SUSTAINABLE ENERGY FOR ALL

INCREASING ENERGY ACCESS IN SIERRA LEONE

Mini-grid survey analysis on tariffs, subsidies and productive use

MARCH 2021

UNOPS

Foreign, Commonwealth & Development Office

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ABBREVIATIONS

ABC	Anchor-Business-Community
AfDB	African Development Bank
AMDA	Africa Mini-Grid Developers Association
ARPU	Average revenue per user
BOO	Build-Own-Operate
BOT	Build-Operate-Transfer
CaaS	Cooling-as-a-Service
Capex	Capital expenditure
CAPM	Capital Asset Pricing Model
CEADIR	Climate Economic Analysis for Development, Investment and Resilience
CHC	Community health centre
DBO	Design-Build-Operate
DFI	Development Finance Institution
DisCo	Distribution company
DRE	Distributed renewable energy
EaaS	Energy-as-a-Service
EDSA	Electricity Distribution and Supply Authority
EEI	Energizing Economies Initiative
EGTC	Electricity Generation and Transmission Company
EIA	Environmental impact assessment
EPA	Environmental Protection Agency
ESMP	Environmental and Social Management Plan
EU	European Union
EUCS	Electricity Users Cooperative Society
EWRC	Electricity and Water Regulatory Commission
FCDO	Foreign, Commonwealth and Development Office (formerly the Department for International Development, DfID), UK
FGN	Federal Government of Nigeria
FI	Financial institution
GBP	British pound sterling
GoSL	Government of Sierra Leone
GPRBA	Global Partnership for Results-Based Approaches
GST	Goods and services tax
IBT	Increasing block tariff
IEC	International Electrotechnical Commission
IEP	Integrated electrification pathway
IFAD	International Fund for Agricultural Development
IMAS	Interconnected Mini-Grid Acceleration Scheme
IRR	Internal rate of return
KMM	KeyMaker model
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt peak

LCOE	Levelized cost of electricity
LV	Low voltage
M&E	Monitoring and evaluation
MAS	Mini-Grid Acceleration Scheme
MCCU	Millennium Challenge Coordinating Unit
MLGRD	Ministry of Local Government and Rural Development
MoE	Ministry of Energy
MoF	Ministry of Finance
MoHS	Ministry of Health and Sanitation
MSME	Micro, small and medium enterprise
MTF	Multi-Tier Framework
MW	Megawatt
MYTO	Multi-year tariff order
NEP	Nigeria Electrification Project
NERC	Nigerian Electricity Regulatory Commission
NESP	Nigerian Energy Support Programme
NGN	Nigerian naira
NPSP	Nigeria Power Sector Programme
O&M	Operation and maintenance
Opex	Operating expenditure
PAYG	Pay-as-you-go
PBG	Performance-based grant
PPA	Power purchase agreement
PPP	Public-private partnership
PRESSD-SL	Promoting Renewable Energy Services for Social Development in Sierra Leone
PRPM	Performance-related profit margin
PUE	Productive use of energy/electricity
RAB	Regulatory asset base
RBF	Results-based financing
REA	Rural Electrification Agency
REAN	Renewable Energy Association of Nigeria
REASL	Renewable Energy Association of Sierra Leone
REEEP	Renewable Energy and Energy Efficiency Project
REF	Rural Electrification Fund
RESIP	Rural Electrification Strategy and Implementation Plan
RISE	Regulatory Indicators for Sustainable Energy
ROGEP	Regional Off-Grid Electrification Project
RR	Revenue requirement
RREP	Rural Renewable Energy Project
SHS	Solar home system
SLEWRC	Sierra Leone Electricity and Water Regulatory Commission
SLL	Sierra Leonean leone
SME	Small and medium-sized enterprise
TA	Technical assistance
TAR	Total allowed revenue
TOU	Time of use
UNOPS	United Nations Office for Project Services
USD	United States dollar
VAT	Value-added tax
WACC	Weighted average cost of capital
WAPP	West African Power Pool
Wh	Watt hour
WP	Work package
Wp	Watts peak
WTP	Willingness to pay

ACKNOWLEDGEMENT

This report was commissioned by Sustainable Energy for All (SEforALL), with funding support from the UK's Foreign, Commonwealth & Development Office (FCDO) and with administrative support from the United Nations Office for Project Services (UNOPS) in Sierra Leone.

The SEforALL team that oversaw the development of the report consisted of Luc Severi, Emi Mizuno and Ingrid Rohrer.

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We would like to thank the numerous organizations and individuals who contributed to the findings of the report, including the Ministry of Energy in Sierra Leone, the Sierra Leone Electricity & Water Regulatory Commission (EWRC), Energicity, PowerGen, and Winch Energy. We would also like to express our gratitude to the numerous community members and stakeholders who provided valuable feedback and facilitated site visits and detailed stakeholder interviews.

Valuable guidance and oversight was provided by Damilola Ogunbiyi (Chief Executive Officer and Special Representative of the UN Secretary-General for Sustainable Energy for All), Keith Hammond (Senior Infrastructure Advisor, FCDO), Jasmin Roberts (Team Leader, Technical Assistance and Capacity Building, UNOPS) and Nicholas Gardner (Country Manager, UNOPS).

We would like to thank SEforALL staff for their support: Sameer Ahmad, Juan Cerda, Andrea Stojanov and Meriam Otarra.

We also acknowledge the funding provided by the Austrian Development Agency, the Ministry for Foreign Affairs of Iceland and the IKEA Foundation for their core support to our work. For a full list of our supporters, please visit our website at www.SEforALL.org.

IN SUPPORT OF

EXECUTIVE SUMMARY

The purpose of this study is to provide practical guidance and recommendations to the Government of Sierra Leone (GoSL) for the sustainable development of the country's mini-grid sector by building upon lessons learned from the ongoing Rural Renewable Energy Project (RREP) as well as from mini-grid sector development in Nigeria. Important lessons can be learned from the two countries with respect to their mini-grid policy and regulatory frameworks, market development approaches, and potential options for agricultural productive use of electricity (PUE) to facilitate both mini-grid electrification and rural economic development. This report — and this Executive Summary — is broadly structured as follows: **Part I** covers mini-grid regulatory frameworks, tariff structures and subsidies; **Part II** focuses on PUE and mini-grid site selection. This Executive Summary concludes with a **summary of the report's main findings and recommendations** for policymakers and key energy sector stakeholders.

1 MINI-GRID FRAMEWORKS, TARIFFS AND SUBSIDIES

Mini-Grid Electrification Planning and Market Development in Sierra Leone and Nigeria

Most mini-grid projects in nascent markets have slim or non-existent profit margins, as projects require significant resources for pre-feasibility, development and operation relative to potential revenue, driven by the need to engage communities, the remoteness of sites and the tailor-made nature of mini-grid projects. A supportive policy and regulatory framework that de-risks projects for developers is therefore critical, as nascent markets are particularly sensitive to overly-burdensome regulation.[1] Above all, the goal of a regulatory framework for mini-grids should be to promote good service at the lowest possible cost-recovery tariffs, while remaining predictable but flexible enough to evolve as the market matures.[2]

Mini-Grid Policy and Regulatory Frameworks in Sierra Leone and Nigeria

Sierra Leone has one of the lowest rates of electricity access in the world; the country has a national electrification rate of 26 percent, although this figure declines to 6 percent in rural areas where the majority of the population lives.[3] Where main grid connections exist, power supply is often unreliable, with fewer than one-third of firms and households reporting reliable access to electricity when surveyed.[4] There are a number of barriers to expanding grid-based electricity access and improving service quality, including a weak and limited transmission and distribution system; non-technical deficiencies with the utility, which result in high technical and commercial losses; insufficient generation capacity; seasonal variability in hydropower production; and institutional and regulatory constraints.

In Nigeria, access to electricity remains an ongoing challenge and is a key barrier to economic development; the country has a national electrification rate of 57 percent, while the rural electricity access rate is 31 percent.[5] Where the grid is available, consumers experience frequent power cuts ranging from four to 15 hours per day.[6] Nigeria has a significant electricity supply deficit, with only one-third of its 12.5 GW of installed generation capacity typically available. Meanwhile, tens of millions of on-site diesel generators are used to meet the country's actual daily

1 Practical Guide to the Regulatory Treatment of Mini-Grids, National Association of Regulatory Utility Commissioners, 2017.
2 Mini-Grids for Half a Billion People, World Bank ESMAP, 2019.
3 Tracking SDG7: The Energy Progress Report 2020.
4 Blimpo, M., and Cosgrove-Davies, M., "Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact," AFD and World Bank, Africa Development Forum, (2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31333/9781464813610.pdf?sequence=6&isAllowed=y
5 Tracking SDG7: The Energy Progress Report 2020.
6 State of the Global Mini-Grids Market Report 2020.

peak electricity demand, which is estimated to exceed 40 GW. This situation is the result of several factors: a stagnation of on-grid generation due to limited additions of new generation capacity; the poor state of the national grid and a corresponding lack of investment in grid maintenance and new transmission networks; liquidity issues faced by electricity utilities and distribution companies (DisCos); and associated issues of commercial and technical losses.

A key difference between the two countries is that Sierra Leone does not have an agency such as the Nigerian Rural Electrification Agency (REA) dedicated exclusively to rural electrification and energy access; all rural electrification planning in Sierra Leone is currently managed by the Ministry of Energy (MoE). While Sierra Leone does not have a rural electrification master plan, its off-grid electrification strategies are broadly defined in its various energy policy documents, including the Electricity Sector Reform Roadmap 2017–2030, which provides a framework for restructuring the power sector to achieve long-term electrification objectives over the next decade. Despite the existence of this roadmap, there has been no formal adoption of its recommendations, which means new energy projects are not implemented as part of, or in support of an integrated sector plan. In the mini-grid sector, the Electricity and Water Regulatory Commission (EWRC) has developed a comprehensive regulatory framework — the 2019 Mini-Grid Regulations — that provides specific guidance on licensing procedures, consumer service, grid interconnection and commercial arrangements to support the development of mini-grids.

In Nigeria, the government adopted the 2017 Rural Electrification Strategy and Implementation Plan (RESIP), under which the REA provides developers with financial incentives and technical support to expand rural electricity access. The Mini-Grid Regulations enacted by the Nigerian Electricity Regulatory Commission (NERC) in 2016 provide the necessary regulatory and permitting guidelines for the development and operation of mini-grids in the country, including clear guidance on tariff setting through the REA Mini-Grid Tariff Tool methodology.

Mini-grid development in Sierra Leone has not been part of a national strategy but rather implemented under two donor-funded projects,[7] the largest of which – the RREP – followed a public-private partnership (PPP) model of public ownership and private management driven by a top-down approach. In Nigeria, mini-grid development has followed a more bottom-up, private sector-led approach (see **Section 2.1**).

Mini-Grid Tariff Frameworks in Sierra Leone and Nigeria

Mini-Grid Regulations

In June 2019, the EWRC approved the 2019 Mini-Grid Regulations, which were subsequently ratified by parliament later that year. The mini-grid regulations in Sierra Leone closely mirror those enacted by the NERC in 2016; both regulations include provisions for market-entry, cost-reflective retail tariffs, contractual arrangements, technical and service standards, and the arrival of the main grid, with unique guidelines and licenses for mini-grid projects based on capacity and whether they are isolated and interconnected. **Section 3.1.1.1** and **Section 3.1.1.2** cover each component of the regulation in detail in Sierra Leone and Nigeria, respectively.

Tariff Affordability and Cost of Service

In 2016, prior to the rollout of the RREP in Sierra Leone, a demand assessment carried out by the project encompassing 68 rural communities, 2,500 interviews, and feedback from 1,950 household respondents found that households would benefit from savings of up to 52 percent with the advent of mini-grid electricity, based on average costs of alternative sources of energy (i.e., expenditures on kerosene, batteries, fuel etc.). The survey estimated the average amount rural customers were able to pay was approximately USD 6/month (SLL 59,400/month), mainly for lighting, mobile phone charging and other household uses. The study also found that rates of electricity demand could increase by a factor of 20 with the arrival of mini-grid electrification, with average consumption between 3.5 and 6.3 kWh per month per household. Subsequent studies conducted by the MoE following the inception of the project found evidence that the cost of electricity from mini-grids remains lower than alternative sources of energy.

