

OCTOBER 2019

Off-Grid Solar Market Assessment

Rwanda

Power Africa Off-grid Project

ABOUT POWER AFRICA

The Power Africa Off-grid Project is a four-year program that launched in November 2018 to accelerate off-grid electrification across sub-Saharan Africa. RTI International implements the project in collaboration with Fraym, Norton Rose Fulbright, Practical Action Consulting, and Tetra Tech. Power Africa is comprised of 12 U.S. Government agencies, over 145 private companies, and 18 bilateral and multilateral development partners that work together, supporting sub-Saharan governments to increase the number of people with access to power.

Power Africa aims to achieve 30,000 megawatts of new generated power, create 60 million new connections, and reach 300 million Africans by 2030.

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Abbreviations and Acronyms

AB	Swedish term for limited company (Aktiebolag)
AC	Alternating current
ACE	Africa Clean Energy
AfDB	African Development Bank Group
AG	German public limited company (Aktiengesellschaft)
ALCB Fund	African Local Currency Bond Fund
BIO	Belgian Investment Company for Developing Countries (Belgische Investeringsmaatschappij voor Ontwikkelingslanden)
BMZ	German Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
BPR	People's Bank of Rwanda (Banque Populaire du Rwanda)
BRD	Development Bank of Rwanda (Banque Rwandaise de Développement)
BTG	Beyond the Grid Solar Fund
BV	Abbreviation for a Dutch private company (besloten vennootschap)
C&I	Commercial and industrial
CAPEX	Capital expenditure
CBEA	Cross Boundary Energy Access
CBF	Competitive Business Facility
CDC	Commonwealth Development Corporation (UK)
CMU Africa	Carnegie Mellon University Africa
CPP	Captive power plant
DC	Direct current
DCA	Development Credit Authority
DEG	German Investment Corporation (Deutsche Investitions- und Entwicklungsgesellschaft)
DESCO	Distributed energy service company

DFI	Development finance institution
DFID	UK Department for International Development
DGIS	Directorate General for International Cooperation (Netherlands)
DIV	Development Innovation Ventures
DRC	Democratic Republic of the Congo
E-SWAP	Energy Sector Wide Approach Program
E4I	Energy4Impact
EAC	East African Community
EDCL	Energy Development Corporation Limited
EDFI	European Development Finance Institutions
EEP	Energy and Environment Partnership
EFSD	European Fund for Sustainable Development
EICV5	Fifth Rwanda Integrated Household Living Conditions Survey (Enquête Intégrale sur les Conditions de Vie des ménages) completed in 2016-2017
EnDEV	Energising Development
EPD	Energy Private Developers
ESMAP	Energy Sector Management Assistance Program
ESSP	Energy Sector Strategic Plan
EUCL	Energy Utility Corporation Limited
EUR	Euro
FEI OGEF	Facility for Energy Inclusion Off-Grid Energy Access Fund
FI	Financial institution
FMO	Netherlands Development Finance Company (Nederlandse Financierings-Maatschappij voor Ontwikkelingslanden N.V.)
FONERWA	National Fund for Environment in Rwanda (Fonds national pour l'environnement au Rwanda)
GBP	Pound sterling
GDP	Gross domestic product

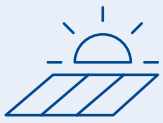
GIZ	German Society for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit)
GOGLA	Global Off-Grid Lighting Association
ha	Hectare
ICT	Information and communications technology
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IGM	Infrastructure Gender Mainstreaming Strategy
IPP	Independent Power Producer
IT	Information technology
KfW	Credit Institute for Reconstruction (Kreditanstalt für Wiederaufbau), also known as the KfW Development Bank
kW	Kilowatt
kWh	Kilowatt-hour
m	Meter
MFI	Microfinance institution
MIGEPFROF	Ministry of Gender and Family Promotion
MININFRA	Ministry of Infrastructure
MOU	Memorandum of Understanding
MTF	Multi-Tier Framework
MTN	Mobile Telephone Network (cell phone provider)
MW	Megawatt
N/A	Not applicable
NDF	Nordic Development Fund
NEFCO	Nordic Environment Finance Corporation
NEP	National Electrification Plan
NISR	National Institute of Statistics Rwanda
NST	National Strategy for Transformation

OPEC	Organization of the Petroleum Exporting Countries
OPIC	Overseas Private Investment Corporation
PAOP	Power Africa Off-grid Project
PAYGO	Pay-as-you-go
PPA	Power purchase agreement
PV	Photovoltaic
QV	Quality Verified
RBF	Results-based financing
RDB	Rwanda Development Board
REF	Renewable Energy Fund
REG	Rwanda Energy Group
RES	Rural Electrification Strategy
RSB	Rwanda Standards Board
RURA	Rwanda Utilities Regulatory Authority
RVO	Netherlands Enterprise Agency (Rijksdienst voor Ondernemend)
RWF	Rwandan Franc
SACCO	Savings and credit cooperative organization
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goals
SE4All	Sustainable Energy for All
SECO	Swiss State Secretariat for Economic Affairs
SET Fund	Solar Energy Transformation Fund
SHS	Solar home system
Sida	Swedish International Development Cooperation Agency
SIMA	Social Investment Managers and Advisors
SIR	Solar Irrigation in Rwanda
SME	Small and medium enterprise

SOGE	Scaling Off-Grid Energy
SOGER	Scaling Up Off-Grid Energy in Rwanda
SWG	Sector Working Group
TPG	Texas Pacific Group
TV	Television
TVET	Technical and vocational education and training
TWG	Technical Working Group
UKAid	United Kingdom Aid
UNDP	United Nations Development Programme
USAID	U.S. Agency for International Development
USD	U.S. Dollar
VAT	Value-added tax
WC	Working capital
WDA	Workforce Development Authority
WIRE	Women in Rwandan Energy
Wp	Watt-peak

INTRODUCTION

This report by Power Africa provides insights into the opportunities and risks associated with Rwanda's off-grid solar energy market and gives companies, investors, governments, and other stakeholders a deeper understanding of the market. While other stakeholders (i.e., development partners) have conducted market assessments, Power Africa has identified market information gaps and seeks to bridge those gaps in the following ways:



This report provides a comprehensive and detailed review of solar home systems (SHSs), mini-grids, productive use of energy, and other aspects of the off-grid solar value chain. Additionally, this report includes details on policy and regulatory issues, the structure and historical context of the energy sector, and gender mainstreaming.



This report draws upon the most up-to-date sales and investment data from GOGLA in order to keep pace with the ever-changing dynamics of the off-grid solar sector. It also includes a geospatial analysis that highlights potential areas for off-grid solar market expansion.



Insights in this report help Power Africa Off-grid Project (PAOP) plan and prioritize activities across work streams of policy and regulations, market intelligence, business performance, access to finance, and cross-sectoral integration throughout sub-Saharan Africa.

The report also serves as a baseline for Power Africa's technical advisors to guide their continuing work and provides a snapshot that can be used to determine growth and changing dynamics of the market over time. Insights provided in this report include characteristics of Rwanda's electricity sector, electrification targets, government regulations, donor-funded activities, and details on subsectors of the off-grid solar energy market. Additionally, this report includes expert knowledge from Power Africa lead advisors, information gathered from stakeholder interviews, and data from the Global Off-Grid Lighting Association (GOGLA).

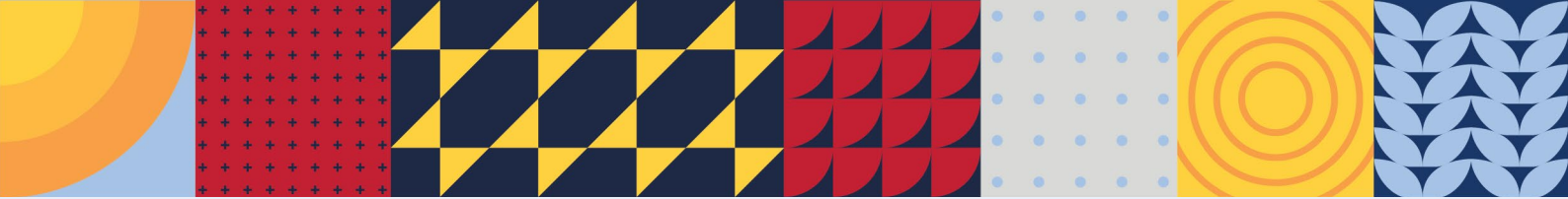
About Power Africa and the Power Africa Off-grid Project (PAOP)

Power Africa aims to accelerate off-grid electrification across sub-Saharan Africa through targeted, context-specific interventions with private-sector companies, governments, investors, and donors. Power Africa's goal is to increase electricity access by adding 30MW of new generation capacity, and 60 million new connections through grid and off-grid solutions by 2030. The goal of the Power Africa Off-grid Project is to provide support to private off-grid companies and make the markets in sub-Saharan Africa more attractive for investment and operations. Power Africa defines "access" as the direct or actual number of new households and businesses connected to electricity via an on- or off-grid solution. The project focuses on accelerating off-grid energy access through household SHSs and mini-grids, with the goal of facilitating six million new connections by 2022. The project aims to accelerate off-grid electrification across ten focus countries in Africa: Cameroon, the Democratic Republic of the Congo, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Niger, Rwanda, Senegal, and Tanzania. Figure ES-1 identifies the countries in Africa receiving Power Africa support, with the focus countries highlighted. The pins represent the locations of the project's in-country advisors.

FIGURE ES-1. THE PROJECT PROVIDES SUPPORT TO 20 COUNTRIES IN AFRICA



The Power Africa Off-grid Project (PAOP) is a Power Africa project funded by the U.S. Agency for International Development (USAID). Power Africa brings together technical experts with stakeholders from the public and private sectors to increase energy access rates in sub-Saharan Africa. The Power Africa Off-grid Project is implemented by RTI International and headquartered in Pretoria, South Africa.



I EXECUTIVE SUMMARY

Rwanda has made substantial progress towards its goal in energy access, moving from 6 percent on-grid access in 2000 to 37 percent on-grid access in 2019. Despite this impressive progress, the low starting point represents an opportunity for the off-grid sector to flourish. It has already reached 14 percent of the population. These numbers indicate that although other countries may have larger markets in terms of absolute size, the impacts of the off-grid sector within the overall energy sector are very high in Rwanda. The Government of Rwanda (GOR) has also shown its commitment to the off-grid sector by setting a target for 48 percent of the population to be served by an off-grid product by 2024.

To date, small solar home systems (SHSs), sold through a pay-as-you-go (PAYG) model, have dominated the off-grid sector, which is a situation similar to other markets in East Africa. However, according to results from the Fifth Integrated Household Living Conditions Survey (EICV5), the ability to pay is low in Rwanda. The survey shows that 75 percent of off-grid households spent less \$1.67 per month on lighting and telephone charging. This constraint has been recognized by GOR, which is working with development partners to design a subsidy.

SHS market. In Rwanda, 14 percent of the population is electrified through an off-grid solution. According to the Global Off-Grid Lighting Association (GOGLA), more than 800,000 solar products have been sold in Rwanda since 2014. Some of these solar products count toward the definition of access and some do not. The issue regarding the ability to pay means that a vast majority of solar products sold in Rwanda to date are small, as 97 percent of SHSs and solar lanterns sold are 10 watt-peak (Wp) or smaller. Considering the 48-percent target for off-grid access, the total addressable market size for off-grid in Rwanda is approximately 1.4 million households through 2024. Five companies occupy more than 90 percent of the market share as of 2017. Sales volumes grew quickly until mid-2017, which were then followed by a slight downturn and have since flattened. Some of the major reasons cited for this fluctuation include regulatory uncertainty, free distribution of SHSs by the government, and affordability, as the easiest-to-reach customers have already been served.

To address affordability concerns, GOR has been in discussion with development partners to implement a results-based financing program to subsidize the cost of a system that qualifies as household access as per GOR's guidelines. GOR is designing the program according to its socioeconomic metric "Ubudehe," which determines support received from other poverty reduction programs. The program aims to make SHSs affordable for poorer households.

Financing for the SHS sector is similar to neighboring countries in East Africa. Most of the financing comes from international sources, and a significant portion coming from development finance institutions, impact investors, and specialized investment funds. One source that has increased in its importance over the past few years has been crowdfunding. In 2018, crowdfunding supplied more than \$19 million of funding in East Africa, up from \$2.5 million in 2017, and \$0 in 2015.

Local financing only comprised a small percentage of the overall funding for these companies. However, the \$48.9-million World Bank Renewable Energy Fund (REF), launched in 2017, is designed to support the development of local debt financing by providing funding to commercial banks, savings and credit cooperative organizations (SACCOs), and microfinance institutions. The fund will also provide direct lending to SHS companies and mini-grid developers.

Mini-grid overview. Because of the country's high population density, mini-grids hold significant promise for the Rwandan market, though there are only a handful in use to date. There are now several mini-grid developers active in the country, and more are expressing interest in entering the sector. Regulations passed in 2015 address many of the typical concerns involving mini-grids, such as licensing, tariffs, and provisions for grid arrival. The primary cause for delays was GOR's effort to identify off-grid areas for the National Electrification Plan (NEP), which went through a few iterations. The NEP was finalized in June 2019, deployment is expected to continue now that developers have clarity about where they can build. Because of low demand in rural areas and high upfront costs, an estimated 40 to 70 percent of the capital expenditure (CAPEX) must be subsidized for a mini-grid to be economically viable. Support to the mini-grid sector has focused on grants for CAPEX and productive use. In addition, the World Bank REF has a window to support developers through debt financing.

Agricultural and productive-use solar sector overview. The productive-use sector is at an early stage in Rwanda, and most companies and projects are running pilot projects or completing research. Several different technologies have been tested, including solar egg incubation, off-grid cold storage, and solar irrigation. In addition, demand stimulation activities for mini-grids have focused on productive-use activities, such as refrigerators, popcorn machines, milling, welding, and tailoring. In Rwanda, solar irrigation and off-grid cold storage are the closest to being viable at scale. If the market develops further, solar irrigation may be economically viable for farmers.

2 COUNTRY CONTEXT

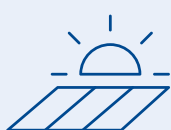
Rwanda has developed a reputation for being one of the safest and most corruption-free countries in Africa in recent years. High gross domestic product (GDP) growth rates have seen the GDP per capita jump from \$218 in 1995 to \$748 in 2017.¹ This increase reflects the progress that the country has made in the 25 years since the genocide against the Tutsi. The economy has become significantly larger and more diversified, with notable improvements in tourism, information technology (IT) services, and manufacturing. The demographics of the Rwandan population are presented in Table I.

TABLE I. RWANDAN DEMOGRAPHIC INFORMATION

Population size	12,187,400 (2018 est.)
Population density	495 people/km ²
Population growth rate	2.3%
Household size	4.3
Number of female-headed households	31%
Urban/rural populations	17.2% urban 82.8% rural
Rate of urbanization	2.9% annual rate of change
Local and main languages spoken	Kinyarwanda, English, French, Kiswahili

Sources: ²

For these industries to function and grow, a reliable electricity supply is required, and Rwanda has made significant progress in developing its electricity sector by increasing access and adding additional generation capacity.



The off-grid sector has matured in recent years, and it now plays a key role in electricity access efforts with government plans expecting an even more substantial role in the future.

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¹ The World Bank, “GDP Growth.”

² The World Factbook, “Africa : Rwanda”; The World Bank, “Population Density”; United Nations, “Household Size and Composition Around The World 2017.”

TABLE 2. INFORMATION ABOUT RWANDA'S ECONOMY

GDP per capita	\$748 (2017)
Main industries	Cement, agricultural products, small-scale beverages, soap
Main agricultural products	Coffee, tea, pyrethrum, bananas, beans, sorghum, potatoes, livestock
Main exports	Coffee, tea, metal ore
Main areas of employment	Agriculture: 66.6% Industry: 8.8% Services: 24.6%
Land usage	Agricultural land: 74.5% Forest: 18% Other: 7.5%

Sources: ³

2.1 POLITICAL LANDSCAPE

In the period following the genocide against the Tutsi in 1994, Rwanda has achieved stability and experienced sustained growth, with an average growth rate of 7.2 percent since 2010.⁴ The Rwandan government is well-known for its stability and efficiency because of its aggressive efforts to eliminate corruption. Public-sector institutions are highly results-driven, with leaders at each level of government and in each sector required to develop and sign performance contracts, or “imihigo”.⁵ This requirement has helped to establish an environment in which results are expected, and if targets are not met, the official in charge faces consequences (and is replaced if they continue to exhibit performance issues). It is against this backdrop that the energy sector has improved from 6 percent electrification in 2000 to over 50 percent (on- and off-grid) today.⁶

³The World Bank, “GDP per Capita”; The World Factbook, “Africa : Rwanda”; OEC, “Rwanda (RWA) Exports, Imports, and Trade Partners”; The World Bank, “Employment in Agriculture.”

