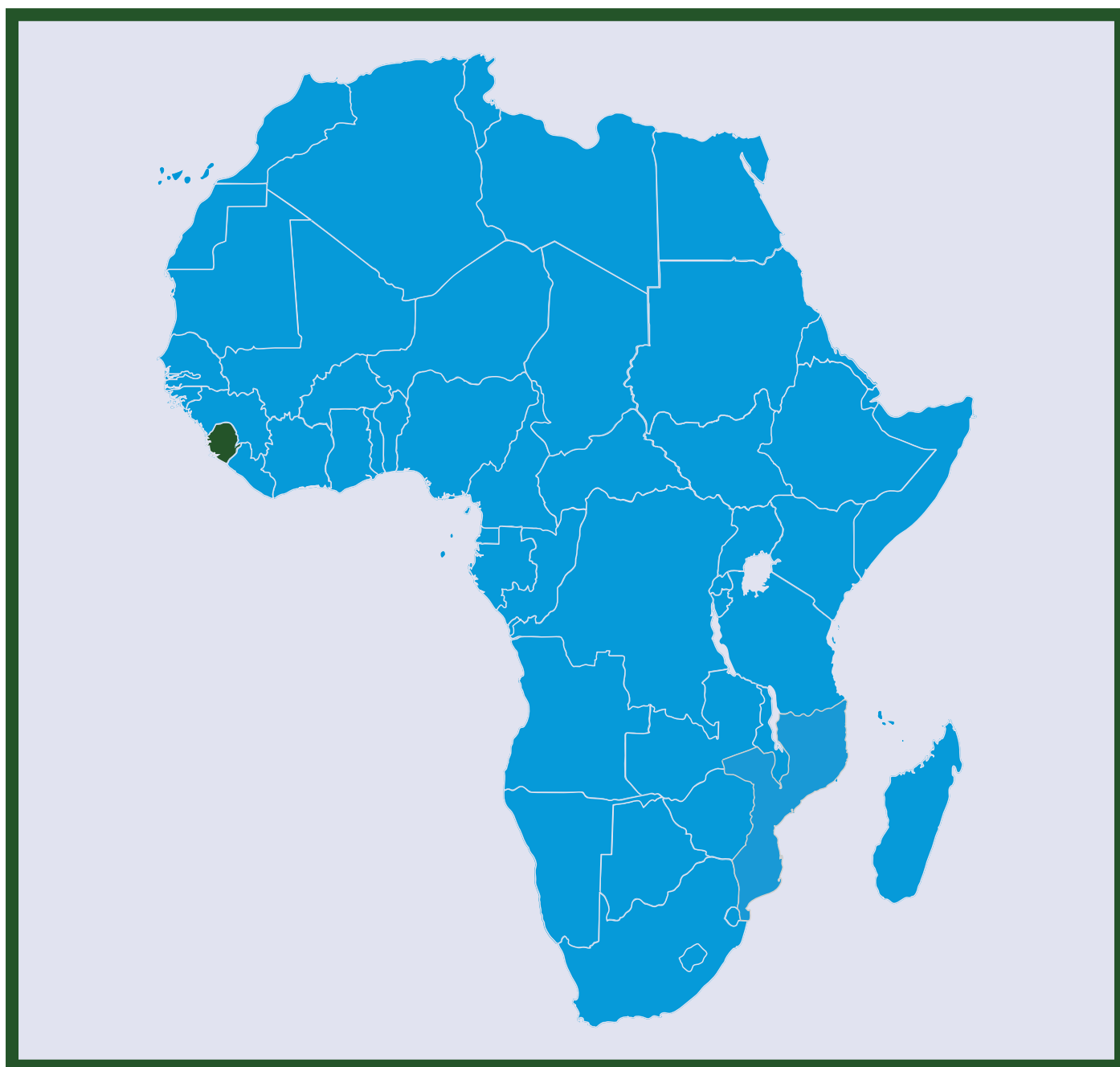


Mini-Grid Market Opportunity Assessment: Sierra Leone

Green Mini-Grid Market Development Programme:
African Development Bank (AfDB) and Sustainable Energy Fund for Africa
(SEFA)

November 2019





The Sustainable Energy Fund for Africa (SEFA) is a multi-donor trust fund administered by the African Development Bank to support small and medium scale Renewable Energy (RE) and Energy Efficiency (EE) projects in Africa. SEFA supports private sector-led economic growth initiatives under three financing windows: project preparation, equity investments and enabling environment support



The African Development Bank has an overarching objective to spur sustainable economic development and social progress in its Regional Member Countries (RMCs), contributing to poverty reduction. The Bank Group aims to achieve this objective by mobilising and allocating resources for investment in RMCs and providing policy advice and technical assistance to support development efforts.



The Carbon Trust wrote this report based on an impartial analysis of primary and secondary sources. The Carbon Trust's mission is to accelerate the move to a sustainable, low carbon economy. It is a world leading expert on carbon reduction and clean technology. As a not-for-dividend group, it advises governments and companies around the world, reinvesting profits into its low carbon mission.



The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) aspires to contribute to the sustainable economic, social and environmental development of West Africa by improving access to modern, reliable and affordable energy services, energy security and reduction of negative environmental externalities of the energy system (e.g. GHG emissions, local pollution).

The Carbon Trust would like to thank the following organisations for their interview contributions to this report: the Government of Sierra Leone (GoSL) Ministry of Energy (MoE), Public-Private Partnership (PPP) Unit, Environmental Protection Agency (EPA), the Tony Blair Institute (TBI), Electricity Generation and Transmission Company (EGTC), Electricity Distribution and Supply Authority (EDSA), German Cooperation (GIZ), Department for International Development (DfID), Renewable Energy Association Sierra Leone (REASL), Power for All, EnergiCity, INENSUS, Eon OffGrid, UNOPS, and Seli Hydropower

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PREFACE

This paper, part of the Green Mini-Grid Market Development Programme (GMG MDP) document series, assesses the green mini-grid market in Sierra Leone. Green-mini grids include mini-grids powered by renewable energy resources – solar radiation, wind, hydropower or biomass – either exclusively, or in combination with diesel generation.

Mini-grids are not a new phenomenon in Africa. Almost all national utilities own and operate diesel-powered generating facilities not connected to the main grid which supply electricity to secondary towns and larger villages. This solution to rural electrification often results in significant financial losses for the utility, who may be needed to sell power at prices significantly below the cost of production and delivery. It also leaves the most remote towns and villages without reliable access to electricity, even when there is provision. The latest Sustainable Energy for All (SEforALL) Global Tracking Framework estimates that the urban-to-rural divide in access to electricity in Africa is as high as 450 percent, with 69 percent of the population in urban areas electrified compared to only 15 percent in rural areas.

There are three principal options for providing new connections to currently unserved populations in Africa, namely: extension of the national grid; installation of separate “mini” grids to operate independently from the main grid; and stand-alone generating systems that supply individual consumers. The most cost-effective approach for powering mini-grids is to use renewable energy sources, which are widely available across Africa.

However, the development of GMGs is not without its challenges. In addition to unfavourable policy and regulatory frameworks, barriers to growth of the private mini-grids sector in Africa include the lack of proven business models, market data and linkages, key stakeholder capacity, and access to finance.

In response to these challenges, the SEforALL Africa Hub at the African Development Bank (AfDB) designed and launched Phase 1 of the GMG MDP in 2015 with grant funding from the AfDB’s Sustainable Energy Fund for Africa (SEFA).¹ The GMG MDP is a pan-African platform that addresses the technical, policy, financial and market barriers confronting the emerging GMG sector. It is part of a larger Department for International Development (DFID) funded GMG Africa Programme, which also has GMG initiatives in Kenya and Tanzania; country-specific GMG policy development through SEFA; and an action learning and exchange component implemented by the World Bank’s Energy Sector Management Assistance Program (ESMAP). Phase 2 of the GMG MDP, greater in scope and scale as compared to Phase 1, was launched in November 2017.

In its Africa Energy Outlook 2014, the International Energy Agency (IEA) predicted that by 2040, 70 percent of new rural electricity supply in Africa will most affordably come from stand-alone systems and mini-grids. The GMG MDP, SEforALL, SEFA, ESMAP and similar programmes, which are contributing to falling costs, technological advances and more efficiencies in GMG development, will help ensure that up to two thirds of this supply is powered by renewables.

The goals of the GMG programme are central to AfDB’s mission of spurring sustainable economic development, social progress and poverty reduction in its regional member countries. Off-grid and mini-grid solutions are a key component of the AfDB’s New Deal on Energy for Africa, launched by the Bank’s president in January 2016. The New Deal, a transformative, partnership-driven effort, aspires to achieve universal access to energy in Africa by 2025.

This report was prepared by the Carbon Trust and the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) at the request of the AfDB. It was written by Sophie Bordat and Gracia Munganga of the Carbon Trust, and reviewed by Benjamin Curnier and Hamadou Tchiemogo, of the Carbon Trust and ECREEE respectively. The Carbon Trust is a mission-driven organisation helping businesses, governments and the public sector accelerate the move to a low carbon economy. ECREEE is a specialised agency of the Economic Community for West African States.

The content of this report was reviewed by Dipta Majumder and Hannah Kabir from Inensus on behalf of the AfDB’s GMG team and cleared by Brendan Coleman, Energy Specialist and Project Manager at the AfDB. The report was further edited by Ruth Lumley.

1 The SEforALL Africa Hub partnership includes the African Union Commission, the New Partnership for Africa’s Development (NEPAD), the United Nations Development Programme (UNDP), and the Regional Economic Communities (RECs), which are represented on a rotating basis. <http://www.se4all-africa.org>

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LIST OF ACRONYMS

APC	All People's Congress
ASIC	Advanced Science and Innovation Company
BBC	British Broadcasting Corporation
BOO	Build Own and Operate
BOT	Build Operate and Transfer
CHC	Community Health Centres
CSLG	Cote Ivoire, Liberia, Sierra Leone and Guinea
DFID	Department for International Development
DFS	Digital Financial Services
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EDSA	Electricity Distribution and Supply Authority
EGTC	Electricity Generation and Transmission Company
EIA	Environmental Impact Assessment
ENFO	Energy for Opportunity
EPA	Environmental Protection Agency
EPA-SL	Environmental Protection Agency of Sierra Leone
EPC	Engineering, Procurement and Construction
ESMP	Environmental and Social Management Plan
EVD	Ebola Virus Disease
EWRC	Electricity and Water Regulatory Commission
GDP	Gross Domestic Produce
GHG	Greenhouse Gas
GHI	Global Horizontal Irradiation
GIS	Geographic Information System
GIZ	German Agency for International Cooperation
GMG	Green Mini-Grid
GST	Goods and Services Tax
HCI	Human Capital Index
HDI	Human Development Index
HFO	Heavy Fuel Oil
HV	High Voltage
ICT	Information and Communication Technology
IDA	International Development Agency
IDB	Islamic Development Bank
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IMF	International Monitoring Fund
INDC	Intended National Determined Contributions
IPP	Independent Power Producer

IRENA	International Renewable Energy Agency
JICA	Japanese International Cooperation Agency
JRC	Joint Research Centre
KMM	Key Maker Model
LUCF	Land-use Change and Forestry
MAFFS	Ministry of Agriculture, Forestry and Food Security
MCC	Millennium Corporation Challenge
MDP	Market Development Programme
MGP	Mini-Grid Partnership
MIGA	Multilateral Investment Guarantee Agency
MOE	Ministry of Energy
MOFED	Ministry of Finance and Economic Development
MTI	Ministry of Trade and Industry
MV	Medium Voltage
MW	Megawatt
NEA	National Electricity Act
NEC	National Electoral Commission
NGO	Non-Governmental Organisation
NPA	National Power Authority
NREAP	National Renewable Energy Action Plan
PAYG	Pay-As-You-Go
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PV	Photovoltaic
RBF	Results-based financing
RE	Renewable energy
REA	Rural Electrification Agency
REASL	Renewable Energy Association of Sierra Leone
REF	Rural Electrification Fund
ROGEP	Regional Off-Grid Electrification Project
RREP	Rural Renewable Energy Programme
RUF	Revolutionary United Front
SEFA	Sustainable Energy Fund Africa
SHS	Solar Home System
SL-EWRC	Sierra Leone Energy and Water Regulatory Commission
SLP	Sierra Leone People's Party
SSA	Sub-Saharan Africa
TBI	Tony Blair Institute
UK	United Kingdom
UNOPS	United Nations Office for Project Services
WAPGP	Western Area Power Generation Project
WAPP	West African Power Pool
WHH	Welthungerhilfe

EXECUTIVE SUMMARY

This country report is one of a series of country reports under the Market Intelligence business line of the African Development Bank's Green Mini-Grid Market Development Programme (GMG MDP). The MDP has the ultimate objective of fostering access to electricity across Africa by promoting the development of green mini-grids markets and overcoming barriers to scaling up investment. . The Market Intelligence business line aims to provide comparable, actionable data on the potential for GMGs across countries in Sub-Saharan Africa (SSA). This report provides an analysis for Sierra Leone. Previous country reports can be downloaded from the GMG Help Desk (<http://greenminigrid.se4all-africa.org>).

This report's methodology combines a high-level opportunity assessment with practical knowledge and information tailored for mini-grid practitioners. Information provided includes analysis of key stakeholders, compiled data on physical and non-physical factors of GMG markets and analysis of the latest policy and regulatory developments. Assessing the potential for mini-grids is challenging as such analysis is data intensive and must depend on assumptions. A thorough assessment must include several criteria that are driven by the business model and approach of the implementing agency for each case. This report therefore aims to capture available data and highlight general assessments that would be relevant to most mini-grid stakeholders. Raw data is provided with this report so stakeholders may further conduct their own specific analysis.

Sierra Leone is a coastal country situated in West Africa with a total land area of 71,740Km² and a population of 7.6 million in 2017. The country experienced an extensive civil war from 1991 to 2002, which resulted in 70,000 casualties and 2.6 million displaced people. During this period Sierra Leone's physical and human capital were severely damaged. Sierra Leone is one of the poorest countries in the world, with a total GDP of \$3.8 billion, per capita annual income of \$499.5, a poverty rate of 66.4% and a Human Capital Index (HCI)² of 0.35 below the world average of 0.57. Economic growth was also severely damaged by the Ebola Virus Disease (EVD) crisis which hit the country in May 2014, leading to widespread disruption of trade and economic activities. Sierra Leone's national electrification rate is very low at an national average of 20%, with urban areas at c.49 % and rural areas at only 5%.

The Ministry of Energy (MoE) has oversight responsibility for the energy sector and is the public authority responsible for developing policies and programmes for the provision of affordable and sustainable energy services for the population of Sierra Leone. The power sector in Sierra Leone has undergone significant changes over the last eight years. Notably through the adoption of the National Electricity Act (NEA, 2011) which revoked the National Power Authority Act of 1982, and unbundled the then vertically integrated public utility, National Power Authority (NPA), into two entities responsible for generation and distribution. The two new entities are the (i) the Electricity Generation and Transmission Company (EGTC) and (ii) the Electricity Distribution and Supply Authority (EDSA). Neither of these independent utilities are today financially sustainable and remain heavily reliant on government subsidies.

The Electricity and Water Regulatory Commission Act of 2011 established the regulatory authority; the Sierra Leone Electricity and Water Regulatory Commission (EWRC). The EWRC's mandate is to issue generation licences, approve and determine tariffs, and to formulate and monitor quality and compliance processes.

Sierra Leone has an estimated total on-grid installed capacity of 199MW concentrated in the Western Area (where the capital is located) and the Northern region. This installed capacity is dominated by thermal plants using diesel and HFO (106.7MW), followed by hydropower (56MW), biomass (30.3MW) and solar (6MW). Grid intermittency means that there is substantial 'back-up' power in the country. The 2030 Sector Roadmap³ estimates that there are currently 35,000 diesel generators in use which amount to approximately 180MW of installed capacity (this includes the captive power from the mining sector).

2 The Human Capital Index is a measurement created by the World Bank that measures the amount of human capital that a child born today can expect to attain by age 18, given the risks of poor health and poor education that prevail in the country where the child lives.

3 http://www.energy.gov.sl/wp-content/uploads/2018/04/Draft_Final_Roadmap_12092017_Master_Copy.pdf

The Sierra Leone electricity grid consists of isolated interconnected regions which suffer from significant losses due to ageing infrastructure. The main connection line is the 161kV line that extends from Freetown to the surrounding Western Area, supplied by the Bumbuna Phase 1 hydropower plant 220km from Freetown.

Rural electrification in Sierra Leone is implemented at present by the Renewable Energy Unit within the MoE, which in the absence of any implementation agency such as a REA, receives considerable support from several donor organisations. The role that off-grid systems must play in enabling universal energy access by 2030 is highlighted across various national plans, mainly the NREAP (2015) and the 2030 Electricity Sector Reform Roadmap (2017-30). The NREAP (2015), estimates that a total of 178MW out of the total 1,228MW future installed capacity will be off-grid, mostly produced from renewable energy and that 27% of the population will be best served by mini-grids, and 10% by standalone systems respectively.

There is limited information about the exact number of mini-grids in Sierra Leone. Most mini-grids that exist are either diesel, or mini-hydro projects. The main mini-grid programme is the DFID funded £43 million Rural Renewable Energy Programme (RREP). UNOPS were appointed by DfID and MoE as the implementing entity. RREP's main goal is to improve rural renewable energy access through the deployment of 97 mini-grids connecting 360,000 people.

Our analysis estimates that 2.9 million people (47% of the non-electrified population) will be best served by mini-grid solutions in Sierra Leone. A further 875,000 people (14% of the non-electrified population) will be best served by solar home systems (SHS) and 2.4 million people (39% of the non-electrified population) will be best served by grid extension, based on proximity to the existing grid. This calculation is based on the current grid coverage only and any planned grid extensions will reduce the estimated market size. The Sierra Leonean mini-grid market is outside of the Western area (where Freetown is located) due to their low electrification rates (i.e. 2% on average), limited grid coverage, and population densities high enough to support mini-grids.