After the Work Package 1 (WP-1) mini-grids began operating in 2019 (see **Section 1.1.2** for a description of the RREP Work Packages), 80 percent of mini-grid community respondents surveyed by the GreenMax field

7 (1) The EU-funded Promoting Renewable Energy Services for Social Development in Sierra Leone (PRESSD-SL) and (2) the RREP.

research team who did not connect to the mini-grid cited affordability of the electricity tariff as the main reason for not connecting.[8] The initial tariffs for WP-1 sites ranged from USD 0.82/kWh to 0.87/kWh, with an average tariff level of about USD 0.85/kWh. Given the focus on providing access for WP-1 sites (i.e., targeting smaller sites in order to avoid deliberate selection of only larger and more economically attractive locations), these initial sites had a lower targeted number of customers. This dynamic — smaller sites with relatively limited demand — combined with high project development and overhead costs for developers, contributed to a higher tariff, which was necessary to make projects bankable. Another factor that increased costs was the initial requirement for operators to maintain a reserve account for WP-1 batteries,[9] which has since been addressed through an FCDO subsidy under Work Package 7 (WP-7) of the RREP.[10]

Under the next phase of the project, Work Package 2 (WP-2), operators are co-investing in the development of 40+ larger mini-grids under a "split-asset" model in which the GoSL is covering the capital costs of the distribution assets. As the operators begin to connect more customers and bring larger mini-grid systems online, project development costs are gradually decreasing. The most recent round of tariff negotiations, combining the WP-1 and WP-2 sites, resulted in a range of USD 0.74/kWh to 0.82/kWh, with an average tariff of USD 0.79/kWh.[11]

By comparison, according to the REA, mini-grid tariffs in Nigeria range from USD 0.39/kWh to 0.79/kWh (NGN 150/kWh – 300/kWh), with an average tariff level of about USD 0.58/kWh (NGN 220/kWh).[12] Interviews with mini-grid operators in Nigeria found that there have been relatively few complaints from communities surrounding tariff affordability, as the majority of end users spend less on electricity from the mini-grid than they did on expensive and polluting alternative sources of energy prior to the mini-grid's installation. For instance, the levelized cost of electricity (LCOE) from a small diesel generator is at least USD 0.75/kWh (NGN 250/kWh) and is vulnerable to fuel price volatility.[13]

Key Drivers of the Disparity in Tariffs between Sierra Leone and Nigeria

It is important to provide context around these numbers in order to understand what is driving the disparity in tariffs between the two countries. Despite the above-mentioned similarities in their mini-grid policy and regulatory frameworks, there are also several important differences between the mini-grid markets in Sierra Leone and Nigeria, including *inter alia*:

- The two mini-grid markets are at different stages of development and have pursued different mini-grid planning approaches (see **Section 2.1**) and subsidy schemes (see **Section 3.2**).
- The larger size of the Nigerian market (and increased scale of electricity demand) plays an important role in driving cost reductions vis-à-vis Sierra Leone, where there are fewer mini-grid customers in more sparsely populated rural villages.
- Household income levels are lower in Sierra Leone (56.8 percent national poverty headcount ratio compared to 40.1 percent in Nigeria in 2018), contributing to a lower household consumption rate.[14]

It is important to emphasize that although the mini-grid tariff in Sierra Leone is considered unaffordable by many, a large number of mini-grid customers had never used electricity in this form prior to the arrival of the mini-grid and ended up consuming more electricity than they could afford. Public and private sector resources should therefore focus heavily on community sensitization, consumer education and training around electricity usage and expenditures, energy efficiency, mini-grid load capacity, appliance usage, PUE, and other benefits and cost savings of mini-grid electrification. As consumer awareness around energy usage and expenditures improves over time, mini-grid usage can be optimized.

As the Sierra Leonean mini-grid market continues to evolve and electricity demand increases, tariffs are expected to continue to decrease. Indeed, as is indicated above, the

8 NB: These findings do not reflect the fact that perceptions on affordability do not take into account the increase in consumer spending on electricity from the mini-grid as a result of the use of appliances, they also do not reflect a like-to-like comparison of end-user spending on electricity from the mini-grid in comparison to expensive and polluting alternative sources of energy prior to the mini-grid's installation.

9 A substantial delay between the time the mini-grid systems were installed and the sites were electrified (mainly due to delays in the tendering process) led to the capacity reduction of batteries.

10 http://www.energy.gov.sl/wp-content/uploads/2020/10/Fact-sheet_RREP-Updated-September-2020.pdf

11 Stakeholder consultations, 2021.

12 Figures are from solar hybrid mini-grids ranging in size from 30-234 kWp that have been commissioned under the AfDB/World Bank Nigeria Electrification Project (NEP) Performance-Based Grant Programme and the EU/GIZ Nigerian Energy Support Programme I (NESP I); see Table 8 in Section 3.2.1.2.

13 "Mini-Grid Investment Report: Scaling the Nigerian Market," Rocky Mountain Institute, (2018): https://rmi.org/wp-content/uploads/2018/08/RMI_Nigeria_Minigrid_Investment_Report_2018.pdf

14 World Bank: Poverty headcount ratio at national poverty lines: https://data.worldbank.org/indicator/SI.POV.NAHC?locations=NG-SL

most recent tariffs in Sierra Leone are already comparable to the higher end of the spectrum of mini-grid tariffs in Nigeria.

Section 3.1.2.2 provides a detailed summary of findings vis-à-vis mini-grid tariff frameworks in Sierra Leone and Nigeria.

Mini-Grid Subsidy Schemes in Sierra Leone and Nigeria

In Sierra Leone, the RREP utilized donor and government funds to cover all of WP-1 construction expenses and also provided an 'in-kind' subsidy to operators by covering the capital costs of the distribution assets under WP-2, thereby enabling them to charge a lower connection fee to customers. However, when interviewed, operators indicated that the pre-financing mechanism under the RREP was not necessarily their preferred approach, as they would have preferred an alternative structure that may have provided them with more flexibility.[15]

In addition, the Finance Act of 2017 provides duty exemptions on the importation of solar equipment (excluding ancillary materials such as batteries and inverters etc.) that meets International Electrotechnical Commission (IEC) global quality standards, and the Finance Act of 2021 provides corporate tax exemptions and a goods and services tax (GST) waiver for mini-grid projects. While these fiscal incentives should ostensibly result in lower tariffs, the process for the 2017 tax exemption is not fully clear and requires the adoption of streamlined procedures to make it simpler for operators to apply for them.[16] The 2021 exemptions have yet to be implemented, so it is too early to draw any conclusions regarding their efficacy.

A comparative analysis of previous and ongoing mini-grid subsidy programmes in Sierra Leone and Nigeria is presented in **Table ES-1**.

15 Stakeholder interviews, 2020.
16 AfDB Green Mini-Grid Market Development Programme - Mini-Grid Market Opportunity Assessment: Sierra Leone, 2019.

Photo: GreenMax Capital Advisors Inc.

TABLE ES-1

Mini-Grid Subsidy Programmes in Sierra Leone and Nigeria

Indicator	Summary of Lessons Learned
Speed of delivery	• Similar to most programmes of its size, scope and ambition, the RREP is complex in its design, involving lengthy negotiation and financing processes that require significant resources to manage; programme delays were largely attributed to extended application processes to obtain licenses and other permits, as well as to ongoing general elections in Sierra Leone in early 2018. Continuous learning by doing (by regulators, developers and communities) and the subsequent refinement and streamlining of permitting/contract negotiation processes is a key lesson learned. • A key area of consideration for mini-grid contracts is that contract negotiations for energy projects in Sierra Leone typically take 18 months from the start of the negotiation process to approval at the cabinet level. These processes were transferred to the negotiation of the RREP PPP contract, which involved all the same stakeholders as energy IPP contracts. • The first mini-grid deployed under the Nigeria Electrification Project (NEP) that utilizes results-based financing (RBF) was commissioned in December 2019 – just three months after the project's grant agreement signing under the performance-based grant (PBG) component of the programme and nine months after the programme was launched. According to the REA, the transparency and speed of the NEP process is due to the e-procurement method utilized together with the national data management platform, Odyssey.[17] • Recent experience with various auction programmes in Nigeria (MST, MAS, IMAS, REF) suggests that this structure is generally more prone to delays. Nevertheless, it is worth noting that the NEP has also faced some delays related to a lack of access to finance, developers' limited capacity and engagement with distribution companies (DisCos). • A key takeaway from the experience in Nigeria thus far is the need for some early disbursement of subsidies, particularly in the context of the COVID-19 crisis, as 40 percent of the RBF payments under the NEP PBG had to be paid up-front to reduce delays due to financing difficulties, while the balance is paid after 90 days according to the original payment schedule. There is also a need for the provision of concessional local currency debt facilities (e.g., the above-mentioned Nigeria Infrastructure Debt Fund) as well as technical assistance (TA) to support developers with access to finance needed to cover the portion of capex not covered by subsidies.

17 Odyssey Energy Solutions is a web-based data platform to simplify, streamline, and reduce the costs of developing and financing mini-grids in emerging markets.

Photo: GreenMax Capital Advisors Inc.

Indicator	Summary of Lessons Learned
Tariff Reduction	• Average end-user mini-grid tariffs for solar hybrid mini-grids in Sierra Leone started with an average of USD 0.85/kWh (USD 0.82/kWh – 0.87/kWh) for WP-1 sites in 2019, which recently came down to an average of USD 0.79/kWh (USD 0.74/kWh – 0.82/kWh) for WP-1 and WP-2 sites combined, while the average tariff in Nigeria is USD 0.58/kWh, with a range of USD 0.39–0.79/kWh. • In Sierra Leone, as operators begin to connect more customers and bring larger mini-grid systems online, project development costs are gradually decreasing. • In Nigeria, there is a direct correlation between the level of subsidy and the tariffs. A comparison of the REF and NEP PBG programmes shows that REF subsidies cover 50-70 percent of capex, while the NEP PBG covers only about 30 percent. Consequently, tariffs for NEP sites are generally higher by 25-108 percent compared to tariffs for REF sites. It is worth noting that there are other factors that influence tariffs, including location, presence of productive uses, cost of financing, site accessibility etc.
Economies of scale	• Operators in Sierra Leone opined that the RREP was structured in a way that does not allow them to sufficiently take advantage of economies of scale. • In Nigeria, discussions with the REA revealed that it would like to see private companies develop large portfolios of mini-grid sites to realize economies of scale, which could potentially lead to a reduction in tariffs. Under the NEP Minimum Subsidy Tender, developers are allowed to develop 40-50 sites together. However, given that the programme has yet to progress to the implementation stage, the cost reduction impacts of this mechanism cannot be assessed.

2 PRODUCTIVE USE OF ENERGY AND SITE SELECTION

Productive Use of Electricity and Mini-Grids

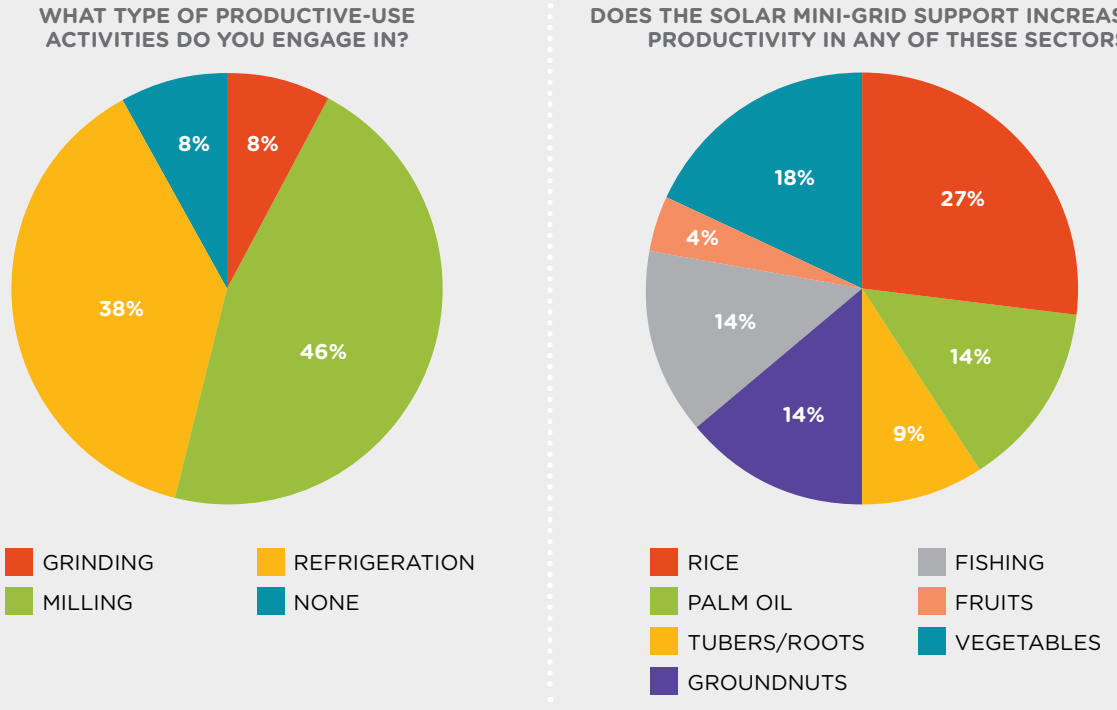
In Sierra Leone, where most of the population lives in rural areas and engages in subsistence agriculture, mini-grids can power rural agricultural productivity and create new businesses or expand existing ones linked to the agricultural value chain.

Consultations with rural mini-grid community stakeholders in Sierra Leone found that milling and refrigeration are among the most common productive-use applications, while solar mini-grid electrification can support increased productivity across a variety of agricultural sectors, led by rice, palm oil, fish, vegetables and groundnuts via agricultural processing and cold storage applications (**Figure ES-1**).

In Sierra Leone, the ability to pay for mini-grid electrification among rural agrarian communities is highly dependent upon the seasonality of income, crop yield etc. This makes the utilization of PUE a critical tool going forward, as it can provide a steady source of income and help increase the purchasing power of communities in the long term. Operators will also need the support of key public and private sector partners to expand PUE; these private sector partnerships and financing arrangements are already being pursued under WP-6 of the RREP with funding from the FCDO.

Winch Energy, operating in Sierra Leone, has already formed several key partnerships to develop local enterprises and expand access to appliances in its WP-1 mini-grid communities. The company has partnered with EasySolar to offer consumers electrical appliances

FIGURE ES-1
Mini-Grid Community Productive Use Survey Results



Source: GreenMax Capital Advisors field surveys, 2020

available on microcredit and is working with the telecommunications operator Orange to expand access to mobile money services in its communities.[18] In Nigeria, under the NEP, the REA and its development partners rolled out a successful PUE equipment-financing scheme (in partnership with PowerGen). Under the Energizing Economies Initiative (EEI), the REA pursued an end-to-end approach for electrifying commercial hubs/economic clusters. Both the NEP and EEI initiatives can serve as a blueprint for Sierra Leone to integrate PUE into mini-grid development (more on PUE in **Section IV**).