⁴The World Bank, “GDP Growth.”

⁵Think Tank Initiative, “IPAR-Rwanda: Evaluating Performance Contracts (Imihigo) That Improve the Lives of Rwandans.”

⁶The World Bank, “Access to Electricity.”

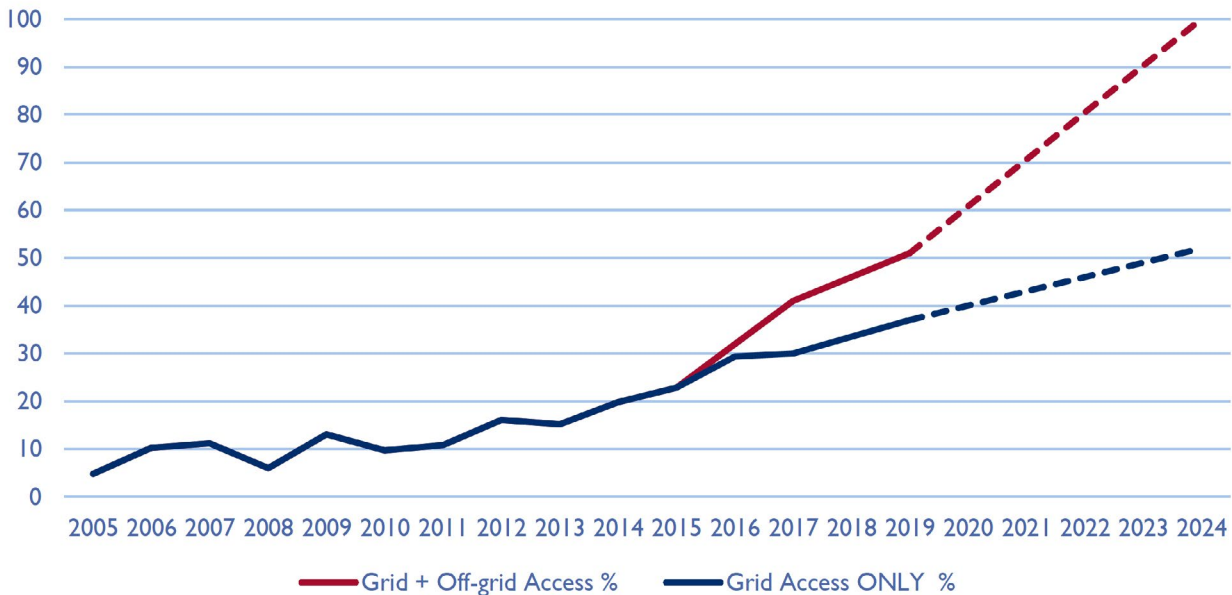
3 ENERGY SECTOR OVERVIEW

Compared to other countries over the same period, Rwanda had a low starting point for electrification, with only 6 percent of the population having access in 2000.⁷ In comparison, today, 51 percent of the population has energy access—either through the grid (37 percent) or a solar home system (SHS) or mini-grid (14 percent)—a clear demonstration of the country’s progress in this area. The government is targeting 2024 for universal electrification, with 52 percent on-grid and 48 percent off-grid.⁸ However, the energy sector’s growth is hampered by a combination of high tariffs and low demand.⁹ Rwanda had planned to have 563 megawatts (MW) of generation capacity by 2018, but these barriers led the country to scale back its target to avoid oversupply issues.¹⁰ The current generation capacity is 218 MW.¹¹

3.1 FUTURE ELECTRIFICATION TARGETS

Rwanda has been aggressively working to achieve universal access by 2024 and has made impressive progress to date. The country has taken a unique path toward this goal, targeting a large part of the population for off-grid electrification (48 percent) to meet the universal electrification goal in the quickest and most cost-effective way. Figure I shows the progress that Rwanda has made, as well as expected targets through 2024 for both grid connections and on- and off-grid access combined.

FIGURE I. ENERGY ACCESS IN RWANDA FROM 2005 TO 2019 AND THE FORECAST TO REACH THE TARGET FOR UNIVERSAL ACCESS IN 2024



Source: World Bank 2017a and Ministry of Infrastructure 2018d

⁷ The World Bank.

⁸ Ministry of Infrastructure, “Government of Rwanda Committed to Achieving Universal Energy Access by 2024.”

⁹ Bimenyimana, Asemota, and Li, “The State of the Power Sector in Rwanda.”

¹⁰ Climatescope, “Climate Scope 2017 - The Clean Energy Country Competitiveness Index.”

¹¹ Power Africa, “Rwanda Energy Sector Overview.”

3.2 POPULATION DENSITY

Two characteristics that distinguish Rwanda from many countries in Africa are its population density and the relatively uniform geographic distribution of its population. Indeed, Rwanda has the highest population density in continental Africa at 494 people per km².¹² This high population density gives Rwanda an advantage in terms of cost per household to connect to the grid (currently estimated at \$700–800). Furthermore, although the capital (Kigali) with a population of approximately 1 million residents, represents a substantial portion of the total, Rwanda’s population is spread across the country relatively evenly, with population density ranges from 178 to 2,124 people per km². Even the least populated district would rank fifth in population density in continental Africa and compared to that district, the population densities in the vast majority of Rwanda’s districts are considerably higher.

The population density affects more than just the average cost to connect a household. First, because the main transmission and distribution lines have already been installed, much of the remaining population to be connected to the grid by 2024 will gain access through densification efforts rather than extension projects. Indeed, only approximately 1 million people (217,000 households representing 8% of the population) live more than 15 km from the current grid.¹³ As long distances from the grid are often cited by mini-grid developers as protection from the threat of grid encroachment, this situation limits the areas in which mini-grids can be practically deployed in the country.

Second, it is important to clearly define on- and off-grid areas because most villages in the country are located close to the grid. Information about which areas are on-grid vs. off-grid has some importance for SHS companies if subsidies are only available in off-grid areas. In contrast, this information is critical for mini-grids, as significant upfront investments are required, and the developer must bear the loss if grid access becomes available. Because grid encroachment may occur, even in areas the government has demarcated as off-grid, proper regulations must be in place to compensate mini-grid developers if the grid arrives within a defined time period.

3.2.1 DEFINITION OF ACCESS

In its Rural Electrification Strategy (RES), the Rwandan government uses the SE4All Multi-Tier Framework to define targets for electrification. Unlike many countries, Rwanda’s universal access target includes off-grid solutions. Currently, the plan is to have 52 percent of households connected to the grid and 48 percent with at least a Tier 1 off-grid connection (either SHS or mini-grid).¹⁴

The multi-tier framework is summarized in Table 3. Tier 1 is the target for households classified as off-grid.

TABLE 3. MULTI-TIER FRAMEWORK SUMMARY DESCRIPTIONS OF DIFFERENT CONNECTION TIERS

LEVEL	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Energy usage	Household lighting, radio, and phone charging	Household lighting, radio, phone charging, and basic appliances (e.g., televisions, fans)	Tier 2 plus medium appliances, such as low-power refrigeration	Tier 3 plus high-power appliances, such as pumps for irrigation	24/7 power suited to commercial and industrial uses
Minimum hours of access per day	4 hours	4 hours	8 hours	16 hours	23 hours

¹² The World Bank, “Population Density.”

¹³ EnergyData.Info, “Off-Grid Market Opportunities.”

¹⁴ Ministry of Infrastructure, “Rural Electrification Strategy.”

In addition to its definition of access, Rwanda has specified a minimum level of service and minimum system performance standards for SHSs, as discussed in Section 5.4.1.

3.3 GRID ELECTRIFICATION SUMMARY

3.3.1 GRID CONNECTIONS

Table 4 provides Rwanda’s grid connection statistics. Even with the progress in grid electrification, only 17.7 percent of rural households are connected to the grid, and many of these households are candidates for off-grid products.

TABLE 4. GRID CONNECTION STATISTICS

National grid access rate	34% (April 2019 [REG])
Number of grid-connected customers in urban areas	80% (Global Off-Grid Lighting Association [GOGLA])
Number of grid-connected customers in rural areas	17.7% (GOGLA)
Percentage of population more than 15 km from the grid	8%

Source: ¹⁵

3.3.2 UTILITIES

Rwanda Energy Group (REG) is the national electrical utility with two subsidiaries, EUCL and EDCL. These subsidiaries utilize a model that differs from the typical way that utility functions are unbundled (i.e., generation, transmission, and distribution). Specifically, EUCL handles the day-to-day operations of government-owned power plants and the grid, while EDCL is responsible for “big picture” long-term planning for all parts of the grid (except for direct connections to customers) and the development of new sources of electricity, including those that provide off-grid access.¹⁶

Rwanda Energy Group (REG)

REG holds a monopoly on transmission and distribution in the country, and supplies approximately 120 MW of the 220 MW of capacity currently connected to the grid.^{17 18} REG relies on two subsidiaries to operate and develop Rwanda’s electricity system: Energy Utility Corporation Limited (EUCL) and Energy Development Corporation Limited (EDCL). These subsidiaries officially operate independently of REG, which is responsible for coordination and monitoring.

EUCL

EUCL’s two main functions are to maintain the electrical grid—including publicly owned generation, transmission, and distribution—and to manage the sale of electricity to customers. Thus, EUCL is responsible for optimizing generation dispatch, improving operational efficiency, and increasing the number of connections. EUCL also plays a key role in the execution of power purchase agreements and holds importing and exporting power.¹⁹

¹⁵ EnergyData.Info, “Off-Grid Market Opportunities.”

¹⁶ Rwanda Energy Group, “Rwanda Energy Group: History.”

¹⁷ Economic Regulation Unit, “Electricity Statistics Report as of December of the Year 2018.”

¹⁸ Author calculation based on Economic Regulation Unit, Electricity Statistics Report 2018.

¹⁹ Economic Regulation Unit, “Electricity Statistics Report as of December of the Year 2018.”

EDCL

EDCL's main tasks are to manage investments into new generation projects to meet national targets, ensure that the proper transmission infrastructure is in place, and execute energy access projects, including those involving off-grid solutions.

3.3.3 GRID TARIFFS

Grid tariffs in Rwanda are high, largely because of the high cost of generation and low demand. Even at current levels, these tariffs are subsidized to make them affordable for households and to ensure that industrial and commercial businesses remain viable.

The high cost of generation is attributable to the fact that diesel power plants currently make up 27 percent of total installed capacity²⁰ and are required during peak demand hours.²¹ In addition, REG has signed a number of "take-or-pay" contracts, further raising the net price.²² In 2014, the World Bank estimated that the true cost of electricity service in Rwanda was \$0.43/kWh.²³ Because of these issues, grid tariffs are subsidized by the government, which is also under pressure from both industry and households to lower tariffs as Rwanda has the highest tariffs in East Africa.²⁴

On the residential side, REG introduced a lifeline tariff in January 2017 for the first 15 kWh/month at RWF89/kWh,²⁵ which is almost half the rate charged for the higher tiers.²⁶ Table 5 presents the tariffs for residential customers. The connection cost is RWF56,000 if the customer's house is within 37 meters of the grid (no additional pole required – the most common situation), with additional charges associated with greater distances.²⁷

TABLE 5. RESIDENTIAL ELECTRICITY TARIFFS

ELECTRICITY TARIFFS FOR RESIDENTIAL CUSTOMERS BY KILOWATT HOURS (KWH) (18% VALUE-ADDED TAX [VAT] EXCLUDED)

0–15 kWh	RWF89/kWh
15–50 kWh	RWF182/kWh
>50 kWh	RWF210/kWh

3.3.4 QUALITY OF GRID SERVICE

While grid reliability is generally better in Rwanda than in other African countries, reliability remains an issue for customers and may encourage some households to seek alternatives for backup. The World Bank Multi-Tier Framework (MTF) survey found that 50.4 percent of households receive electricity for less than 23 hours per day, seven days per week, and that 76.7 percent of households experience four or more interruptions per week.²⁸

3.3.5 ELECTRICITY CONSUMPTION LEVELS

Residential expenditure on electricity in Rwanda is quite low, with an average monthly consumption of only 9.9 kWh per month in rural areas and 29.2 kWh per month in urban areas, well below the 130–140 kWh per month that would be required for the utility to break even on the investment required to extend the

²⁰ Economic Regulation Unit.

²¹ Rwanda Energy Group, "Thermal."

²² BloombergNEF, "Climatescope 2018: Rwanda."

²³ The World Bank, "Renewable Energy Fund- Implementation Status & Results Report."

²⁴ Bimenyimana, Asemota, and Li, "The State of the Power Sector in Rwanda."

²⁵ Using exchange rate of RWF905/US\$1 as of May 17, 2019

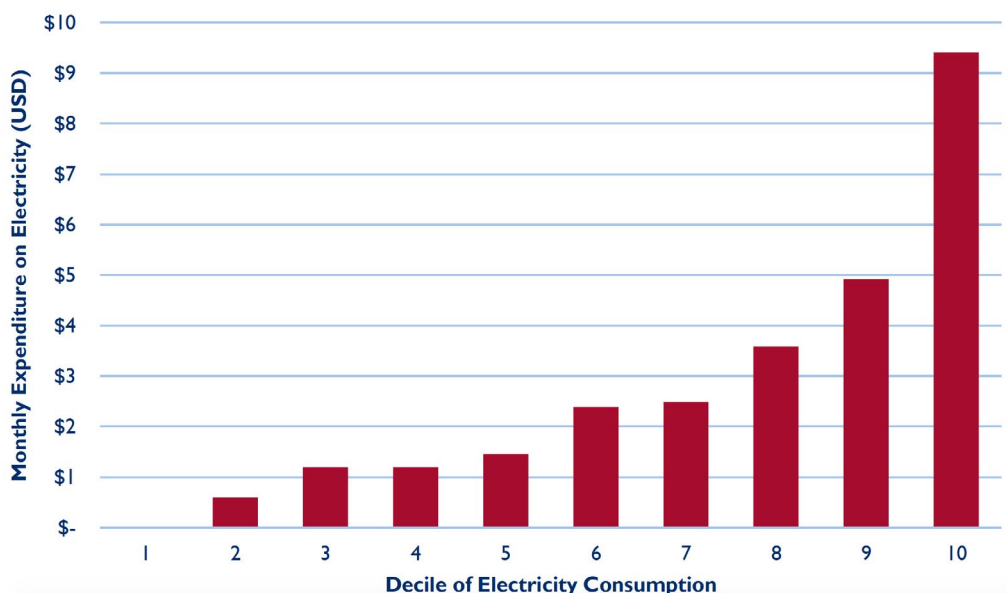
²⁶ Rwanda Energy Group, "ELECTRICITY NEW TARIFF."

²⁷ Rwanda Energy Group, "New Connection Process."

²⁸ Ministry of Infrastructure, "Rwanda: Energy Access Diagnostic Results Based on Multi-Tier Framework."

grid.²⁹ Thus, the government ultimately provides a fairly high subsidy to each new rural residential connection. Cheaper off-grid solutions that are more appropriately sized to meet customer demand are, therefore, a potentially cost-effective means to provide access to many rural households. Figure 2 plots households' monthly expenditure on electricity in terms of their electricity consumption.

FIGURE 2. MONTHLY HOUSEHOLD GRID ELECTRICITY EXPENDITURE BY ELECTRICITY CONSUMPTION



Source: The authors based this analysis on microdata provided publicly by the National Institute of Statistics in Rwanda. Annex B describes the methodology in detail.

3.3.6 ELECTRICITY SOURCE MIX

Rwanda's main electricity source has long been hydropower, but recently, the diversity of its sources increased to include some unique alternatives. First, Rwanda has started to extract and exploit the methane reserves under Lake Kivu on its western border, most notably through Project KivuWatt (26 MW), and there are plans for more such projects in the future. Rwanda has also been developing peat-to-power as an additional source as the country's peat reserves are sufficient to generate 150 MW for 30 years.³⁰ Diesel and solar are other significant generation sources.³¹

3.4 RELEVANT LAWS, POLICIES, AND REGULATIONS

3.4.1 VISION 2020 AND VISION 2050

Vision 2020 is a policy document that was originally developed in 2000 to describe the future envisioned for Rwanda in 2020. It outlines a path for Rwanda to become a middle-income country by 2020³². Vision 2050 is a similar document that aims for Rwanda to become an upper-middle-income country by 2035 and an upper-income country by 2050 and specifies measures needed to achieve the required GDP growth rate of

²⁹ Ministry of Infrastructure, "Energy Sector Strategic Plan 2018/19-2023/24."

³⁰ Rwanda Energy Group, "Peat."

³¹ Rwanda Energy Group, "Installed Generation Capacity on the National Grid."

³² Republic of Rwanda, "Rwanda Vision 2020 - Revised 2012."

over 10 percent annually.³³ All lower-level policies, including energy-related ones, must align with the high-level goals outlined in these documents.