In summary, this report estimates an annual mini-grid market size of USD\$33 million in Sierra Leone, based on an average mini-grid tariff of USD\$0.9/kWh, and average household demand per day of 0.2kWh/day. This implies per capita annual electricity expenditure of \$11.7 within the population best served by mini-grids. Based on an estimated cost-reflective tariff of \$0.9/kWh. Our analysis shows that the mini-grid market potential is spread among the following five main districts - Kailahun, Kambia, Kenema, Kono and Tonkolili, spread in the northern, southern and eastern provinces.

1. INTRODUCTION TO THE GREEN MINI-GRID MARKET DEVELOPMENT PROGRAMME

The African Development Bank's (AfDB) Green Mini-Grids Market Development Programme (GMG MDP) aims to foster access to electricity across Africa. The MDP aids a range of stakeholders in overcoming the challenges for widespread and sustainable implementation of Green Mini-Grid (GMG) projects, by:

- Establishing a comparable, actionable understanding of the GMG market opportunity in Sub-Saharan Africa (SSA);
- Promoting the linkages between communities, public institutions, developers, financiers, and technology providers required for successful mini-grid development;
- Strengthening capacity of developers to develop and operationalise GMG business models;
- Promoting a sound policy and regulatory environment; and
- Engaging project financiers and supporting the development of suitable financial solutions.

This country report is one of a series of country reports of the MDP's Market Intelligence business line, each of which provides an analysis of the GMG potential per country. These reports provide comparable, actionable data on the GMG potential across countries in SSA. GMG Opportunity Assessments for other countries can be downloaded from the GMG Help Desk (<http://greenminigrid.se4all-africa.org>).

The Market Development Programme is funded by the Sustainable Energy Fund for Africa (SEFA), a multi-donor trust fund administered by the African Development Bank.

The development of clean energy mini-grids is also the primary objective of the Mini-Grid Partnership (MGP) for which the African Development Bank is playing a lead role for Africa. The Mini-Grid Partnership (formerly the Clean Mini-Grids HIO), including the co-ordination group, secretariat and wider membership, is the established forum for discussion and co-ordination of the efforts of development partners to advance the adoption of GMGs. The Partnership aims to galvanize action on the barriers facing the sector, with the engagement of public, private and civil society expertise and resources. The MDP was designed from the beginning to be integrated and closely coordinated with the activities carried out in the framework of the Partnership.

2. COUNTRY OVERVIEW AND SECTOR OVERVIEW

2.1 COUNTRY OVERVIEW

Sierra Leone is a coastal country situated in West Africa with a total land area of 71,740Km² and a population of 7.6 million in 2017⁴. Sierra Leone shares borders with the Republic of Guinea and the Republic of Liberia and has a coastline of 465km along the Atlantic Ocean (SEforALL, 2014).⁵

The population of Sierra Leone has undergone major urbanisation since the 1980s. Today, 40% of the population lives in urban areas, slightly higher than the average urbanisation rate of Sub-Saharan Africa of 35%⁶.

Table 1: Sierra Leone Country Overview⁷

Indicator/criteria	Value
Area (Km ²)	72,300
Population (million) in 2017	7,557,212
Population Growth (%) per annum	2.2%
Share of rural Population (%) in	60%
Languages	English, Krio (Creole language derived from English). There are up to 23 local languages, but the most widely spoken are Mende, Temne and Limba ⁸
Religions	Islam, Christianity

Sierra Leone is divided into four regions, namely: i) the Northern Region, made up of five district towns of Kambia, Port Loko, Bombali, Tonkolili and Koinadugu; ii) the Southern Region, made up of four district towns of Bo, Moyamba, Pujehun and Bonthe; iii) the Eastern Region, made up of three district towns Kenema, Kono and Kailahun; and iv) the Western Area or Free Town Peninsula, divided into Western Area urban (mainly the capital city Freetown) and Western Area rural (SEforALL, 2014) ⁹

The climate of Sierra Leone is described as wet tropical monsoon with a single wet season each year. The average annual rainfall is about 2,540mm. There are two distinct seasons: the wet season, which lasts from May to October, and the dry season from November to April. Normal temperature range is between 21°C to 33°C although, temperatures can drop to as



Figure 1: Map of Sierra Leone provinces (WorldBank, 2018)

⁴ <https://data.worldbank.org/country/sierra-leone>

⁵ SEforALL Investment Prospectus for Sierra Leone and National Energy Policy for Sierra Leone

⁶

⁷ SEforALL Investment Prospectus for Sierra Leone - 2017 and Power for All: Sierra Leone Call to Action | March 2017

⁸ <https://www.bbc.com/news/world-africa-14094194>

⁹ Source SEforALL Investment Prospectus for Sierra Leone.

low as 100C at night during the Harmattan season in January. Harmattan is a season in West Africa, characterised by the dry and dusty north-easterly trade winds from the Sahara Desert into the Gulf of Guinea, between the end of November and middle of March.

Sierra Leone is one of the poorest countries in the world, with a GDP of US\$3.8 billion, per capita income of \$499.5, a poverty rate of 66.4% and a Human Capital Index (HCI) of 0.35 below the world average of 0.57 (WorldBank, 2018). Sierra Leone's GDP ranks 151 out of 188 in the International Monitoring Fund (IMF) rankings, and 183rd out of 187 on the UN Human Development Index (HDI). Half of government revenue comes from foreign aid. Basic infrastructure is lacking throughout the country, making commerce, transit and transportation difficult, especially outside urban and peri-urban areas and even more so during the six-month rainy season (from May to October). Two-thirds of Sierra Leone's 7.6 million people are directly involved in subsistence agriculture, which is also the largest employer (80% of the population) and accounts for roughly half of GDP.

Sierra Leone experienced an extensive civil war from 1991 to 2002, which resulted in 70,000 casualties and 2.6 million displaced people. During the period of unrest, Sierra Leone's physical and human capital was severely damaged (UNDP,2005)¹⁰. The war was characterised by widespread atrocities, including systematic rape and kidnapping of children led by the Revolutionary United Front (RUF). The main contributing factors that sparked the civil war included: a repressive state, a struggle for control of its mineral resources (notably diamonds), the exclusion of a large youth population, ease of access to small arms after the end of the Cold War, and interference from regional neighbours. Despite a decade of peace and strong economic growth since 2002 when the civil war ended, living conditions in Sierra Leone continue to be difficult. Physical infrastructure, particularly electricity, water, and sanitation, suffered widespread destruction at the time, and there has been a lack of maintenance since.

The peace agreement with the RUF of July 1999 led to the restoration of democracy and opened the country to the international community's commitment and aid, led by the UN, IMF and World Bank, to alleviate poverty, restore institutions, rebuild the economy and reintegrate the military into civilian life. National and local elections since 2002 have reinforced the multiparty system enshrined in the 1991 constitution. From 2002 to 2018, the country has experienced peaceful democratic elections which were generally considered to be free, fair and transparent, thanks to the work of the National Electoral Commission (NEC), as well as to international support. Three presidents have succeeded one another; Elhadji Tidjan Kabbah, Ernest Bai Koroma and the current President Julius Maada Bio. The leading political parties are the Sierra Leone People's Party (SLPP) led by the current elected president who came to power in April 2018, and the All People's Congress (APC), the current main opposition.

The economy has made an uneven, but continuous recovery since the end of the civil war in 2002, with GDP growth averaging 7.8% between 2003 and 2014. Sierra Leone's GDP growth accelerated to 12% in 2012 and reached its peak at 20% in 2013, due to government efforts to create a conducive environment for doing business and fighting corruption.

Economic growth was severely damaged by the Ebola Virus Disease (EVD) crisis which hit the country in May 2014, leading to widespread disruption of trade and economic activities. In total, the EVD resulted in c.4,000 deaths (Centre for Disease Control and Prevention, 2016) from May 2014 to early 2016. The negative economic impact of the Ebola crisis was further exacerbated by the worldwide drop in commodities prices which negatively impacted the foreign-exchange earners of the country such as iron ore and oil and saw the closure of two iron ores mines. As a result, the economy shrunk by more than one-fifth of its size in 2015 (Figure 2). The country experienced a negative GDP growth of 21% that year, witnessing only a slight recovery (about 5%) in 2016.

10 <http://web.undp.org/evaluation/documents/thematic/conflict/SierraLeone.pdf>



Figure 2: Sierra Leone GDP Growth, from 2006 to 2017 (AfDB)

Recent growth has not yet recovered the losses incurred during the Ebola crisis. Per capita income, estimated at US\$506 in 2018, remains below the pre-EVD levels (\$660). Similarly, the 2018 Sierra Leone Integrated Household Survey provisionally showed that the poverty headcount¹¹ was at 56.7% in 2018 compared to 53.8% in 2011. Poverty remains higher in rural areas (72.2%) compared to urban areas (18.4%) in Freetown (WorldBank, 2018).

Mining is one of the primary industries, and mineral exports generate most of the foreign exchange. Sierra Leone has significant reserves of iron ore, diamonds, rutile, bauxite, and gold. Gem-quality diamonds represent roughly half of exports, having previously been a key factor in the country's decade-long civil war. Other mineral reserves include chromite, platinum, copper, nickel, clay, zinc, lignite and lead. Manufacturing accounted for a mere 1.6% of GDP in 2014, declining from 2.3% in 2010, indicating the fact that Sierra Leone has urbanised rapidly without associated industrialisation and the required supporting infrastructure (UNDP, 2018). Agriculture, including forestry, fishing and hunting, continue to account for more than half of GDP, where two-thirds of the population are directly involved in subsistence agriculture.



Figure 3: Road network in Sierra Leone

The country's infrastructure sector comprises roads, harbours, airports and an ICT sub-sectors. These were extensively damaged during the civil war and there have been limited resources to invest in repairs, maintenance and new developments. Sierra Leone's network of trunk and feeder roads is severely deteriorated and unable to provide all-weather access to key producing centres. This keeps agricultural producing areas isolated from the market economy and pulls tradable commodities across borders rather than into the interior or for global export through Freetown's port. Sierra Leone has a public road network of about 11,700 kilometres of which 8,700km are functionally classified in the National Road System (Figure 3). The other 3,000km consists of local roads and unclassified roads and tracks. Sierra Leone does not currently have a rail network: the 762mm (2ft 6in) gauge Sierra Leone Government Railway from Freetown to Kenema and Daru closed in 1974 as volumes were low and maintenance costs high (DCLA, 2018). Furthermore, the country also does not share a rail network with its neighbours, Guinea and Liberia. Road transport is the most dominant mode of transport and represents about 85% of the transport system in Sierra Leone,

¹¹ Determined by comparing expenditure in purchasing power parity (PPP) adjusted dollars, per capita expenditure per year between 2018 and 2011.

95% of the inland transport of passengers and goods is carried out on roads. The existing railway between the port of Pepel and the Marampa iron ore mine is being refurbished by African Minerals PLC. This is a common carrier railway but will be used predominantly for transporting iron ore.

The liberalisation and licensing of private entrants in mobile telephony has expanded telecommunications services significantly, which has experienced double digit growth rates in the last decade. The Demographic and Health Survey (2013) found that household ownership of mobile phones increased from 28% to 55% between 2008 and 2013. The British Broadcasting Corporation (BBC) Media Action's 2015 survey shows that 53% of adult Sierran individuals own a mobile phone, while 83% of Sierrans can access a cell phone through a household member. This makes mobile phones the medium with the most rapid expansion and potential to reach many people in Sierra Leone (Figure 4)

The GoSL has over the past decade focused on the implementation of a plan to attract private sector participation in infrastructure development and funding, particularly water, power and transport. These include incentives for infrastructure projects, according to the GoSL's online investors prospectus, exemption from income taxes for 15 years for development costs exceeding US\$20 million.¹²

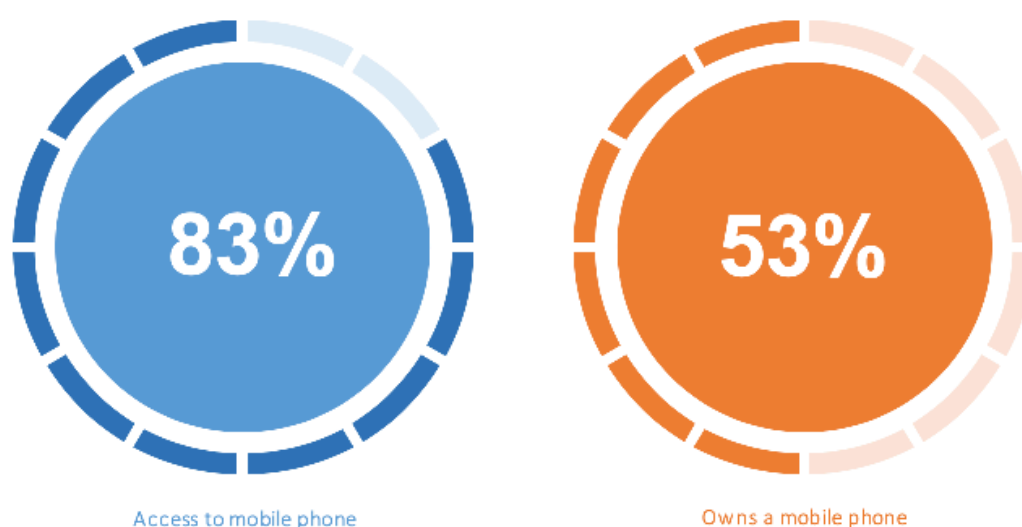


Figure 4: Percentage of the population with either access to or ownership of a mobile phone (BBC, 2015)

2.2 OVERVIEW OF THE ENERGY SECTOR

2.2.1 ENERGY MIX, EMISSIONS AND TRENDS

Sierra Leone's total annual primary energy consumption in 2013 was 3.93 (Mtoe/year), with 3.62 Mtoe coming from biomass (Table 2), which remains the major source of energy in the country, i.e. fuel-wood accounts for over 93% of the overall domestic primary energy consumption. Roughly 30% of harvested wood is used for charcoal production (REEP,2012). The remainder is supplied by crude oil and its by-products, namely kerosene, cooking gas and other petroleum products. Sierra Leone has abundant primary energy resources which includes crude oil, natural gas reserves and renewable energy resources such as hydro, solar, wind and biomass, but remains a net energy importer.

¹² <https://www.investingsinsierraleone.com/infrastructure/>

Table 2: Sierra Leone Energy Sector Background (WorldBank/ECOWREX)

Type of energy	Value (Mtoe)
Primary energy supply (Mtoe), 2013	3.93
Primary biomass energy (Mtoe)	3.62
Renewable Energy (Mtoe)	0.015
Primary fossil energy/petroleum products (Mtoe)	0.29

Based on 2013 data, grid-generated electricity accounted for only 4% of the country's energy consumption. Sierra Leone's electrified population is extremely small, with roughly 130,000 connected customers, and an average national electrification rate of 20% (5 % in rural areas). The country's energy needs are dramatically under-served, and the lack of a reliable energy supply is the principal impediment to Sierra Leone's economic and social development as a result. Sierra Leone's access to electricity has increased considerably in the last few years from c.11% in 2010 to 20% in 2017.

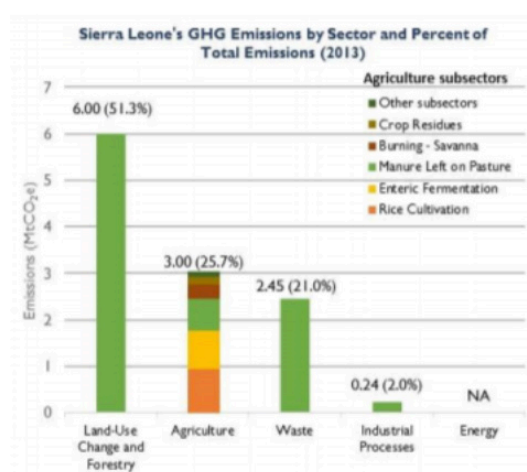


Figure 5¹³: Sierra Leone's GHG emission by Sector and % of total emissions (2013)

and Action Plan (NCCS&AP, 2015) which paved the way for the country's Intended National Determined Contribution (INDC). The INDC aims to maintain the country's relatively low emission levels (defined as close to the world average of 7.58 MtCO₂e) by 2035 and be carbon neutral by 2050 by reducing its carbon footprint with support from the international community¹⁴. Sierra Leone's INDC, developed with the support of Irish Aid, includes priority climate change adaptation and mitigation aspirations, such as:

- Institutionalise co-ordination, monitoring, reporting and verification of climate change issues by strengthening the Sierra Leone Environment Protection Agency (EPA)
- Strengthen the National Meteorological Services of Sierra Leone and strengthening of Climate Change Early Warning System of Sierra Leone
- Promote energy efficiency and vary the energy mix mainly through promotion of cleaner cooking fuels, and reduction of transmission and distribution network losses through upgrade of existing infrastructure), through uptake of renewable energy sources (Solar, Wind, Hydro, Biomass) particularly in the rural areas of Sierra Leone

Despite having total country GHG emissions of only 11.69 MtCO₂ (0.02% of the world total), Sierra Leone has been ranked as the third most vulnerable nation after Bangladesh and Guinea Bissau to the effects of climate change. This is mainly due to the country's low resilience and ability to adapt as a result of the country's high dependence on rain-fed agriculture, extreme poverty, unemployment and environmental degradation. Physical impacts from climate change is expected to include increases in temperature and more extreme weather events. 51.3% of emissions are from land-use change and the forestry (LUCF) sector,¹³ where changes to forest land contributes 95% of the sector emissions (Figure 5).