Mini-Grid Site Selection in Sierra Leone and Nigeria

In Sierra Leone, the RREP beneficiary communities were selected in 2016 by a steering committee led by the MoE based on a nationwide list of villages with Community Health Centres (CHCs) provided by the Ministry of Health and Sanitation (MoHS) in the wake of the Ebola crisis. The GoSL selected the sites based on the following criteria: (i) existence of a CHC; (ii) size of the community with respect to households, businesses and population density (a minimum of 250 structures was required in order to ensure economic viability); (iii) distance of the community to the CHC (to reduce the cost of using medium voltage lines); and (iv) distance of the community to any existing or planned transmission lines and/or the existence or plan for any other electrification project. The criteria for selecting mini-grid sites were the same for both WP-1 and WP-2; however, less emphasis was placed on demand-side considerations during the initial WP-1 site selection, which above all prioritized supplying electricity to the CHCs. In contrast, WP-2 focused more on PUE opportunities, with several studies commissioned by UNOPS to support the operators in this regard (see **Section 4.3.1**).

In Nigeria, under the NEP, an RBF mechanism provides financial incentives for private sector-led development of identified off-grid sites with high customer density characteristics that are best suited for mini-grid electrification. At the commencement of the NEP mini-grid programme in 2017, the REA supported a detailed survey that prioritized over 200 sites with demand of at least 100 kW across five states. The assessment utilized georeferenced data to assess the following key parameters for site selection: (i) sufficient load/density; (ii) productive-use, daytime, and flexible loads; (iii) supportive local and state government; (iv) community engagement; and (v) accessibility. Detailed surveys were carried out in each selected community using a computer-aided personal interview app on a mobile device.

The REA is working hard to engage with and sensitize the identified mini-grid communities, including through the promotion of productive activities designed to increase employment and income and in turn enable local capacity and willingness to pay.[19] **Section V** provides more details surrounding the site selection approaches under the RREP in Sierra Leone and the NEP in Nigeria.

18 "Winch Energy celebrates project success in Sierra Leone," African Review, (26 October 2020): https://www.africanreview.com/energy-a-power/renewables/winch-energy-celebrates-project-success-in-sierra-leone

19 Mini-Grid Investment Report: Scaling the Nigerian Market, Rocky Mountain Institute, 2018.

3 SUMMARY OF RECOMMENDATIONS

A summary of recommendations for mini-grid policymakers, regulators and operators in Sierra Leone is presented in **Table ES-2**. For more details, see also **Section 3.3**, **Section 4.5** and **Section 5.3**.

NOTE: The analysis/findings presented in this report are based on a market assessment (interviews, survey activities etc.) that was carried out in early to close gap mid-2020. The mini-grid markets in Sierra Leone and Nigeria are extremely dynamic, with frequent changes and new developments in programme structures, regulatory frameworks, and other public and private sector activities in the sector. For example, in late 2020, RREP WP-2 sites in Sierra Leone started coming online; the FCDO provided a new tariff subsidy under WP-7; and the EWRC switched its tariff regulation methodology to a multi-year tariff order (MYTO) tool. In Nigeria, the NEP's mini-grid components and programmes are only just launching, making it difficult to draw any conclusions or lessons learned. The COVID-19 pandemic has only complicated things further. Wherever possible, the authors have tried to account for these developments, but it is suggested that this document be viewed as a working document to be updated as the mini-grid markets in both countries continue to evolve.

TABLE ES-2
Summary of Recommendations

Indicator	Summary of Recommendations
GoSL policymakers should…	
Policy and Regulatory Framework	• Develop and implement a coherent **long-term strategy** that builds upon the strong foundation of the RREP and the existing regulatory framework and aligns the priorities of all market actors — government, developers, end users and financiers — to de-risk and mobilize mini-grid financing and expand mini-grid electrification in the country. This can be in the form of a '**master plan**' but should include **clear national targets for mini-grid expansion in the long term**. This will foster private sector participation and provide clarity and predictability to mini-grid market players, notably for investors and companies who need to consider multi-year plans involving significant capital expenditure or borrowing. • **Expand the internal capacity of the MoE** and/or create either a separate **directorate within the MoE** or an entirely new **rural electrification agency** dedicated to managing the rollout of a national mini-grid programme, with a long-term vision and targets in order to provide clarity and predictability to mini-grid market players. • Adopt policy and planning approaches that create opportunities for developers to take advantage of **economies of scale** (with fixed costs spread over far larger volumes of kWh sold) to reduce costs and expedite market development (i.e., allow for a **bottom-up approach** to coexist in the market). • **Streamline import duty exemptions** for solar equipment, including the adoption of clear guidelines for all relevant public institutions; consider expanding existing import duty exemptions to cover ancillary equipment such as distribution equipment, inverters and batteries to further reduce development costs. • Implement policy measures to **ensure standards/quality** of equipment in the off-grid/mini-grid sector. • Support local market growth through collaboration with the Renewable Energy Association of Sierra Leone (**REASL)** (e.g., to certify and train local entrepreneurs), as the use of local suppliers and engineers will reduce project development costs.

Indicator	Summary of Recommendations
Tariff Setting	• Utilize available data to propose a **benchmark return** on equity based on existing market conditions in Sierra Leone (or financing opportunities for mini-grids internationally) to simplify the tariff review process and provide a **clear market signal to developers** on the profitability of their potential investments. • Make explicit the required subsidy to reach a certain tariff (e.g., via RBF, per kWh or % capex subsidies), which would provide clarity to the private sector and clear benchmarks for government on costs of decentralized electrification vs. central grid expansion.
Subsidy Mechanisms	• Adopt an **up-front cash grant/RBF hybrid scheme** (as opposed to an 'in-kind' subsidy) **to reduce project costs and potentially lower tariffs**; the hybrid structure will reduce developers' up-front capital constraints while also ensuring quality of service as developers are fully paid based on the deployment and verification of the connections; the value of the subsidy should be high enough to achieve tariff reduction. • Adopt a **simplified, streamlined and consistent process** across all relevant public agencies to **reduce complexity** and the amount of time/resources required of developers for licensing and permitting. • Adopt a **framework contract** that can be used on an ongoing basis to streamline project approvals, save time and reduce project delays/costs. • Design subsidy programmes to **ensure quality of construction** by making developers/ subsidy recipients responsible for installing and testing all mini-grid assets. • Incorporate **long-term maintenance** of mini-grids in subsidy design. • Identify areas where project developers may need support and provide **technical assistance** through the MoE and/or donor-funded programmes (e.g., to access available financing, transaction advisory services etc.). • Utilize **data analytics and e-procurement** to increase transparency and speed of project delivery. • Consider how subsidies will eventually be removed; a **three-phase approach** can be adopted to gradually transition towards a sustainable market (see **Figure 16** in **Section 3.2.1**).
Productive Use of Electricity	• Develop and implement programmes providing technical and financial support to mini-grid developers to stimulate **PUE** and revenue-generating activities in mini-grid communities, which provide anchor clients for mini-grid power supply and increase customer income levels and purchasing power. Rolling out PUE in mini-grid communities on a large scale will require **extensive coordination across various public agencies** (e.g., MoE, Ministry of Agriculture and Forestry, Ministry of Planning and Economic Development, Ministry of Local Government and Rural Development), **as well as private sector support**, including from the local financial sector (e.g., Sierra Leone Association of Microfinance Institutions) to improve access to local currency financing for the sector. • Raise awareness of the **benefits and long-term cost savings associated with switching to equipment powered by clean energy**; off-grid communities typically use equipment that is powered by diesel generators; thus, there is a need for interventions in order to raise customer awareness and provide associated training (e.g., on how to use new solar-powered equipment and appliances).

Indicator	Summary of Recommendations
Productive Use of Electricity	• Incorporate **productive-use appliance and equipment financing for households and small and medium-sized enterprises (SMEs)** into mini-grid business models and planning; providing business support services to SMEs on the use of appliances will increase productive activities, stimulate electricity demand, and thus increase their overall capacity to pay for electricity consumed; grant funding has already been made available by the FCDO under Work Package 6 (WP-6) to increase access to PUE among the RREP mini-grid communities. • Provide **TA and financing to help local businesses grow and expand their access to a wider market** for their products (beyond their communities). • **Apply lessons learned from Nigeria**: In Nigeria, under the EEI, the REA identified suitable commercial and agricultural hubs that could benefit from mini-grid electrification, then carefully selected and integrated appropriate PUE equipment through an appliance-financing mechanism with ongoing business development support (see **Section 4.5**). Policymakers in Sierra Leone can refer to the EEI as a blueprint for Sierra Leone to follow to integrate PUE into mini-grid development.
Site Selection	• Adopt a **private sector-led model with a dual focus on increasing connections and improving the commercial viability of sites**. In Nigeria, under the NEP, the REA pursued a comprehensive site selection approach that included detailed site assessments and community sensitization initiatives. • Utilize **GIS/georeferenced data** and other **consumer and market intelligence tools**[20] to support the site selection process; in Nigeria, the REA implemented a **national data management platform** (Odyssey) that provides information to developers (e.g., demand forecasting, tariff calculation etc.) in an effort to streamline project development and improve customer demand estimation and avoid power underutilization. • Emphasize **productive-use activities as the primary method of stimulating electricity demand** in the community. Electricity demand assessments currently focus more on personal consumption at the household level (e.g., lighting and phone charging etc.), which may lead to lower levels of electricity uptake for projects. Developers need both financial and technical assistance from the government and/or development partners to support robust assessments of PUE potential during the site selection process. • Pursue a robust **community sensitization and consumer education and training campaign** as part of the site selection process. Given that mini-grid electrification remains cheaper than alternative sources of energy currently utilized by rural communities (e.g., purchasing of kerosene for lighting, diesel for generators etc.), it can be deduced that the inefficient use of energy from the mini-grid is at least partially contributing to misperceptions surrounding affordability in Sierra Leone. End users who are receiving electricity access for the first time may lack an understanding of how much they can afford to spend on power. Public and private sector resources should therefore focus heavily on community sensitization, consumer education and training around electricity usage (especially vis-à-vis monthly expenditures), mini-grid load capacity, appliance usage, PUE, and other benefits and cost-savings of mini-grid electrification. As consumer awareness around energy expenditures improves over time, mini-grid usage can be optimized. In Nigeria, during the rollout of the NEP, the REA led a comprehensive effort to raise awareness and sensitize rural communities by mobilizing locals to form/join Electricity Users Cooperative Societies (EUCSs).

20 Off-grid energy services companies are increasingly making more demand-side data available through customer and market insights. For example, Nithio provides data on customer creditworthiness, expenditure patterns; Fraym offers advanced geospatial data solutions (see: http://www.nithio.com and https://fraym.io)

1 INTRODUCTION

1.1 Background and Context of the Assignment

The purpose of this report is to provide practical guidance and recommendations to the Government of Sierra Leone (GoSL) for the sustainable development of the country's mini-grid sector by building upon lessons learned from the ongoing Rural Renewable Energy Project (RREP) as well as from mini-grid sector development in Nigeria. The report provides comparisons of and lessons learned from the two countries with respect to their mini-grid policy and regulatory environment (including tariff frameworks and subsidy schemes), mini-grid productive-use applications (with a focus on the agricultural sector), and mini-grid site selection criteria (both supply-side and demand-side factors). This report was prepared through a combination of desk research and extensive stakeholder consultations with individuals and organizations in Sierra Leone and Nigeria. A mission was also carried out to survey rural mini-grid community end users in Sierra Leone. A description of the stakeholder engagement activities, research methodology and analytic framework can be found in **Annexes 3-5**.

1.1.1 Mini-Grid Electrification in Sierra Leone

Sierra Leone's power sector is relatively small, with slightly over 150 MW of installed generation capacity operated by the public utility, Electricity Generation and Transmission Company (EGTC). About half of this capacity comes from thermal power, with hydropower making up most of the remaining balance. Sierra Leone has one of the lowest rates of electricity access in the world; according to the 2020 SDG7 Tracking Report, the country has a national electrification rate of 26 percent, although this figure declines to 6 percent in rural areas where the majority of the population lives.[21] Where main grid connections exist, power supply is often unreliable, with fewer than one-third of firms and households reporting reliable access to electricity when surveyed.[22] There are a number of barriers to expanding grid-based electricity access and improving service quality, including a weak and limited transmission and distribution system; non-technical deficiencies with the utility, which result in high technical and commercial losses; insufficient generation capacity; seasonal variability in hydropower production; and institutional and regulatory constraints.

The GoSL has been working with development partners to address these barriers and improve rates of electricity access. In 2017, the government published the Electricity Sector Reform Roadmap 2017–2030, which provides a policy framework for the development of the country's energy sector through 2030, including a series of reform measures and actions to restructure the power sector and achieve long-term electrification objectives through a combination of grid extensions, off-grid renewable energy mini-grids and stand-alone systems.[23] Despite the existence of this roadmap, there has been no formal adoption of its recommendations, which means new energy projects are not implemented as part of, or in support of an integrated sector plan.