3.4.2 NATIONAL STRATEGY FOR TRANSFORMATION I (NSTI) 2017

The NSTI is the overarching national strategy document for the seven-year period from 2017 to 2024, which coincides with the presidential term of office. This strategy outlines goals in the areas of economic, social, and governance transformation. A key point under social transformation is access to modern infrastructure, including electricity.

3.4.3 ENERGY SECTOR STRATEGIC PLAN (ESSP) 2018

The ESSP is updated every six years, provides a snapshot of the current status of the energy sector, and presents plans for the next six-year period. This plan is one of the key documents that defines activities and targets for Rwanda's entire energy sector, including the electricity, biomass, and petroleum subsectors. The high-level objectives to be met by 2024 related to electricity are:³⁴

- › Electrical generation capacity meets demand and has a 15 percent reserve margin (note that since the publication of the ESSP, the Ministry of Infrastructure, MININFRA, now quotes a target of 556 MW).
- › Power interruptions are reduced to 14.7 per year, and average time without power per year is reduced to 91.7 hours.
- › 100 percent of households have access to electricity.
- › 100 percent of productive users have access to electricity.
- › Major national and urban roads have streetlights installed.

3.4.4 NATIONAL ELECTRIFICATION PLAN (NEP)

The NEP categorizes each village in Rwanda to be electrified by grid, mini-grid, or SHS by 2024. It is critically important to the private sector that mini-grid projects only be allowed in mini-grid areas and subsidies for SHS only be available in SHS areas, although the systems can be sold anywhere. Further detail on the NEP is provided in Section 4.2.2.

3.4.5 ELECTRICITY LAW (LAW N°21/2011 OF 23/06/2011 GOVERNING ELECTRICITY IN RWANDA; MODIFIED IN 2018)

licensing requirements. It also governs the determination of tariffs³⁵. This law was modified in 2018 to include notable provisions that assign the responsibility for determining tariffs to the regulator, the Rwanda Utilities Regulatory Authority (RURA), in consultation with MININFRA, and it also defines penalties for criminal offenses relating to electricity.³⁶

³³ Rubangura, "THE RWANDA WE WANT: TOWARDS 'VISION 2050.'"

³⁴ Ministry of Infrastructure, "Energy Sector Strategic Plan 2018/19-2023/24."

³⁵ Ministry of Infrastructure, "Laws, Policies and Regulations."

³⁶ Ministry of Infrastructure, "Law N°21/2011 of 23/06/2011 Governing Electricity in Rwanda; Modified in 2018."

3.4.6 RES

In June 2016, MININFRA released the RES, which outlines how the government plans to provide electricity access to the rural population structured in four program areas:

1. Establish a mechanism for low-income households to access electricity.
2. Establish a risk-mitigation facility that lowers the risk for the private sector to provide solar products and lowers the price paid by the population to an affordable level.
3. Enable mini-grids developed by the private sector with support from the government to establish a framework that ensures their viability and appropriate site identification.
4. Continue rolling out the electrical grid, focusing on areas with high consumption potential that will drive economic growth.

The RES also established the use of the SE4All Multi-Tier Framework described above. Note that the most recent ESSP revised several of the targets established in this document, including the on-grid and off-grid access targets. In addition, since its development, progress has been made to further develop some of these plans, as described in several of the initiatives outlined below.³⁷

3.4.7 RWANDA ENERGY POLICY (2015)

This document provides the overall policy direction for the energy sector with a long-term vision for the state of the sector. The overarching policy goals are as follows:³⁸

- › Ensuring the availability of energy.
- › Creating an enabling environment for increased private-sector participation.
- › Encouraging the efficient use of energy.
- › Preserving the environment during all energy-related activities.
- › Promoting the safe, efficient, and competitive production, procurement, transportation, and distribution of energy.
- › Developing the requisite institutional, organizational, and human capacity related to energy.

3.4.8 TAX AND IMPORT DUTY EXEMPTIONS

Rwanda has adopted friendly policies in this area, with solar products qualifying for exemptions in both import duties and VAT. As part of the East African Community (EAC), Rwanda has adopted the common agreement among these countries to exempt “Specialized equipment for development and generation of solar and wind energy, including accessories and deep cycle batteries which use and/or store solar power.” In addition, in 2015, the Ministry of Finance and Economic Planning added solar components and related accessories to the list of exempted items for VAT. Clean energy projects do have to pay a 5 percent cost, insurance, and freight tax.³⁹ However, spare parts and accessories, including appliances, are no longer exempt from import duty, which has caused price increases in the region.

³⁷ Ministry of Infrastructure, “Rural Electrification Strategy.”

³⁸ Ministry of Infrastructure, “Rwanda Energy Policy.”

³⁹ BloombergNEF, “ClimateScope 2018: Rwanda.”

Some companies have had issues claiming these exemptions in the past, but as clearing agents have become more familiar with the sector, this issue has improved. However, it is recommended that companies hire skilled clearing agents to facilitate this process.⁴⁰

3.4.9 IMPORTATION STANDARDS FOR SHSS

In 2013, GOR adopted the IEC standard “requirements for special installations or locations – Solar photovoltaic (PV) power supply systems” for imported solar products. This standard, which was generally well received, aims to prevent quality assurance issues that might undermine confidence in the industry. However, it applies to component-based solar installations only. Thus, there was a need to adopt Lighting Global and associated IEC standards to ensure the quality of SHS kits, which have become popular in the last five years. In 2018, MININFRA released additional guidelines for SHSs that have concerned some stakeholders. This issue is discussed in more detail in Section 5.4.1.

3.4.10 MINI-GRID REGULATIONS

RURA adopted regulations in 2015 that specify licensing requirements, tariff guidelines, and procedures upon grid arrival.⁴¹ These have been generally well received by private developers, and RURA is in the process of developing the next generation of these regulations, in consultation with developers and other stakeholders.⁴² These regulations are discussed further in Section 6.3.

3.5 GOVERNMENT AND LOCAL INSTITUTIONS

3.5.1 MININFRA

MININFRA’s Energy Division is responsible for energy activities for GOR. MININFRA has supported the off-grid sector in Rwanda, as shown in its official plan to electrify 48 percent of households with off-grid solutions by 2024.

3.5.2 THE MINISTRY OF FINANCE AND ECONOMIC PLANNING

The Ministry of Finance and Economic Planning controls the government’s finances and macroeconomic planning activities. It is responsible for developing both the NST and the government’s poverty-reduction strategies. Its main role in the energy sector is to make decisions regarding government budget allocations and determine regulations related to tax exemptions.

3.5.3 RWANDA DEVELOPMENT BOARD (RDB)

RDB is a key institution for facilitating private sector investment in Rwanda and is influential within the government. Notably, RDB welcomes investors to meet with its officials without an appointment on Fridays and provides a one-stop shop that allows business registration in less than a day.⁴³ In addition, RDB offers a number of incentives to encourage investment in Rwanda, including a preferential corporate income tax rate of 15 percent and a seven-year corporate income tax holiday (for large projects) for the energy sector.

⁴⁴ Because of the country’s focus on creating a positive business environment, including through the efforts of RDB, Rwanda has climbed in the World Bank Doing Business Rankings from 67 in 2010 to 29 in 2019.^{45 46}

⁴⁰ Overseas Development Institute, “Accelerating Access to Electricity in Africa with Off-Grid Solar.”

⁴¹ Rwanda Utilities Regulatory Authority, “Governing The Simplified Licensing Framework for Rural Electrification in Rwanda.”

⁴² International Renewable Energy Agency, “Policies and Regulations for Renewable Energy Mini-Grids.”

⁴³ Rwanda Development Board, “Doing Business Reforms: STARTING A BUSINESS.”

⁴⁴ Rwanda Development Board, “Investment Incentives.”

⁴⁵ World Bank, Doing Business 2010.

⁴⁶ The World Bank, “Doing Business 2019: Training for Reform.”

3.5.4 BANQUE RWANDAISE DE DEVELOPEMENT (DEVELOPPMENT BANK OF RWANDA [BRD])

BRD is Rwanda’s national development bank, and energy has been identified as one of its priority sectors. Its interventions in energy are focused on facilitating improvements in energy generation, energy efficiency, and technical assistance. A key function of BRD within the off-grid sector is its role as the implementing institution of the \$48 million World Bank Renewable Energy Fund (REF) for Rwanda, which is discussed in more detail below.⁴⁷

3.5.5 RURA

RURA is the regulator for Rwanda’s energy sector. Its mandate includes establishing and enforcing regulations, setting tariffs, licensing, and permitting.⁴⁸

3.5.6 NATIONAL FUND FOR ENVIRONMENT IN RWANDA (FONDS NATIONAL POUR L’ENVIRONNEMENT AU RWANDA) OR FONERWA

FONERWA (National Fund for Environment in Rwanda) supports public and private projects that facilitate the transition to a green economy. It received \$5 million in initial support from the United Nations Development Programme (UNDP), \$37 million from the UK Department for International Development (DFID), and \$8 million from Kreditanstalt für Wiederaufbau (KfW), in addition to \$6 million in government support.⁴⁹ In the energy sector, FONERWA supports projects in the areas of renewable energy and energy efficiency.

3.5.7 MINISTRY OF GENDER AND FAMILY PROMOTION (MIGEPROF)

Rwanda has made gender equality a key focus for the government, and it famously has the highest percentage of women in parliament—61 percent—in the world.⁵⁰ In MIGEPROF’s National Gender Policy, it notes the disproportionate effect that energy poverty has on women due to their higher level of involvement in household activities that require electricity. A relevant focus area for off-grid energy is “to ensure that women and men are involved in the development of renewable sources of energy”.⁵¹ This focus is consistent with MININFRA’s new Infrastructure Gender Mainstreaming Strategy outlined in the Section 3.6.

3.5.8 RWANDA STANDARDS BOARD (RSB)

RSB is responsible for setting standards in Rwanda and ensuring conformity to those standards.⁵² Notable for the off-grid sector is their role in evaluating SHS systems against the ministerial guidelines on SHS standards.

3.5.9 ENERGY PRIVATE DEVELOPERS (EPD)

EPD is a trade association and advocacy group for energy companies that falls under the umbrella organization for the private sector in Rwanda, the Private Sector Federation. First announced in 2014, it is currently supported by the U.S. Agency for International Development (USAID) and DFID through

⁴⁷ Development Bank of Rwanda, “Energy Sector.”

⁴⁸ Rwanda Utilities Regulatory Authority, “Electricity.”

⁴⁹ FONERWA, “FONERWA: About.”

⁵⁰ World Economic Forum, “These Countries Have the Most Women in Parliament.”

⁵¹ Ministry of Gender and Family Promotion, “National Gender Policy.”

⁵² Rwanda Standards Board, “The Rwanda Standards Board-RSD.”

the Shell Foundation. It has more than 100 members and has grown significantly since 2016. EPD acts as a bridge between its members, development partners, and the government to represent the interests of the sector. It also acts as a training institution and convener of private-sector players, both on- and off-grid. EPD is a member of Global Off-Grid Lighting Association (GOGLA) and is organized into five subsectors: mini-grids, solar, hydro, clean cooking (biomass/biogas), and liquified petroleum gas.⁵³

3.5.10 DEVELOPMENT PARTNER COORDINATION

MININFRA plays the role of sector coordinator for energy, which involves bringing together all stakeholders, including private sector and development partners. MININFRA achieves this goal through the Energy Sector Wide Approach Program (E-SWAP) Secretariat, which was formed in 2008. Under E-SWAP, the Sector Working Group (SWG) brings together all stakeholders at least twice a year to discuss sector-level issues. There are four Technical Working Groups under the SWG working in specific areas of energy, including generation, access, biomass, and energy efficiency.⁵⁴

3.6 GENDER

As in many other countries, gender inequality exists in the Rwandan energy sector in terms of both employment and access. Female-headed households are less likely to have a grid connection and are approximately twice as likely to use firewood as a lighting source in rural areas.⁵⁵ The inequality in employment is exemplified by the fact that women make up just 18 percent of REG's employees.⁵⁶ Given the underrepresentation of women generally in the energy sector, some gender initiatives have focused on the employment of women as sales agents.

3.6.1 MININFRA INFRASTRUCTURE GENDER MAINSTREAMING STRATEGY (IGM)

In 2017, MININFRA released its IGM for the period until to 2024. The IGM addresses imbalances in the energy sector and identifies three strategic areas to target:⁵⁷

1. Strengthening capacity of institutions to address gender issues.
2. Improving access to job opportunities for women and men.
3. Ensuring supply of energy to women and men.

The IGM is an important step for the sector, but it has not yet been in place long enough for its effectiveness to be determined.

3.6.2 USAID WOMEN IN RWANDAN ENERGY (WIRE)

USAID launched WIRE in May 2019 to support women working in the energy sector and improve women's understanding of energy. One primary goal is to provide women with career guidance about opportunities in the energy sector to improve the gender balance within the sector. Additionally, improving women's understanding of energy will help them make better energy choices for their homes.⁵⁸

⁵³ Energy Private Developers, "EnDev Rwanda - Off-Grid Sector Status Report 2017."

⁵⁴ Ministry of Infrastructure, "Energy SWAP Secretariat."

⁵⁵ National Institute of Statistics Rwanda, "EICV 5 - Main Indicators Report 2016/17."

⁵⁶ Rwanda Energy Group, "REG Celebrated the International Women's Day on High Gear."

⁵⁷ GEG Africa, "Women and The Energy Value Chain: Opportunities for A More Inclusive Renewable Energy Sector in Africa."

⁵⁸ The New Times, "Move to Entice More Young Women Engineers to Join the Energy Sector."

3.7 FINANCIAL INCLUSION

Financial inclusion remains low in Rwanda, with only 37 percent of Rwandans owning a formal financial account. In rural areas, this proportion is just 13 percent, compared to 40 percent in urban areas, with the most common account owned being a mobile money account (23 percent). The lack of financial inclusion may cause problems when off-grid companies that currently use pay-as-you-go (PAYGO) systems which utilize mobile money to collect payments try to reach more rural, less wealthy households to achieve universal electrification.⁵⁹

⁵⁹ Financial Inclusion, “Rwanda · Financial Inclusion Insights by Intermedia.”

4 OFF-GRID ENERGY

4.1 OFF-GRID OVERVIEW

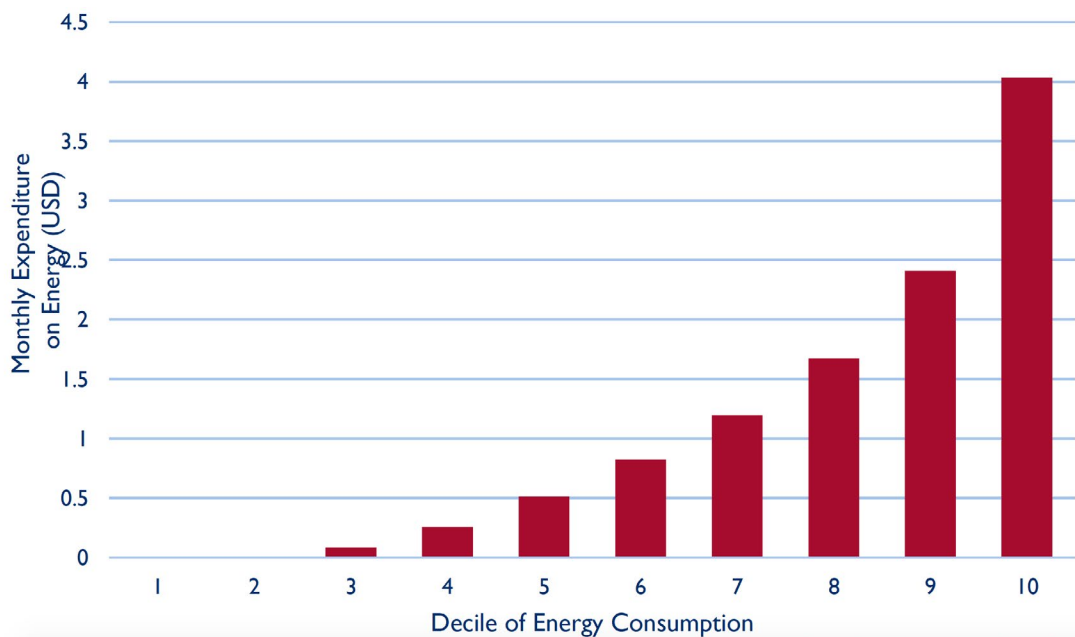
The off-grid sector is expected to play a large role in achieving universal access in Rwanda by 2024. Rwanda has seen significant growth in the deployment of SHSs in the past several years. In addition, mini-grids have drawn considerable interest from the private sector and government but have not scaled as quickly, following a common trend seen in the region. To date, the off-grid sector in Rwanda has been dominated by SHSs and solar lanterns, with most SHSs being small with Tier I capabilities.

This section provides an overview of issues that apply to all sub-sectors of off-grid energy (i.e., SHS, mini-grids, and productive uses), and subsequent sections highlight the issues each sub-sector faces.

