataStorm, and Martin Salmon and Romy Abou Farhat, Enea Consulting.

## SURVEY DESIGN

The key role of the people in charge of survey design was to ensure the quality of data generated during the survey. They oversaw developing the survey framework, including indicators and sampling.

### Statistics Expert

The statistics expert was responsible of building a consistent and reliable methodology of sampling that would ensure statistically robust results from the survey. The sampling methodology was built according to the aim of the study and its context of implementation (indicators to be used, type of stakeholders interviewed, macro social and economic data available on Rwanda, etc.).

### Energy Access Expert

The energy access experts at Enea oversaw the design of the set of indicators, variables, and questionnaires to ensure relevant measurement of change attributable to KivuWatt's project. This approach mainly relied on orienting indicators on possible changes in end users' situation in the event of an improved or increased access to grid electricity.

## SURVEY IMPLEMENTATION

Survey team members were hired based on their skills and experience in various aspects of the survey implementation process and a thorough knowledge of local and country-specific context. Roles and responsibilities of the survey team members are outlined below.

### Survey Team Leader/Survey Coordinator

The key role of the survey team leader is to ensure the overall success of the survey activities; to participate in survey instrument development and recruitment of qualified data collection staff including interviewers, supervisors, and data entry staff as needed; to lead interviewer training activities, and development of training materials; to coordinate and synchronise data collection and data entry efforts to finish them in a timely and efficient manner; and draft the survey descriptive report.

### Field Supervisors

The field supervisors are primarily responsible for explaining the project to, and seek cooperation from, the community/local leaders of the selected villages; arrange interview appointments with households and other facilities for the interviewers with the help of local leaders; assign and distribute interviewing assignments to field enumerators, help them locate sample households if needed, and manage field work; ensure collection and accuracy of data by monitoring field interviews; and reviewing completed questionnaires submitted by the field interviewers.

### Enumerators

Field enumerators are tasked to locate target households and carry out the interviews; ensure the accuracy and completeness of the collected data. Before submitting the completed survey forms to their supervisor, the interviewers must ensure that all answers are recorded correctly and legibly. They must consult with their supervisors to resolve any confusion and survey related issues as opposed to making decisions on their own. Enumerators are prepared to revisit a household if they discover any missing or incomplete items.

### Field Work Organisation

The field work was organized with 7 teams, each composed of 1 supervisor, 6 enumerators and 1 driver. Field work lasted 18 days including a provision of 2 days for traveling to remote villages. Each team visited two villages per day and filled 14 questionnaires per village (10 households, 1 school, 1 health facility and 2 formal businesses). This represents a daily work of 4 questionnaires filled per enumerator per day.

Prior to implementation, the route and survey organisation were discussed with the local partner to optimise the field work budget and to reduce the risk on data collection.

**TABLE 7-8**

FIELD WORK ORGANISATION

| ITEM | VALUE |
|---|---|
| Total number of questionnaires | 2700 |
| Number of days of field survey | 16 |
| Number of days provisioned for travelling | 2 |
| Total number of days | 18 |
| Number of teams | 7 |
| Number of supervisors per team | 1 |
| Number of enumerators per team | 6 |
| Number of questionnaires per village | 15 |
| Number of villages per day per teams | 1 to 2 |
| Number of daily questionnaires per team | 24 |
| Number of daily questionnaires per enumerator | 4 |

# 6 CORPORATE SOCIAL RESPONSIBILITY PROJECTS CONDUCTED BY KIVUWATT

**TABLE 7-9**

A COMPREHENSIVE SAMPLE OF CSR PROJECTS UNDERTAKEN BY KIVUWATT SINCE 2016 [11]

| CSR PROJECT | DATE OF COMPLETION | PROJECT DESCRIPTION |
|---|---|---|
| Community health education | June 2016 | Promotion of safety and environmental projects to extend the education on HIV/AIDs, their prevention and their control among staff and the surrounding communities |
| Environmental museum | 2018 | Provision of credible information about the KivuWatt Gas extraction project at Kibuye's Environmental Museum to educate the public on its good practice and environmental responsibilities |
| Children playground | 2018 | Provision of recreation equipment to children in the community on land donated by the local government |
| Improvement on accessibility to clean water | July 2017 | Currently in Kibuye, many of the residents who are mainly peasant farmers and fishermen do not have access to clean water. To meet this issue, KivuWatt built 5 water collection points across the village to improve accessibility to clean water |
| Improvement of Emergency Facility at Kibuye Hospital | 2018 | The emergency department at the Kibuye Hospital, which is the main referral hospital at the Karongi District, does not have a functional emergency unit. KivuWatt consequently built an emergency unit at the Hospital Management |
| Donation of computers | 2017 | To promote quality education in the surrounding communities, KivuWatt donated 20 computers and 7 laptops, printers and office furniture to five primary schools and provided training to teachers and pupils |
| Provision of firewood | Ongoing since 2017 | Provision of two trucks of firewood every two weeks to the Kiziba refugee camp to help minimise the pressure on the environment due to high demand of wood-based energy |
| Dischargeable latrine project | March 2016 | To improve the health conditions of the refugees, KivuWatt donated USD $16,000 to the American Refugee Committee for the construction of a dischargeable latrine |
| Water sampling and testing | Ongoing since 2017 | KivuWatt has ongoing water sampling and testing projects for the refugee camp in partnership with American Refugee Committee |
| Cow Donation | Ongoing since 2017 | KivuWatt donated 43 high breed cattle as a way of eradicating poverty through milk production and organic manure for subsistence farming |
| Pre-primary school Refurbishment | 2017 | KivuWatt refurbished Kibuye's only pre-primary school, thus giving pupils access to education |
| School Library project | 2017 | KivuWatt built five school libraries to five primary schools in the Bwishyura sector. Thanks to these libraries, students are equipped with educational books for the benefit of their professional career |
| Refurbishment of a kitchen for Bisesero Secondary school | 2018 | The Bisesero Secondary School's kitchen was fully refurbished in December 2018, increasing food security |
| UCOPEVEKA Fish Farming Project | From 2018 onwards | Large ISAMBAZA and Tilapia fish are being harvested in ground ponds and underwater cages in Lake Kivu to increase production intensity. This project aims to generate income for 25 fishermen of 4 fishing cooperatives |
| Donation of sterilisation and ironing unit to Kibuye Hospital | 2018 | KivuWatt donated USD$42,000 worth sterilisation and ironing units to Kibuye Hospital, the only hospital of the region to improve hygiene and healthcare services for the Western Province |

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