The Sierra Leone National Development Plan – the Agenda for Prosperity 2013 to 2018, indicates that Sierra Leone is committed to mainstreaming inclusive green growth in its development process. Sierra Leone recently developed and adopted its National Climate Change Policy (NCCP, 2015) and National Climate Change Strategy

¹³ World Resources Institute Climate Analysis Indicators Tool (WRI CAIT 2.0, 2017). Global Warming Potentials (GWPs) are from the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (SAR).

¹⁴ https://www.climate-links.org/sites/default/files/asset/document/2017_USAID_GHG%20Emissions%20Factsheet_Sierra%20Leone.pdf

- Strengthen transport infrastructure
- Improve waste management practices, and
- Implement climate smart and conservation agriculture

2.2.2 KEY ENERGY AND ELECTRICITY SECTOR STAKEHOLDERS

The Ministry of Energy (MoE) has oversight responsibility over the energy sector and is the public authority responsible for developing policies and programmes for the provision of affordable and sustainable energy services for the population of Sierra Leone.

The power sector in Sierra Leone has undergone significant changes over the last eight years notably through the adoption of the National Electricity Act (NEA, 2011) which revoked the National Power Authority Act of 1982, and unbundled the then vertically integrated public utility, the National Power Authority (NPA), into two entities responsible for generation and distribution respectively. The two new entities are the (i) the Electricity Generation and Transmission Company (EGTC) and (ii) the Electricity Distribution and Supply Authority (EDSA). Although the NEA was promulgated in 2011, the unbundling of the NPA only came into effect in 2015 when EGTC and EDSA became operational. EGTC oversees the generation and transmission at high voltage levels (161kV), while EDSA is responsible for electricity distribution and sub-transmission (33kV and below).

Currently, neither the EDSA nor the EGTC are recovering their costs and remain heavily dependent on government subsidies from the Ministry of Finance and Economic Development (MOFED). This is in part because of significant transmission and distribution losses due to ageing infrastructure (most of which is almost 60 years old) that was also largely damaged during the civil war (c.38% of the existing transmission and distribution network damaged), low revenue collections and electricity theft. EDSA works with a prepaid system and uses a network of seven aggregators for collection of revenue for the residential sector, much like the cell phone operators who then resell it back to users at a fee.

EDSA is in a poor financial state and faces numerous challenges that hinder the organisations ability to be financially sustainable. It is estimated that EDSA had an overall shortfall of 47% of its expected revenue in 2015 and owes EGTC at least \$30 million and is unable to honour the pass-through costs agreement with EGTC. EDSA faces the following challenges: (i) inefficient connection process which slows acquisition of new customers, (ii) inability to produce audited financial statements and lack of adequate accounting of the unbundled assets which inhibits EDSA's ability to access finance, and (iii) the absence of a formalised PPA between EGTC and EDSA which impacts directly on electricity supply. The MoE received a \$21 million grant from ECOWAS which is currently covering the shortfall from EDSA and enables the purchase of fuel for power generation.

Although, the NEA (2011) National Electricity Act enables the participation of independent power producers (IPPs) in power generation and provides a basis for signing power purchase agreements (PPAs); Sierra Leone does not currently have an established IPP procurement framework. Most of the existing IPPs to date were initiated as unsolicited bids to the MoE, and later structured as public private partnership (PPPs) through the GoSL PPP Unit, located within the Office of the President. The PPP Unit was created in 2010 to provide co-ordination and transactional support to various ministries, departments, and agencies, including the MoE, across a range of potential PPPs.

Sierra Leone operates under a “single-buyer” model for projects above 1MW and requires IPPs to sell to EDSA. Notable projects developed to date are (i) the 30MW Addax bioethanol to electricity plant, (ii) the 6MW solar park project funded by the Abu Dhabi Fund, and the mobile 30MW KARPOWER floating HFO plant.

At the same time as the adoption of the NEA, the Sierra Leone Electricity and Water Regulatory Commission Act of 2011 established the regulatory authority; the Sierra Leone Electricity and Water Regulatory Commission (SL-EWRC, <http://ewrc.gov.sl/>). The EWRC's mandate is to issue (i) generation licences, (ii) approve and determine tariffs, as well as (iii) formulate and monitor quality and compliance with regulatory frameworks for the safe, secure, affordable and reliable supply of water and electricity in Sierra Leone. Notable achievements to date for the regulator have been the ratification of the 2018 mini-grids regulations in August 2019, with the support of several donors such as the

UK's Department for International Development (DfID), the United Nations Office for Project Services (UNOPS) and the Millennium Challenge Corporation (MCC). As a newly established entity the EWRC has only issued provisional operations licences to date, including to the EDSA, EGTC and private off-grid GMG operators, and is in the process of developing terms and conditions for a permanent licensing regime for on-grid projects.

The Environmental Protection Agency (EPA) is the authority responsible for approving environmental impact assessments (EIAs) in the country, including for power sector projects, and therefore must provide EIA approvals for IPPs. The EPA revised the compliance process for renewable energy projects with the support of UNOPS, and published the 2018 "Guidelines for Environmental and Social Impact Assessments of Renewable Energy Technologies and Mini-Grids" which has not only simplified the requirements for renewable energy projects, but also led to cost reductions for developers (more details is provided in Section 2.3 and 2.4).

The Millennium Challenge Corporation (MCC), among other international partners, has been providing capacity building to EWRC and EPA to undertake their mandated functions. In addition, the MCC supported the MoE with the development of the Electricity Sector Roadmap Reform 2017 to 2030 (commonly referred to as the "2030 Sector Roadmap" in this report) under their \$44 million Threshold Programme to support reforms in the power and water sectors. The 2030 Roadmap is currently the latest and most comprehensive planning document for the power sector in Sierra Leone. Although it has not been ratified in Parliament, the 2030 Roadmap provides a blueprint for the required interventions to address current challenges, particularly linked to the financially constrained utilities. Apart from MCC, UNOPS has been providing capacity building support to the EWRC and EPA, as well as the rural electrification projects or renewable energy-based projects in general. As part of this capacity building, EWRC mini-grid regulations and EPA guidelines for renewable energy projects were developed which are now under the process of ratification.

Rural electrification in Sierra Leone is implemented at present by the Renewable Energy Unit within the MoE, which in the absence of any implementation agency such as a Rural Electrification Agency (REA), receives considerable support from several donor organisations. These include DfID, the Tony Blair Institute (TBI) embedded in the MoE, GIZ, ECOWAS ECREE, Power for All, Barefoot Solar Women, USAID's Power Africa and UNOPS. UNOPS was appointed by the MoE to implement the DfID-funded £43 million Rural Renewable Energy Project (RREP), one of the largest green mini-grids projects in Sub-Saharan Africa. The RREP's main goal is to improve rural renewable energy access through the deployment of 97 mini-grids connecting 360,000 people. Further details about respective donor programmes in the energy sector is provided in Sections 2.3 and 2.4

Other ministries involved in the energy sector are the Ministry of Agriculture, Forestry and Food Security (MAFFS), the Ministry of Trade and Industry (MTI), and the Ministry of Finance and Economic Development (MoFED). The MAFFS has a key role in matters related to bioenergy and crop-related energy issues, while petroleum marketing and sales are handled by the MTI through the Petroleum Unit (PU). The MoFED also plays a supportive role in fiscal matters and has been providing subsidies to the newly established utilities EDSA and EGTC as these are not financially independent yet. Furthermore, to overcome the weak balance sheet of EDSA (as the sole off-taker based on the 2011 NEA), MoFED and MoE are co-signatories to any PPAs to reduce off-take risk. Further ministries whose roles should be highlighted are both the Ministry of Health (MoH) and the Ministry of Local Development and Rural Development. The MoH was instrumental during the first implementation phase of the Rural Renewable Energy Project (RREP).

The Renewable Energy Association of Sierra Leone (REASL) was formed in February 2016 as a result of a Power for All initiative and is a trade association to promote the development of renewable energy market in Sierra Leone¹⁵. The REASL currently has c.30 members including international companies present in Sierra Leone such as d.light, Azuri, Barefoot Power, TOTAL, Azimuth, BBOX and Ignite Power. The main achievements to date have been (i) establishing minimum quality assurance standards for imported solar products in Sierra Leone, (ii) engaging micro finance institutions, and (iii) successfully lobbying for the removal of the import duty on solar products based in 2016 (Finance Act, paragraph 26, 2011) provided they meet IEC standards. This resulted in a significant increase in uptake of solar home systems (SHS) from 50,000 to 250,000 by end of 2018 based on engagements with REASL. Moreover, the REASL is responsible for general awareness raising through various forums. Of note, is the recent establishment of the off-grid working group chaired by the MoE minister which is one of the first public-private platforms in the energy sector.

2.2.3 GOVERNMENT ENERGY POLICIES, STRATEGIES, TARGETS, ROADMAPS, PLANS AND PROGRAMMES

The **2009 National Energy Policy (NEP)** was developed in partnership with the United Nations Economic Commission for Africa (UNECA) as the overarching guide for the development and management of the Sierra Leone energy sector. The 2009 NEP targets included (i) increase access to electricity services to 35% of the population of Sierra Leone by 2015, (ii) adequate supply of petroleum products to all towns of more than 10,000 inhabitants by 2010, and (iii) increase the access to high quality household energy substantially by 2015. The 2009 NEP developed a high-level action plan, with a targeted set of interventions required such as (i) restructure of the energy sector to allow private sector participation, (ii) rehabilitation of existing generation facilities and diversification of the energy mix to include renewables (biomass, hydro and solar). Having largely failed to meet the intended targets, due in part to factors such as the EVD crisis, the NEP is now being updated and expected to be publicly available once finalised.

Based on the 2009 NEP, the power sector in Sierra Leone underwent a transition through the introduction of the 2011 National Electricity Act (NEA, 2011) to allow for private sector participation. The 2011 NEA unbundled the then vertically integrated National Power Authority (NPA) into the Electricity Generation and Transmission Company (EGTC) and the Electricity Distribution and Supply Authority (EGTC). EGTC does not own the assets that it operates as the transfer of assets to EGTC is not yet completed. EDSA is the sole off-taker of power for projects above 1MW as mandated by the 2011 NEA, responsible for delivering electricity to customers, as well as collections on behalf of the GoSL.

The 2015 National Renewable Energy Action Plan (NREAP) for Sierra Leone was developed as an outcome of the 2014 Sustainable Energy for All (SEforALL) Action Agenda, as part of the GoSL's agreement with the ECOWAS member states. The goals outlined in the 2015 NREAP specifically highlight the contribution of renewable energy (RE) in the Sierra Leone future energy mix, i.e. up to 1,229MW of both grid-connected and off-grid RE by 2030. The NREAP presents 2020, and 2030 targets including solar, hydro, wind and bioenergy (Table 3). Although Sierra Leone is far from meeting the 659MW installed capacity targeted by 2020, the current pipeline of solar and biomass projects are in line with the planned NREAP goals (i.e. 32 MW and 73 MW for bioenergy and solar respectively). This is mainly due to the 30MW Addax biomass project, and the Solar Park and Planet Solar Energy projects.

Table 3: The 2015 National Renewable Energy Plan (NREAP) targets

MW	Baseline (2010)	2020	2030
Small hydro (up to 30MW)	6	42	126
Medium and large hydro (more than 30MW)	50	510	935
Solar		73	95
Wind		2	5
Bioenergy		32	68
Total	56	659	1,229

The 2015 NREAP increased the energy access goal from 35% (2009 NEP) to 92% by 2030, with specific allocation for off-grid electricity targets. Namely, 178MW (Table 4) by 2030 which will serve 37% of the population through a combination of mini-grids (27%) and standalone solar home systems (10%) as presented in Table 5.

Table 4: National 2020 and 2030 off-grid RE targets (NREAP, 2015)

MW installed capacity	2010	2015	2017	2020	2030
Mini-grids (RE and Hybrid))	-	31	48	70	134
PV, pico-hydro and small-scale wind systems	-	4	8	16	44
Total off-grid RE installed capacity	-	35	56	86	178

Table 5: Overview of the energy access targets in Sierra Leone (NREAP, 2015)

%	2010	2015	2017	2020	2030
Population served with electricity, of which:	8.6	19	29	44	92
Grid-connected	8.2	15	22.25	30	55
Mini-grids	0.003	3	5	11	27
Standalone systems	0.1	1	1.75	3	10

In 2016, Sierra Leone was the first African country to sign the Energy Africa Policy Compact with the UK Government. The Energy Compact seeks to support the GoSL's efforts to improve energy access for rural communities and to accelerate the country's household solar market in line with the 2015 NREAP. A DfID financed Power for All campaign was launched and an "Energy Task Force Meeting" established by the GoSL. As a result, the GoSL launched the Energy Revolution, a government-led initiative to promote the solar home system (SHS) market with the goal of reaching 250,000 households with modern solar solutions by 2018 and achieve 'Power for All' by 2025. While there has been progress, particularly in the SHS market thanks to the Energy Revolution, the universal energy access targets are unlikely to be achieved in the proposed timeframes based on the current country energy access statistics (5% on average).

To support the roll-out of solar products in Sierra Leone, the Finance Act of 2017 made the following provisions:

- (i) permanent elimination of import duties for qualifying solar equipment, i.e.** solar products that meet IEC global quality standards harmonised with IFC/World Bank Lighting Africa Global standards) qualify for import tax-free status, and
- (ii) elimination of Goods and Services Tax (GST) sales taxes on sale of qualifying-certified solar products.**

Despite the positive regulation changes to date to encourage private sector participation, the Sierra Leonean electricity sector continues to face several significant challenges and the current status quo is not sustainable: EDSA's performance impacts the entire value chain because successful involvement of independent power producers (IPPs) depends on the financial and operational viability of the distribution utility as the sole mandated off-taker.

To address the above challenges, co-ordinate efforts more effectively in the sector, and engage openly with the private sector, the 2030 Roadmap was initiated by the Millennium Corporation Challenge (MCC), in partnership with the MoE. The 2030 Roadmap provides a blueprint of the expected changes over the next decade in the electricity sector and proposes a set of targeted interventions to address current challenges, particularly linked to the financially constrained utilities, and private sector participations. The two main notable interventions proposed presented below:

1. Revised and updated of power sector targets from the NEP (2009) and NREAP (2015)

- a. The Roadmap sets the ambitious goal for Sierra Leone to have a generation capacity between 1,800 to 2,000MW by 2030, an increase from the NREAP (2015) which anticipated a total installed capacity of 1,229MW by 2030. Renewables, and large-scale hydro are expected to provide 50% of that capacity, and at least two facilities at a regional level, co-ordinated by the West African Power Pool (WAPP), are expected to provide 200 and 300MW, respectively.
- b. Strengthening of the transmission grid consisting of 1200km of 225kV and 161kV lines, plus 800km of 66kV lines

2. Restructure the current electricity sector to create an enabling environment for the private sector through the following key interventions:

- a. **Developing sustainable business model for EGTC and EDSA by (i) amending the NEA (2011) to allow for the creation of a collection account for EDSA** to improve its collection rates and mechanisms, and (ii) appointing an external management contractor for EDSA in charge of developing a viable business plan, improving collections (through the supply and installation of business information and metering equipment), restructuring its commercial performance and building capacity over a three-year period.

- b. **Developing an IPP procurement framework for the GoSL for the timely planning of additional power generation capacity.** The 2030 Roadmap proposes the development of procurement contract/concession for power generation including (i) a single concession agreement with off-grid concessionaires for towns over 20,000 inhabitants (with transfer of public assets owned by public utilities), (ii) a single PPP contractor for towns below 20,000 inhabitants, (iii) the outsourcing from EDSA to private operators for the cities of Freetown and Lungi.
- c. **Developing a licensing framework for off-grid projects. This has been achieved as the EWRC recently drafted the 2018 Mini-Grid Regulations,** which underwent a public participation process in 2019 and have since been under ratification process by Parliament and were expected to be part of the legislation from November 2019 onwards.
- d. The creation of both a rural electrification agency and rural electrification fund to support the energy access goals and off-grid projects in the future.

The main outcome of the 2030 Roadmap has been (i) strengthening of the regulator EWRC to become an independent institution, and the (ii) soon to be ratified 2018 EWRC mini-grid regulations at the time of writing this report, through the co-ordinated support of various donors such as UNOPS, DfID, MCC and the WorldBank. It is worth noting that the 2030 Roadmap is currently being re-evaluated and updated by the MoE, and therefore it is unlikely the remainder above the interventions will be implemented soon.

2.3 OVERVIEW OF THE POWER SECTOR (NETWORK AND INFRASTRUCTURE)

Sierra Leone's national electrification rate is very low at a national average of 20% as of 2017, with urban areas at c.49% and rural areas at only 5%. This equates to c.130,000 connected customers. Electricity access and demand in Sierra Leone are among the lowest in Africa. Public electricity services are limited to selected areas. Sierra Leone's limited power infrastructure (i.e. generation, transmission and distribution equipment) is a major constraint to economic development. The sparse coverage and unreliable service exacerbate poverty conditions.

Sierra Leone has an estimated total on-grid installed capacity of 199MW in 2017 (Table 6) concentrated in the Western Area (where Freetown is located) and the Northern region. The installed capacity is dominated by thermal plants using diesel and HFO (106.7MW), followed by hydropower (56MW), biomass (30.3MW) and solar (6MW).