4.1.1 SPENDING FOR LIGHTING AND PHONE CHARGING FOR OFF-GRID HOUSEHOLDS

As previously discussed, demand for electricity in Rwanda is lower for on-grid customers than in neighboring countries, and the situation is the same for off-grid customers. The chart below shows expenditure by off-grid households for batteries, candles, kerosene, and phone charging. The data indicate that 75 percent of the off-grid population spends less than \$1.67 per month on these products and services. The distribution below is a proxy for willingness to pay for services that could be replaced by an SHS or mini-grid. It demonstrates that affordability is a key issue faced by the sector. Figure 3 plots off-grid households' monthly expenditure on energy for lighting and charging phones, broken down by their energy consumption.

FIGURE 3. OFF-GRID HOUSEHOLDS' MONTHLY LIGHTING/PHONE CHARGING EXPENDITURE BY ENERGY CONSUMPTION



Source: The authors conducted this analysis based on microdata provided publicly by the National Institute of Statistics in Rwanda. Annex B describes the methodology in detail.

4.1.2 SOURCES OF LIGHTING

Unlike some countries in the region, the main source of lighting for off-grid households is not kerosene. As shown in Table 6, batteries are by far the most common source of lighting (other than the grid), followed by solar and candles.

TABLE 6. DISTRIBUTION OF HOUSEHOLDS BY MAIN SOURCE OF LIGHTING

Electricity Distributor	Oil Lamp	Firewood	Candle	Lantern	Batteries	Solar Panel
27.1	1.4	3.7	6.1	3.5	50.1	7.3

Source: ⁶⁰

4.2 KEY CHALLENGES

4.2.1 AFFORDABILITY

In the off-grid space, the current high level of expenditure on kerosene for lighting ⁶¹ is a commonly cited reason that households will be able to afford an SHS. However, as seen in Section 4.1.1, evidence from large household surveys shows that Rwandan families use little kerosene, and their expenditure on other sources of lighting is quite low. It should be noted that surveys cannot determine with precision the premium people are willing to pay for the improved level of service available from an SHS or other off-grid product. Given the large difference between most households' expenditure and the lowest-priced PAYGO SHS product currently available—RWF3,500/month (\$3.87/month)⁶²—affordability will likely be a key issue for any off-grid company (SHS, mini-grid, or productive use) attempting to sell their product to the Rwandan population.⁶³

To demonstrate this problem, a 2016 survey of SHS users showed that 53 percent of customers had missed at least one payment (at a monthly rate of RWF3,500/month or \$3.87) and that 33 percent of non-SHS households surveyed stated that a monthly payment of RWF1,000 (\$1.11) would be too high.⁶⁴ These findings are consistent with the current poverty rate of 38.2 percent, which is based on the most recent household living conditions survey (EICV5).⁶⁵



The government is aware of the affordability problem and is in the process of designing a results-based-financing (RBF) subsidy program (described in Section 5.4.2) to address it. The success of this program will be critical in achieving universal electricity access by 2024.

⁶⁰ NISR, "EICV 5 - Rwanda Poverty Profile Report 2016/17."

⁶¹ Renewable Energy World, "Kenya's M-KOPA Offers Cheaper Solar Power to Off-Grid Villages"; Sunny Money, "Kerosene VS Solar"; Le Page, "People without Electricity Could End up Living the Energy Dream | New Scientist."

⁶² Assuming RWF905/\$1 (May 15, 2019). For clarity, SHS is used throughout this report instead of delineating between SHS and pico-solar. GOGLA defines pico-solar as systems that have less than 10 Wp of solar, and for data collected from GOGLA, systems less than 10 Wp are still considered to be SHS. The reason for doing this is that GOR considers smaller systems to fall under SHS, and so does EnDev, which is also cited in this report. As discussed and shown in Figure 4, in the Rwandan context, most systems are smaller than 10 Wp.

⁶³ The New Times, "FEATURED."

⁶⁴ Collings and Munyehirwe, "Pay-as-You-Go Solar PV in Rwanda."

⁶⁵ KT Press, "Rwanda's Poverty Levels Make Slight Decline – Report."

4.2.2 POLICY AND REGULATORY ISSUES

In addition to affordability, issues faced in Rwanda relate to uncertainty in policy and regulations. As previously stated, although the government has been supportive of off-grid electrification, some government interventions have raised concern among companies. As stated by GOGLA:⁶⁶

“As the Government of Rwanda continues to explore mechanisms to accelerate the realization of Energy Access for All (Sustainable Development Goal 7) through off-grid products, a number of proposals in the first quarter of 2018 caused uncertainty in the sector. While stakeholder engagement has made important progress in this regard, the resolution of a long-term plan would improve certainty.”

At the time, some uncertainty existed regarding what areas would be classified as off-grid by the government in the NEP, as that classification determines where off-grid companies can operate and receive support. However, the NEP was finalized in June 2019, so deployment is expected to continue. Furthermore, ministerial guidelines that could impact the sector significantly are being discussed for both SHSs and mini-grids, and subsidies for off-grid solutions for poorer households are being debated. How the NEP affects the off-grid sector as a whole is discussed below. The other issues are further addressed in Sections 5.4 (SHS) and 6.2 (mini-grids).

NEP

To ensure efficient planning of electrification efforts and alignment with the RES and ESSP, GOR divided the country into on-grid, mini-grid, and SHS areas. GOR developed a map based on potential electricity demand and the cost of various electrification options to provide guidance on grid densification and extension to reach 52 percent of households by 2024. The areas that are not designated for the grid—representing 48 percent of the population—are marked for off-grid solutions. SHS subsidies and new mini-grid sites will be restricted to these areas, with approximately 38 percent and 10 percent of the country allocated to each, respectively. However, these off-grid allocation percentages may change if the rollout of either solution is slower than anticipated.

4.3 ENERGY-RELATED TRAINING INSTITUTIONS, INCUBATORS, AND ACCELERATORS

4.3.1 WORKFORCE DEVELOPMENT AUTHORITY (WDA)

WDA oversees technical and vocational education and training in Rwanda, which has been a focus for the education system to ensure that graduates have practical skills upon graduation from secondary school. Several technical and vocational education and training schools now offer skills training programs related to the energy sector.⁶⁷

4.3.2 CARNEGIE MELLON UNIVERSITY AFRICA (CMU AFRICA)

CMU Africa is a branch of Carnegie Mellon University that was established in 2011 in Kigali with full-time faculty and staff located on site. CMU Africa’s mission is “to produce creative and technically strong engineers, who have been trained in the African context, and prepared to make transformative impact in their communities and the world”.⁶⁸

⁶⁶ GOGLA, “Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data.”

⁶⁷ The New Times, “WDA Moves to Address Skills Gap in Energy Sector.”

⁶⁸ Carnegie Mellon University Africa, “About Carnegie Mellon University Africa in Rwanda.”

Within CMU Africa's Master of Science in Information Technology program, students have the option to choose a concentration in Energy Systems. Upon graduating from this program, students have the skills required to develop and manage energy projects, develop mini-grids, create new electrical appliances, and analyze energy policies and strategies, among others.⁶⁹

4.3.3 KLAB

kLab is a technology hub with a mission to support innovative information and communications technology solutions in Rwanda by giving entrepreneurs a space to turn their ideas into viable businesses with the support of a mentor network. Energy-related start-ups are eligible to use these services.

4.3.4 IMPACT HUB

Impact Hub provides a co-working space, puts on events, and provides consultation to entrepreneurs. Common events include hackathons, talks, and happy hours. In 2018, Impact Hub hosted the Solar Entrepreneur Program, which awarded cash prizes to support entrepreneurial ideas in solar.⁷⁰

4.3.5 INKOMOKO ENTREPRENEUR DEVELOPMENT

Inkomoko supports small- to medium-sized businesses to grow and become more successful by providing operations assessments, bootcamps, data management tools, and funding through a partner organization. Inkomoko has previously supported energy-related companies in Rwanda.

⁶⁹ Carnegie Mellon University Africa.

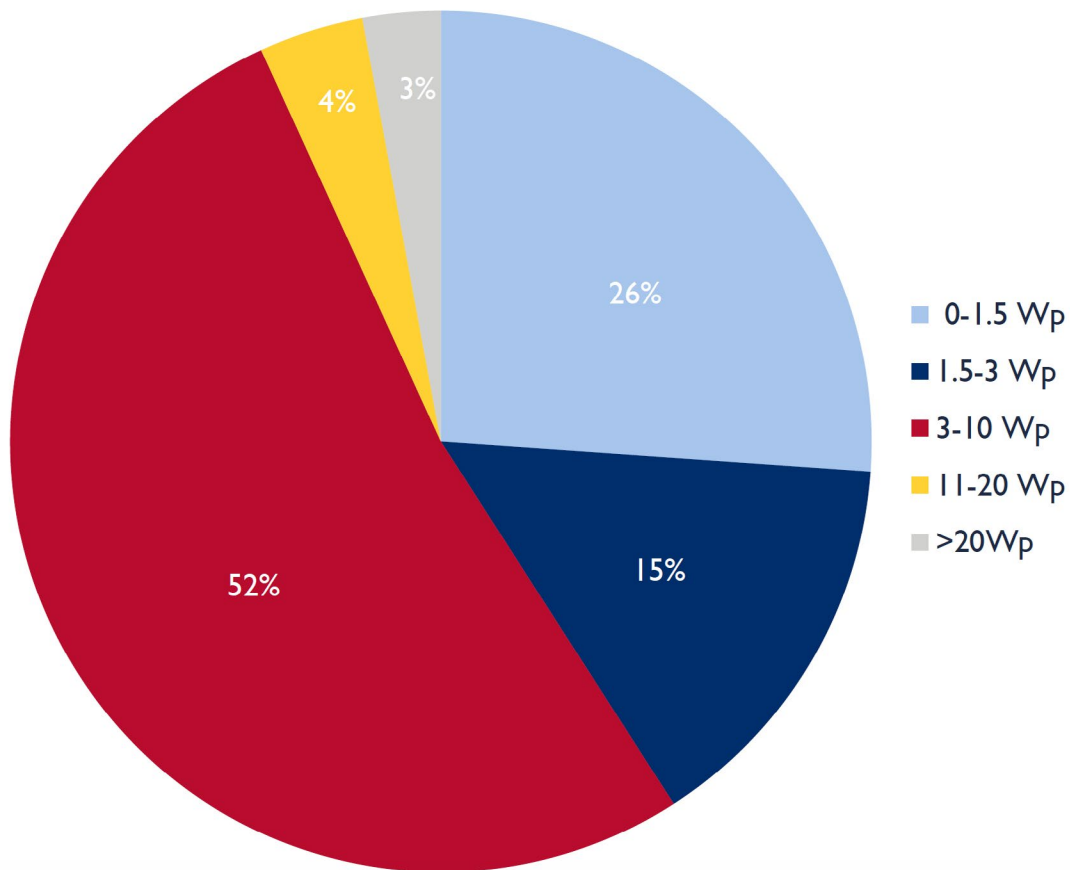
⁷⁰ Impact Hub Kigali, "Solar Entrepreneurship Program 2018."

5 SHS

5.1 SHS⁷¹ COMMERCIAL OVERVIEW

While other countries in East Africa lead off-grid electrification in terms of absolute numbers, Rwanda does not trail far behind and is a global leader relative to its population size. The government has prioritized the off-grid sector as a means of increasing access quickly and cost effectively. Small SHSs of less than 10 watt-peak (Wp) make up the bulk of sales, with 426,000 such systems sold since 2015. These systems are expected to be the future of off-grid electrification, as they can provide the Tier I service required by the government to count as electrified. Figure 4 shows the breakdown of sales volume by system size and shows the dominance of systems smaller than 10 Wp.

FIGURE 4. BREAKDOWN OF SHS SALES VOLUME BY SYSTEM SIZE IN RWANDA



Source: GOGLA 2018

⁷¹ For clarity, the term SHS is used throughout this report instead of delineating between SHS and pico-solar. GOGLA defines pico-solar as systems that have less than 10 Wp of solar, and for data collected from GOGLA, systems less than 10 Wp are still considered to be SHS. The reason for doing this is that GOR considers smaller systems to fall under SHS, and so does EnDev, which is also cited in this report. As discussed and shown in Figure 4, in the Rwandan context, most systems are smaller than 10 Wp.

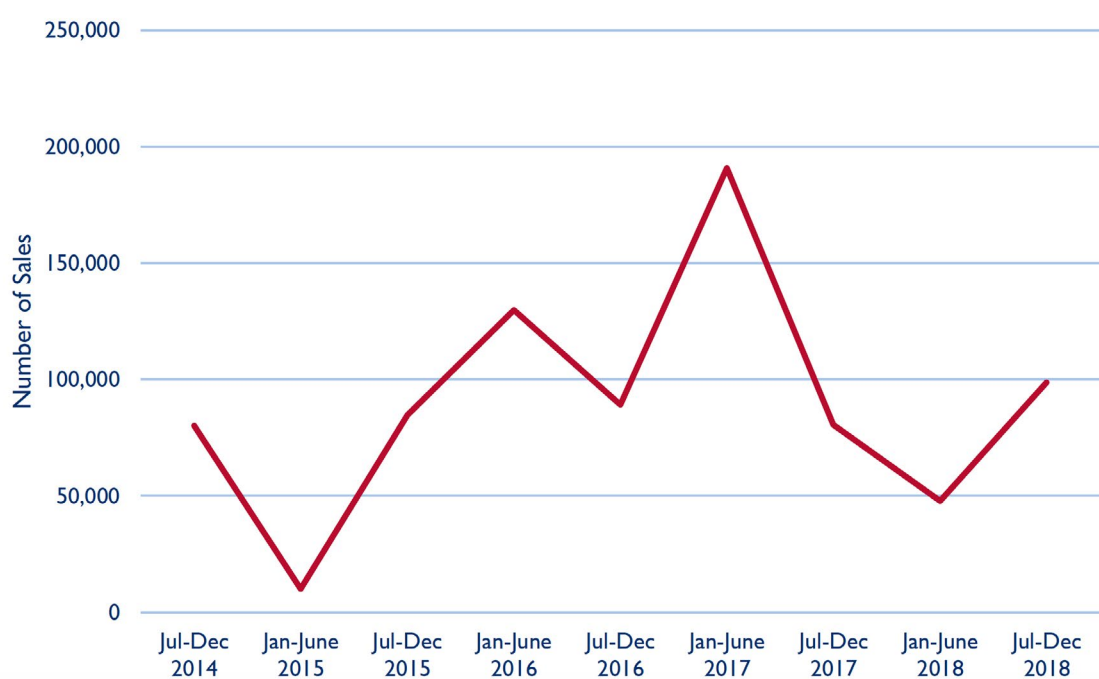
Table 7 presents data on the market value by product category and business model.

TABLE 7. GOGLA SALES DATA BY PRODUCT CATEGORY AND BUSINESS MODEL IN RWANDA								
TIME PERIOD	SUM OF TOTAL	SUM OF 0-1.5 WP	SUM OF 1.5-3 WP	SUM OF 3-10 WP	SUM OF 11-20 WP	SUM OF 21-49 WP	SUM OF 50-100 WP	SUM OF 100+ WP
July-December 2014	80,111	-	-	-	-	-	-	-
January-June 2015	10,000	-	-	-	-	-	-	-
July-December 2015	84,724	9,630	-	935	-	-	6,563	-
January-June 2016	129,779	38,560	5,254	52,365	-	-	-	-
July-December 2016	89,161	4,908	14,312	54,758	-	2,215	-	-
January-June 2017	190,781	-	63,872	69,040	-	-	-	-
July-December 2017	80,529	48,882	-	4,670	4,818	-	-	-
January-June 2018	47,741	-	-	13,012	6,537	-	-	1,648
July-December 2018	98,723	-	1,020	44,659	-	2,614	-	3,825
Total	811,549	101,980	84,458	239,439	11,355	4,829	6,563	5,473

5.1.1 SALES OVER THE YEARS

Figure 5 plots the SHS sales volume from 2014 to 2018 in Rwanda. From mid-2014 through mid-2017, sales volumes grew quickly with a slight downturn and flattening out since then.

FIGURE 5. RWANDAN SHS SALES VOLUMES 2014-2018



Source: GOGLA 2018

5.1.2 MARKET SIZE

Rwanda has a population of about 12 million and 2.7 million households. According to REG, 14 percent of the population already has off-grid access.⁷² The current target of 48 percent of households having off-grid access to electricity means that approximately 1.4 million households will need off-grid solutions by 2024, assuming the population growth projected by NISR. As previously described, many of these customers will need subsidies to address affordability issues.

5.2 SHS BUSINESS MODELS AND VALUE CHAIN

To model how products flow through the SHS market, the value chain is broken down into discrete steps. The different models that exist within these steps are discussed below. The goal of this discussion is not to capture every single model but to describe the most common models within the current market. The steps are manufacturing, assembly, distribution, sales, and after-sales support (Figure 6). These steps are defined in the following sections, along with a few notes on each.