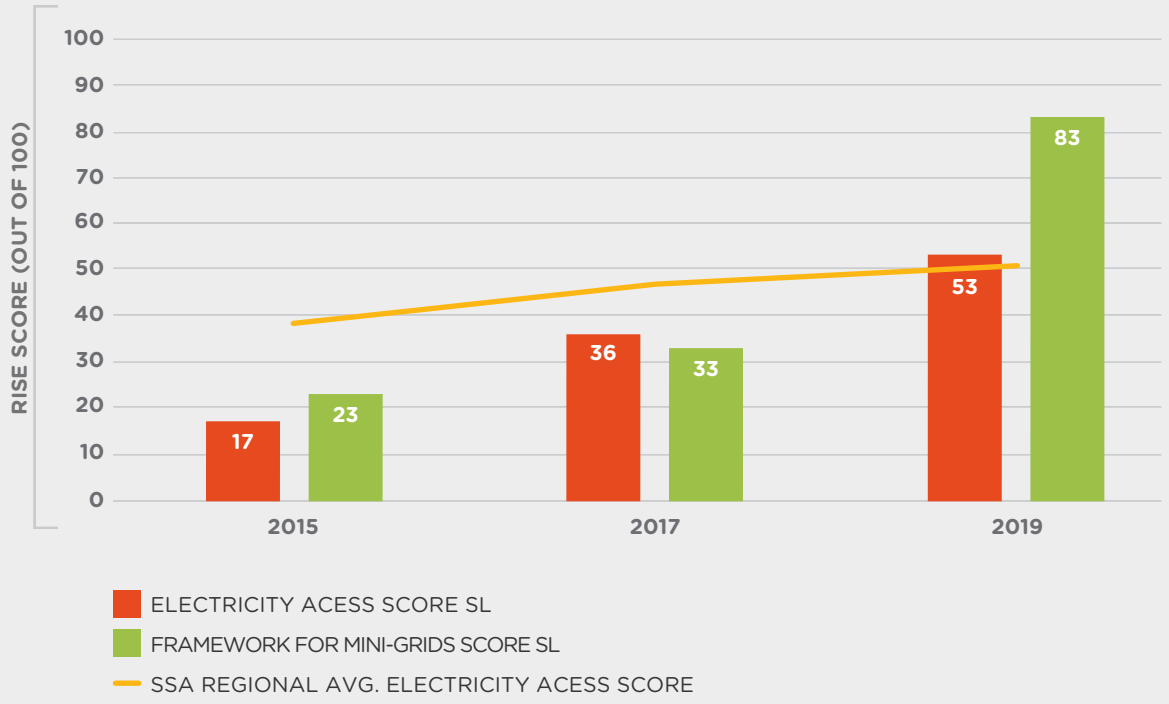
In 2019, the GoSL approved Mini-Grid Regulations that provide specific guidance on licensing procedures, consumer service, grid interconnection and commercial arrangements (e.g., tariff setting) to support the development of the country's mini-grid sector.[24] Overall, the government's efforts to establish

21 Tracking SDG7: The Energy Progress Report 2020.
22 Blimpo, M., and Cosgrove-Davies, M., "Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact," AFD and World Bank, Africa Development Forum, (2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31333/9781464813610.pdf?sequence=6&isAllowed=y
23 "Electricity Sector Reform Roadmap (2017-2030)," Millennium Challenge Corporation, (2017): http://www.mccu-sl.gov.sl/documents/Sierra%20Leone%20Power%20Sector%20Roadmap.pdf
24 SLEWRC Mini-Grid Regulations 2019: https://ewrc.gov.sl/mini-grid-regulations/

a supportive policy and regulatory framework for the off-grid sector are progressing rapidly. In the World Bank's Regulatory Indicators for Sustainable Energy (RISE) index, Sierra Leone's electricity access score has increased substantially in recent years, with notable improvement in its framework for mini-grids, which is about 30 percent higher than the regional average (**Figure 1**).[25]

FIGURE 1

Sierra Leone RISE Electricity Access and Framework for Mini-Grids Scores, 2015–2019



Source: Adapted from World Bank Regulatory Indicators for Sustainable Energy (RISE) index.

To date, there have been a limited number of mini-grid projects deployed in the country, largely concentrated under two donor programmes – the EU-funded Promoting Renewable Energy Services for Social Development in Sierra Leone (PRESSD-SL) project, which installed three solar mini-grids, and the ongoing UK-funded RREP, which aims to develop up to 5 MW of renewable mini-grid capacity in rural areas with private sector involvement. Outside of these key initiatives, about another dozen mini-grids have been developed in agrarian communities throughout the country, powered mainly by diesel and hydropower.[26]

Given the country's persistently low rates of rural electrification, distributed generation, and mini-grids in particular, are expected to play a significant role in providing electricity access to rural communities over the next decade. According to a least-cost electrification analysis conducted in 2019 for the World Bank Regional Off-Grid Electrification Project (ROGEP),[27] by 2030, an estimated 4,365 settlements (about 420,000 households) in Sierra Leone representing approximately 25 percent of the population, can be optimally electrified by mini-grids (**Figure 2**).[28]

25 World Bank Regulatory Indicators for Sustainable Energy: https://rise.worldbank.org/country/sierra-leone

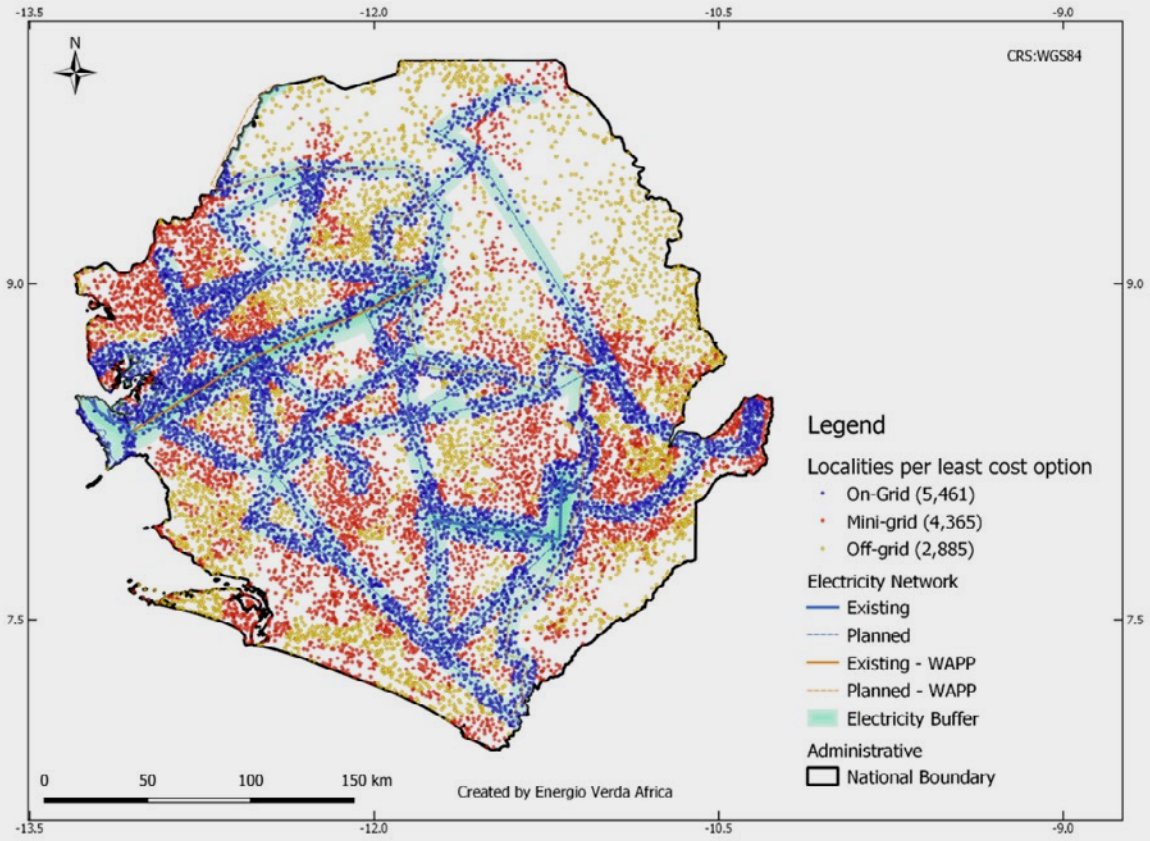
26 Janse, S., "Affordable and reliable mini-grids in Sierra Leone," TU Delft Technology, Policy and Management, (May 2019): https://repository.tudelft.nl/islandora/object/uuid%3Ab98a7726-bb05-430f-832c-53282130edeb

27 "Regional Off-Grid Electrification Project: Off-Grid Solar Market Assessment and Private Sector Support Facility Design: Sierra Leone Report," World Bank, ECOWAS Center for Renewable Energy and Energy Efficiency, (July 2019): http://www.ecreee.org/sites/default/files/ecreee_rogep_sierra_leone_final_report.pdf

28 These estimates are based on the assumption that all planned grid extensions/densification plans will be completed by 2030. The GIS analysis examined the population density, proximity to electrical infrastructure, and economic growth potential of off-grid settlements.

FIGURE 2

Distribution of Settlements by Least-Cost Electrification Option, 2030



Source: Energio Verda Africa GIS analysis; West African Power Pool (WAPP).
World Bank-ECREEE Regional Off-Grid Electrification Project (ROGEP): Sierra Leone Report, 2019.

1.1.2 Rural Renewable Energy Project

In 2016, Sierra Leone's Ministry of Energy (MoE) launched the RREP, funded by the UK Foreign, Commonwealth and Development Office (FCDO), formerly the Department for International Development (DfID), and administered by the United Nations Office for Project Services (UNOPS). The GBP 34 million project aims to establish an enabling environment for a private sector-driven rural mini-grid market in the country, with the objective of supplying up to 5 MW of renewable electricity in rural communities through installations of at least 94 solar mini-grids to be operated and managed by private sector partners. The RREP is being implemented in several phases over a five-year period.

The first phase, Work Package 1 (WP-1), involved the installation of 6 kWp solar generation systems in 54 community health centres (CHCs) as pilot sites in 14 districts across Sierra Leone. The MoE selected the WP-1 sites in districts that are not already targeted by grid extensions or other rural electrification programmes and initiatives. CHCs were established as baseline facilities for electrification under the RREP following the onset of the Ebola crisis, which made it a priority for the GoSL to provide rural health clinics with a reliable source of power. Under the RREP business model, in return for use of the land on which to build the power stations, the CHCs are provided with up to 6 kWh/day of electricity,[29] an arrangement managed through a tripartite Inter-Ministerial Cooperation Agreement signed between the MoE, the Ministry of Health and Sanitation (MoHS) and the Ministry of Local Government and Rural Development (MLGRD).[30] Next, under Work Package 1+, the CHC systems in 50 of the communities were expanded into small mini-grids with capacity of 16–36 kWp, extending electricity access to surrounding households, schools and businesses.

29 Any usage above this threshold is paid by the Ministry of Health.
30 Ministry of Energy - Rural Renewable Energy Project: http://www.energy.gov.sl/home/rural-renewable-energy-project/

Construction of all 50 WP-1 mini-grids was completed in 2018 under the supervision of UNOPS.

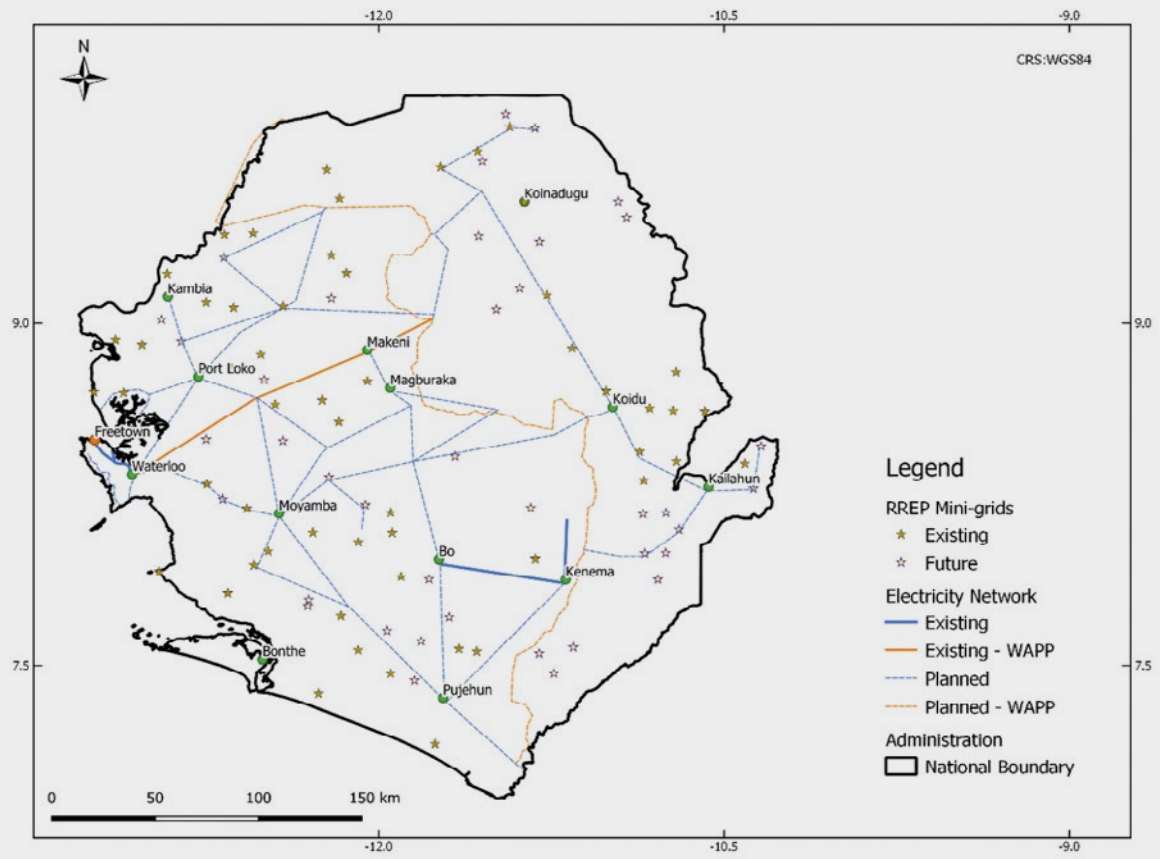
Under the second phase of the RREP, Work Package 2 (WP-2), three private sector companies bid and negotiated public-private partnership (PPP) agreements with the MoE to operate the existing mini-grid systems installed under WP-1 and WP-1+ and to co-invest in the electrification of an additional 44 rural communities with mini-grids ranging in size from 36 kWp to 200 kWp. Under the bidding process, the RREP sites were divided into four lots across 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). The three selected operators — Winch Energy, PowerGen and Energicity — obtained mini-grid licenses from the Electricity and Water Regulatory Commission (EWRC) for their respective lots and began selling electricity to WP-1 customers as of Q4 2019.[31] All three operators have also completed their initial round of financing for development of the WP-2 sites.