Table 6: Installed capacity by Region and by fuel source (ECREEE, 2017)

Region	Solar (MW)	Biomass (MW)	HFO (MW)	Diesel (MW)	Hydro (MW)	Coal (MW)	Total (MW)
Western Area			26.50	25.00			51.50
North		30.25	6.00	7.18	50.30		93.73
South				10.00			10.00
East				2.00	6.00		8.00
Western Area			30.00				30.00
Western Area	6.00						6.00
Total		30.25	62.50	44.18	56.30	0	199.23

Grid intermittency means that there is substantial ‘back-up’ power in the country. The 2030 Sector Roadmap estimates that there are currently 35,000 diesel generators in use, which provide approximately an installed capacity of 180MW (including the captive power from the mining sector). The mining sector relies primarily on captive generation with imported fuel to meet its large power demand. Mining companies account for c. 70MW distributed across Sierra Leone, a demand likely to increase significantly based on the current pipeline of mining projects.¹⁶

Electricity tariffs in Sierra Leone are among the highest in the region, with an average rate of US\$0.28/kWh due to the high cost of imported fossil fuels used for power generation (Figure 6). Interviews with local stakeholders suggest tariffs are likely to be further revised up in the near future. EDSA's tariff structure is presented in Table 7 below, extracted from EDSA's electricity service delivery charter¹⁷. Residential customers pay the lowest and large power users the highest. Large users such as welders, industry, streetlights, hospitals and schools also pay a minimum charge between Le 39,920-177450/kWh (\$4-\$20/kWh).

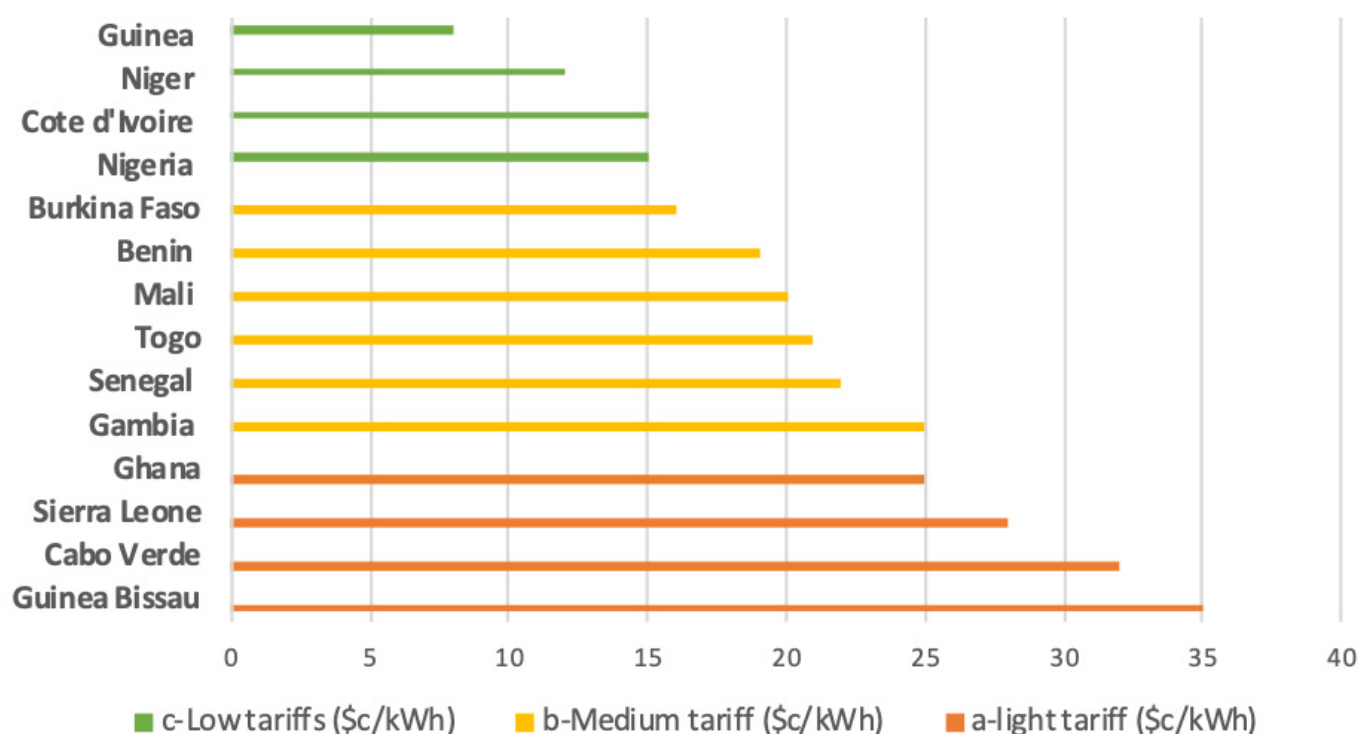


Figure 6: Average tariffs in ECOWAS Countries (Source: ERERA Tariffs, 2018/National Energy Statistics: Bulletin

¹⁶ Technical Assistance Facility for the Sustainable Energy for All Initiative West and Central Africa: SEforALL Investment Prospectus for Sierra Leone

¹⁷

Table 7: EDSA Tariffs Structure¹⁸

Activity	Cost	Units (kWh)	Le/kWh	USD/kWh
Tariff Structure				
Cost of 1 kWh/unit as per tariff category	T1 Residential	0-30	560	0.057
		31-150	800	0.081
		Above 150	1,064	0.11
	T2 Commercial	0-30	977	0.10
		31-150	1,172	0.12
		Above 150	1,269	0.13
	T3 Health and Educational Institutions	All Units	1,172	0.12
		Minimum Charge	48,800	4.96
	T4 Large Power Users	All Units	1,412	0.14
		Demand	2,172	0.22
		Minimum Charge	177,450	18.04
	T5 Street Light	All Units	1,188	
		Minimum Charge	39,927	
	T6 Temporary Supply	All units	1,365	
		Minimum Charge	16,926	
	T7 Welders	All Units	1,490	
		Minimum Charge	53,235	

2.3.2 GENERATION

The current installed capacity in Sierra Leone is spread across eight generation sites mainly located in the Northern and Western Area region (Table 8). Bumbuna hydroelectric power project Phase 1 is the largest site based on installed capacity (50MW) and was completed in 2016. Bumbuna Phase 1 has high seasonal variability, with an estimated peak of 40MW capacity during the wet season, and as low as 5MW during the dry season based on engagements with EGTC. As a result, the system struggles to meet demand, often resulting in load shedding.

To address power shortages, particularly during the dry season, the GoSL through EDSA contracted KARPOWERSHIP in 2016 to supply 30MW of emergency grid tied power (mobile HFO boiler parked at the Freetown Harbour) to Freetown for a duration of two years. This is in the hope that additional generation projects will come online thereafter. Discussions with the EDSA suggested that the MoE is currently considering renegotiating the PPA tariffs in an attempt to reduce the relatively high costs.

¹⁸ <https://www.anticorruption.gov.sl/slides/slide/electricity-service-delivery-charter-edsa-4>

The 30MW Addax biomass plant is a bioethanol to power project, near Makeni (Northern Province) which uses sugar cane to produce bioethanol for export and power generation. Only, 15MW of the 30MW installed are currently used based on the PPA signed with EDSA and is currently supplying the Bumbuna-Freetown grid.

Diesel and HFO plants dominate, but these plants are supplied by expensive and imported fuels which can limit their availability during fuel shortages in the country. These shortages are due to limited port facility and poor supply chain infrastructure which in turn lead to periods of fuel crises, pushing up the price of diesel and creating fuel black markets.

*Table 8: Overview of power generation sites in Sierra Leone owned by the utility EDSA
(Adapted from Janse, 2018)*

Region	City	Name of site	Technology	Owner	Capacity
Northern	Bumbuna	Bumbuna Hydroelectric Power Station	Hydro	Utility	50MW
Northern	Port Loko	Bankasoka Hydro power		Utility	2.2MW
Eastern	Kenema	Goma-Dodo mini-hydro dam		Utility	6MW
Western Area	Freetown	King Tom Diesel Power Station	Thermal -Diesel	Utility	10MW
Northern	Port Loko	Port Loko Thermal Power Station	Thermal-HFO	Utility	30MW
Northern	Makeni	Addax	Biomass	Sunbird Bioenergy	30MW, 15MW operational
Western Area	Freetown Port	KarPower	Thermal	Karadeniz Power Ship	30MW
Western Area	Freetown	Solar Era	Solar PV	ASIC	6MW

The 6MW solar park in Freetown is the first solar IPP project in Sierra Leone, funded the International Renewable Energy Agency (IRENA) and Abu Dhabi Fund for Development (IRENA/ADFD) financing facility. The project was originally conceptualised in 2014 but only delivered in December 2017, delays probably linked with the state of emergency caused by the Ebola crisis. Advanced Science and Innovation Company (ASIC) LLC from the UAE signed a 25-year PPA with EDSA, and the appointed EPC is SMRT Projects and Energy Solutions based in Sierra Leone. The total project costs are estimated at \$13 million, and in addition to the 6MW Power Plant, assets such as a necessary extension of the 161KV grid power line, a distribution substation, and a MV/HV substation formed part of the total project.

The 2030 Roadmap has set the ambitious target of increasing the generation capacity to 1,800 to 2,000MW by 2030 where the bulk of the capacity will be dominated by large-scale hydro (700MW) owned by EGTC and potential concessionaires. In this scenario renewable energy would account for over 50% of the generation capacity mix by 2030 (c.950MW including the 700MW of large-scale hydro) with 140MW of small-scale hydro, 60MW of Solar PV and 50MW from biomass.

The Cote d'Ivoire Liberia Sierra Leone Guinea (CSLG) interconnector would supply 5% of the installed capacity (around 100MW expected to be supplied by a 450MW coal plant in Cote d'Ivoire as planned by the West Africa Power Pool (WAPP) early next year, 2020. The CSLG line is funded by a mix of donors including ECOWAS and AfDB, and delivered by Transco CSLG, the special purpose vehicle, created by the four countries to deliver the cross-country transmission line. According the 2030 Roadmap, the remainder could be supplied through a mix of either a MW local thermal plant, or potentially a regional coal/gas plant by the WAPP. However, this is not finalised. The Ministry of Energy and Public-Private Partnership (PPP) Unit is in discussion with several potential independent power producers (IPPs) for heavy fuel oil, thermal, solar, and hydro projects in addition to the current installed capacity. Notable projects developed and signed to date:

- **Western Area Power Generation Project (WAPGP)**

The WAPGP will see the development of a \$138 million, 57MW greenfield heavy fuel oil plant in Kissy industrial (East of Freetown) with a 20-year Power Purchase Agreement (PPA). The land at the Kissy Industrial site, owned by the GoSL, has been leased to the Project Company under a plant site lease agreement signed in March 2015 with a tenure of 26 years.

The WAPGP ownership project structure is complex and was structured to address the Sierra Leone power sector market risks through several instruments. The private investors are CDC and Tempus Constant Qualitas Power Ltd from Abu Dhabi which contributed 50.1% and 49.9% of the equity portion respectively (\$34 million). While the senior debt portion was provided by the World Bank Group first through the IFC (\$30 million), (ii) the Multilateral Investment Guarantee Agency (MIGA) with a \$60 million political risk cover guarantee, the International Development Agency (IDA), which provided a \$40 million guarantee to back EDSA's PPA. The remainder of the debt came from a mix of bilateral donors such as the African development Bank (AfDB), Emerging Africa Infrastructure Fund and FMO (the Dutch development bank). The PPA was signed with EDSA with the possibility of expanding the capacity to 128MW at a later stage. (WorldBank, 2018).

- **Bumbuna Phase II**

The Bumbuna Phase II will see the extension of Bumbuna Phase 1, and upon completion will be Sierra Leone's largest power project. The project is located on the Upper Seli River in North East Sierra Leone, and will have an installed capacity of 143MW, and aims to provide a minimum of 80MW of reliable, all-year round capacity. Seli Hydropower, a local developer jointly owned by Joule Africa will be responsible for building, owning and operating Bumbuna II. The project has experienced many delays, partly due to the Ebola crisis, but Joule Africa and the GoSL signed a 25-year Power Purchase Agreement (PPA) in 2017. More recent engagements with Seli Hydropower indicated that the environmental licence would be issued before the end of 2019, and would therefore allow commencement of the construction phase, expected to be completed in 2022.

Planet Solar Energy was appointed by the GoSL through a PPP agreement to develop a 50MW project, split into two components: the first will see the construction of a \$40 million, on-grid 25MW solar PV project in Makarie Gbanti (Bombali District) funded by the African development Bank (AfDB) and the IFC. While the remainder 25MW will come from various off-grid projects in the following localities (Kambia, Portloko, Kamakwi, Kono, Mile 91, Moyamba, Pujehun, Bo, Kailahun and Bonthe)¹⁹. Discussions with the PPP Unit during the time of the site visit indicate the agreed tariffs are expected to be \$12 c/kWh with de-escalation of 1.1. cents every five years over a 20-year period based on the PPA negotiations²⁰. The project was expected to reach financial close before the end of 2019 at the time of writing this report .

In the absence of an IPP procurement framework, many of the approved projects from the private sector have been unsolicited bids and structured as PPPs. PPAs were negotiated with the MoE, MOFED and EDSA as the single buyer through transactional advisory support from the PPP Unit. Sierra Leone does not provide sovereign guarantees, only a three-month cash flow guarantee in the form of a credit letter. In terms of the PPA risk, to overcome the weak balance sheet of EDSA (as the sole off-taker based on the 2011 NEA), the Ministry of Finance and Ministry of Energy are co-signatories to the PPA to reduce political risk.

19 <https://www.afrik21.africa/en/sierra-leone-ifc-finances-50-mw-solar-project/>

20 <http://www.parliament.gov.sl/dnn5/LinkClick.aspx?fileticket=BDJwibqOFYE%3D&tabid=210&mid=753>

2.3.3 TRANSMISSION AND DISTRIBUTION

Sierra Leone cannot be said to have an interconnected grid across the country but rather isolated connected regions. The main connection line is the 161kV line that extends from Freetown to the surrounding Western Area, covering about 40% of their residents, supplied by the Bumbuna Phase 1 hydropower plant 220km from Freetown. Then, the Makeni grid (Northern Province) provides electricity to the town of Makeni in Port Loko District, also supplied by the Bumbuna hydropower plant. Lastly, there is a 33kv distribution line in Bo-Kenema, providing electricity to the towns Bo and Kenema, capitals of their respective districts in the South Eastern part of the country.

The 2030 Sector Roadmap has the ambitious goal of extending the transmission grid by 220km to over 1,200km of 225kV (and 161kV) lines and 800km of 66kV lines by 2030. To achieve the above, the GoSL with several regional and international partners are currently engaged in Transmission and Distribution (T&D) intervention nationwide with the goal to connect all district head towns by 2030.

The main project is the West African Power Pool interconnecting Cote Ivoire, Liberia, Sierra Leone and Guinea (CSLG line), which involves the construction of a 1,357-long double high voltage (225kV) line to connect the national networks of the four countries. The line will be 525km long in Sierra Leone and transverse seven districts (Pujehun, Kenema, Kono, Tonkolili, Bombali, Koinadugu and Kambia Districts), which are set to benefit as the project also encompasses a rural electrification component which will see a total of 28 Sierra Leonean communities receive electrification for schools and health centres. The construction of this line is part of the West African Power Pool (WAPP) master plan, and element of which proposes interconnection of the Mano River Union countries. The project is funded by the African Development Bank.

Other transmission and distribution upgrading works include:

- The \$15 million WorldBank funded grid works for the (WAPGP) in the Western Area to build a new 33kV substation at Kissy and enhance the Blackhall road existing line's evacuation capacity.
- Rehabilitation of Transmission and Distribution (T&D) network by the Japanese International Cooperation Agency (JICA) in the Western Area, to the value of \$3.8 million (Roadmap, 2030), and reinforcement and expansion of the medium and low voltage network in the Western Area under the Islamic Development Bank (IDB)

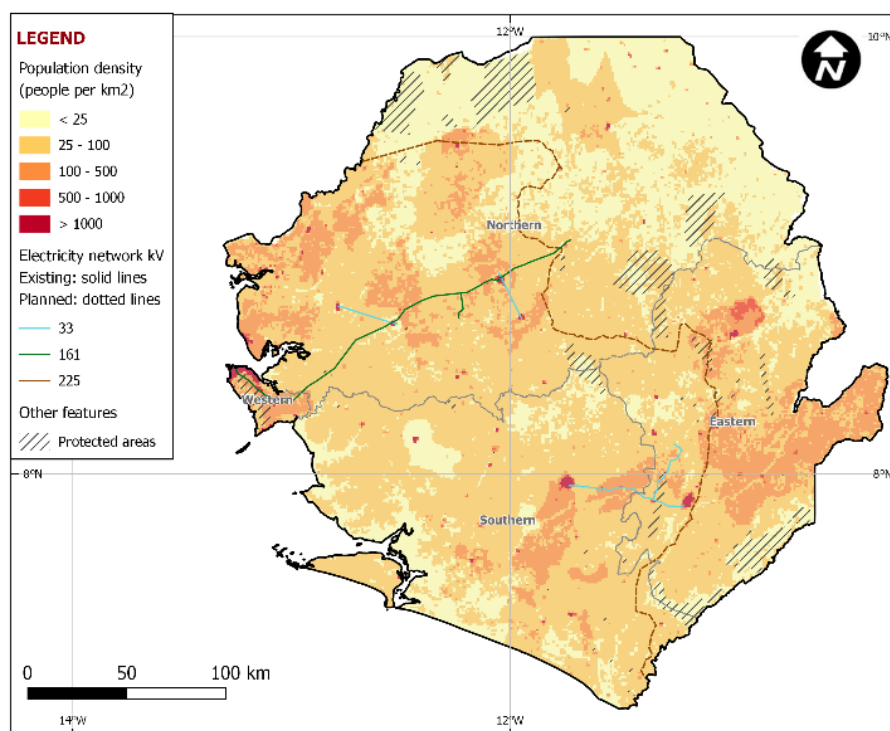


Figure 7: Sierra Leone Electricity Grid and Population Density

2.4 OVERVIEW OF THE OFF-GRID SECTOR (POLICY AND REGULATION)

2.4.1 ENERGY ACCESS POLICY AND PLANNING

The Ministry of Energy (MoE) has led and co-ordinated rural electrification efforts in Sierra Leone to date. The role that off-grid systems must play to achieve 92% energy access by 2030 is highlighted across various national plans, mainly the NREAP (2015) and the 2030 Electricity Sector Reform Roadmap (2017-30). The NREAP (2015), estimates that a total of 178MW out of the total 1,228MW future installed capacity will be off-grid, mostly produced from renewable energy where 27% of the population will be best served by mini-grids 10% by standalone systems.