FIGURE 6. SHS VALUE CHAIN STEPS



5.2.1 MANUFACTURING AND ASSEMBLY

Currently, all manufacturing and most assembly of SHSs occurs in other countries. The most common country of origin is China. Some companies are vertically integrated and control the manufacturing process, while others buy products from manufacturers. Each of these approaches has trade-offs for the companies in terms of pricing, flexibility, and company differentiators.

Companies that are vertically integrated and control the manufacturing capability are typically able to pay a lower overall cost in production and can likely address quality assurance issues more quickly by handling them internally. Additionally, they can tailor their product to align with their company business model.

Conversely, a company that buys products from a manufacturer can focus more on the distribution and sales aspect of their business. Sales and distribution arguably constitute a more substantial value addition, because the SHS market has developed to the point where specialized manufacturers offer products similar to those produced by vertically integrated SHS companies. In addition, this type of company is not responsible for research and development activities, which can be costly and time-consuming. Furthermore, they are more flexible. They can pick products off the shelf and start distributing them in a shorter time period. When a product does not perform well, they can move on quickly, compared to a vertically integrated company.

5.2.2 SALES AND DISTRIBUTION

Because of the nature of the market, potential customers are often located far from urban centers in places difficult to reach. The success of SHS companies depends on their ability to reach these customers in a cost-effective way. The most common strategy is to employ sales agents who typically work on commission, allowing companies to have low overhead while directly rewarding sales.

⁷² Rwanda Energy Group, “Electricity Access.”

As many customers have no credit history, a key aspect to building an SHS business over the long term is identifying “good” customers who pay for their systems reliably and then offering them additional products later. Because the company already has data demonstrating that these customers will likely repay loans, sales of these new products are less risky, and thus, the transaction costs are lower as compared to the costs of acquiring new customers.

5.2.3 SALES TO END CUSTOMERS (FINANCING)

The key breakthrough for the SHS sector (in addition to the lower costs of solar) was the invention of PAYGO systems that eliminated the need for a customer to pay the entire cost of a system upfront. Instead, in a PAYGO system, the customer pays over an established period of time, while the company has the ability to turn off the system if the daily or weekly amount required is not paid. This system also mitigates the risk associated with giving loans to customers with no credit history by incentivizing them to pay if they want service. The vast majority of SHSs sold in Rwanda are PAYGO systems.

5.2.4 AFTER-SALES SUPPORT

Providing after-sales support is important for companies to build and maintain consumer confidence in their products. Critically, during the repayment period, customers will not pay unless their SHS is functional. As in other aspects of the business, the dispersed nature of the customer base poses a challenge, as does the cost to maintain the systems. As such, some companies take advantage of sales agents to serve as initial points of contact when issues arise, and most provide a hotline for customers to call.

Some Memoranda of Understanding (MOUs) signed with EDCL in 2016–2017 specify that Tier 1 systems must be provided with a two-year warranty, and Tier 2 systems must have a three-year warranty. These requirements are consistent with the warranties currently provided by several manufacturers. For example, Greenlight Planet offers a two-year warranty, whereas Mobisol, which generally sells larger products, offers a three-year warranty.⁷³ In contrast, BBOX operates through a fee-for-service model, so it will maintain its products indefinitely as long as the customer continues to pay for the service.

The ministerial guidelines on SHS that are currently under debate could change these requirements, as they specify a warranty period of three years for SHS products.⁷⁴

5.2.5 END-OF-LIFE DISPOSAL

The disposal of SHSs at the end of their life is attracting increased attention, as detailed in a recent New York Times article. Even though SHSs represent a small percentage of total e-waste, the batteries used in these systems can have particularly harmful effects on the environment and on people who come into contact with them. An e-waste recycling plant was opened in Rwanda in December 2017, and at least one SHS company (Mobisol) is working with the facility to recycle components at the end of their life.⁷⁵

5.3 MAJOR PLAYERS

According to the Energising Development (EnDev) Off-Grid Sector Status Report, there are a handful of major players in the SHS sector. The tables below show the respective market shares as of 2017 for each major player for SHSs (Table 8) and solar lanterns (Table 9).⁷⁶

⁷³ Greenlight Planet, “FAQ”; Mobisol, “Mobisol Rwanda.”

⁷⁴ Ministry of Infrastructure, “Ministerial Guidelines on Minimum Requirements for Solar Home Systems.”

⁷⁵ The New York Times, “Electronic Marvels Turn Into Dangerous Trash in East Africa.”

⁷⁶ Energy Private Developers, “EnDev Rwanda - Off-Grid Sector Status Report 2017.”

TABLE 8. SHS MARKET SHARE BY COMPANY

COMPANY	MARKET SHARE
Ignite	37%
BBOX	32%
One Acre Fund	12%
Mobisol	8%
Others	11%

TABLE 9. SOLAR LANTERN MARKET SHARE BY COMPANY

COMPANY	MARKET SHARE
One Acre Fund	61%
Waka Waka	21%
SaferRwanda	9%
Others	9%

5.3.1 MANUFACTURERS

Greenlight Planet and d.light have both sold a significant number of SHSs through their distributors in Rwanda. In addition, the Government of Rwanda has distributed more than 50,000 Itara-branded SHSs for free.

5.4 KEY ISSUES IN THE SHS MARKET

5.4.1 MINISTERIAL GUIDELINES ON SHS STANDARDS

In addition to the guidelines laid out in the Rural Electrification Plan requiring minimum Tier I service for households, MININFRA released further specification on service-level and system performance requirements in 2018. The stated motivation for these requirements is to protect customers by mandating that all imported SHS kits are Lighting Global-certified. Separate service-level requirements to provide phone charging and a certain number of hours of lighting and radio are also specified.

Service-Level Requirements

To enforce these requirements, a number of technical and sizing requirements are included in the document:

“The average household who has gained access to electricity in Rwanda has a system capable of supplying enough electricity to power at least:

- a) Three (3) lamps of at least 120 lumens each, operating at least four (4) hours per day.
- b) A mobile phone charge supply for at least two (2) hours per day.
- c) A radio charge supply for at least 5 hours per night,.
- d) Supply for the above loads for least one day without input from the solar module/when there is no sunshine.
- e) Product labelling for system parts is mandatory. The following information should be included on each of the following component types. The information should be included on the body of the product (or on an attached label or sticker):
 - › Lights: voltage, power, luminous flux.
 - › Other appliances included with the system: voltage, power.

- › Solar modules: open circuit voltage, short circuit current, maximum power at standard test conditions of 1000W/m² and 25°C.
- › Batteries: voltage, storage capacity (in mAh, Ah, or Wh), battery chemistry (e.g., lead-acid, lithium iron phosphate, lithium-ion, etc.), dismountable system parts (e.g., lamp and battery), and system compatibility is recommended to allow for spare parts replacement.

NB: To achieve this level of service, products should deliver enough electricity to meet the lighting service requirement while having sufficient remaining energy to meet the energy needs of the mobile phone charging and radio operation, given a solar resource of 4.5 kWh/m² per day. If a radio is included with the system, the daily energy requirement for powering it is based on the consumption of the included radio (as reported in a test report from an appropriately accredited test laboratory). If a radio is not included, then the system should provide at least 5Wh per day to operate the radio. The minimum energy allocated for mobile phone charging is 2Wh per day”.⁷⁷

The private sector has applauded the requirements that products be Lighting Global-certified. Such requirements will reduce the number of poor-quality products on the market, although the proportion of such products in Rwanda is small compared to those in other countries. However, companies have expressed concerns about the service-level requirements and their potential impact on a significant portion of the market: the most affordable SHSs. Notably, the methodology that will be followed to implement the standards remains under discussion within GOR.

5.4.2 RBF PROGRAM (PROPOSED)

Recognizing affordability concerns and using the model of the EnDev RBF program, REG is working with development partners to design a larger RBF to reach poorer households with SHSs in Rwanda. The design of this program would provide different subsidy amounts to each Ubudehe category. Ubudehe 1 will receive the most assistance, as it represents the most vulnerable part of the population (Table 10). If approved, the implementation of this program will significantly impact the future of the SHS sector.

Table 10. Ubudehe Categorization

CATEGORY	DESCRIPTION	PERCENTAGE OF POPULATION
Ubudehe 1	Do not own a house and struggle to meet basic needs	16.0%
Ubudehe 2	Own their own house or rent one but do not have full-time jobs	29.8%
Ubudehe 3	Are full-time employees or farmers able to sell some of their produce (beyond subsistence farming)	53.7%
Ubudehe 4	Own large businesses, work for international organizations, or are public servants	0.5%

Sources: ⁷⁸

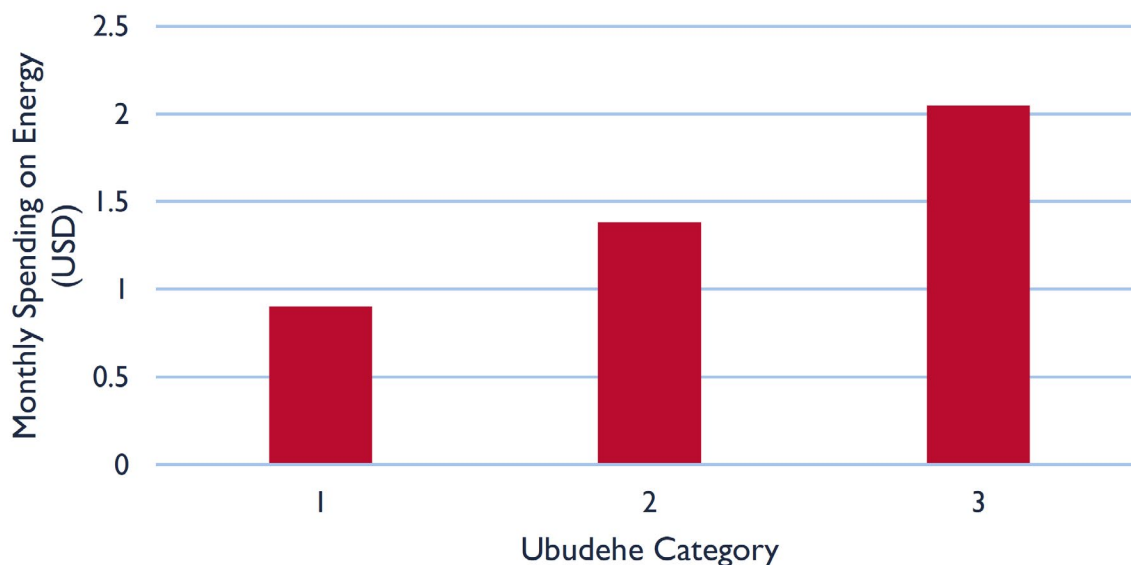
As discussed above, current prices for SHSs are considerably higher than current energy spending in Rwanda. The proposed RBF program is intended to alleviate this problem, but it is subject to the usual complications associated with subsidies. In addition, on average, all three Ubudehe categories spend

⁷⁷ Ministry of Infrastructure, “Ministerial Guidelines on Minimum Requirements for Solar Home Systems.”

⁷⁸ Collings and Munyehirwe, “Pay-as-You-Go Solar PV in Rwanda”; Anne-Michèle Paridaens, “Comprehensive Food Security & Vulnerability Analysis (CFSVA) 2018.”

substantially less than the price of an SHS, and the difference in spending between categories is relatively small.^{79 80} Figure 7 plots households' monthly expenditure for lighting and phone charging by their Ubudehe category.

FIGURE 7. HOUSEHOLDS' MONTHLY LIGHTING/PHONE CHARGING EXPENDITURE BY UBUDEHE CATEGORY



As is the case when any subsidy is made available, the implementation of this program does not mean that every household will be able to afford an SHS. However, a significantly higher percentage of households will likely be able to purchase one, thereby accelerating progress toward the government's universal access target.

5.5 GOVERNMENT AND DONOR PROGRAMS

5.5.1 MOU_s BETWEEN SHS COMPANIES AND EDCL

Since 2015, more than 20 companies have signed MOUs with EDCL to sell and distribute SHSs in Rwanda and, thereby, execute the RES.⁸¹ These companies have been vetted by the government, and the MOUs commit them to providing warranties and after-sales servicing. An MOU is also required for participation in some government rural electrification programs.

5.5.2 WORLD BANK REF

Launched in November 2017, the \$48.94-million REF targets providing off-grid electricity access for 1.8 million people (445,500 households) by the end of 2023. The REF is implemented by BRD and provides four lending windows to facilitate financing to the sector:⁸²

⁷⁹NISR, "EICV 5 - Rwanda Poverty Profile Report 2016/17."

⁸⁰Methodology explained in Annex B.

⁸¹Rwanda Energy Group, "Solar Home Systems"; The New Times, "FEATURED"; IGIHE, "Mobisol Rwanda Ltd, a Strategic Partner of EDCL: 50,000 Solar Systems in 4 Years."

⁸²The World Bank, "Strategic Climate Fund-Scaling-Up Renewable Energy."

- › Window 1: On-lending from REF through savings and credit cooperative organizations (SACCOs) to households and businesses to purchase Tier 1 or above solar systems.
- › Window 2: On-lending from REF through commercial and microfinance banks to households and businesses to purchase Tier 1 or above systems.
- › Window 3: Direct financing to mini-grid developers, which will provide up to 75 percent of the construction cost for renewable energy-based mini-grid systems. It is designed to complement an RBF scheme by providing a bridge loan until RBF financing arrives, as well as providing longer-term financing.
- › Window 4: Direct financing of off-grid solar companies. Companies must provide Tier 1 or higher systems and leverage REF financing in a 2:1 ratio.

Window 4 was closed until 2019 to encourage the development of other financing options but is now open as progress has been slower than expected in the other windows.⁸³

5.5.3 RBF (ENDEV)

The stated objective of RBF is to overcome market failures to facilitate improved access to modern energy services for the poor. The key feature of the program is providing payment upon delivery of results, meaning that private implementers must bear the risk of service delivery. The role of this subsidy is intended to be temporary and to help advance the sector by moving along either the learning-experience curve or the cost-reduction curve.⁸⁴ In Rwanda, companies receive a financial incentive for selling solar lamps (including SHSs) and mini-grids. The program has supported 220,500 people gaining access to electricity and will end in 2019.⁸⁵

5.6 SHS FINANCING OVERVIEW

5.6.1 COMPANY FINANCE

Similar to other parts of East Africa, the financing landscape is dominated by international companies, such as BBOX, Mobisol, Zola, and Ignite, which have been able to attract significant financing from Development Finance Institutions (DFIs), equity and impact investors, and specialized investment funds. Currently, local financing only makes up a small percentage of the overall funding for these companies, but the REF has the potential to change this situation.

Financing Raised

Comprehensive data are not available on financing specifically in the Rwandan market, but GOGLA aggregates financing information on a sub-regional level (i.e., East Africa, West Africa, and Central Africa). Because most companies that are active in Rwanda are multi-national and, from a financing standpoint, Rwanda generally follows patterns similar to those of neighboring countries, insights can be drawn from financing data on East Africa.

⁸³ The World Bank, “Renewable Energy Fund- Implementation Status & Results Report.”

⁸⁴ Energising Development, “Results-Based Financing (RBF) Energising Development (EnDev) Partnership.”

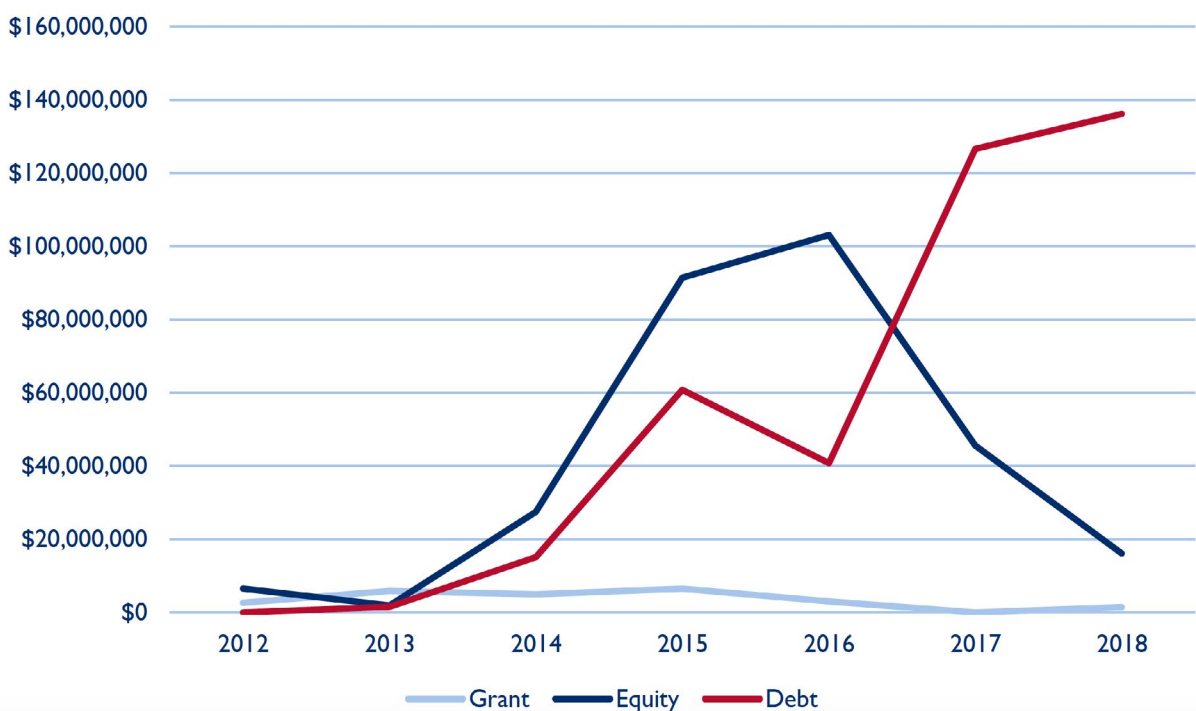
⁸⁵ Energy Private Developers, “EnDev Rwanda - Off-Grid Sector Status Report 2017.”