In addition to mini-grid electrification of rural health centres and communities, the RREP provided institutional capacity building and technical assistance (TA) to the MoE, the EWRC and other relevant agencies under Work Package 3 (WP-3), with the objective of improving the regulatory environment in order to encourage private sector investment and facilitate long-term, commercially sustainable mini-grid development and operations. Subsequent work packages covered emergency response (WP-4) and monitoring and evaluation (WP-5) functions, while Work Package 6 (WP-6) intends to bolster private sector development. The objective of WP-6 is to stimulate demand for the electricity provided to the beneficiary communities by promoting productive use of energy (PUE) applications and projects, thus supporting the commercial viability of the privately-operated mini-grids and improving the economic and social welfare of local communities. Grant funding has been made available by the FCDO under WP-6 to increase access to productive-use equipment and appliances among the mini-grid communities. Work Package 7 (WP-7) was approved by the FCDO in 2020 to support the reduction of mini-grid tariffs through additional subsidy for non-generation, public assets (namely electricity metering and indoor connection materials) and the reserve account for replacement of WP-1 generation assets (batteries and inverters).[32]

31 "Mini-Grid Market Opportunity Assessment: Sierra Leone," Green Mini-Grid Market Development Programme, African Development Bank and Sustainable Energy Fund for Africa, (November 2019): https://greenminigrid.afdb.org/sites/default/files/sierra_leone_gmg_final_report.pdf

32 http://www.energy.gov.sl/wp-content/uploads/2020/10/Fact-sheet_RREP-Updated-September-2020.pdf

FIGURE 3
Map of RREP Mini-Grids



Source: Energio Verda Africa GIS analysis; West African Power Pool (WAPP).
World Bank-ECREEE Regional Off-Grid Electrification Project: Sierra Leone Report, 2019.
NOTE: Existing = Work Package 1 mini-grid sites; Future = Work Package 2 mini-grid sites.

1.1.3 Mini-Grid Electrification in Nigeria

Nigeria is Africa's most populous nation and has its largest economy. More than 80 percent of installed capacity comes from thermal generation with most of the remaining balance coming from hydropower. Access to electricity remains an ongoing challenge and is a key barrier to economic development; according to the 2020 SDG7 Tracking Report, the country has a national electrification rate of 57 percent, while the rural electricity access rate is 31 percent.[33] Where the grid is available, consumers experience frequent power cuts ranging from four to 15 hours per day.[34] The Federal Government of Nigeria (FGN) has set a target to increase the national electrification rate to 90 percent by 2030 and aims to achieve universal access by 2040.

Nigeria has a significant electricity supply deficit, with only one-third of its 12.5 GW of installed generation capacity typically available. Meanwhile, tens of millions of on-site diesel generators are used to meet the country's actual daily peak electricity demand, which is estimated to exceed 40 GW.[35] This situation is the result of several factors: a stagnation of on-grid generation due to limited additions of new generation capacity; the poor state of the national grid and a corresponding lack of investment in grid maintenance and new transmission networks; liquidity issues faced by electricity utilities and distribution companies (DisCos); and associated issues of commercial and technical losses.

In order to address these challenges and achieve its energy access targets, Nigeria will need to provide

33 Tracking SDG7: The Energy Progress Report 2020.
34 "State of the Global Mini-Grids Market Report 2020: Trends of renewable energy hybrid mini-grids in Sub-Saharan Africa, Asia and island nations," Bloomberg New Energy Finance, Mini-Grids Partnership and Sustainable Energy for All, (July 2020): https://www.seforall.org/system/files/2020-06/MGP-2020-SEforALL.pdf
35 "Mini-Grid Market Opportunity Assessment: Nigeria," African Development Bank Green Mini-Grid Market Development Programme, (June 2018): https://greenminigrid.afdb.org/sites/default/files/minigrid_market_opportunity_assessment_nigeria_june_2018.pdf

electricity to more than 1 million households per year and add an estimated 25 GW to its power generation capacity. This will require solutions beyond grid extensions, namely the utilization of off-grid stand-alone systems and distributed generation from isolated and interconnected mini-grids to provide access in rural areas as well as in urban and peri-urban areas that receive very unreliable centrally-generated power. The economics for off-grid solar are extremely advantageous in Nigeria, as a significant share of the economy is already powered by small-scale generators and nearly half of the population has limited or no access to the grid. The country's vast and underdeveloped mini-grid sector offers revenue potential of an estimated USD 8 billion (NGN 2.8 trillion) annually.[36] In its electrification planning, the Rural Electrification Agency (REA) of Nigeria estimates that mini-grids will represent the least-cost electrification method for approximately 15.3 million people.[37]

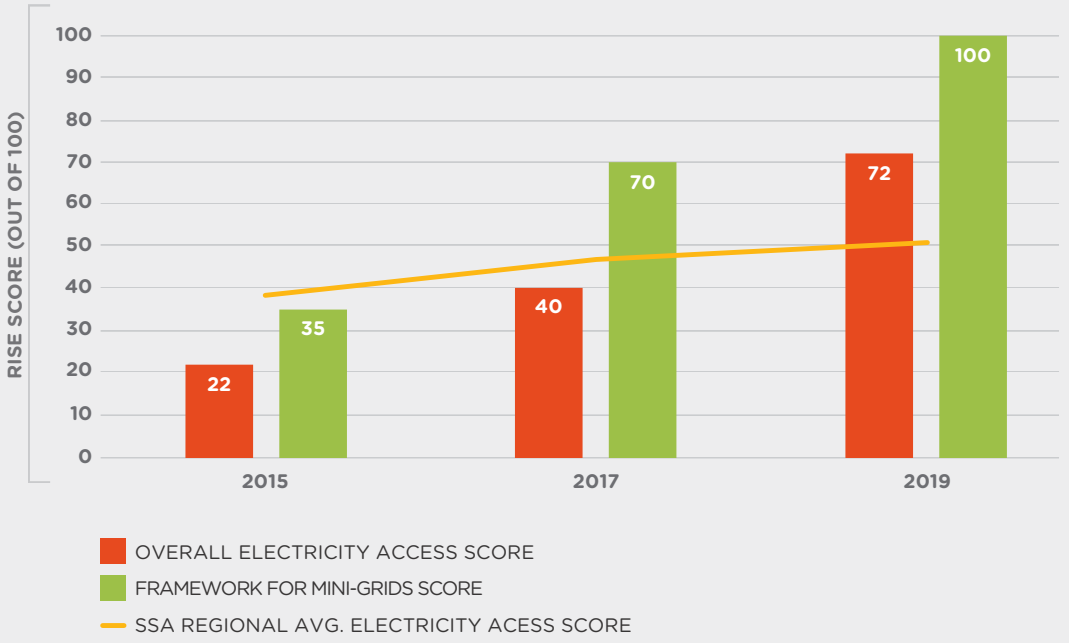
The FGN has prioritized off-grid solutions in its electrification planning and is currently implementing several policies, programmes and financial interventions to support the development of the country's rapidly growing off-grid sector. Under the 2017 Rural Electrification Strategy and Implementation Plan (RESIP), the REA will administer a Rural Electrification Fund (REF) to provide developers with financial incentives to expand rural electricity access.[38] The Mini-Grid Regulations enacted by the Nigerian Electricity Regulatory Commission (NERC) in 2016 provide the necessary regulatory and permitting guidelines for the development and operation of mini-grids in the country, including clear guidance on tariff setting through the REA Mini-Grid Tariff Tool methodology. Funding in the form of subsidies provided under programmes such as the World Bank and African Development Bank (AfDB)-funded Nigeria Electrification Project (NEP), the GIZ-funded Mini-Grid Acceleration Scheme (MAS) and Interconnected Mini-Grid Acceleration Scheme (IMAS) among others, has supported the development and installation of mini-grids across the country, allowing operators to charge more affordable tariffs. Much like Sierra Leone, Nigeria's World Bank RISE electricity access score has improved sharply in recent years, driven by the implementation of enabling policies and regulations in the off-grid sector – particularly for mini-grids, with Nigeria receiving a perfect score in this category in the 2019 RISE index (**Figure 4**).[39]

The number of commercial mini-grid developers has grown to at least nine active members of the Nigerian chapter of the Africa Mini-Grid Developers Association (AMDA). At the end of 2019, Nigeria had an estimated 59 mini-grids (2.8 MW of installed capacity), of which 52 used solar (**Figure 5**).[40] The number of commercial mini-grids is set to increase rapidly, with an estimated 200 projects currently in the pipeline, which would yield approximately an additional 10 MW of installed mini-grid capacity throughout Nigeria and, at current costs for development, would require USD 28 million (NGN 10 billion) in investment.[41]

36 Mini-Grid Investment Report: Scaling the Nigerian Market, Rocky Mountain Institute, 2018.
37 Babamanu, S., "Creating an Enabling Environment for a 10,000 Mini-Grids Market: World Bank Mini-Grid Action Learning Event and Summit," Rural Electrification Agency, (June 2019): https://atainsights.com/wp-content/uploads/2019/06/7.-Suleiman-Babamanu-Nigeria-Rural-Electrification-Agency-1.pdf
38 "Rural Electrification Strategy and Implementation Plan," Federal Ministry of Power, Works and Housing, Rural Electrification Agency, (2016): http://rea.gov.ng/file/2017/09/RESIP.pdf
39 World Bank Regulatory Indicators for Sustainable Energy: https://rise.worldbank.org/country/nigeria
40 State of the Global Mini-Grids Market Report 2020.
41 Mini-Grid Investment Report: Scaling the Nigerian Market, Rocky Mountain Institute, 2018.

FIGURE 4

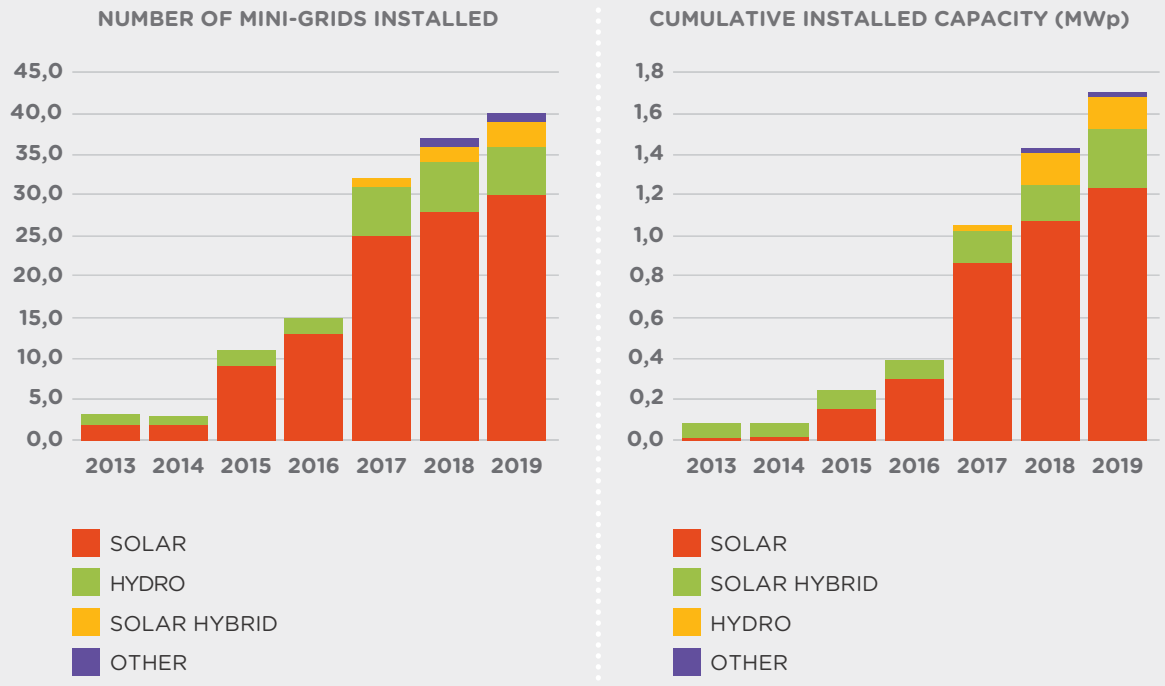
Nigeria RISE Electricity Access and Framework for Mini-Grids Scores, 2015–2019



Source: Adapted from World Bank Regulatory Indicators for Sustainable Energy (RISE) index.