Table 9: Rural Electrification Targets in Sierra Leone (Source: NREAP, 2015)

%	2010	2015	2017	2020	2030
Population served with electricity, of which:	8.6	19	29	44	92
Grid connected	8.2	15	22.25	30	55
Mini-grids	0.003	3	5	11	27
Standalone systems	0.1	1	1.75	3	10

The main rural electrification projects to date have been the UK aid funded Energy Revolution developed from the Africa Energy Compact (as previously discussed in Section 2.3). The Africa Energy Compact is an initiative of the UK Government with the main goal of achieving universal energy access by 2030. The Policy Compacts are voluntary bilateral agreements with the UK, and the then president committed to the following ambitious goals. (i) modern power to one million people by 2020; (ii) Power for All campaign to achieve universal energy access by 2025 (five years ahead of SDG7); (iii) 50,000 homes with solar home systems (SHS) in 2016 (growing from <1% to 5%), and (iv) at least 250,000 homes electrified by 2017 (~20% market penetration of households). The above targets, particularly the number of people with modern power and universal energy access have not been achieved to date. However, engagements with Power for All Sierra Leone revealed that they exceeded the 250,000 homes with SHS last year. The next rural electrification project entails the provision of 5,000 streetlamps and 2,500 traffic lights sponsored by the Akon Foundation, as part of the country's energy efficiency policy ratified in 2018 ²¹.

Sierra Leone has attracted several international home solar systems (SHS) providers such as Azuri, Bboxx and d.light, providing Pay-As-You-Go (PAYG) systems. Although, there is a nascent private sector off-grid solar market in Sierra Leone, it is estimated that these companies have collectively only served less than 5% of the household's market opportunity.

There is limited information about the exact number of mini-grids in Sierra Leone. Previously, most mini-grids have been either diesel, or mini-hydro projects. There are at least three privately operated diesel mini-grids owned by mining companies to service their staff in Daru, Kamala and Kambia. The national utility, EDSA is operating at least three mini-grids: a 600kW diesel system in Kono and two mini-hydro projects in Goma (6MW) and Port Loko (2MW) respectively. The remainder are donor supported mini-hydro, and solar PV projects developed either by non-governmental organisations (NGOs), or through a public-private partnership with the MoE. For example, Welthungerhilfe (WHH) in collaboration with ECREEE built a 120kW mini-hydro community project in River Number 2 and Obey. The mini-grid is currently operated by the NGO Energy for Opportunity (ENFO) and providing power to at least 200 households ²².

²¹ The agreement was recently signed by President Maada Bio with Senegalese rapper Akon (<https://www.afrik21.africa/en/sierra-leone-ifc-finances-50-mw-solar-project/>)

²² <https://www.welthungerhilfe.org/our-work/countries/sierra-leone/energy-for-the-future/>

The NREAP (2015) stipulates a target of 178MW from off-grid renewables by 2030. To achieve the above, the 2030 Sector Roadmap proposes interventions to enable development of off-grid projects, which are yet to be implemented. These are:

- **The creation of a Rural and Peri-Urban Electrification Authority spun off from EDSA, to be called “Modern Energy Access Authority”.** It is worth noting that Sierra Leone does not currently have a rural electrification agency. Although a rural electrification unit was recently established under the MoE with the intent of co-ordinating rural electrification efforts, the unit is currently vacant as the MoE still needs to appoint staff members.
- **The creation of a rural electrification Fund (REF) to fund rural electrification efforts through a levy.** However, details about the structure and source of funds has not been established yet.
- **Feed-in tariffs for independent power producers (IPPs) which was originally proposed as part of the IPP procurement framework for small scale projects (i.e. below 5MW) in the 2030 Roadmap.** Notably, the Mini-Grids Regulations have adopted a cost-reflective tariff determination methodology developed by UNOPS through INENSUS, with DFID funds (more details are provided in Section 2.4.2). Developers must submit their proposed tariffs for EWRC approval prior to securing a licence from the regulator.

There are two main mini-grid solar projects in Sierra Leone. The first is the donor funded Promoting Renewable Energy for Sustainable Development project in Sierra Leone - PRESS-D (Ministry of Energy, 2017) ²³. The project was funded by a mix of donors namely the European Union, Oxfam, and the German Agency for International Cooperation (GIZ) in partnership with Welthungerhilfe (WHH) to install a combination of mini-grids and solar home systems (SHS) in six districts (Kono, Kenema, Kailahun, Bombali, Portloko and Kambia) across the country, which include:

- A 128kW of solar mini-grid for the Segbwema community
- A 20kW solar system for the Segbwema Nixon Hospital
- An 86kW solar mini-grid in Panguma in the Kenema District
- Several energy hubs created for charging of mobile phones
- Distribution of SHS in surrounding communities

The mini-grids in Segbwema, Segbwema and Panguma have been completed and serve around 16,000 households. Research by Janse (2018), shows that the PRESS-D tariff structure varies across the three regions based on the estimated affordability of the respective community and presence of commercial clients. In Segbwema, for example, the tariffs include a fixed connection charge, plus an additional fee between 2500 to 3500Le/kWh (\$0.3 to \$0.42/kWh) depending on categories of customers based on a maximum power allocation (Table 10). Most customers except for industrial three phase, have a maximum usage allocation per day.

The PRESS-D mini-grids are currently operated by WHH and the NGO PowerNerd but are highly dependent on additional donor support for maintenance as the tariffs are said to be too low to be self-sustainable and attract any private sector operator. The revenue is collected via both prepaid and post-paid meters for residential and industrial/commercial clients respectively. The pre-paid meters are set up as PAYG systems, through a network of retailers who buy the prepaid cards (5, 28 or 56kWh) in bulk and sell them at a profit to the customers. Janse (2018) suggests that the 5kWh cards are the most popular.

23 Information extracted from the Sierra Leone Ministry of Energy (MoE) 2014 - 2017 Progress Report

The second project is the £43 million DFID funded Rural Renewable Energy Project (RREP), to install a total 5MW of mini-grids between 2016 and 2020, which originated from the Government of Sierra Leone (GoSL) President's Recovery Priorities (PRP) post the Ebola crisis in 2016/2017. During the Ebola crisis, many community health centres (CHCs) did not have power and could not preserve medication, which in turn aggravated the outbreak. The RREP was developed as a result, priority was given to electrifying community health centres (CHCs) to preserve medicine and vaccines, providing access to electricity in unserved rural districts of Sierra Leone.

The RREP was implemented in two phases by the United Nations Office for Project Services (UNOPS). Appointed by DFID and owned by the Government of Sierra Leone through the Ministry of Energy (MoE), the first phase provided electrification to 54 CHCs as part of the rapid response Ebola Recovery Plan. The community health centres have been given a maximum free allocation (6.6kWh/day), beyond which the CHC will have to pay an approved tariff. Upon completion of the first 54 CHC sites, UNOPS officially handed over to the Ministry of Energy (MoE). In the second phase, private operators bid and negotiated Public-Private Partnership (PPP) Agreements with the MoE to operate and manage the existing 54 CHCs, extending connections beyond the CHCs to households and businesses within the communities. Under the PPP Agreement, private operators will implement an additional c.40 larger mini-grids with private financing. The RREP project is managed by UNOPS with technical assistance from INENSUS across three work packages:

- **Work Package 1:** UNOPS initially installed 6kWp solar PV mini-grids at 54 CHCs in 13 as part of the Ebola Recovery Plan. Later in 2018, UNOPS extended the capacities up to 36kWp in 50 sites (out of 54) to convert the systems to small mini-grids covering the nearby communities (also known as WP1+).
- **Work package 2:** This entails the expansion of the programme to provide larger mini-grid installations with more private investments to a further 44 communities, which would lead to a total project's generation capacity of 5MW with over 97 mini-grids (Figure 8). Under this work package, the generation assets and distribution assets are owned by the private and public entities (MoE) respectively.

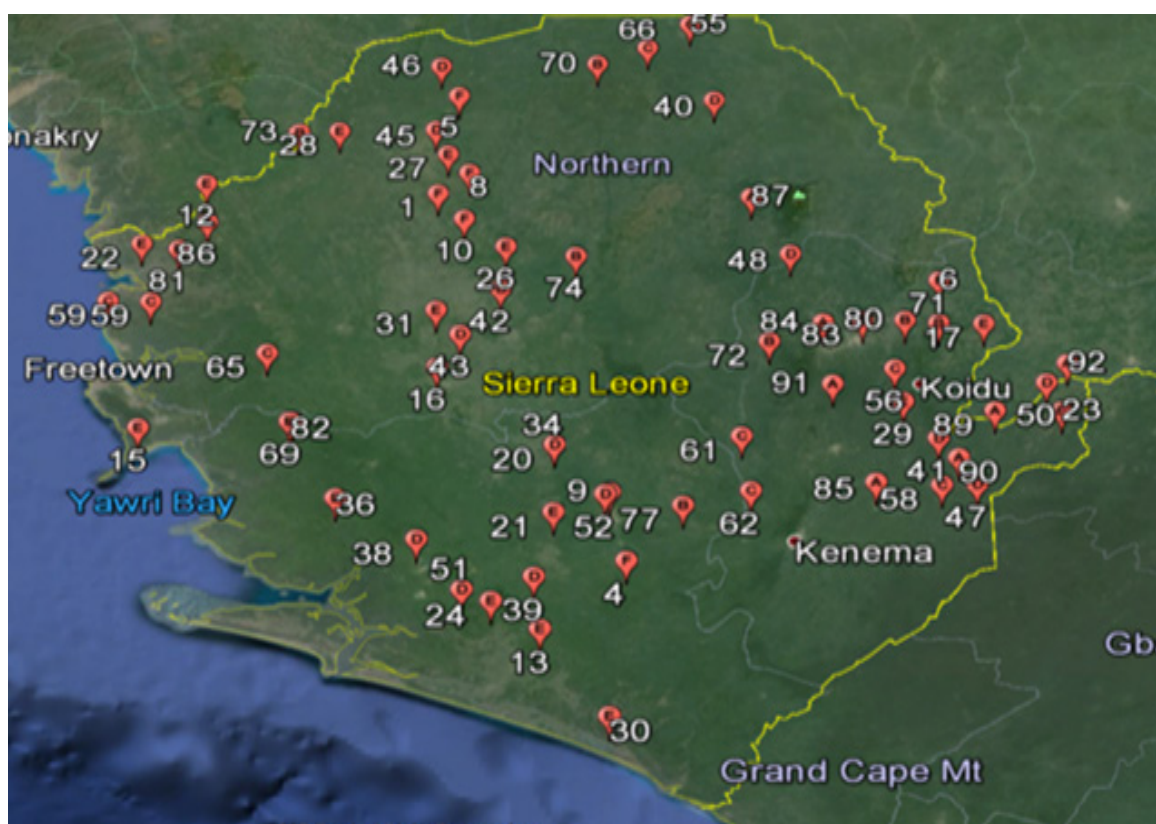


Figure 8: Overview of RREP mini-grids sites in Sierra Leone

- **Work package 3:** This entails mainly developing an enabling environment for mini-grids in Sierra Leone through technical assistance and institutional support (capacity building) to the GoSL and relevant agencies, i.e. EWRC, EPA. UNOPS supported the EWRC with the development of the 2018 Mini-Grid Regulations and the mini-grid tariff methodology, and the EPA-SL with development of Guidelines for Renewable Energy Technologies and Mini-grids.

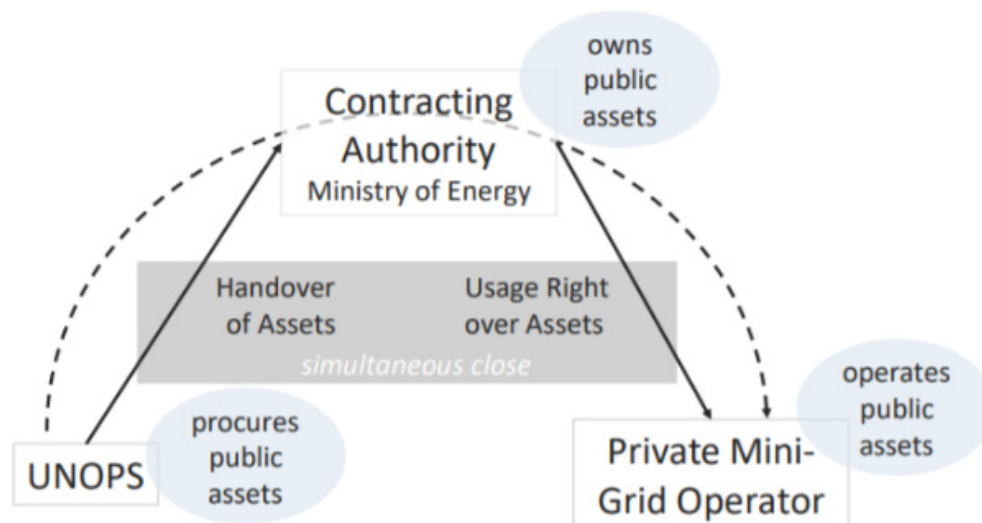


Figure 9: Ownership transfer structure of publicly owned assets of the RREP

With regards to operation of the mini-grids, the MoE with the support of UNOPS decided to appoint private sector operators, given that neither the MoE nor the EDSA have the capacity to manage the installations post construction. MoE with the support of the PPP Unit ran a competitive PPP bidding process in December 2018 to appoint private sector operators to bid for the operation rights of the various concessions. The RREP sites were divided into four lots, namely across the different regions: Lot 1 (Kailahun), Lot 2 (Bo, Kenema, Bonthe and Pujehun), Lot 3 (Falaba, Bombali and Koinadugu) and Lot 4 (Kambia, Port Loko and Moyamba).

Bidding rounds were proposed relating to two of the previously described workstreams (Work Package 1 and Work Package 2) for the four lots. Under workstream 1, the scope of works included operation and maintenance of the 54 CHCs systems over a 20-year period, the capex for the generation and distribution network equipment having already been paid for by DfID. However, partners are expected to fund metering systems to the surrounding end-users/customers.

Under work package 2, partners were solicited to construct, operate and maintain the proposed 44 mini-grids (i.e. 36kW and above). Under this element, DFID (through UNOPS) will fund the distribution network equipment while the private sector is expected to cover the costs of the generation equipment. Private companies are expected to secure environmental and other regulatory licences including a mini-grid licence from EWRC for the respective lots.

The three companies appointed through the competitive process were Winch Energy, Eon-Off Grid Power through their African subsidiary Rafiki Power and Energicity (SL Ltd) who were each awarded different lots based on the planned 90 mini-grids. Eon Off-Grid has been recently been acquired by PowerGen. The contract signed is a PPP agreement and structured as a hybrid between a Build Own and Operate (BOO) and Build Operate and Transfer (BOT) model. At the end of the 20-year concession period, the public assets (i.e. generation and distribution equipment for Work Package 1 and distribution assets for Work Package 2 respectively) will be returned to the MoE.

All three companies have obtained provisional mini-grids licences which have been approved on a tariff based on the cost-reflective tariff methodology set by the EWRC for Work Package 1. Project developers were expecting the licence approval in May/June 2019. Although the tariff negotiations have been separate from the ratification of the regulation, the process was delayed due to one-on-one price negotiations with the developers, with limited capacity and experience within the regulator regarding mini-grid tariffs. Although the exact figures are not certain as it is commercially

sensitive information, the tariffs are believed to be between \$0.8-\$0.9/kWh on average post consultation with the EWRC and the community representatives. Operators have already started selling electricity at the approved tariff to the end users/customers under Work Package 1 from Quarter 4 of 2019.

In summary, there are currently approximately 63 mini-grids in Sierra Leone, mainly located in agrarian communities with a population size between 100 to 2,000 households (Janse, 2018). Most mini-grids are PV- and part of the RREP programme. From the 54 mini-grids in Phase 1 of RREP, the capacity ranges from 16kWp to 36kWp. Table 10 below provides a summary of the mini-grids in Sierra Leone.

Table 10: List of existing mini-grids projects to date in Sierra Leone

Location	Capacity (kW)	Ownership	Key stakeholders and funders
Diesel			
Daru	120	Private	
Kambia	1000	Private	
Kono	600	Utility	
Kabala	500	Private	
Moyamba	200	Community	ENFO, private donor
Hydro			
Goma	6000	Utility	
Port Loko	2000	Utility	Chinese Government, MoE
Yele	250	Private	INGO LHF, Zebra
Makali	128	Hybrid	Chinese Government, MoE
River No. 2	120	Community	WHH, ECREEE
PV			
Gbinty	79	Hybrid	WHH, Oxfam, ENFO, EU
Panguma	66	Hybrid	WHH, Oxfam, ENFO, EU
Segbwema	127	Hybrid	WHH, Oxfam, ENFO, EU
Mattru	10	ECREEE	ENFO, ECREEE, World Bank
14 mini-grids	16	Hybrid (Solar PV and battery)	UNOPS, DfID, MoE
22 mini-grids	26	Hybrid (Solar PV and battery)	UNOPS, DfID, MoE
14 mini-grids	36	Hybrid	UNOPS, DfID, MoE

2.4.2 LICENSING

Section 66 of the Sierra Leone National Electricity Act (NEA, 2011) established the Electricity and Water Regulatory Commission (EWRC) as the regulator and licensing authority in the power sector. The EWRC, with support from MCC and UNOPS in line with the 2030 Sector Roadmap, have developed the 2018 mini-grids regulations, soon to be ratified in Parliament. The regulations allow for two licence categories (i) a basic mini-grid licence for projects below 100kW, and (ii) full mini-grid licence for projects between 100kW and 10MW for the following activities:

- Generation.
- Distribution via a network built in compliance with the distribution code and metering devices approved by the EWRC. The EWRC currently requires developers to comply with IEC standards as a minimum, as the grid code mentioned in the 2030 sector roadmap has not been developed yet.
- Sale of electricity.