In total, more than \$697 million has been raised for the sector in East Africa since 2012: \$292 million as equity, \$381 million as debt, and \$24 million in grants. All three of these types of funding have played a role in the development of the sector.

Figure 8 plots the evolution over time, showing that debt financing has steadily increased, while grant financing has become steadily less available as the markets have matured. The trend in equity funding has been less steady, with a few larger deals driving up the totals in some years and saturation among current investors causing reductions in recent years.

FIGURE 8. SHS FINANCING IN EAST AFRICA BY DEBT, EQUITY, AND GRANTS, 2012–2018



Source: GOGLA 2018

A substantial growth in debt investments occurred in 2018, mainly driven by DFIs. Major increases in debt investment included debt raised from banks and financing institutions, which increased by 57 percent, and debt raised through crowdfunding platforms, which saw an increase of more than 600 percent. Key uses of these funds included scaling up businesses, geographic market expansion, and bridging working capital needs. Governments, including DFIs, remain top investors in the off-grid space, with investment growth of 8 percent in 2018. Table D-6 includes detailed information on financing trends through the years. A list of funding options for companies is included in Annex C, including African and sub-regional financing options.

Crowdfunding

Crowdfunding has evolved into an important part of the funding landscape since 2016, with an estimated \$19 million raised in 2018, up from almost nothing in 2015, according to a 2018 GOGLA report. Trine has emerged as a notable leader in crowdfunding. Founded in 2016 as a platform dedicated to raising money for energy access, Trine has so far raised more than €20 million for solar companies, while providing investors with an average interest rate of 6 percent.⁸⁶ This platform has been very helpful for earlier-stage companies that need lower levels of financing than the larger players. As of March 2019, BBOXX has been able to raise €6 million through this platform for its operations in the Democratic Republic of the Congo, Guinea, Kenya, Mali, Rwanda, and Togo.⁸⁷

Local Bank Involvement

In February 2017, BBOXX reached an agreement with Banque Populaire du Rwanda (People's Bank of Rwanda [BPR]) on a \$2-million debt facility in the local currency to grow its operations in Rwanda.⁸⁸ In addition to this deal, in October 2017, BBOXX signed a trilateral deal with Deutsche Bank and BPR for a \$5 million debt facility supported by a USAID Development Credit Authority (DCA) guarantee and a hedge against foreign currency risk by MFX.⁸⁹ The financing for this deal is provided by Deutsche Bank and managed by BPR.

5.6.2 CONSUMER FINANCE

PAYGO

As previously mentioned, PAYGO is the primary method for financing customers in Rwanda, as many lack credit histories. PAYGO is a major contributor to the growth of the sector and has been facilitated by a strong mobile money sector, as noted below.

Mobile Money

Mobile money has shown strong growth in Rwanda over the past several years, and as of 2018, the two active telecom companies, Airtel and MTN, report 1.9 and 1.7 million mobile money subscriptions, respectively.⁹⁰ All the major SHS companies with PAYGO platforms use mobile money, which has been a significant enabler of the SHS sector in the country. However, only 23 percent of Rwanda's population own a mobile money account. Thus, as companies target lower-income households, it should not be assumed that all potential customers own a mobile money account.

Microfinance Institutions (MFIs) and SACCOs

MFIs and SACCOs were targeted through the REF to help increase SHS adoption, but the number of loans so far remains small. The ability and capacity of these institutions to acquire new customers is also low. Additionally, SHS companies also offer financing options for SHSs, creating competition between these companies and MFIs and SACCOs. Although prices are slightly lower through SACCOs, SHS companies do not require collateral, which is a serious consideration for potential customers.

⁸⁶ Trine, "Trine."

⁸⁷ BBOXX, "BBOXX Receives Largest Crowd-Funded Debt Raise."

⁸⁸ The New Times, "BBOXX Secures Unique Financing Facility with BPR to Support the Government's off-Grid Electrifications Goals."

⁸⁹ Medium, "BBOXX Changes Everything in Rwanda - Power Africa."

⁹⁰ BiztechAfrica, "MTN Rwanda Launches 2018 Mobile Money Month at Nyamata Market"; The New Times, "Airtel-Tigo to Pay Rwf120 Million in Interest to Mobile Money Subscribers."

6 MINI-GRID COMPANIES

6.1 MINI-GRID OVERVIEW AND APPLICABILITY

The Rwandan government has been supportive of mini-grid deployments and considers them to be a key part of the RES. However, the mini-grid sector in Rwanda remains small, and no companies have deployed more than one alternating current mini-grid. This slow adoption is partially attributable to companies waiting for NEP mapping to be complete before deploying mini-grids. However, the NEP's finalization in June 2019 has addressed this concern.

Initially, mini-grids in Rwanda were typically small hydropower projects that were not privately developed. As the cost of solar has decreased, mini-grids of this type have become more viable and will likely play a significant role in the future of the sector in Rwanda.

6.1.1 ACTIVE MINI-GRID COMPANIES

Table II summarizes the private mini-grid deployments in Rwanda.

TABLE II. CURRENT PRIVATE MINI-GRID DEPLOYMENTS IN RWANDA

COMPANY	TECHNOLOGY	SIZE	NUMBER OF HOUSEHOLD CONNECTIONS
MeshPower	Solar DC	1 kilowatt (kW) x 57 systems	2,046
MeshPower	Solar AC/DC Hybrid	4 kW AC/1 kW DC	78
NESELTEC	Solar AC	30 kW	183
RENERG	Solar AC	30 kW	121
Absolute Energy	Solar AC	50 kW	505
ECOS	Hydro	11 kW	303

Source: ⁹¹

6.2 BARRIERS

Similar to SHSs, mini-grids have faced uncertainty in recent years regarding the areas designated for them. In addition, as no large-scale deployment of privately held mini-grids has occurred, uncertainty exists about the viability of business models at scale. Currently, mini-grids require significant grant support—40–70 percent of capital expenditure (CAPEX)—to be viable, and subsidies are expected to be needed in the short- to medium-term.⁹² As the number of mini-grids deployed increases, it may be possible to reduce grant levels. Both grant (EnDev RBF and upfront) and debt (REF) financing tools are available in Rwanda.

⁹¹ Energy Private Developers, “EnDev Rwanda - Off-Grid Sector Status Report 2017.”

⁹² Energy Private Developers.

The most immediate roadblock affecting the further development of mini-grids was the lack of clarity regarding off-grid areas in the NEP. Without clearly defined areas, developers and financiers were reluctant to move ahead with projects. However, deployment is expected to continue with the NEP's finalization.

6.3 MINI-GRID REGULATIONS

In 2015, RURA adopted regulations that specify licensing requirements, tariff guidelines, and procedures upon grid arrival.⁹³ These have been generally well received by private developers, and RURA is in the process of working with ESMAP to develop the next generation of these regulations in consultation with developers and other stakeholders.⁹⁴

6.3.1 LICENSING REQUIREMENTS AND TERMS

The RURA regulations cover isolated grids below 1 MW and specify that those below 50 kW are exempt from licensing. Although the regulations are currently ambiguous regarding whether the tariff and grid arrival compensation provisions apply to exempted mini-grids, RURA has stated that they are intended to apply to all mini-grids below 1 MW. That clarification will also be included in the revised version currently under consideration by stakeholders.

The term of the license can be anywhere from five to 25 years, but it is typically ten years for isolated grids. The licensee has the exclusive right to distribute and sell electricity within the geographical area defined in the license (assuming the electricity produced is adequate to serve all customers in the area and barring the arrival of the main grid). However, the license does not grant them the exclusive right to power generation in their specified geographic area.

6.3.2 TARIFF REGULATION

The RURA regulations specify that developers of isolated grids can charge cost-reflective tariffs with a reasonable margin. RURA does maintain the authority to review the reasonableness of the tariff. This provision is generally critical for developers to make a return on their investment unless there is an additional, significant subsidy above what is currently available.

6.3.3 ARRIVAL OF THE GRID

In the case of grid arrival, licensees have three options: (i) relocate assets, (ii) sell assets to the main grid (REG), or (iii) become a small power producer and/or a distributor of electricity purchased from the main grid.

If a licensee takes the second option, the main grid may buy generation assets without buying distribution assets. In the case of a dispute about the purchase price, RURA will act as the arbitrator and make the final determination.

⁹³ Rwanda Utilities Regulatory Authority, "Governing The Simplified Licensing Framework for Rural Electrification in Rwanda."

⁹⁴ International Renewable Energy Agency, "Policies and Regulations for Renewable Energy Mini-Grids."

6.4 MINI-GRID FINANCING AND SUPPORT PROGRAMS

Presently, all financing for mini-grids in Rwanda comes from development partners or DFIs in the form of either grants or debt. One program is focusing on demand stimulation to support local businesses and increase the viability of mini-grid business models.

6.4.1 RBF (ENDEV)

The EnDev RBF provides grants of up to 70 percent CAPEX for solar or hydropower mini-grids upon commissioning. Approved projects receive significant technical assistance, including on the business model and technical design. This support is intended to ensure that the mini-grid is completed, and that it is a viable, long-term business.⁹⁵

6.4.2 ENERGY4IMPACT (E4I)

E4I provides technical assistance and upfront grants (unlike RBF through EnDev) for CAPEX to approved mini-grids. E4I currently has a pipeline of 10 pico-hydro and solar projects.⁹⁶

6.4.3 WORLD BANK REF

The third lending window under REF is for mini-grid companies and will supply up to 75 percent of construction costs in the local currency. The loan can either be for long-term financing or bridge financing until RBF funds are released upon the mini-grid's commissioning. Although there are a number of applications pending, no mini-grid projects had been approved for financing as of April 2019.⁹⁷

6.4.4 BUSINESS DEVELOPMENT AND APPLIANCE FINANCING SUPPORT (E4I)

The mere availability of energy does not necessarily translate into economic growth. Thus, supporting local businesses to make use of the electricity is critical. E4I provides support in the form of business advisory services and financing of productive-use appliances. It supports local businesses through its Scaling Up Off-Grid Energy in Rwanda (SOGER) program by providing training in business management (including pricing, record keeping, customer service, and marketing) and partial grants for equipment. Examples of businesses supported by this program include tailoring shops, internet kiosks, phone charging shops, a health center, and a business that uses refrigeration.⁹⁸

⁹⁵ Energy Private Developers, "EnDev Rwanda - Off-Grid Sector Status Report 2017."

⁹⁶ Energy Private Developers.

⁹⁷ Development Bank of Rwanda, "Renewable Energy Fund Project."

⁹⁸ Energy For Impact, "Solar Mini-Grids Re-Energise Rural Rwandan Economy."



7 AGRICULTURAL AND PRODUCTIVE-USE SOLAR COMPANIES

7.1 AGRICULTURAL AND PRODUCTIVE-USE SOLAR COMMERCIAL OVERVIEW

Even compared to mini-grids, the productive-use sector is at a very early stage, and most companies and projects can be described as being in the pilot phase. Several different technologies for stand-alone productive-use products have been tested in Rwanda, including solar egg incubation, off-grid cold storage, and solar.⁹⁹ In addition, mini-grids are a key conduit for improving access to productive-use equipment in off-grid areas, with current mini-grids supporting refrigerators, popcorn machines, milling, welding, and tailoring.¹⁰⁰ Of these, solar irrigation and off-grid cold storage have made the most progress. A unique model that combines sterilized drinking water production with off-grid energy is described in Section 7.4.

7.2 OFF-GRID COLD STORAGE

Given the long distances between farms and demand centers for produce, spoilage during transit is a significant concern for some crops. Cold storage has been proposed as a solution to reduce spoilage and thereby increase incomes across different value chains.

Cold storage encompasses products ranging from traditional refrigerators to meet military, medical, or commercial needs (e.g., SunDanzer), to refrigerators based on 20- or 40-foot containers (e.g., Inspira Farms) that are designed to meet the cooling needs along crop value chains.¹⁰¹ In Rwanda, Inspira Farms has installed 11 total facilities, ten of which support a GOR (Ministry of Agriculture) program to reduce post-harvest losses by bringing cold storage facilities closer to farmers. An additional system was installed for a private produce aggregation and distribution company in Kigali. Inspira Farms has been able to raise €4.15 million through two Series A investment rounds for operations globally, demonstrating investor interest in this area.¹⁰²

7.3 SOLAR IRRIGATION

Agriculture plays a large role in the Rwandan economy, with 70 percent of the population engaged in the sector, and supplying 33 percent of total GDP.¹⁰³ Rwanda has a much higher percentage of arable land compared to other countries in sub-Saharan Africa, with 46.6 percent of the country's land classified as arable, compared to 9.0 percent for sub-Saharan Africa as a whole. However, because of its high population density, Rwanda has approximately half the arable land per capita (0.097 ha/capita) compared to sub-Saharan Africa overall (0.208 ha/capita). Thus, increasing production is particularly important for the country, especially to mitigate the effects of climate change, and irrigation can play a key role.¹⁰⁴ The

⁹⁹ The New Times, "How University Student Hatched the Idea of an Automated Egg Incubator."

¹⁰⁰ Energising Development, "Absolute Energy with Support of EnDev Successfully Installed a Solar Hybrid Mini-Grid"; Energy For Impact, "Building Mini-Grid Markets to Improve Living Standards in off-Grid Rwanda."

¹⁰¹ SunDanzer, "SunDanzer | Solar Refrigerators & Freezers"; InspiraFarms, "Rwanda Moves to Cut Postharvest Losses through Refrigerated Storage in Six Rural Districts."

¹⁰² Rodriguez, "Cold Chain Technology Proving a Cool Choice for Impact Investors"; Rodriguez, "InspiraFarms Closes a €1.65 Million of Series-A Investment."

¹⁰³ Food and Agriculture Organization of the United Nations, "Rwanda at a Glance | FAO in Rwanda."

¹⁰⁴ Food and Agriculture Organization of the United Nations, "Arable Land (% of Land Area)."

government recognizes this need and released an Irrigation Master Plan in 2010 identifying almost 600,000 ha as potential areas where irrigation solutions could be adopted.¹⁰⁵



Small-scale irrigation (defined as smaller than 10 ha) is the area in which solar can have a significant impact. As of 2016, only 4,000 hectares of land was under small-scale irrigation, but the Rwanda Agriculture Board has identified an additional 121,000 hectares as having potential.

The government aims to add 2,000 ha per year and offers a 50 percent subsidy on small-scale irrigation technology to support this target.¹⁰⁶

Rwanda has two rainy seasons that allow most farmers to have two harvests per year through rain-fed agriculture. An irrigation system has the potential to both guard against insufficient rainfall during the rainy seasons and to add an additional planting season.

7.3.1 ECONOMIC VIABILITY OF SOLAR IRRIGATION

A simple calculation to estimate the expected increase in revenue for a farmer using an irrigation system and thereby evaluate the economic viability of solar irrigation systems in Rwanda is shown below (Table 12). Input costs are not included, as they are expected to be constant across both scenarios. The price for maize quoted is the market price, which is not necessarily the price farmers would obtain, especially if they sell their crops to middlemen (farm gate price). One acre (0.4 ha) is taken as an average farm size. Maize is used as the example crop because of its importance for food security in the country. Notably, as maize is a relatively low-value crop, if a system is viable for maize, it will almost certainly be viable (with additional potential income expected) for higher-value horticulture crops, such as tomatoes or onions.

TABLE 12. INPUTS AND VIABILITY CALCULATION FOR A SOLAR IRRIGATION SYSTEM FOR MAIZE IN RWANDA

Price of Maize ¹	Average Yield in Rwanda for Maize (Mt/ha; per season)	Expected Increase in Production from Irrigation ²	Revenue for 0.4 ha (1 acre) Over One Year Without Irrigation ³	Revenue for 0.4 ha (1 acre) over One Year with Irrigation ⁴	Increase in Revenue from Irrigation over a Year
RWF350/kg	1.758	54%	RWF492,240	RWF1,137,047	RWF644,807

Sources: ¹⁰⁷

¹ Average of RWF300–400 range; ² Average of 31–77 percent range; ³ Assumes two planting seasons at country average for yield;

⁴ Assumes three planting seasons with increased production (calculated from average yield for Rwanda).