FIGURE 5

Nigeria's Installed Mini-Grids by Project and Capacity, 2019



Source: SEforALL State of the Global Mini-Grids Market Report, 2020.

PART I

MINI-GRID FRAMEWORKS, TARIFFS AND SUBSIDIES

2 MINI-GRID ELECTRIFICATION PLANNING AND DEVELOPMENT IN SIERRA LEONE AND NIGERIA

2.1 Mini-Grid Electrification Planning and Development

This section presents a brief overview of the key components of mini-grid policy development — including planning methods and business models — which have implications for the speed of delivery, the tariff framework, and the associated funding required for development and/or subsidies.

The aim of mini-grid sector policy and regulation is to direct the industry's performance towards improving the collective benefit gained by customers and operators.[42] In unregulated markets, mini-grid operators determine the tariff charged to customers. Government-implemented policies and regulations for mini-grids that take into consideration their unique requirements (size, typical customer class, etc.) are capable of supporting policies that promote mini-grid development. When these frameworks are clear, consistent, enforceable and transparent, and reflect the commercial and economic realities of the market, they engender confidence in potential financiers, and in the long-term viability of mini-grids as an off-grid electrification model for a given market. Where policy and regulatory frameworks fall short of these standards, they can constitute barriers to growth of the private mini-grid sector.[43]

Most mini-grid projects in nascent markets have slim or non-existent profit margins, as projects require significant resources for pre-feasibility, development and operation relative to potential revenue, driven by the need to engage communities, the remoteness of sites and the tailor-made nature of mini-grid projects. A supportive policy and regulatory framework that de-risks projects for developers is therefore critical, as nascent markets are particularly sensitive to overly-burdensome regulation.[44] Above all, the goal of a regulatory framework for mini-grids should be to promote good service at the lowest possible cost-recovery tariffs, while remaining predictable but flexible enough to evolve as the market matures.[45]

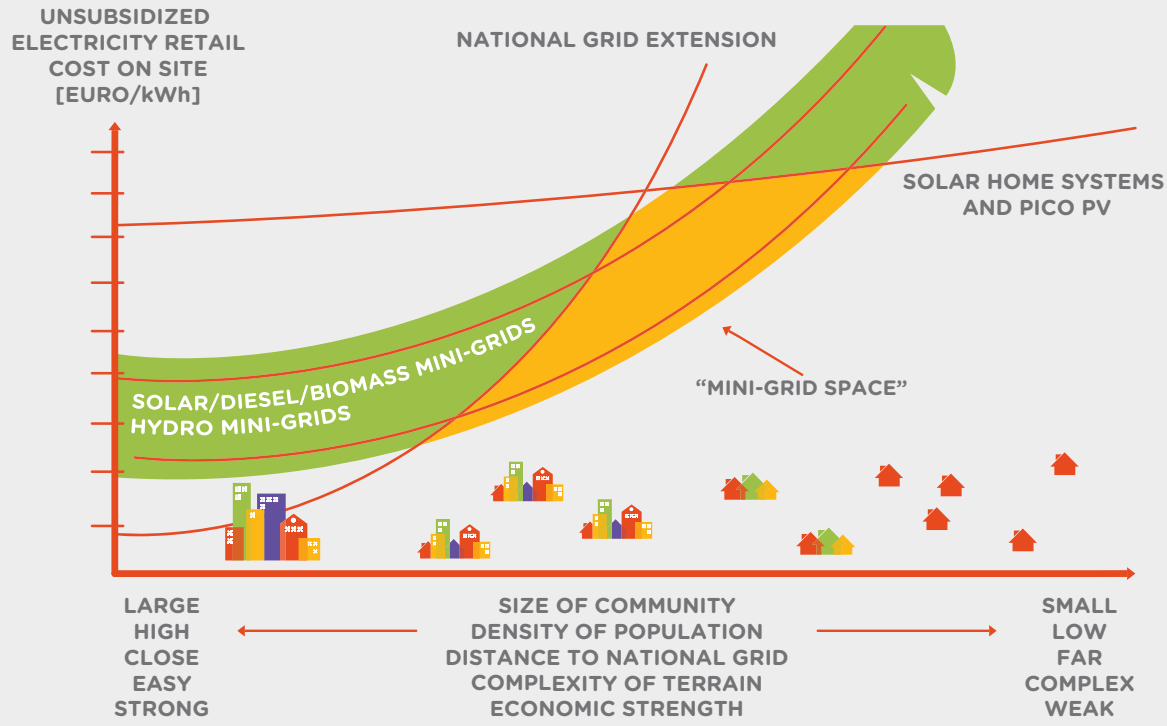
2.1.1 Mini-Grid Electrification Planning

Rural electrification can be accomplished using some combination of three main approaches: grid extensions, mini-grids, and solar home systems (SHSs). In rural areas of Sub-Saharan Africa, the average cost of electrification (per connection) is estimated to be between USD 2,000 and 3,000 for grid extensions, USD 500 and 1,200 for mini-grids, and USD 150 and 500 for SHSs.[46] When comparing the cost between different solutions, it is important to consider the tier of energy access provided (see **Key Definitions**). In electrification planning (**Figure 6**), some of the factors that determine whether a mini-grid is optimal for delivering energy access include *inter alia* the cost of electricity from the main grid; the community's distance from the main grid, income levels, economic activities and willingness to pay (WTP) for electricity; whether the community is scattered or concentrated; the availability and cost of energy sources used to power the mini-grid (solar, wind, hydropower, bioenergy, diesel fuel, or some hybrid of these technologies); and the cost of alternative energy sources (kerosene, diesel generation etc.).[47] Through an integrated planning approach and supportive regulation, governments can deploy mini-grids

42 Batlle C., and Ocaña C., "Electricity Regulation Principles and Institutions: Regulation of the Power Sector," Springer, London, 2013. https://link.springer.com/chapter/10.1007%2F978-1-4471-5034-3_3
43 USAID: https://www.usaid.gov/energy/mini-grids/regulation/elements
44 Practical Guide to the Regulatory Treatment of Mini-Grids, National Association of Regulatory Utility Commissioners, 2017.
45 Mini-Grids for Half a Billion People, World Bank ESMAP, 2019.
46 Kyriakarakos, G. and Papadakis, G., "Multispecies Swarm Electrification for Rural Areas of the Developing World," *Applied Sciences*, 9, (2019): https://www.mdpi.com/2076-3417/9/19/3992/htm
47 "The Potential for Alternative Private Supply of Power in Developing Countries," Economic Consulting Associates (ECA), World Bank (2014): https://www.eca-uk.com/wp-content/uploads/2016/10/APS_Report.pdf

to serve areas that cannot be reached by the national grid, or that require more electricity than can be provided by stand-alone systems, thus ensuring alignment between rural electrification and economic development goals.[48]

FIGURE 6
The Mini-Grid Space in Rural Electrification[49]



Source: INENSUS, Mini-Grid Policy Toolkit.

In the context of mini-grid sector development, government regulation falls along a spectrum of light-handed to comprehensive regulation. Determining the appropriate level of regulation depends on market conditions and political will, among other factors, and can be achieved through flexible regulation that evolves as the market matures. Likewise, governments can adopt a centralized/top-down approach to planning, a decentralized/bottom-up approach, or some combination of the two. Each approach has key trade-offs that policymakers and regulators need to consider when determining what is most appropriate for their national context. During regulatory framework design, policymakers should allow both top-down and bottom-up approaches (**Table 1**) to coexist in the market and should not restrict themselves to a particular approach.[50]

48 Practical Guide to the Regulatory Treatment of Mini-Grids, National Association of Regulatory Utility Commissioners, 2017.
49 "Mini-Grid Policy Toolkit: Policy and Business Frameworks for Successful Mini-Grid Roll-outs," European Union Energy Initiative Partnership Dialogue Facility (EUEI PDF), (2014): http://www.euei-pdf.org/sites/default/files/field_publication_file/RECP_MiniGrid_Policy_Toolkit_1pageview_%28pdf%2C_17.6MB%2C_EN_0.pdf
50 Tenenbaum, B., Greacen, C., Siyambalapitiya, T., and Knuckles, J., "From the Bottom Up: How Small Power Producers and Mini-Grids Can Deliver Electrification and Renewable Energy in Africa," World Bank, (2014): https://openknowledge.worldbank.org/bitstream/handle/10986/16571/9781464800931.pdf?sequence=1&isAllowed=y

TABLE 1

Mini-Grid Electrification Planning Approaches

Electrification Planning Approach	Advantages	Disadvantages
Top-Down Under a centralized, top-down approach, the government identifies sites for mini-grid development and leads procurement of developers for each site; this approach often includes a governmental role in the development and/or ownership of mini-grid assets. A top-down approach is usually associated with some form of incentive for developers, such as a subsidy and/or guarantee that the operator can have an exclusive right to supply a given service area without threat of competition for a given period.	• Allows government to control the mini-grid development process, increasing the likelihood that sites will be developed, while simultaneously removing the early-stage costs of development that would have been borne by a developer • Ensures that mini-grid developers provide access to all, including the most vulnerable households; may lead to a more equitable pathway to achieving universal electricity access	• Requires significant financial and human resources, as well as coordination on the part of government authorities • Requires significant capacity to identify and assess sites, develop and manage approval processes, and manage competitive bidding processes, among other responsibilities • May constrain the ability of entrepreneurs and communities to develop projects in areas not included in centralized plans, thereby hindering experimentation with innovative business models
Bottom-Up A decentralized, bottom-up approach relies on developers to take the initiative to identify and develop sites; under this approach, the government still manages the regulatory framework for site development (e.g., by developing eligibility requirements for projects) but usually does not procure developers. There may or may not be a subsidy included, and there is usually no protection from competition through concession contracts or a tariff-setting framework.	• Takes advantage of the diverse knowledge and skills that developers bring in identifying and developing sites • Can reduce development costs and risks, since developers have more influence over the direction of projects • Fosters competition and allows progress to move at the pace of the private sector, provided that the government has set up an enabling regulatory environment	• May lead to confusion and lack of coordination, particularly if multiple developers are interested in pursuing projects in the same area, or if a developer is interested in a site slated for grid extension • The government has less control over site selection; as a result, projects may not be developed in areas that would provide the greatest public good

Source: NARUC, 2017 and World Bank ESMAP, 2014.

2.1.2 Mini-Grid Business Models

A wide range of business models exist in the mini-grid sector, with varying risk-sharing arrangements and roles for the public and private sector in the ownership and operation of mini-grid assets (see **Annex 1**).[51] Public-private partnerships (PPPs) are often an effective way of distributing responsibilities to optimize government and private sector capacities and can also enable mini-grid developers that do not have substantial financial resources to enter the market.[52] When selecting ownership models, governments need to consider the strengths and weaknesses of each option as well as the impact that a given approach will have on the speed of delivery, consumer tariffs, economic viability and costs of project development. In general, governments should seek to encourage and incentivize private sector participation to ensure long-term market growth and sustainability. Policymakers should design and implement flexible regulatory frameworks to accommodate any potential business models that may emerge as the market develops.

In addition to the various approaches described in **Annex 1** (which also categorizes business models in relation to their ownership structure), several other mini-grid electrification models have been deployed with varying degrees of success. One common example is the Anchor-Business-Community (ABC) model, which allows developers to serve rural areas by leveraging the continuous demand from 'anchor' customers (e.g., telecommunications towers, institutional facilities, mining operations etc.) to provide a reliable revenue stream, thereby mitigating the risk of providing energy to businesses and community/household customers in rural areas.[53] The ABC model can be deployed under different types of ownership schemes (public, private, PPP etc.).

51 "Mini-Grids for Timely and Low-Cost Electrification in Ghana: Exploring Regulatory and Business Models for Electrifying the Lake Volta Region," World Bank ESMAP, (November 2017): https://openknowledge.worldbank.org/bitstream/handle/10986/29017/121824-ESM-GhanaESMAPGhanaTechnicalReportDECclean-PUBLIC.pdf?sequence=1&isAllowed=y

52 "Mini-Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers," World Bank ESMAP, (June 2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31926/Mini-Grids-for-Half-a-Billion-People-Market-Outlook-and-Handbook-for-Decision-Makers-Executive-Summary.pdf?sequence=1&isAllowed=y

53 Givens, R., "The Anchor-Business-Community Model for Rural Energy Development: Is it a Viable Option?" Nicholas School of the Environment of Duke University, (April 28, 2016): https://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/11940/MP%20Final_Givens.pdf?sequence=1&isAllowed=y

Mini-grid business models can be based on different types of customer payment/tariff structures. In Tanzania, the solar mini-grid developer JUMEME has carefully selected communities where a mini-grid can be integrated into existing economic activities to boost its output, or where it can be the base for essential public services (see **Section IV**).[54] Devergy is a mini-grid company that charges its customers for "bundles of energy" similar to how a mobile network operator offers internet packages. For each bundle, customers can consume a maximum amount of energy for a certain period of time (e.g., one week or one month), with limits on how much power can be consumed instantaneously.[55] In Zambia, a local mini-grid developer, Standard Microgrid, utilizes a similar Energy-as-a-Service (EaaS) model (see **Key Definitions)** to deliver affordable and reliable solar electricity to its customers, billing for energy services rather than kWh.[56] These concepts are examined in further detail in **Section 3.1.1**.