The licence can be granted to multiple sites under the above thresholds. The RREP is the first implementation of the mini-grid licence application, the process is expected to be a three-month process based on the 2018 Draft Regulations. Applications to EWRC are in the form specified in schedule [1] of the Regulations “Application form for basic mini-grid licence”; schedule [2] “Application form for full mini-grid licence”, or schedule [3], “Application form for full mini-grid licence (multiple project sites)” of these regulations, as applicable. Mini-Grids that were commissioned before these 2018 mini-grid regulations came into force are allowed a grace period of 12 months to apply for a mini-grid licence, as previous projects were granted temporary licences (valid for one year). These are the PRESS-D, mini-hydro from ECREEE and EDSA respectively.

Mini-grid developers also require an environmental licence from the Environmental Protection Agency of Sierra Leone (EPA-SL), the licensing authority for environmental impact assessment (EIA). The 2018 “Guidelines for Environmental and social impact assessments of renewable energy technologies and mini-grids” were developed in line with the EPA Amendment Act (2010) with the support of UNOPS. As a result, the application for renewable energy projects has been simplified, and the licence application costs are significantly cheaper (from several thousands of dollars previously) to c.\$25.

The EPA guidelines allow for amalgamation of several sites under a single EWRC mini-grid licence provided the thresholds (i.e. 1MW) are not exceeded. Renewable energy projects below 1MW do not require a full EIA: projects between 100kW and 1MW require an environmental and social management plan (ESMP) while projects below 100kW can simply fill the ESMP template developed by the EPA (Figure 12). Figure 10 provides a summary of the authorisation process for mini-grids in Sierra Leone.

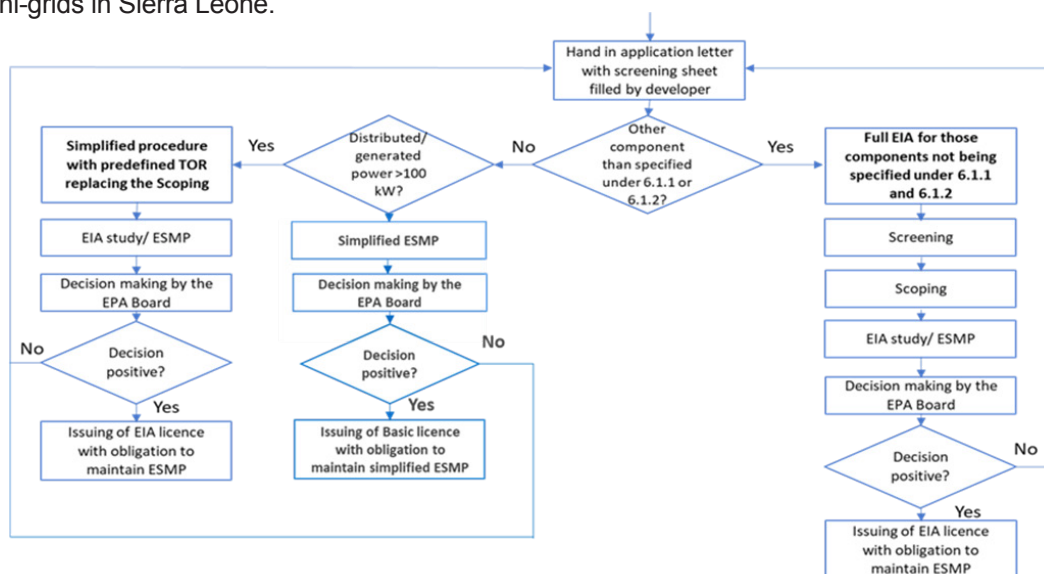


Figure 10: EPA permitting decision tree for mini-grids projects

Access to land linked with community engagements is essential, mini-grid developers are expected to work with the Local Community Councils and their traditional leaders, the paramount chiefs. The paramount chief is head of a local chieftdom who speaks on behalf of the community. The chief is responsible for community development, resource mobilisation and accountability at the community level. This can be a cumbersome process as land transactions and lease agreements cannot be signed without permission of the paramount chief. The MoE plans to organise awareness campaigns to demonstrate the benefits of RREP for communities as part of Work Package 2 to ensure access to land is streamlined for developers.

Furthermore, clearance from the nuclear agency to demonstrate limited radiation risks is required for all energy related projects in Sierra Leone to evaluate potential radiation risks. Engagements with the EPA revealed this is expected to be a simplified process for renewable energy projects given the limited applicability to renewable energy and mini-grids projects.

2.4.3 MINI-GRIDS TARIFFS

The 2018 EWRC Mini-Grid Regulations provide scope for cost-reflective tariffs. These stipulate that basic mini-grid licence holders (i.e. below 100kW) can charge a consumer any special tariff agreed between the licence holder and the consumer, provided an agreement is reached with the appropriate community authority (chiefs). For full mini-grid licences (100kW to 10MW), developers must submit their tariffs for EWRC approval. A full mini-grid licence holder (subject to the Commission's approval), can propose (i) a retail tariff structure e.g. flat rate; (ii) propose retail tariffs for specific consumer categories based on the amount of electricity sold, the number of connections and/or the power provided or consumed. For example, Table 11 below presents the Segbwema mini-grid tariff structure of PRESS-D.

Table 11: Mini-Grids Tariffs in Segbwema

Tariff	User	Power limit (9W)	Energy limit (kWh/day)	Energy price Le/ kWh (USD/kWh)	Minimum monthly charge (Le) (USD/ kWh)	Connection Fee (Le) (USD/kWh)
1.0	Residential basic	440	1	2,500 (0.25)	20,000 (2.03)	350,000 (35.58)
1.1	Residential advanced	2,200	4	2,900 (0.29)	35,000 (3.560)	700,000 (71.16)
2.0	Commercial	3,500	7	3,200 (0.33)	55,000 (5.59)	
3.0	Industrial single phase	10,000	15	3,500 (0.36)	70,000 (7.12)	
3.1	Industrial three phase	11,000	Unlimited	3,500 (0.36)	70,000 (7.12)	1,744,000 (177.28)

The RREP benefited from subsidies mainly in the form of capex from the DfID, estimated at a minimum of \$300 to 500/connection for WP1, comparable to subsidies offered in more established markets such as Nigeria. The end users are expected to pay cost-reflective tariffs (estimated between \$0.8 to \$0.9/kWh) with mobile payments using USSD, which will cover the running costs of the mini-grid. Developers are expected to submit annual performance reports to the EWRC, which could also include tariff revision as stipulated in the 2018 Mini-Grid Regulations. This has been viewed quite positively by developers, as affordability and uptake of the electricity is currently a cause of concern based on community poverty levels.

Furthermore, the MoE required that maintenance costs be held into a joint escrow account, meant to be accessible to MoE and the three developers on a needs basis in future. Developers are therefore expected to pay a portion of their revenue into this escrow account. Note, this is not a requirement of the 2018 mini-grids regulations, but rather negotiated during the PPP agreement with the developers. There are current concerns about both the administrative burden and speed at which the funds will be released. However, this process is new and has not been tested yet.

2.4.4 SUBSIDIES AND INCENTIVES

There are currently no ongoing subsidy schemes for mini-grids with proposed tariffs being cost reflective. The only market incentive has been the removal of the import duty on IEC certified approved solar products (excluding ancillaries such as distribution equipment, batteries, etc). However, engagement with the developers indicated the process for the exemption is not clear, which often leads to delays. As a result, many have not benefitted from this incentive.

Beyond the DFID funded RREP, it is anticipated the Sierra Leonean mini-grid market will continue to be largely driven by donor funded programmes as there is currently no procurement framework to support and finance large scale roll-out of mini-grids in Sierra Leone. The MoE is currently in discussions with several donors, notably DFID and the WorldBank through their Regional Off grid Electrification Project (ROGEP) for a RREP scale up phase. Engagements with developers suggest that the next phase would support the establishment of a result-based financing (RBF) facility as suggested in the 2030 Roadmap, however this is not finalised.

2.4.5 POWER PURCHASE AGREEMENTS

Power purchase agreement requirements and procedures are not currently part of the 2018 mini-grid regulations as they do not require power purchase agreements (PPAs) for projects below 1MW. However, PPAs with the utility EDSA are required for projects above 1MW. The process to secure a PPA with EDSA in the absence of a defined IPP procurement framework is currently unclear. To date, all projects above 1MW have been initiated as unsolicited bids and developed as public-private partnerships (PPPs) with the MoE/EDSA with the support of the PPP Unit.

2.4.6 TECHNICAL RULES

Although the 2018 mini-grid licence regulations mention a mini-grid code for Sierra Leone, it has not been published by the commission yet. Until such a time, full mini-grid licence holders are required to build their generation and distribution assets according to the relevant IEC standards and/or British standards valid at the time of the construct. Electricity meters must be suitable for Sierra Leone's climatic conditions according to IEC 62052-11 and IEC 62053-21, suitable rated current of 6A, must fulfil IP54 and have suitable protection against the sunlight and rainwater. Full licence holders must submit a test certificate from an independent internationally accredited testing laboratory (accredited according to ISO/IEC 17025 or comparable) with their application.

2.4.7 ARRIVAL OF THE GRID

The 2018 Mini-Grid Regulation provides protection for grid-overtaken (or grid-stranded) for full mini-grid licensees, although no such scenario has yet arisen in practice. For basic licence holders, the regulations stipulate that licence holders are required to decommission and remove their assets within two months without any compensation. For full licence holders, there are two options when the main utility expands its network to an area already served under a full mini-grid licence. The first option allows conversion to an interconnected mini-grid based on a contract between the full mini-grid licensee and the main-grid utility. The second option allows, before arrival of the grid, to transfer all assets that the utility wants to retain on the respective site in return for financial compensation. The financial compensation could be based on any of the following options (i) the residual value of activated and amortised privately financed project development cost for the respective mini-grid site using the tariff setting methodology, (ii) the residual value of privately financed assets after past depreciation, and/or (iii) the audited revenue the full mini-grid licensee generated from 12 months prior to the date of connection of the mini-grid to the main grid utility's distribution network. However, this process has not been tested yet.

2.4.8 MOBILE SERVICES

The percentage of mobile phone users in Sierra Leone is 45% (where 21% are internet users, i.e. possess a smart phone, and 24% are limited to voice and text only) in line with the average cellular phone usage trends in West Africa (Figure 11). There are various mobile phone operators, namely Orange Sierra Leone (Bharti Airtel, formerly Zain, Celtel), Comium, Africell (Lintel), Sierratel, Cellcom, Ambitel/Green and Smart Mobile.

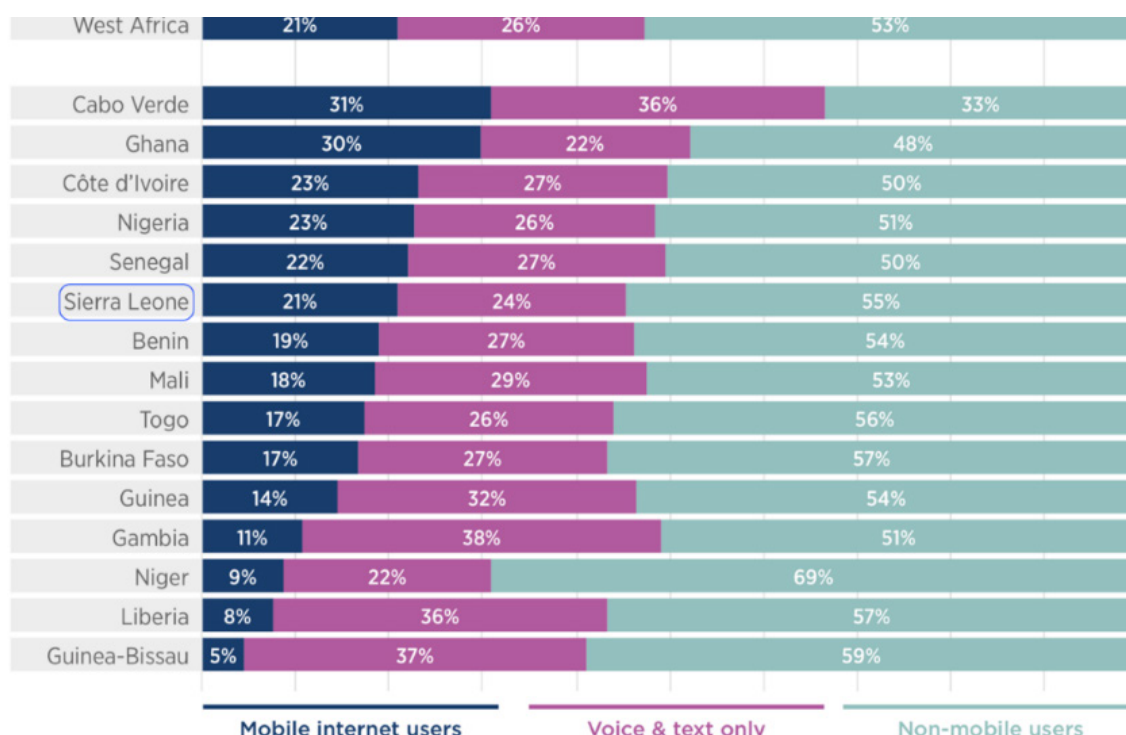


Figure 11: West Africa Mobile Internet penetration (Source: The Mobile Economy: West Africa, 2018²⁴)

Adoption of mobile money or digital financial services (DFS) continues to grow in Sierra Leone. The number of adult users increased from six to 10% from 2016 to 2017, according to the 2017 Digital Financial Services (DFS) Annual Provider Survey. The same report shows that there are ten providers in the market, including two mobile network operators and eight banks.

2.4.9 BARRIERS AND POTENTIAL INTERVENTIONS FOR MINI-GRID DEPLOYMENT

The mini-grid sector in Sierra Leone is in its burgeoning phase, with positive recent strides, namely: (i) the roll-out of the DfID-funded RREP project with a comparable subsidy to larger markets such as Nigeria (i.e. \$300 to 500/ connection for WP1); (ii) private sector companies (i.e. Winch Energy, Eon Off-grid and Energicity) participation under a PPP with the MOE; (iii) the ratification of the 2018 EWRC mini-grid regulations, and consequently (iv) issuance of licences and (v) approval of \$0.8 to 0.9/kWh tariffs which have laid the foundation for a robust off-grid market.

However, there remain several challenges and uncertainties around a clear institutional framework for the organised development of off-grid solutions in Sierra Leone, particularly outside of the DFID funded RREP and further for mini-grid projects above 1MW which require a PPA from the non-bankable utility EDSA.

Unclear responsibilities and mandates between different government institutions such as the MoE, PPP Unit, MOFED and the regulator could further slowdown the roll-out of mini-grid projects in Sierra Leone. Although the 2030 Roadmap suggests the creation of a rural electrification agency, this has not been implemented. To date, there has been

²⁴ <https://www.gsmainelligence.com/research/?file=e568fe9e710ec776d82c04e9f6760adb&download>

a limited number of mini-grids projects most of which have either been grant funded and owned either by the MoE under a PPP model and/or non-governmental organisations (NGOs). The absence of a clear procurement framework for IPPs (both on-grid and off-grid) is critical for the successful large-scale deployment of mini-grids to meet the country's energy access goals of 92% by 2030.

Access to land also remains an important challenge. Foreign investors are presently not allowed to buy land, and so to access land one needs to rent land either from the Government or a community, through its representative, which can be a lengthy process.

Financial sustainability/affordability for the end users, particularly linked to mini-grids tariffs has been cited as one of the main anticipated challenges due to the low income per capita of the average Sierra Leonean. To address financial sustainability of the RREP for the developers, UNOPS has commissioned a feasibility study to identify productive use hotspots (30kW systems and above) such as food processing, welding or fish farming. The study is led by INENSUS, using their Key Maker Model (KMM) and will assist project developers to identify anchor tenants. The Key Maker Model (KMM) is a concept developed by INENSUS aiming to improve the economics of a mini-grid project by unlocking local market potential. The virtue of the concept relies on leveraging on the mini-grid stable supply of electricity and established mini-grid management structures in order to create high revenue commercial opportunities from a community's agriculture/farm product's value chain, usually at the local processing and trading stages. This in turn leads to potential synergies and cost-sharing options between the KMM business and the mini-grid operation.

Strengthening of public sector players, particularly the regulator EWRC is important for effective roll out of mini-grid projects. Capacity building and strengthening institutions has been a strong focus of donor agencies such as the Tony Blair Institute (currently embedded in the MoE), DFID and UNOPS through the appointment of INENSUS. INENSUS provided technical assistance for the 2018 mini-grid regulations and designed the tariff determination methodology.

Many of the above challenges have been identified in the 2030 Sector Roadmap, although the MoE is currently reviewing the roadmap targets and implementing key recommendations. These include the IPP framework, establishment of the rural electrification agency in charge of driving energy access goals, and establishment of funding facility for renewables, which would lead to establishing Sierra Leone as an attractive market for the private sector.

3. GREEN MINI-GRID POTENTIAL

Estimating the potential for mini-grids is a challenging task that requires robust data and/or assumptions. Some physical factors, such as resource availability and geographic features, can be collected remotely through satellite data, but other factors require availability of local datasets and surveys. Certain non-physical factors, such as demand and consumption patterns, require precise settlement-level data to be collected. This data is often unavailable, out of date, or highly resource intensive to obtain. In addition, opportunity assessments rely upon criteria that differs depending on the approach of the implementing agency. For example, a private developer might consider purely financial metrics, whereas a community scheme might focus on quality of services provided. Given these constraints, the opportunity assessment in this report is designed to be of relevance to all mini-grid stakeholders but will not address the individual needs of all.