Pricing information for solar pumps was taken for Futurepump and Sunculture (Table 13), two of the larger distributors of solar pumps in East Africa that offer PAYGO solutions. The calculations included in the table assume that 75 percent of the increased revenue could go toward paying for the pump. This assumption also corrects for farm gate vs. market price issues.

¹⁰⁵ Ministry of Agriculture & Animal Resources, “Rwanda Irrigation Master Plan.”

¹⁰⁶ The New Times, “How Small Scale Irrigation Has Turned Rwandan Farmers into Multi-Millionaires”; Rwanda Water Portal, “Hillside Irrigation.”

¹⁰⁷ Food and Agriculture Organization of the United Nations, “FAO GIEWS Country Brief on Rwanda -”; Kondylis et al., “Impacts and Sustainability of Irrigation in Rwanda.”

TABLE 13. PAYBACK PERIOD FOR SOLAR PUMPS

	SUNCULTURE RAINMAKER	FUTUREPUMP SF2
Cost of pump	\$480 (RWF434,400)	\$675 (RWF610,875)
Estimated payback period (in years)	0.9 years	1.26 years

Source: ¹⁰⁸

While this is a simple calculation, it demonstrates that a payback period of two to three years is reasonable for a product like this one and demonstrates the market potential if conditions are correct. However, these products are representative of what is available elsewhere in East Africa (Kenya), not necessarily in Rwanda. Water must be available for either of these pumps to be used. The Irrigation Master Plan outlines areas that can potentially be irrigated through different sources (e.g., groundwater, lakes, rivers). The Futurepump has a maximum pumping height of 15 meters (surface pump), and the Sunculture pump has a maximum pumping height of 100 meters (submersible).¹⁰⁹

7.3.2 SOLAR IRRIGATION IN RWANDA (SIR) PROJECT (E4I)

As stated previously, solar irrigation is at a very early stage in Rwanda, and pilots are underway to develop and validate business models and the market more generally. The SIR project aims to develop the solar irrigation market in Rwanda by supporting new financing and building farmer awareness through trainings. The project works through cooperatives and farmer groups and aims to reach 3,000 farmers within the first two years, and 65,000 farmers within five years.¹¹⁰

From a financial perspective, there is a need to address solar pumps' high upfront costs compared to diesel pumps, establish payment terms that allow farmers to pay as they harvest, and provide bridge financing until government subsidy payments are disbursed.¹¹¹ SIR plans to develop mechanisms that work for farmers in terms of timing (i.e., payments that reflect when farmers have cash), address affordability (i.e., by determining appropriate subsidy levels), and create market linkages for farmers to sell products.

In terms of awareness, SIR is setting up different types of pumps at demonstration sites for farmers and these are undergoing testing from a technical perspective and to ascertain impacts on yield.

7.4 DRINKING WATER AND OFF-GRID ENERGY

The viability of mini-grids is often determined by anchor customers that consume significant portions of the energy produced. OffGridBox takes a similar approach by using centralized solar generation to purify water for drinking in addition to charging portable batteries that provide MTF Tier I service for lighting and phone charging. Customers currently pay for clean drinking water and battery recharging as a bundle. The company is piloting new additions to the business model, including sales of water to peri-urban and urban shops.¹¹² The inclusion of water services is a unique model that could potentially increase the viability of private sector provision of electricity access in rural areas.

¹⁰⁸ REEEP, "The Business Case for Solar Irrigation in Kenya."

¹⁰⁹ REEEP.

¹¹⁰ REEEP.

¹¹¹ Monsarrat, "Let's Get Pumping!"

¹¹² "OffGridBox: Technology."

ANNEX A LIST OF DEVELOPMENT PARTNER PROJECTS FOR OFF-GRID ENERGY

DONOR	PROJECT NAME OR DESCRIPTION
African Development Bank Group (AfDB)	Solar home systems (SHSs) for households in Southern and Western Provinces
	Green mini-grid feasibility studies and roll-out plan
UK Department for International Development (DFID)	Energy Africa
	EnDev Mini-Grid Results-Based Financing (RBF)
	EnDev Off-Grid Solar Home System RBF
	Support to REG-EnDev Off-Grid RBF Program (Former Pro-Poor RBF)
Energising Development (EnDev) Core Budget	On-Grid Hydropower
European Union	Prepaid energy rent-to-own SHSs
Power Africa	SHS RBF Program
	Off-Grid Monitoring and Verification System
	Loan guarantee for off-grid lending and technical assistance to banks
Swedish International Development Cooperation Agency (Sida)	Scaling up Off-Grid Energy in Rwanda (SOGER)
Sida	Portfolio Guarantee for Renewable Energy in Rwanda
World Bank	Renewable Energy Fund (REF)

ANNEX B METHODOLOGY FOR THE EICV5 ANALYSIS

This analysis used micro data from the EICV5 survey from the National Institute of Statistics Rwanda (NISR) from 2016-2017 which is used to determine poverty levels in Rwanda. However, the data is rich and contains detailed consumption data that was taken for the survey set of households, including energy expenses. The households were chosen to be representative of the population, and thus give an excellent picture of the true consumption patterns of the entire population of Rwanda. This analysis is looking at the amount spent by households on lighting and electricity.

For the survey, households were visited multiple times and asked about their expenses on items between trips (for the first trip, respondents were asked about expenses in the 7-day period leading up to the first visit). The survey period for these expenses was varied depending on whether the household was in Kigali or not (Kigali = 37 days, non-Kigali = 21 days), and the expenses were normalized to 30 days (one month) for each group.

To determine the amount spent on lighting/electricity, expenses for batteries, kerosene, candles, and electricity were summed for each household across all visits.

To determine an equivalent amount currently spent by off-grid customers for similar services, lighting and mobile phone charging were combined to determine off-grid spending.

The original questionnaire was referenced to identify the specific questions asked of the households and prevent misinterpretation of the data.

Energy spending was broken down by decile of energy consumption (population ordered by energy spending from low to high and broken into 10 equal segments). The quantile function in R was used to determine the spending level at specified percentiles. The midpoint of each decile was taken to give a median for each segment (5%, 15%, ... ,95%). The method used by the R function to determine the spending levels is linear interpolation. This decile calculation was also completed for several sub-groups including on- and off-grid households.

Customers were identified as off-grid that answered “No electricity” for electricity source. This group will not include current SHS, solar lantern, and mini-grid using households.

ANNEX C FINANCING MATRIX FOR OFF-GRID COMPANIES IN RWANDA

TABLE C-1. RWANDA-SPECIFIC FUNDING FACILITIES

RWANDA FUNDING FACILITIES: OFF-GRID ENERGY							
FUNDING FACILITY	MANAGING ENTITY	SPONSOR/PARTNERS	CAPITAL TYPE/ FUNDING INSTRUMENT	FUND SIZE	TICKET	FOCUS/SCOPE	WEBSITE
Renewable Energy Fund (REF)	Banque Rwandaise de Développement (Development Bank of Rwanda [BRD])	World Bank	On-lending to SACCOs and commercial banks. Direct lending to mini-grid developers and solar home system (SHS) companies	\$48.94 million		SHS and mini-grid funding	http://documents.worldbank.org/curated/en/684571498183375303/Rwanda-Renewable-Energy-Fund-Project
Energising Development (EnDev) Results-Based Financing (RBF)	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Society for International Cooperation [GIZ])	GIZ, UKAid, Ministry of Foreign Affairs of the Netherlands, Norwegian Ministry of Foreign Affairs, Swiss Agency for Development and Cooperation (SDC), Sweden	RBF grants	\$17.5 million		SHS and mini-grid funding	https://endev.info/content/Rwanda
U.S. Agency for International Development (USAID) Development Credit Authority	USAID	USAID	Off-grid loan facility	\$2 million		General	https://www.usaid.gov/what-we-do/economic-growth-and-trade/development-credit-authority-putting-local-wealth-work
Solar Irrigation in Rwanda (SIR)	Energy4Impact (E4I)	Organization of the Petroleum Exporting Companies (OPEC) Fund for International Development	Market building for solar irrigation, including grant support	\$1 million		Solar irrigation	https://www.energy4impact.org/about/programmes
Scaling Up Off-Grid Energy in Rwanda (SOGER)	E4I	Swedish International Development Cooperation Agency (Sida)	Commercial equity, grants, debts, grants for connections, and access to FIs			Support to mini-grids (hydro and solar) and for productive-use appliances used in mini-grids	https://www.energy4impact.org/about/programmes

TABLE C-2. OTHER FINANCING OPTIONS WHERE RWANDA IS INCLUDED AS PART OF THE GEOGRAPHIC SCOPE

REGIONAL/WORLDWIDE FUNDING FACILITIES: OFF-GRID ENERGY							
FUNDING FACILITY	MANAGING ENTITY	SPONSOR/PARTNERS	CAPITAL TYPE/ FUNDING INSTRUMENT	FUND SIZE	TICKET	FOCUS/SCOPE	WEBSITE
ElectriFi	EDFI Management Company	Multi Donor Project: European Union, PA, and Government of Sweden	Direct investments and indirect investments. Equity, quasi-equity, junior debt, senior debt, and guarantees.	EUR221 million	EUR0.5–10 million	Renewable energy and energy efficiency projects with a development impact. Mini-grids, SHSs, IPP, and CPP.	www.electrifi.eu
Responsibility's Energy Access Fund	Responsibility AG	Shell, International Finance Corporation (IFC), and OPEC	Short- and long-term debt, working capital focused	\$30 million	\$0.5–3 million	Sub-Saharan Africa	https://www.responsibility.com/en/investment-products/responsibility-energy-access-fund-sa-sicav-sif
Lendahand Crowdfunding	Hands-on BV	Private funders and crowdfunding	Short- and medium-term working capital facilities and structured asset financing	EUR40 million raised so far	EUR1–5 million	Energy access and access to finance, SME finance, global emerging market focus	www.lendahand.com
Energise Africa Crowdfunding	Lendahand Ethex Ltd	Private and public funders, crowdfunding supported by UKAid and other institutional investors	Short- and medium-term working capital facilities and structured asset financing	GBP10 million raised so far	GBP1–5 million	Solar Energy For sub-Saharan Africa	www.energiseafrica.co.uk
Facility for Energy Inclusion Off-Grid Energy Access Fund (FEI OGEF)	Lion's Head	African Development Bank Group (AfDB), Nordic Development Fund (NDF), Global Environment Facility, and Calvert Impact Capital	Debt: long and short term; US dollars (USD) and local currency	\$58 million first close (June 2018)	>\$1 million	Off-Grid Energy Facility (\$100 million) for emerging pay-as-you-go (PAYG) off-grid SMEs, affordable working capital in local currency, and mini-and micro-grid lending	https://www.ogef africa.com/
European Union EFSD and AfDB DESCOs Financing Program	AfDB	AfDB and European Union EFSD	Local currency receivables financing (debt and guarantee)	\$200 million initially	\$10 million and up	Credit enhancement instruments (partial credit guarantees) to de-risk receivables-backed financing facilities to fund the expansion of DESCOs activities and crowd in private sector investors. Beneficiaries are DESCOs or financial intermediaries funding a portfolio of DESCOs' receivables.	
FMO Infrastructure Development Fund/ Direct Investment	FMO	DFI network: DEG, Proparco, IFC	Debt: long and short term	EUR362 million	EUR5–20 million	Off-grid, sub-Saharan Africa	
CDC Group	CDC	Funded by the UK Department for International Development (DFID)	Equity and debt (specific fund for off-grid local currency lending)		\$5–10 million+	Off-grid renewable energy (SHS, C&I, and mini-grids) across Africa	www.cdcgroup.com

REGIONAL/WORLDWIDE FUNDING FACILITIES: OFF-GRID ENERGY							
FUNDING FACILITY	MANAGING ENTITY	SPONSOR/PARTNERS	CAPITAL TYPE/ FUNDING INSTRUMENT	FUND SIZE	TICKET	FOCUS/SCOPE	WEBSITE
EnDev Program	GIZ, RVO	Multi-donor partnership: the Netherlands, Germany, Norway, Australia, United Kingdom, Switzerland, and Sweden	Grants and RBF mechanism		Variable	Sustainable access to modern energy services that meet the needs of the poor	https://endev.info/content/Main_Page
EEP Africa	NDF	Austria, Finland, and NDF	Grants and repayable grants	EUR28 million	EUR200,000–1 million (depending on project size and co funding)	Renewable energy and energy efficiency projects with a development impact, including household solar businesses, targeting Southern and Eastern Africa	https://eepafrica.org/
Africa Clean Energy (ACE) programme and Competitive Business Facility (CBF)		Donor: DFID.	Short- and medium-term working capital facilities and structured asset financing	EUR40 million raised so far	EUR1–5 million	Energy access and access to finance, SME finance, global emerging market focus	www.lendahand.com
Contractor being procured through a competitive tender.		~\$20 million	\$0.3–1 million+	Household solar	https://devtracker.dfid.gov.uk/projects/GB-1-204637	Solar Energy For sub-Saharan Africa	www.energiseafrica.co.uk
Power Africa: Beyond the Grid Fund for Africa	NEFCO	USAID and Sida	Concessional debt	\$50 million		Energy service companies in Africa	https://www.sida.se/English/press/current-topics-archiv/2019/sida-invests-usd-50-million-to-increase-off-grid-energy-access-in-africa/
OPIC	OPIC	US Government funding	Debt			Including off-grid, Africa-wide	https://www.opic.gov/opic-action/overview
IFC	IFC	Multi-donor funded	Debt			Including off-grid, Africa-wide	
Development Innovation Ventures (DIV)	USAID	USAID					https://www.usaid.gov/div
DEG Upscaling (German Development Finance Institution)	DEG	German Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung [BMZ]) plus own funds	Repayable grant to be repaid in five years. Funds need to be matched.		EUR500,000	Sector agnostic. Early-stage enterprises in Africa with innovative business models.	www.deginvest.de/upscaling
Kiva	Kiva.org	Crowdfunding loans	Credit lines through qualifying local financial institutions or social enterprises	\$4 million	Dependent on the financial institution/social enterprise product structure	Broad: Includes off-grid energy	www.kiva.org

REGIONAL/WORLDWIDE FUNDING FACILITIES: OFF-GRID ENERGY

FUNDING FACILITY	MANAGING ENTITY	SPONSOR/PARTNERS	CAPITAL TYPE/ FUNDING INSTRUMENT	FUND SIZE	TICKET	FOCUS/SCOPE	WEBSITE
Social Investment Managers and Advisors (SIMA) Off-Grid Solar and Financial Access Senior Debt Fund I	SIMA Fund	MetLife, FMO, BIO, USAID, Church Pension Fund, AXA, Mercy Investments, ImpactAssets, Heifer International Foundation, Wallace Global Fund, private foundations, and individuals	Senior secured debt (working capital, inventory finance, and receivables finance); small carve-out for younger distributors	Target: \$75 million	\$250,000–9.5 million	Off-grid solar and financial access, sub-Saharan Africa and South Asia	www.simafunds.com
				Estimated: \$96 million			
Solar Energy Transformation Fund (SET Fund)	SunFunder	OPIC, Calvert Impact Capital, Ceniart, and IKEA	Senior debt fund facility, receivables financing, and local currency	\$85 million	\$200,000–7 million	Off-grid energy companies and projects in Africa	www.sunfunder.com
Beyond the Grid Solar Fund (BTG)	SunFunder	OPIC, FMO, and Rockefeller Foundation	Debt	\$50 million	\$250,000–5 million	Off-grid energy companies and projects in Africa (and Southeast Asia)	www.sunfunder.com
Cross Boundary Energy Access (CBEA) Fund I	Cross Boundary Energy	Rockefeller Foundation, Ceniart, and Shell Foundation	Debt	\$16 million first close		Mini-grids in Africa	www.crossboundaryenergy.com
Social Investment Fund 6.0	Global Partnerships	Key sponsors: OPIC/FMO	Direct lending: Senior debt fund facility, receivables financing, and local currency	\$75 million	\$0.5–4 million	Off-grid energy companies, distributors, and manufacturers operating in Africa	https://globalpartnerships.org/
Impact First Development Fund	Global Partnerships	Key sponsors: OPIC/FMO	Direct lending: Senior debt fund facility, receivables financing, and local currency	\$50 million at first close in June 2019	\$0.5–4 million	Off-grid energy companies, distributors, and manufacturers operating in Africa	https://globalpartnerships.org/
Solar Frontier Capital	African Frontier Capital	Private funders and Scaling Off-Grid Energy (SOGE): USAID, Shell Foundation, DFID, and AfDB	Receivables financing, local currency, hard currency, and off balance sheet		\$0.5–100 million	PAYGO SHSs in Africa and beyond	https://africanfrontiercapital.com/solar-frontier-capital.html
bettervest Crowdfinancing Platform	bettervest GmbH	Private funders and crowd-funders	Debt (subordinate loans) and debt-based project financing, mainly inventory financing	EUR 100,000–2.5 million	Variable for crowd investors, with a minimum of EUR50 and a maximum of EUR10,000	Aim = SDGs	https://www.usaid.gov/div
Nithio	Kupanda Holdings	TPG Rise Fund, UKAid, and Kupanda Capital	Receivables-backed financing vehicle		Not applicable (N/A)	Sub-Saharan off-grid energy	https://www.nithio.com/
Crowd4Projects	N/A		Short-term debt		N/A	Climate change- and energy-focused projects in developing countries	www.crowd4projects.com
Trine Debt Facilities	Trine AB	Retail and institutional investors	Debt: Short term, WC, and off balance sheet		\$1–20 million	Off-grid energy, Africa	www.trine.com