Business models can also rely on innovative funding mechanisms. For example, in 2020, the Congolese solar developer Nuru commissioned the 1.3 MW township mini-grid project in Goma, the capital of North Kivu Province, becoming Africa's largest off-grid solar mini-grid in operation to date.[57] It is the first renewable energy project from which Energy Peace Partners will issue Peace Renewable Energy Credits – an innovative funding mechanism designed to accelerate the transition to renewables in conflict-affected areas (the revenue from their sale will fund the construction of public streetlights connected to the mini-grid in the Ndosho neighborhood of Goma).[58]

2.2 Status of Mini-Grid Sector Development in Sierra Leone and Nigeria

2.2.1 Sierra Leone

Mini-Grid Policy, Regulatory and Institutional Landscape

Under the Rural Renewable Energy Project (RREP), the government has utilized a top-down approach during initial stages of market development by pre-defining project sites, promoting pilot projects through the healthcare sector, and retaining international firms to bring international best practices to the market. Outside of the RREP, mini-grid systems in Sierra Leone are largely owned by the private sector or communities, with the Electricity Generation and Transmission Company (EGTC) operating a few larger thermal systems.

The ownership model adopted by the Government of Sierra Leone (GoSL) under the RREP is a hybrid model, whereby public and private entities are developing mini-grids jointly (**Figure 7**). Work Package 1 (WP-1) sites were developed under a public ownership/private management model, while Work Package 2 (WP-2) followed the "split-asset" ownership model (see **Annex 1**). The PPP agreement signed between the Ministry of Energy (MoE) and the three operators is structured as a hybrid between a Build-Own-Operate (BOO) and Build-Operate-Transfer (BOT) model (see **Key Definitions**) and includes two key components:

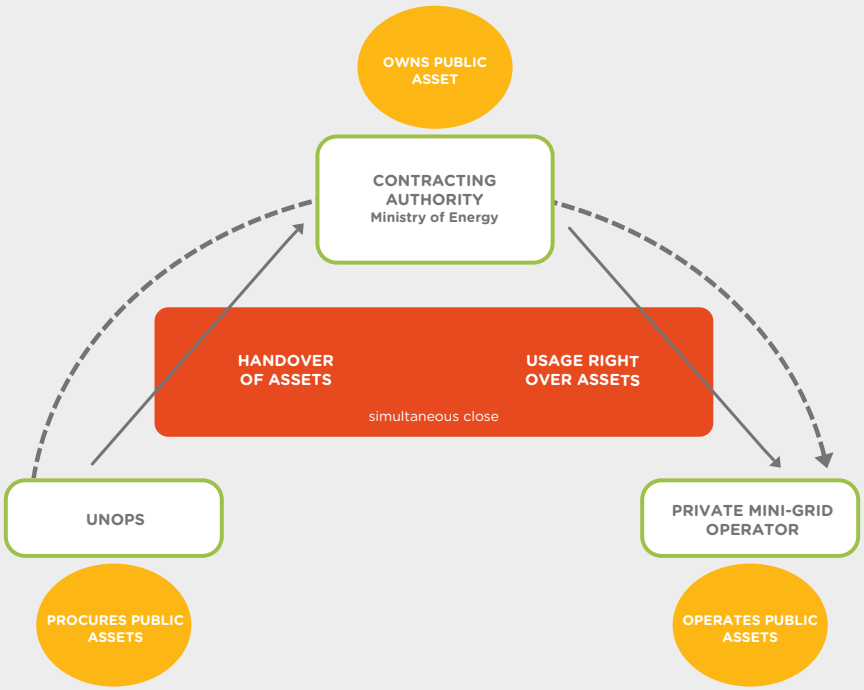
i. a Usage Rights Agreement, under which the private operators paid the GoSL a fee for usage of WP-1 assets that had already been developed; and
ii. a Project Development Agreement signed for the projects to be co-financed and developed under WP-2.

The WP-1 scope of work for the private operators includes operation and maintenance (O&M) of the 54 community health centre (CHC) systems over a 20-year period, with the capex for the generation and distribution network equipment having already been paid for by the FCDO.[59] Under WP-2, the FCDO (through UNOPS) funded the distribution network equipment, while the private operators covered the costs of the generation equipment and were required to obtain all necessary licenses and permits for the mini-grid projects. At the end of the 20-year concession period, the public assets (i.e., generation and distribution equipment for WP-1 and distribution assets for WP-2) will be transferred to the MoE.[60]

54 "JUMEME's business model for mini-grids reaping multiple benefits in Tanzania," Sustainable Energy for All, (27 May 2020): https://www.seforall.org/news/jumemes-business-model-for-mini-grids-reaping-multiple-benefits-in-tanzania
55 Devergy: https://devergy.com/about/
56 Standard Microgrid: https://standardmicrogrid.com
57 Takouleu, J., "DRC: Nuru connects 1.3 MW solar off-grid hybrid project in Goma," Afrik21, (7 February 2020): https://www.afrik21.africa/en/drc-nuru-connects-1-3-mw-solar-off-grid-hybrid-in-goma/
58 "Newsletter: First P-REC Pilot Project in Operation," Energy Peace Partners, (8 April 2020): https://www.energypeacepartners.com/blog/newsletter-first-p-rec-pilot-project-in-operation
59 The WP-1 PPP arrangement closely resembles a Design-Build-Operate (DBO) model, whereby the government has fully financed the initial construction of the mini-grids (see **Key Definitions**).
60 AfDB Green Mini-Grid Market Development Programme - Mini-Grid Market Opportunity Assessment: Sierra Leone, 2019.

FIGURE 7

Ownership Structure of Public and Private Assets under the RREP

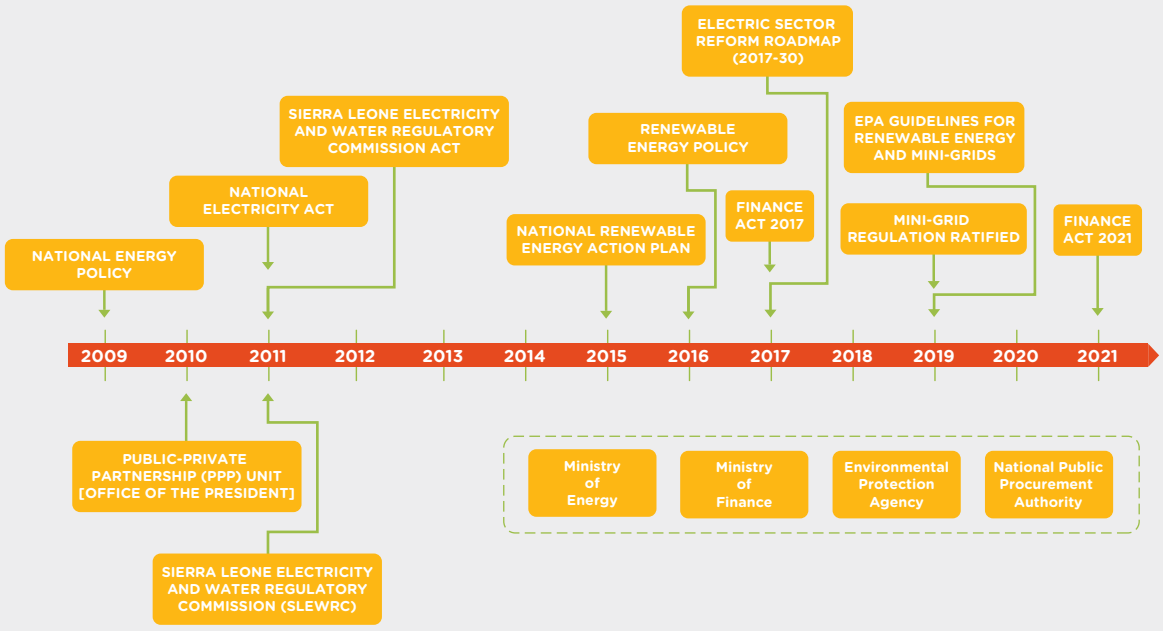


Source: AfDB Green Mini-Grid Market Development Programme.

The key government stakeholders, and the policies, laws, regulations and roadmaps guiding the development of Sierra Leone's rural electrification efforts are summarized in **Figure 8**. More information is available in **Annex 2**.

FIGURE 8

Key Government Stakeholders, Policies, Laws and Regulations in Sierra Leone's Mini-Grid Sector



Cost of Service

In 2016, prior to the rollout of the RREP in Sierra Leone, a demand assessment carried out by the project encompassing 68 rural communities, 2,500 interviews, and feedback from 1,950 household respondents, found that households would benefit from savings of up to 52 percent with the advent of mini-grid electricity, based on average costs of alternative sources of energy (i.e., expenditures on kerosene, batteries, fuel etc.). The survey estimated the average amount rural customers were able to pay was approximately USD 6/month (SLL 59,400/month), mainly for lighting, mobile phone charging and other household uses. The study also found that rates of electricity demand could increase by a factor of 20 with the arrival of mini-grid electrification, with average consumption between 3.5 and 6.3 kWh per month per household. Subsequent studies conducted by the MoE following the inception of the project found evidence that the cost of electricity from mini-grids remains lower than alternative sources of energy.

After the WP-1 mini-grids began operating in 2019 (see **Section 1.1.2** for a description of the RREP Work Packages), 80 percent of mini-grid community respondents surveyed by the GreenMax field research team who did not connect to the mini-grid cited affordability of the electricity tariff as the main reason for not connecting.[61] The initial tariffs for WP-1 sites ranged from USD 0.82/kWh to 0.87/kWh, with an average tariff level of about USD 0.85/kWh. Given the focus on providing access for WP-1 sites (i.e., targeting smaller sites in order to avoid the deliberate selection of only larger and more economically attractive locations), these initial sites had a lower targeted number of customers. This dynamic — smaller sites with relatively limited demand — combined with high project development and overhead costs for developers, contributed to a higher tariff, which was necessary to make projects bankable. Another factor that increased costs was the initial requirement for operators to maintain a reserve account for WP-1 batteries,[62] which has since been addressed through an FCDO subsidy under Work Package 7 (WP-7) of the RREP.[63]

Under the next phase of the project, WP-2, operators are co-investing in the development of 40+ larger mini-grids under a "split-asset" model in which the GoSL is covering the capital costs of the distribution assets. As the operators begin to connect more customers and bring larger mini-grid systems online, project development costs are gradually decreasing. The most recent round of tariff negotiations, combining the WP-1 and WP-2 sites, resulted in a range of USD 0.74/kWh to 0.82/kWh, with an average tariff of USD 0.79/kWh.[64]

Quality of Service

The regulatory framework in Sierra Leone requires operators to follow minimum service quality standards that are defined in the mini-grid regulations (technical and service standards for Sierra Leone are described in further detail in **Section 3.1.1.1**). When surveyed by the GreenMax field research team, about three-quarters of mini-grid community respondents were satisfied with the overall quality of power supplied by the mini-grid (**Figure 9**). The survey covered quality of service broadly in relation to service reliability, voltage stability, and responsiveness to outages.

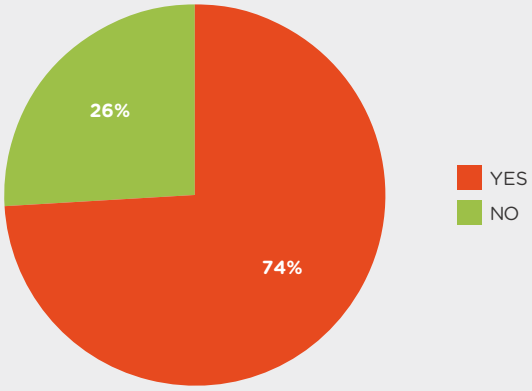
61 NB: These findings do not reflect the fact that perceptions on affordability do not take into account the increase in consumer spending on electricity from the mini-grid as a result of the use of appliances, nor do they reflect a like-to-like comparison of end-user spending on electricity from the mini-grid in comparison to expensive and polluting alternative sources of energy prior to the mini-grid's installation.

62 A substantial delay between the time the mini-grid systems were installed and the sites were electrified (mainly due to delays in the tendering process) led to the capacity reduction of batteries.

63 http://www.energy.gov.sl/wp-content/uploads/2020/10/Fact-sheet_RREP-Updated-September-2020.pdf

64 Stakeholder consultations, 2021.

FIGURE 9
User Satisfaction with Mini-Grid Quality of Service



Source: Mini-Grid Community Survey, 2020.

Discussions with operators found that about one-third of the WP-1 sites have experienced technical problems related to installation quality and the capacity reduction of batteries arising from a substantial delay between the time the mini-grid systems were installed and the sites were electrified (mainly due to delays in the tendering process). Other challenges that were identified include system-sizing issues to match the specific demand requirements of the community, while many mini-grids are experiencing low levels of capacity utilization. In some sites, the operators are planning to expand the solar generation capacity or to run diesel generators, while the GoSL is providing distribution grid materials to operators so that the additional demand can be met. Downtime for the mini-grid systems can vary from a few hours to a few days; operators work closely with local staff to address maintenance issues and are generally responsive to quality-of-service issues that arise.