This chapter aims to give mini-grid stakeholders an understanding of the size of the opportunity for green mini-grids in Sierra Leone. Market size estimates are calculated based on a number of considerations: (1) **physical opportunity size** according to GIS datasets (population density, load centres, existing grid, etc.); (2) **existing electricity expenditure** by rural households; (3) maximum **customer affordability** and willingness to pay, and (4) **tariffs** currently allowed in-country. Comparisons will be made between an existing market size, based on affordability and in-country tariff limitations, and the theoretical market size based on cost-reflective tariffs ²⁵. The difference between current and theoretical market size will allow an approximation of any subsidy requirement for opening the market (in percentage terms).

3.1 DATA AVAILABILITY

In Sierra Leone, population density data can be sourced from World Pop ²⁶ and information on population distribution across the country is also available from Statistics Sierra Leone (Stats SL²⁷). World Pop data estimates numbers of people per grid square, with national totals adjusted to match UN population division estimates.

The electricity transmission network map of Sierra Leone was sourced from the West African Power Pool (WAPP) GIS database. This dataset is distributed by ECREEE providing details on the existing and planned transmission grid network (medium and high voltage lines) in the whole Economic Community of West African States (ECOWAS) region and some countries in West Africa. Grid extension populations within the 15km buffer of the current grid were inferred based on a combination of high voltage (HV) line data (obtained from the IFC GIS data: [electricity transmission and distribution grid maps](#)) and satellite mapping of night lights. Off-grid populations are those outside of these areas.

The Renewable Energy Association in Sierra Leone (REASL) in partnership with GIZ is also maintaining a web-based platform *Renewables Salone*²⁸, which provides information on existing renewable energy projects across Sierra Leone as well as their location.

3.2 ASSESSING MINI-GRID POTENTIAL: METHODOLOGY

The first step in understanding mini-grid potential in Sierra Leone is to identify numbers of potential mini-grid customers, based on population (or household) density and proximity to the grid. To do this, the country's land area is segmented into three area categories — grid extension, mini-grid and standalone system (SHS) — based on distance between the existing transmission and distribution network and the population.

²⁵ Cost-reflective tariffs are assumed to be \$0.4/kWh across SSA, based on cash flow modelling for typical mini-grids seen across SSA and elsewhere in the world. It should be noted that \$0.4/kWh may be conservative in some markets, particularly those that face supply chain challenges.

²⁶ www.worldpop.org.uk

²⁷ <https://www.statistics.sl/>

²⁸ <http://www.renewables-salone.info/>

- Grid extension areas: defined as areas within 15km of the grid
- Mini-grid areas: defined as areas further than 15km from the grid²⁹, with household density greater than 50 households per km²
- Standalone system (SHS) areas: defined as areas further than 15km from the grid, with household density less than 50 households per km²

To understand where these different areas lie, the national grid is inferred using a combination of high voltage (HV) line GIS data and satellite mapping of night-lights, buffered by 15km to produce the grid-extension area³⁰. Potential off-grid populations are outside of this grid extension area, with mini-grid populations identified based on population density greater than 50 households per km².

Once mini-grid population sizes are established, mini-grid market sizes can be estimated by multiplying the number of potential mini-grid customers by likely electricity expenditure (either per capita or by household). This report uses four different electricity expenditure scenarios:

Existing rural household expenditure on electricity based on the World Bank Global Consumption Database (World Bank, n.d.). This approach assumes that 60% of rural household energy expenditure is on electricity, and that household revenue comprises 60% of the total revenue of a mini-grid (when including revenue from businesses, public sector buildings and industrial users).

Existing rural household expenditure on electricity based on other literature and sources. This may be based on international or local studies, or local stakeholder interviews (in theory, this should yield similar results to scenario (1) above, although this may not be the case in practice).

Potential rural household expenditure on electricity, estimated on a bottom-up calculation of what would be required to deliver SEforALL Tier 2/3 energy access nationwide, and an average allowable tariff currently used in-country. This approach assumes that the average rural household's electricity use would be approximately 2.2kWh/day; according to the SEforALL Multi-Tier Framework, this represents a supply level between Tier 3 (1kWh per day) and Tier 4 (3.4kWh per day), which allows for electrical lighting, air circulation, television and phone charging (Tier 2 level), plus additional appliances that can allow for productive uses.

Potential rural household expenditure on electricity, estimated on a bottom-up calculation of what would be required to deliver SEforALL Tier 2/3 energy access nationwide, and a flat tariff of \$0.4/kWh. This tariff has been chosen as the minimum tariff needed for private developers to recover their costs. Such a rate is assumed to be one which in many contexts in Sub-Saharan Africa, and in other developing countries, is cost-reflective. It has been used to allow comparisons across countries in terms of market size, but also to highlight the shortfall between feasible tariffs, and often cost-reflective tariffs.

Results from these four scenarios are discussed in the results section that follows.

29 While we have assumed GMG populations are those beyond 15km of the grid, some developers may also wish to consider regions already serviced by the grid. In some areas currently reached by the grid, mini-grid market potential exists due to both high main grid connection costs, as well as its lack of reliability due to the ageing grid network. The possibility of mini-grids in proximity to the main grid is not considered in our analysis due to its high dependence on the business model used and local demographics.

30 Using this combination of night lights and HV line datasets provides a more comprehensive picture of current electrification than using HV lines alone. Although HV grid line data is commonly available for countries in Sub-Saharan Africa, these lines provide a limited view of electrified areas, since medium voltage (MV) lines are often used to reach towns at distances exceeding 15km. This analysis therefore infers the position of the MV lines from satellite data of night-time light emissions, pre-processed to provide yearly average datasets from which noise and cloud cover have been removed.

3.3 ASSESSING MINI-GRID POTENTIAL: RESULTS

Sierra Leone does not have an interconnected grid across the country, with only one main 161kV connection line that extends to Freetown and the surrounding Western Area which is fed by the Bumbuna Hydro Plant Phase I. In future, the planned CSLG line is the 225kV from the West African Power Pool (WAPP) which will connect Sierra Leone from North to South, across seven districts - Pujehun, Kenema, Kono, Tonkolili, Bombali, Koinadugu and Kambia (Figure 12).

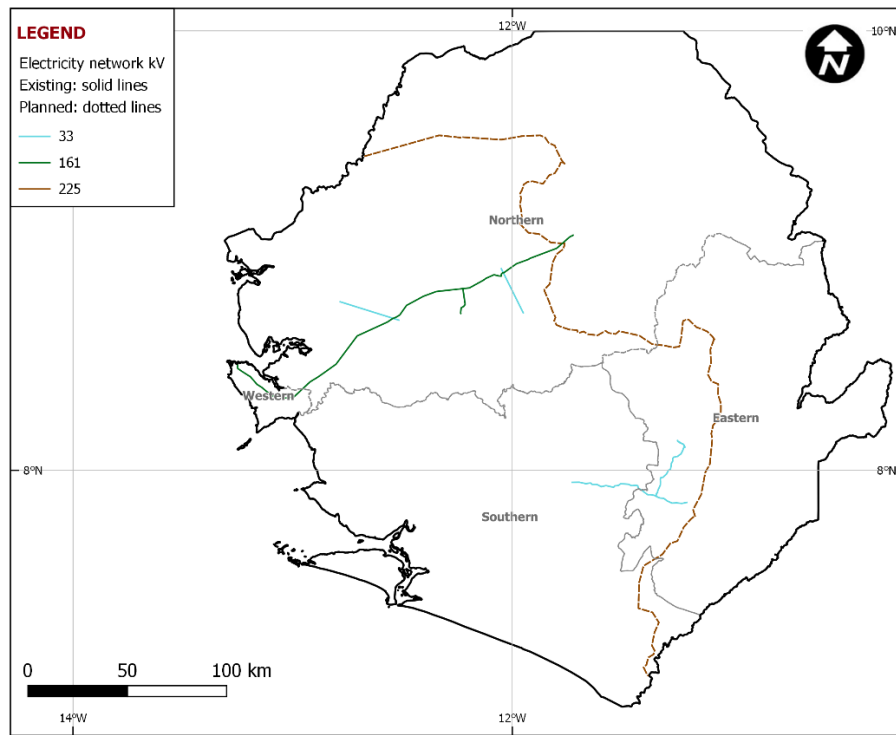


Figure 12 : Sierra Leone transmission and distribution network (excluding MV/LV coverage inferred from night lights)

By inferring the presence of the 33kV Makeni distribution transmission line using night lights, and overlaying population density (Figure 13) onto the resultant map, we can identify those areas best served by mini-grids (Figure 14).

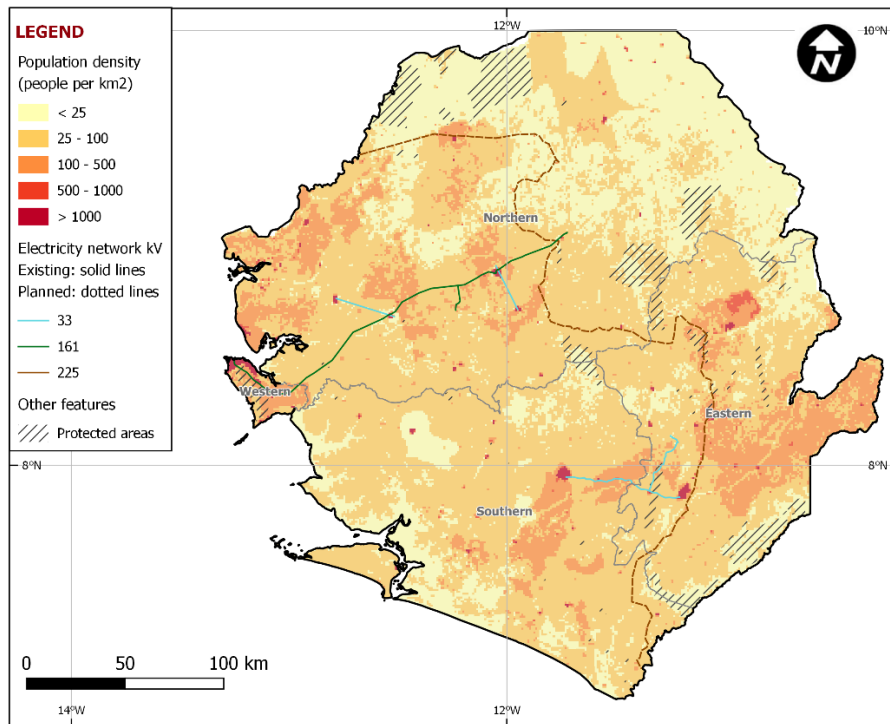


Figure 13: Population density in Sierra Leone

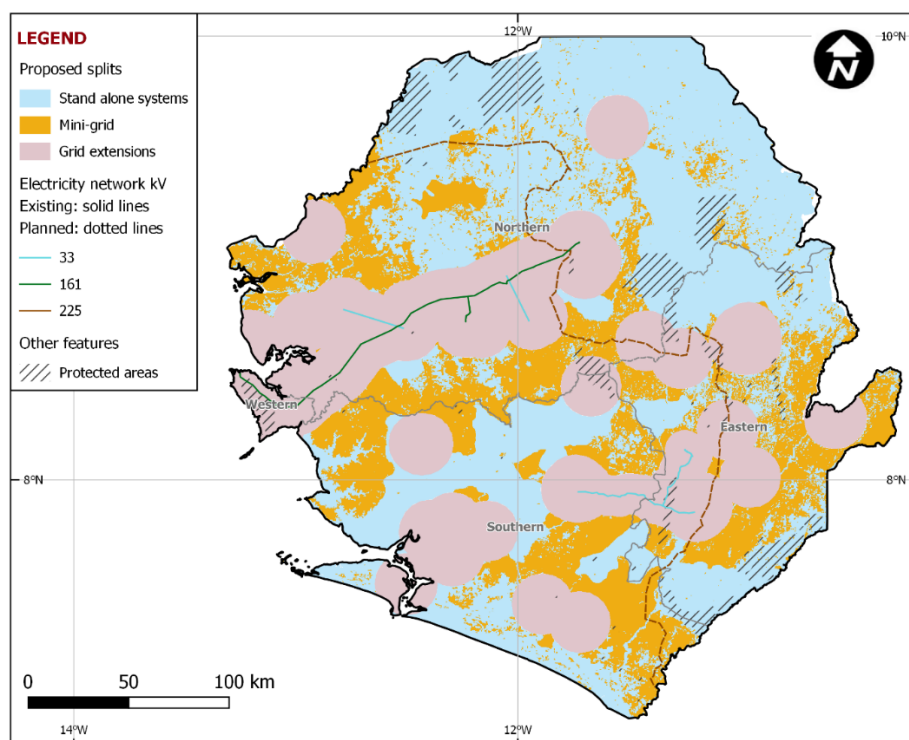


Figure 14: Regions best served by grid extension, mini-grid and standalone systems, shown with major and minor population centres. (Carbon Trust analysis)

Our analysis estimates that 2.9 million people (47% of the non-electrified population) will be best served by mini-grid solutions in Sierra Leone. A further 876,000 people (14% of the non-electrified population) will be best served by solar home systems (SHS) and 2.3 million people (39% of the non-electrified population) will be best served by grid extension, based on proximity to the existing grid. This calculation is based on the current grid coverage only 31; any planned grid extensions will reduce the estimated market size.

Population sizes best served by either grid extension, mini-grid or SHS are shown by province in Table 12:

Table 12: Suitable electrification solutions by province in Sierra Leone (Carbon Trust analysis)

Province	Current Grid Network					Planned Grid Extension			
	Electrification rate	Population (thousands)			Mini-Grid Market (\$m)	Population (thousands)			Mini-Grid Market (\$m)
		<15 km of grid	Mini grid	SHS		<15 km of grid	Mini-Grid	SHS	
Eastern	2%	248	1,054	185	60	704	653	129	37
Northern	2%	593	1,076	405	62	894	874	307	50
Southern	2%	276	748.1	286	43	392	639	279	37
Western	2%	1,188	3	0.1	0.1	1,188	3	0.1	0.1
Total		2,305	2,881	876	165	3,178	2,169	715	124

The Sierra Leonean mini-grid market is outside of the Western area (where Freetown is located) due to their low electrification rates (i.e. 2% on average), limited grid coverage, and population densities high enough to support mini-grids. Our analysis shows that the mini-grid market potential is spread among the following five main districts - Kailahun, Kambia, Kenema, Kono and Tonkolili, spread in the Northern, Southern and Eastern provinces. The number of people that will be best served by mini-grids in Kailahun, Kambia, Kenema, Kono and Tonkolili is 385; 281; 285; 384 and 294 ('000) respectively, corresponding to around 36.5% of the population on average in each province. The provinces with the largest percentage of the population best served by SHS technologies are Koinadugu and Moyamba, corresponding to 52% and 35% of the population respectively in each province.

District	Electrification rate	Total population within grid buffer	Grid Extension (population)	GMG (population)	SHS (population)
		Population (thousands)			
Bo	2%	297.4	297.4	187.6	82.4
Bombali	2%	240.4	240.4	143.8	102
Bonthe	2%	-		105	60.4
Kailahun	2%			385.3	25
Kambia	2%			281.4	27.9
Kenema	2%	278.3	278.2	85	64.4
Koinadugu	2%	2.3	2.3	104.1	211.4
Kono	2%			383.5	95.1
Moyamba	2%	5.5	5.5	202.5	110.3
Port Loko	2%	287.8	287.8	253.3	26
Pujehun	2%			53.1	32.7
Tonkolili	2%	104.3	104.3	293.6	38.1
Western Area Rural	2%	233	233	2.3	
Western Area Urban	2%	979.4	979.4		
Total Populations		2,428.4	2,428	2,880.3	875.2

31 High voltage lines plus lights seen from satellite, which are used to infer the presence of medium and low voltage lines (note: this method may camouflage a significant existing off-grid contribution from diesel gensets, meaning that this mini-grid market size result is likely to be conservative; further studies in-country are required)

In terms of potential revenue, the size of the market based on 2.9 million potential customers varies according to the four electricity expenditure scenarios described in Section 3.1.2. It is worth noting however that there was insufficient data to estimate the mini-grid market size based on methodology 2 and 3.

1. **Existing rural household expenditure on electricity from the World Bank Global Consumption Database: According to this database, average rural household spend on energy consumption in Sierra Leone is US\$ 68.2 annually.** To convert this to expenditure on electricity, we use two assumptions: (1) that around 60% of household energy spend is on electricity, and (2) that household spending comprises 60% of the total revenue of a mini-grid (when including revenue from businesses and community buildings). Given that the average number of persons per household in Sierra Leone is 5.6, this translates to per capita electricity expenditure of approximately \$7.30 annually, or an overall market size of \$21.1m annually (assuming 2.9 million customers). Based on grid expansion projections to 2025, this market size will drop to \$15.8 m (assuming 2.2 million customers).
2. **Existing rural household expenditure on electricity based on other reports/literature: this is unavailable for Sierra Leone**
 1. **Potential rural household expenditure on electricity, estimated on a bottom-up calculation of what would be required to deliver SEforALL Tier 2/3 energy access nationwide, and an average allowable tariff currently used in-country.** Annual cost of electricity from a mini-grid was estimated on forward-looking household electricity consumption of 0.2kWh per day (based on a recent on-going study conducted by Inensus), representing annual per capita electricity demand of 13kWh (5.6 persons per household). The average off-grid tariff in Sierra Leone is assumed to be around \$0.9/kWh (based on the RREP project), giving an average annual electricity expenditure of USD\$73 per person and an overall annual mini-grid market size of \$34m (assuming 2.9 million customers). Based on grid expansion projections, this market size will drop to \$25 million (assuming 2.2 million customers).
 1. **Potential rural household expenditure on electricity, estimate on a bottom-up calculation of what would be required to deliver SEforALL Tier 2/3 energy access nationwide, and a flat tariff of \$0.4/kWh.** This tariff is assumed to be cost-reflective. Based on annual electricity demand of 143.4kWh per capita, a tariff of \$0.4/kWh gives an average annual electricity expenditure of USD\$57.36 per capita: an overall annual mini-grid market size of \$165.3 million given a mini-grid population of 2.9 million.