REGIONAL/WORLDWIDE FUNDING FACILITIES: OFF-GRID ENERGY

FUNDING FACILITY	MANAGING ENTITY	SPONSOR/PARTNERS	CAPITAL TYPE/ FUNDING INSTRUMENT	FUND SIZE	TICKET	FOCUS/SCOPE	WEBSITE
InfraCo	InfraCo	Private funders	Grants/debt		\$1–3 million	Off-grid; Mini-grids and early-stage projects with the potential to be bankable and raise sufficient investment at financial close. Focus: sub-Saharan Africa	http://www.infracoafrica.com/our-projects/
The Emerging Africa Infrastructure Fund	Investec	DFID/DGIS/Sida/Swiss State Secretariat for Economic Affairs (SECO)/DGIS	Project and corporate loans		\$10–50 million	Including Off-grid; mini-grids, sub-Saharan Africa	https://www.eaif.com/what-we-do/loan-products/
African Local Currency Bond Fund (ALCB Fund)	Lion's Head	KfW, BMZ, IFC, AfDB	Debt: Local currency bonds and project financing debt	\$30M	\$2–4 million, project financing	Including off-grid, sub-Saharan Africa	https://www.alcbfund.com/

ANNEX D DETAILED SALES INFORMATION FOR THE OFF-GRID MARKET IN RWANDA

TABLE D-1. SALES VOLUME BY CASH PURCHASE VS. PAYGO OVER TIME

SALES VOLUMES	BUSINESS MODEL		
	CASH+PAYG	CASH ONLY	PAYGO ONLY
July–December 2014	80,111	-	-
January–June 2015	10,000	-	-
July–December 2015	84,724	-	-
January–June 2016	129,779	-	-
July–December 2016	89,161	-	-
January–June 2017	190,781	-	-
July–December 2017	80,529	-	-
January–June 2018	47,741	9,400	38,341
July–December 2018	98,723	26,751	71,972
Total	811,549	36,151	110,313

TABLE D-2. MARKET VALUE OVER TIME

TIME PERIOD	TIME PERIOD TOTAL
July–December 2015	\$3,015,729
January–June 2016	\$6,685,482
July–December 2016	\$4,575,664
January–June 2017	\$4,053,836
July–December 2017	\$482,630
January–June 2018	\$4,760,009
July–December 2018	\$14,653,582
Total	\$38,226,932

TABLE D-3. MARKET VALUE BY CASH PURCHASE VS. PAYGO OVER TIME

SALES VOLUMES	BUSINESS MODEL	
	CASH ONLY	PAYGO ONLY
July–December 2015	\$3,015,729	-
January–June 2016	\$6,685,482	-
July–December 2016	\$4,575,664	-
January–June 2017	\$4,053,836	-
July–December 2017	\$482,630	-
January–June 2018	\$279,934	\$4,480,075
July–December 2018	\$290,248	\$14,363,334
Total	\$19,383,522	\$18,843,409

TABLE D-3. MARKET VALUE BY CASH PURCHASE VS. PAYGO OVERTIME

TIME PERIOD	SUM OF TOTAL	SUM OF QV	SUM OF NON-QV
July–December 2014	80,111	-	
January–June 2015	10,000	0	10,000
July–December 2015	84,724	78,851	5,873
January–June 2016	129,779	101,736	28,043
July–December 2016	89,161	75,097	14,064
January–June 2017	190,781	186,879	3,902
July–December 2017	80,529	75,118	5,411
January–June 2018	47,741	46,033	1,708
July–December 2018	98,723	91,162	7,561
Total	811,549	654,876	76,562

TABLE D-5. GOGLA ESTIMATED SALES DATA FOR BUNDLED APPLIANCES IN EAST AFRICA REGION

APPLIANCES	PERIODS	SALES VOLUMES
Fans	July–December 2016	—
	January–June 2017	—
	July–December 2017	27,140
Televisions	July–December 2016	21,042
	January–June 2017	113,502
	July–December 2017	126,701

TABLE D-6. BREAKDOWN OF EAST AFRICA REGION FUNDING TYPES, TRANSACTIONS, BUSINESS MODELS, USE OF FUNDING, AND FUNDING FLOW BY INVESTOR TYPE

GEOGRAPHY		2012	2013	2014	2015	2016	2017	2018
Type of Investment	Total	\$9,164,448	\$9,340,391	\$47,517,751	\$158,733,313	\$146,884,361	\$172,223,400	\$153,712,881
	Grant	\$2,642,965	\$5,875,826	\$4,929,570	\$6,500,000	\$3,000,000	\$0	\$1,458,211
	Equity-common shares	\$6,521,483	\$1,900,000	\$27,458,230	\$91,476,170	\$97,533,144	\$45,585,405	\$16,076,046
	Equity-preferred shares	\$0	\$0	\$0	\$0	\$5,575,000	\$0	\$0
	Debt-note/bond	\$0	\$0	\$350,000	\$6,957,143	\$12,940,000	\$5,936,940	\$1,693,556
	Debt-Bank or FI loan	\$0	\$1,564,565	\$5,000,000	\$13,300,000	\$24,692,315	\$45,146,950	\$71,109,311
	Debt-crowdfunding	\$0	\$0	\$0	\$0	\$1,143,902	\$2,554,104	\$19,728,048
	Debt-securitization and/or factoring	\$0	\$0	\$9,779,951	\$40,500,000	\$2,000,000	\$73,000,000	\$43,647,710
	Other	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Transactions	Number of Transactions	7	10	10	21	42	36	107
	Average transaction size	\$1,309,207	\$934,039	\$4,751,775	\$7,558,729	\$3,497,247	\$4,783,983	\$1,436,569
	Median transaction size	\$642,965	\$925,000	\$3,629,115	\$4,500,000	\$997,439	\$743,470	\$182,664
Business Model	Total	\$9,164,448	\$9,340,391	\$47,517,751	\$158,733,313	\$146,884,361	\$172,223,400	\$153,712,881
	PAYGO	\$3,364,448	\$8,590,391	\$47,517,751	\$158,733,313	\$144,821,783	\$171,993,068	\$138,781,163
	Non-PAYG	\$5,800,000	\$750,000	\$0	\$0	\$2,062,578	\$230,331	\$14,931,718
	Total	\$0	\$0	\$656,000	\$18,320,000	\$107,385,422	\$17,950,000	\$67,659,139
	Uncertain	\$0	\$0	\$0	\$0	\$0	\$0	\$0
	Business plan development, corporate set-up, and proof of concept	\$400,000	\$1,900,000	\$7,000,000	\$0	\$0	\$0	\$441,332
	Introduction of product to the market and/or product refinement	\$8,764,448	\$7,440,391	\$17,479,570	\$49,750,000	\$180,346	\$964,632	\$2,724,169
	Business scale-up and reaching a critical mass of customers	\$0	\$0	\$13,258,230	\$42,883,313	\$44,828,456	\$36,819,877	\$54,061,278
	Geographic expansion, addition of new products, and/or acquisition	\$0	\$0	\$0	\$15,100,000	\$79,485,181	\$37,936,940	\$17,509,157
	Bridging of working capital needs, including financing of consumer loans extended	\$0	\$0	\$9,779,951	\$48,500,000	\$22,390,378	\$96,501,950	\$66,676,945
Use of Funding	Refinancing of existing liabilities	\$0	\$0	\$0	\$2,500,000	\$0	\$0	\$12,300,000
	Other	\$0	\$0	\$0	\$0	\$0	\$0	\$0

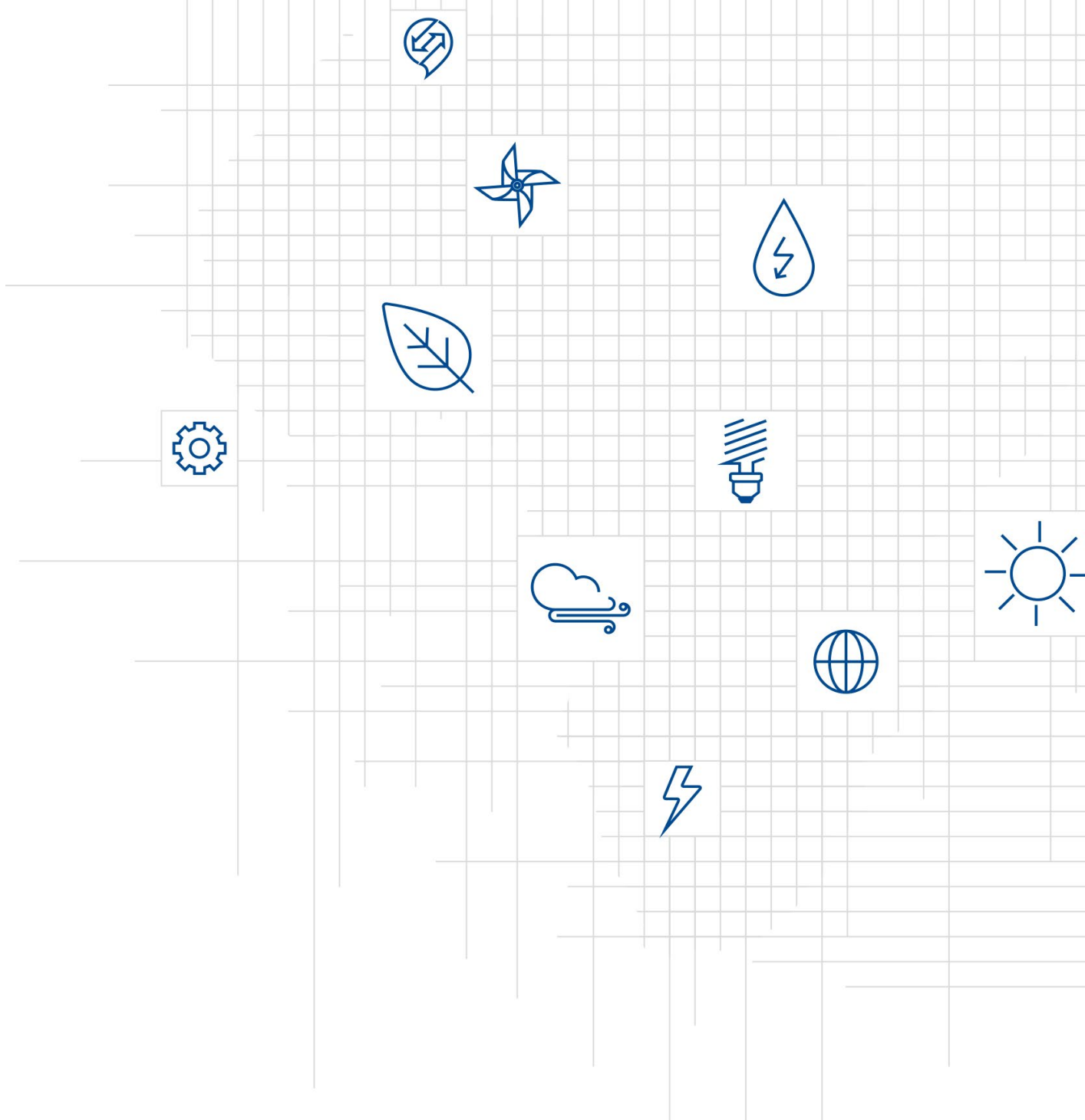
GEOGRAPHY		2012	2013	2014	2015	2016	2017	2018
Funding Flow by Investor Type	Total	\$9,164,448	\$9,340,391	\$47,517,751	\$158,733,313	\$146,884,361	\$172,223,400	\$153,712,881
	Crowdfunding	\$0	\$0	\$0	\$0	\$1,143,902	\$2,554,104	\$20,062,280
	Government, including DFIs	\$1,642,965	\$5,125,826	\$4,929,570	\$23,383,313	\$24,735,181	\$57,154,050	\$61,947,724
	Strategic corporates	\$0	\$750,000	\$0	\$1,500,000	\$0	\$22,000,000	\$0
	For-profit finance	\$400,000	\$1,564,565	\$9,779,951	\$2,500,000	\$54,000,000	\$34,000,000	\$4,410,930
	Family office/foundation	\$7,121,483	\$0	\$6,150,000	\$54,100,000	\$23,690,000	\$1,406,940	\$1,514,639
	Impact finance	\$0	\$1,900,000	\$26,658,230	\$75,050,000	\$36,965,378	\$55,108,305	\$38,167,710
	Unknown	\$0	\$0	\$0	\$2,200,000	\$6,349,900	\$0	\$27,609,598

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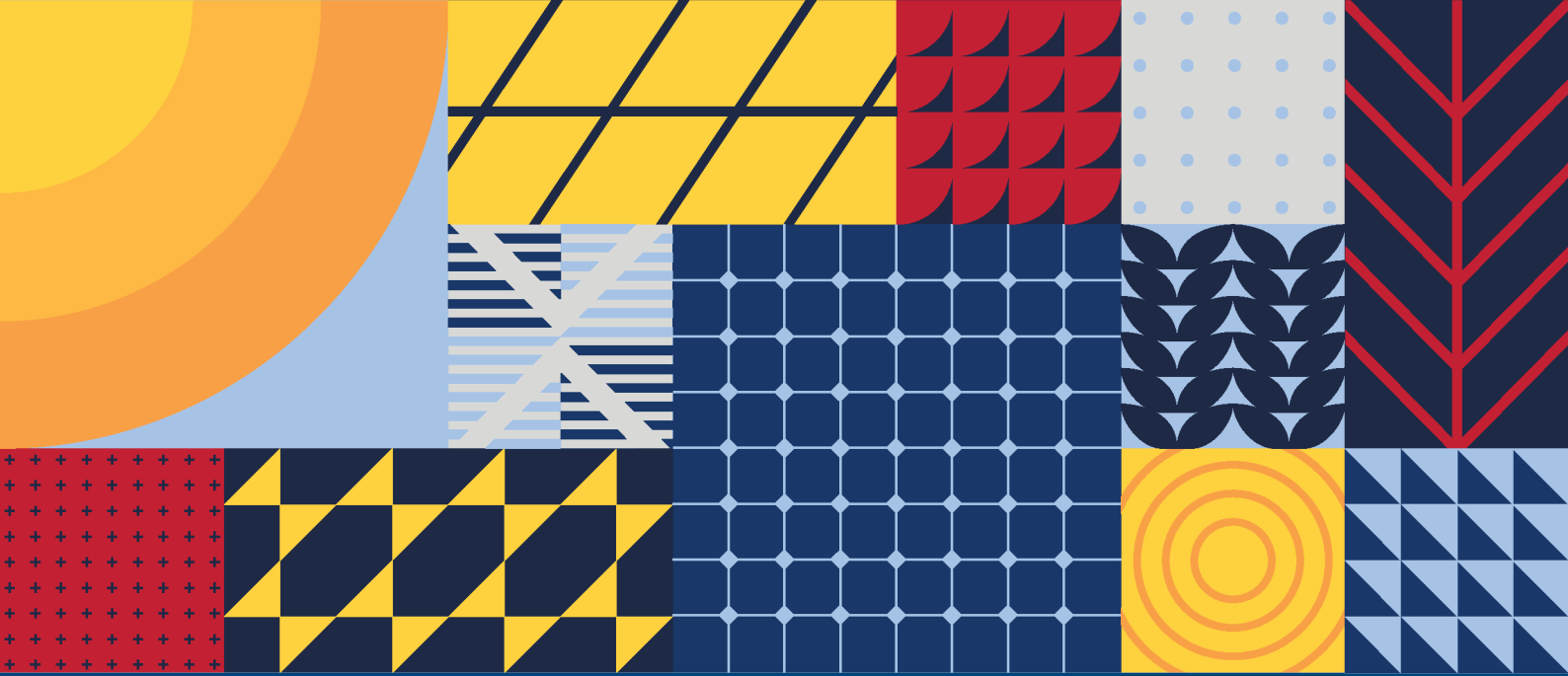
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Power Africa aims to achieve 30,000 megawatts of new generated power, create 60 million new connections, and reach 300 million Africans by 2030.