A summary of these four market size estimates is shown in Table 13.

Table 13: Market Size Estimates for the Four Scenarios

Scenario	Estimated per capita annual costs for GMG (\$m)	Market Size given current GMG population (\$m)	Market Size of GMG population (given planned grid extension) (\$m)
1 World Bank Database	\$7.3m	\$21.1m	\$15.8m
2 Other Donor Reports	Data not available	Data not available	Data not available
3 'Bottom-up' + existing tariff	\$11.7m	\$33.7m	\$25.4m
4 'Bottom-up' + theoretical tariff	\$57.36m	\$165.3 m	\$124.3 m

Scenario 3 is chosen as the most realistic estimate of the size of the market required to drive productive use of electricity in Sierra Leone. Scenario (1) reveals electricity demand which is significantly below that needed to deliver Tier 2/3 energy access in Sierra Leone. A recent ongoing study undertaken by Inensus supports Scenario 1 where the annual household consumption collected data is estimated to be between 0.16 to 0.2kWh/day. For this reason, scenario (3) is chosen as the most realistic estimate.

In summary, this report estimates an annual mini-grid market size of USD\$33 million in Sierra Leone, based on an average mini-grid tariff of USD\$0.9/kWh, and average household demand per day of 0.2kWh/day. This implies per capita annual electricity expenditure of \$11.7 within the population best served by mini-grids. Based on an estimated cost-reflective tariff of \$0.9/kWh.

3.4 RENEWABLE ENERGY POTENTIAL FOR MINI-GRID

3.4.1 HYDROPOWER

Hydropower is a major energy source in Sierra Leone and represents the bulk of the installed capacity with an estimated 56MW installed (30%). The biggest hydropower plant is the 50MW Bumbuna Phase 1, commissioned in 2009 with a 161kv transmission line connecting Bumbuna and Freetown (Renewables Salone, 2018). It is estimated that Bumbuna Phase 1 generates 30 to 40MW during the wet season, and as low as 5MW during the dry season (February to April) due to river flow fluctuations leading to frequent power blackouts. The other hydro plants are the 6MW Goma plant owned by the utility (EGTC), and three mini hydro plants: Bankosoka (2MW), Charlotte (2MW) and Makali (120kW) developed by the utility in partnership with United Nations Industrial Development Organisation (UNIDO) and the Chinese Government.

The average hydropower potential, which remains virtually untapped, is estimated at 2,000MW spread across 27 different sites between 2MW and 160MW (Mittelstand Global Export Initiative, 2016). However, the most viable sites are: Yiben I and II, Bekongor III, Kambatibo, Betmai III, and Bumbuna II in terms of generation cost. Furthermore, the Renewable Energy Association of Sierra Leone identifies a potential for Pico hydro systems (from 5kW to 1MW) which is not quantified and has not been exploited much to date (Renewables Salone, 2018³²). Many sites, however, suffer from significant flow variations between the wet and dry season limiting their viability.

The 2030 Sector Roadmap has allocated 700MW of large-scale hydro, and 140MW of small-scale hydro respectively. Table 14 below presents a list of the most viable sites according to a SEforAll Energy Sector Gap Analysis (2012). The Bumbuna Phase II is the most advanced and will see the extension of Bumbuna Phase 1 with an installed capacity of 143MW. The project is estimated to provide a minimum of 80MW of reliable all-year round capacity, and construction is set to start next year.

Table 14: Overview of future electricity generation planned projects (SEforAll, 2012)

Location	Size/Capacity
Bumbuna II	143MW
Bekongor II and III	160MW (80MW and 85MW)
Mange	100MW
Moyamba	10MW
Yiben I	61MW
Yiben II	62MW
Kambatibo	65MW
Betmai III	36MW

32 <http://www.renewables-salone.info/index.php/projects-new/logo-editing>

3.4.2 BIOMASS

Energy consumption in Sierra Leone is dominated by biomass, which accounts for 80% of the energy used on average. Wood fuel and charcoal are the largest and cheapest fuel available locally and as a result, over 96.8% of the population in Sierra Leone uses firewood or charcoal for cooking according to the 2015 Census ³³. The use of agricultural crop residues such as rice husks, straw, residues from palm oil and cassava production, as well as bagasse from the sugar industry, remains limited.

The biomass from agricultural residues is estimated to be 656,400 tonnes/annum equivalent to 2,706GWh (Netherlands Enterprise Agency, 2017 ³⁴). The project, close to Makeni, uses sugar cane to produce 90,000 m³/annum bio-ethanol from sugarcane for export to the EU and production of power to supply the Bumbuna-Freetown grid. The 30MW plant is the only biomass installed capacity to date. It is currently supplying 15MW based on the PPA signed with EDSA at an estimated tariff of \$0.20/kWh, developed as a public-private partnership (PPP).

The 2030 sector road plans for 50MW of installed capacity. However, there are currently no projects in the pipeline based on engagements with stakeholders during the country visit. Sierra Leone puts almost all of its refuse into landfill sites, which represents an additional potential feedstock for power generation. However, this has not been explored to date. Biomass mini-grids are most likely to be viable near industrial sites producing biomass wastes, where surplus power could be used for nearby communities.

3.4.3 SOLAR ENERGY

The Global Horizontal Irradiation (GHI) values in Sierra Leone ranges between 1,700 to 2,200kWh/m² with an estimated six hours of sunshine/day, according to data from the Ministry of Energy and the Joint Research Centre (JRC) of the European Commission (REEEP, 2012). The best solar power potential lies in the Northern region of the country, with Global Horizontal Irradiation (GHI) values above 1,800 to 1,900kWh/m² (Figure 15).

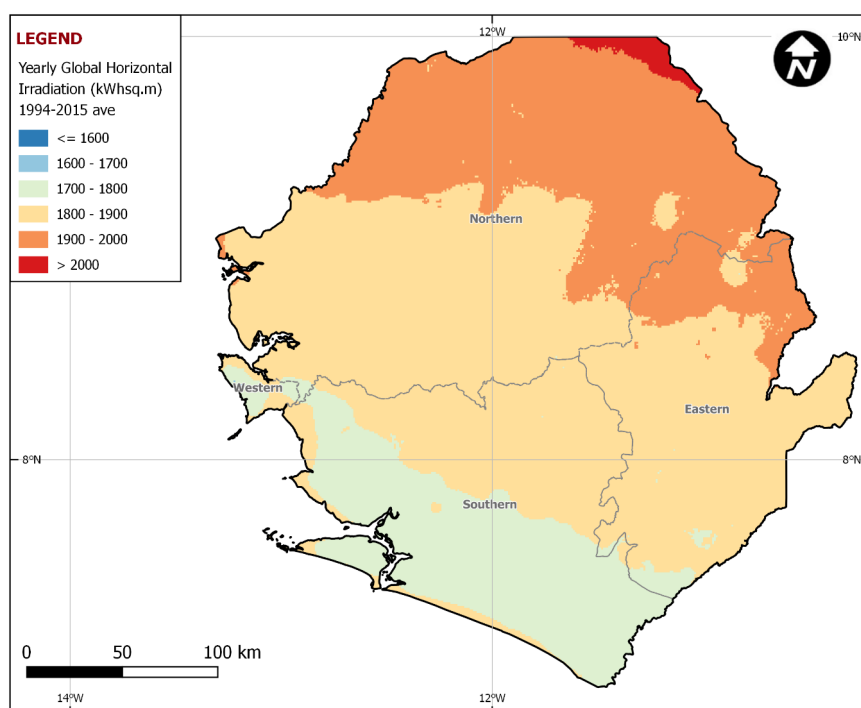


Figure 15: Yearly Global Horizontal Irradiation (kWh/sq. m). 1994 to 2015 averages.

33 2015 Sierra Leone Population and Housing Census (https://www.statistics.sl/images/StatisticsSL/Documents/final-results_-2015_population_and_housing_census.pdf)

34 Sector Scan: The Energy Sector in Sierra Leone for the Sierra Leone Netherlands Business and Culture Council

The notable solar projects mostly developed as public-private partnerships are (i) the EU-funded PRESS-D project; (ii) the DfID-funded Rural Renewable Energy Programme (RREP) estimated to 5MW once fully implemented, and the 6MW Solar Era park commissioned last year. The notable future project is the 50MW Planet Solar Energy in Bombali District organised in two phases: the first an on-grid 25MW, and the second will see the development of distributed off-grid sites.

The 2030 Sector Roadmap targets a total solar power installed capacity of 60MW. The planned installed capacity is most likely going to be exceeded sooner than anticipated based on the current pipeline of projects. The recent regulatory changes supporting the participation of IPPs namely the 2011 NEA, and the EWRC 2018 Mini-Grids Regulations for off-grid projects, also create opportunity for additional projects.

3.4.4 WIND

Sierra Leone has a low to moderate potential for wind power with only a few selected areas reaching speeds sufficient for electricity generation. The country average wind velocities vary between 3 to 5m/s, where the wind speed can increase to up to 8m/s at higher altitudes in the Northern Area, which has the highest peak in West Africa (Metrological Statistics, 2012) as illustrated in Figure 16.

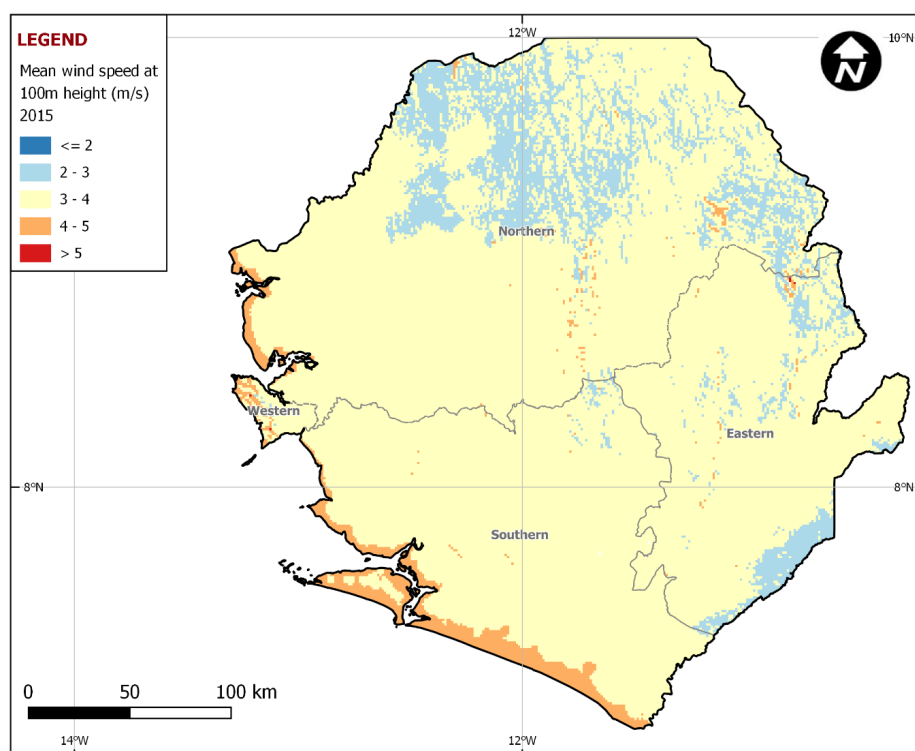


Figure 16: Mean wind speed at 100m height (m/s), 2015

There has been insignificant interest in wind energy for Sierra Leone to date. According to the Renewable Energy Association, there is only one 5kw small turbine in Sierra Leone, located in the Bonthe District, along the south coastline area.

The Sierra Leone Renewable Energy Association mentions wind speeds as high as 12m/s particularly along the coastline where offshore wind power could be viable in selected locations. However, there has been no detailed wind studies to date to support the above as evidence.

4. DIRECTORY

ENERGY SECTOR POLICIES AND REGULATORY FRAMEWORKS DIRECTORY

The 2009 National Energy Policy

<http://repository.uneca.org/bitstream/handle/10855/18320/Bib.%2029377.pdf?sequence=1>

The 2009 NEP was the first comprehensive planning document for the Sierra Leone energy sector facilitated by the United Nations Economic Commission for Africa (UNECA) with the main goal of increasing energy access by 35% by 2015.

The 2011 National Electricity Act

<http://www.sierra-leone.org/Laws/2011-16.pdf>

The 2011 NEA has led to the biggest shift in the sector, through unbundling the then vertically integrated National Power Authority, into two entities, the Electricity Generation and Transmission Company (EGTC) and the Electricity Distribution and Supply Authority (EDSA).

The 2011 Electricity and Water Regulatory Act

<http://www.sierra-leone.org/Laws/2011-13.pdf>

The Electricity and Water Regulatory Act 2011 established a regulatory body, the Sierra Leone Energy and Water Regulatory Commission was established (SLWERC) to determine tariffs, issue licences and monitor regulatory compliance of various energy generation projects.

The 2018 SLEWRC Mini Grid regulations

<http://ewrc.gov.sl/wp-content/uploads/2018/12/Mini-Grid-Regulations-2018-1.pdf>

The framework guides a smooth and sustainable enrolment of mini-grids in Sierra Leone (51). Based on the conceptual text (91), the policies and regulation provide formal regulation for licensing procedures, tariff determinations, bidding procedures, and give clarity about interconnection and coverage issues.

The 2016 Energy Efficiency Policy

<http://www.energy.gov.sl/wp-content/uploads/2018/01/Energy-Efficiency-Policy-2nd-signed.pdf>

This Energy Efficiency Policy aims to enhance energy access while transforming the energy sector towards greater sustainability, taking into account the recent government Agenda for Prosperity's (AfP) call for the need of Sierra Leone to expand its energy supply and to increase the current rate of access to electricity, which is at 13%, and power system operations efficiency rated at 55%.

Electricity Sector Reform Roadmap (2017 to 2030)

http://www.energy.gov.sl/wp-content/uploads/2018/04/Draft_Final_Roadmap_12092017_Master_Copy.pdf

The 2030 Electricity Roadmap was initiated by the Millennium Corporation Challenge (MCC), in partnership with the GoSL. It provides a blueprint of the expected changes over the next decade in the electricity sector and proposes a set of targeted interventions to address current challenges, particularly linked to the financially constrained utilities, and private sector participations.

INVESTMENT INCENTIVES DIRECTORY

The 2017 Finance Act

<https://sierralii.org/sl/legislation/act/2017/30>

The Act guarantees duty waivers for imported solar products that fulfil IEC Standards. However, many developers have reported being unaware of this incentive and/or unsure due to unclear administrative processes and long delays.

DATA SOURCES DIRECTORY

This methodology was developed during the second phase of this project, the Green Mini-Grids Market Development Programme - Market Intelligence business line, which is also available via the African Development Bank.

This analysis, the results of which are provided in Section 3, considers the potential for mini-grids by segmenting the countries into two areas: grid and off-grid areas. This split is based on the distance of 15km from the power network. We have used the planned power network for up to 2030. The GIS sources used in this analysis are detailed below.

Source:

West African Power Pool- Existing and Planned Transmission,

<http://www.ecowrex.org/mapView/?mclayers=layerDistributionGrid>

Global Atlas: IRENA

<http://www.irena.org/globalatlas>

Solar Irradiation & Wind atlas - Irena

LandScan 2015 Global Population Database

<http://web.ornl.gov/sci/landscan/>

World Pop

<http://maps.worldpop.org.uk/#/map/layers/ppp-2015>

Population Growth: IMF WEO database:

<https://www.imf.org/external/pubs/ft/weo/2017/01/weodata/index.aspx>

STAKEHOLDER DIRECTORY

Institutions	Contacts
Ministry of Energy <ul style="list-style-type: none"> ○ Director of Energy together with the Directors of RE and Director Rural Electrification ○ Courtesy visit to the Permanent Secretary of the Ministry 	Office of the Permanent Secretary Ministry of Energy Stronge Tower, 3 & 3A Pademba Road, Freetown Email: info@energy.gov.sl http://www.energy.gov.sl/
Tony Blair Institute	Website: https://institute.global/advisory/sierra-leone
Electricity Generation and Transmission Company (EGTC)	No information available online
Electricity Distribution and Supply Authority (EDSA)	Electricity Distribution & Supply Authority Electricity House 36 House Siaka Stevens St Freetown, Sierra Leone Email: inquiry@edsa.sl , customercare@edsa.sl Website: http://www.edsa.sl/index.php/contact-item
Sierra Leone Electricity and Water Regulatory Commission (SLEWRC)	Sierra Leone Electricity & Water Regulatory Commission 55 Berick Street Freetown Telephone: +232 78 359 299 Email: info@ewrc.gov.sl Website: https://ewrc.gov.sl/
PPP Unit	Address: Public Private Partnership Unit Office of the Vice President 3a Wellington Street 3rd Floor Freetown Sierra Leone Email: info@ppp.gov.sl Website: https://ppp.gov.sl/contact-us/
UNOPS	UNOPS Sierra Leone 58, Sir Samuel Lewis Road Aberdeen, Freetown Sierra Leone Tel: 00232 3019 4083, 00232 3775 1055 Website: https://www.unops.org/sierra-leone

Power for All	Website: https://www.powerforall.org/countries/sierra-leone
DFID	DFID Sierra Leone 5 Off Spur Road Wilberforce Freetown Sierra Leone Email: enquiry@dfid.gov.uk Tel+232 22 233 620 Fax+232 22 235 769
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Seli Hydropower/Joules Energy	Website: http://www.selihydropower.sl/ Email: info@selihydropower.sl
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Green Mini-Grids
Market Development Programme
Document Series
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