2.2.2 Nigeria

Mini-Grid Policy, Regulatory and Institutional Landscape

In contrast to Sierra Leone, Nigeria has adopted a more bottom-up, private sector-driven approach to mini-grid sector development. As described in **Section 1.1.3**, the Nigerian off-grid market has several unique characteristics that make it favourable for investment. Mini-grids can provide reliable electricity to unserved and underserved areas throughout the country, with opportunities for significant customer savings while also providing developer returns. In addition to these advantageous market conditions, the country has implemented a robust and supportive policy and regulatory framework for mini-grids. With assistance from various development partners, the Federal Government of Nigeria (FGN), led by the Rural Electrification Agency (REA), continues to pursue innovative solutions to scale up mini-grid development. For instance, with funding from the USAID Renewable Energy and Energy Efficiency Project (REEEP) and the EU/GIZ Nigerian Energy Support Programme (NESP), an innovative "split-asset" ownership model (see **Annex 1**) was piloted with private developer Rubitec Solar to finance the development of a mini-grid in Gbamu Gbamu, a village in Ogun State.[65]

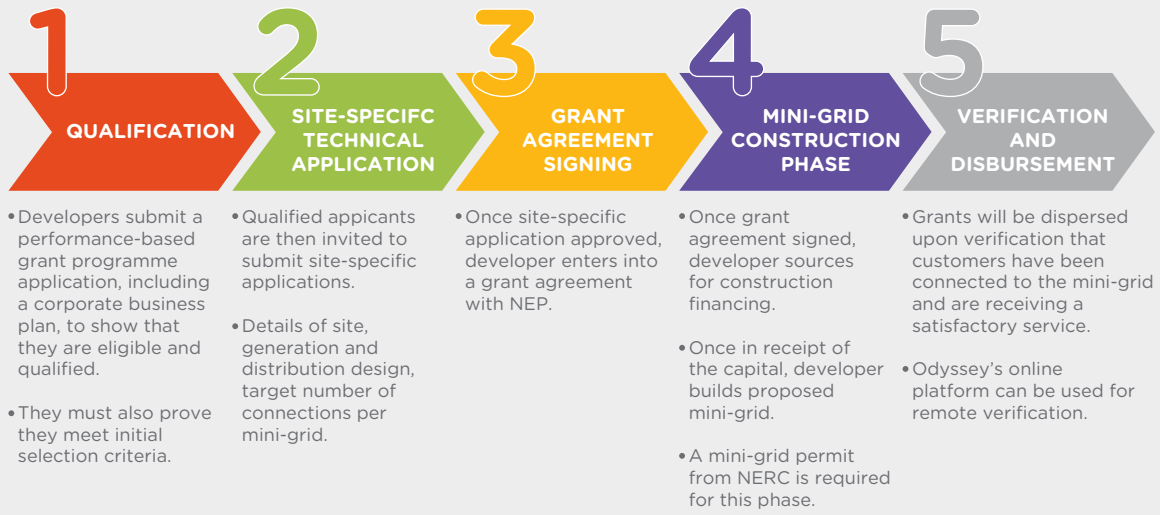
The Nigeria Electrification Project (NEP) combines both top-down and bottom-up approaches to accelerate the rollout of mini-grids. Initially, the project uses a top-down approach with solicited proposals to electrify 250 prioritized communities across four states (Niger, Sokoto, Ogun and Cross River) in the first phase, followed by a bottom-up approach driven by private developers and supported by a results-based financing (RBF) instrument in a second phase. With USD 220 million in funding from the World Bank and the African Development Bank (AfDB), the RBF programme utilizes a performance-based grant (PBG) and minimum subsidy tender mechanism to

65 Warren, C., "In Nigeria, A Template for Solar Powered Mini-Grids Emerges," Greentech Media, (February 20, 2018): https://www.greentechmedia.com/articles/read/nigeria-solar-powered-minigrids

help developers finance isolated solar hybrid mini-grid projects (**Figure 10**).[66] The REA aims to provide project developers with georeferenced data on the most viable sites to let them choose which sites they are interested in developing (on a spontaneous basis), with the grant amount set at USD 350 per connection. The mini-grids will be developed on a Build-Own-Operate (BOO) model (see **Key Definitions**).[67]

FIGURE 10

Nigeria Electrification Project: Performance-Based Grant Programme



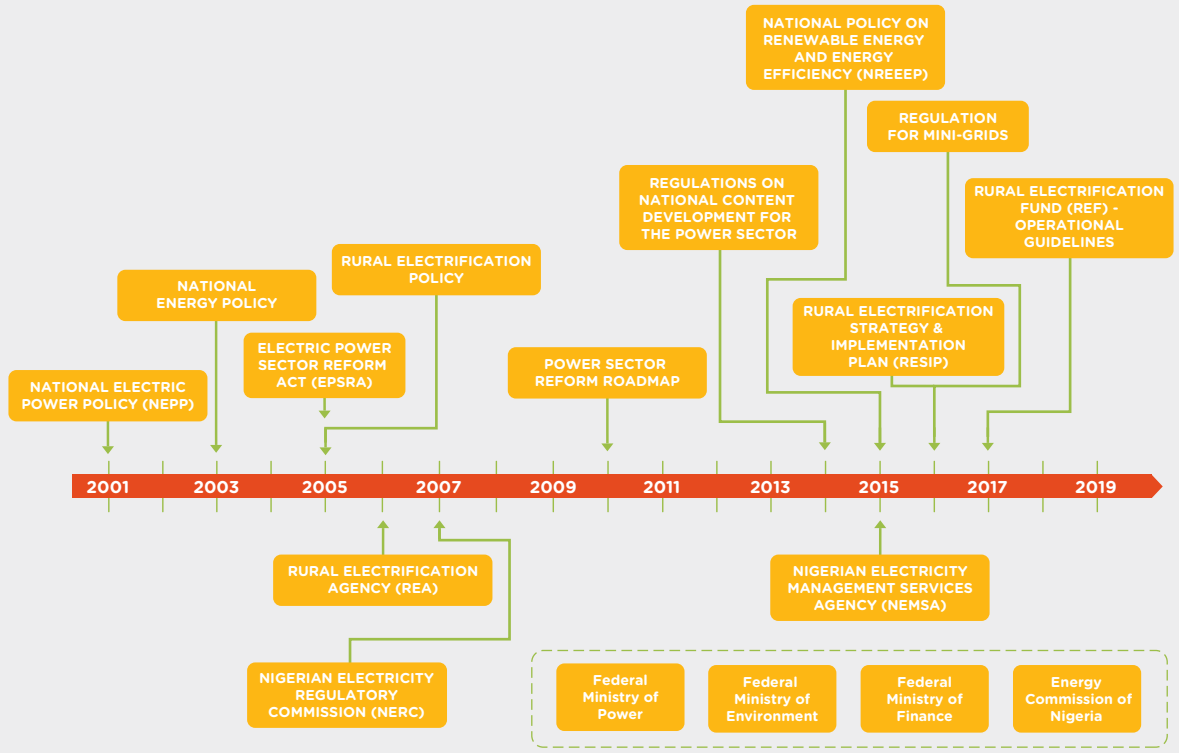
Source: Bloomberg New Energy Finance; Rural Electrification Agency.

The key government stakeholders, and the policies, laws, regulations and roadmaps guiding the development of Nigeria's rural electrification efforts are summarized in **Figure 11**. More information is available in **Annex 2**.

66 State of the Global Mini-Grids Market Report 2020.
67 Babamanu, 2019.

FIGURE 11

Key Government Stakeholders, Policies, Laws and Regulations in Nigeria's Mini-Grid Sector



Cost of Service

By comparison, according to the REA, mini-grid tariffs in Nigeria range from USD 0.39/kWh to 0.79/kWh (NGN 150/kWh–300/kWh), with an average tariff level of about USD 0.58/kWh (NGN 220/kWh).[68] Interviews with mini-grid operators in Nigeria found that there have been relatively few complaints from communities surrounding tariff affordability, as the majority of end users spend less on electricity from the mini-grid than they did on expensive and polluting alternative sources of energy prior to the mini-grid's installation. For instance, the levelized cost of electricity (LCOE) from a small diesel generator is at least USD 0.75/kWh (NGN 250/kWh) and is vulnerable to fuel price volatility.[69]

Quality of Service

The mini-grid regulatory framework in Nigeria requires mini-grid license holders to meet minimum technical requirements and ensure quality of service in accordance with their agreements with beneficiary communities.[70] Under the NEP RBF scheme, all installations must be quality-verified for developers to receive the subsidy. Mini-grid technical and service standards for Nigeria are described in **Section 3.1.1.2**.

2.2.3 Summary of Findings

The Nigerian mini-grid sector is regulated by the NERC Regulation for Mini-Grids 2016, while Sierra Leone's mini-grid sector is regulated by the Electricity and Water Regulatory Commission (EWRC) Mini-Grid Regulations 2019. As described in **Sections 1.1.1-1.1.3**, both countries have developed various policies and guidelines to support the development of renewable energy generation capacity and rural electrification (**Figure 8** and **Figure 11**). Sierra Leone does not have an agency such as the Nigerian REA which is dedicated exclusively to rural electrification and energy access; all

68 Figures are from solar hybrid mini-grids ranging in size from 30-234 kWp that have been commissioned under the AfDB/World Bank Nigeria Electrification Project (NEP) Performance-Based Grant Programme and the EU/GIZ Nigerian Energy Support Programme I (NESP I); see **Table 8** in **Section 3.2.1.2**.

69 "Mini-Grid Investment Report: Scaling the Nigerian Market," Rocky Mountain Institute, (2018): https://rmi.org/wp-content/uploads/2018/08/RMI_Nigeria_Minigrid_Investment_Report_2018.pdf

70 "Mini-Grids in Nigeria: A Case Study of a Promising Market," World Bank ESMAP, (November 2017): http://documents1.worldbank.org/curated/en/352561512394263590/pdf/ESM-dNigeriaMiniGridsCaseStudyConfEd-PUBLIC.pdf

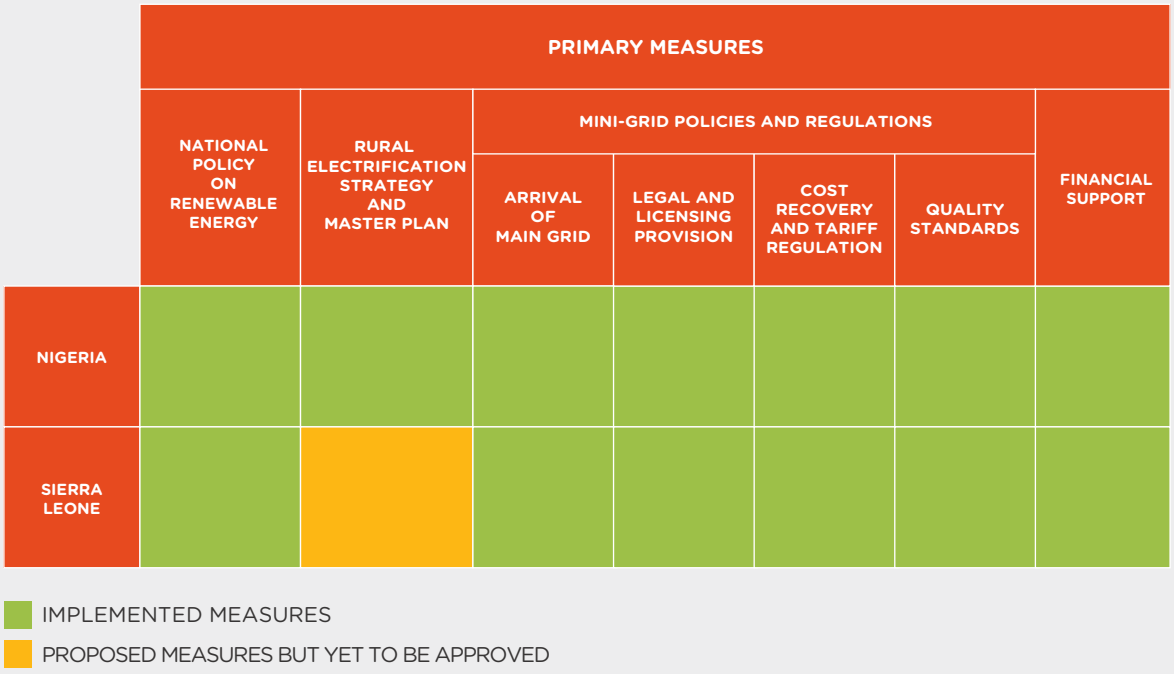
rural electrification planning in Sierra Leone is currently managed by the MoE.

Regulatory and policy measures to support mini-grids are broadly similar between Nigeria and Sierra Leone (**Figure 12**). The similarities between the measures in both countries are not unrelated to the fact that the GoSL developed and approved its mini-grid regulatory framework based on the existing strong regulatory models in Nigeria, Tanzania, and at the state level in India.[71] Both countries have regulations specifying relevant standards, licensing provisions, tariff mechanisms and grid interconnection rules, and both frameworks encourage private sector participation in the mini-grid markets, albeit through contrasting approaches – mini-grid development under the RREP in Sierra Leone has broadly followed a public ownership/private management model driven by a top-down approach, whereas mini-grid development in Nigeria has followed a more bottom-up, private-sector driven approach.

While Sierra Leone does not have an integrated rural electrification master plan, its off-grid electrification strategies are broadly defined in its various policy and roadmap documents including the Electricity Sector Reform Roadmap 2017–2030, the Sierra Leone Renewable Energy Policy and the National Renewable Energy Action Plan, among others.

FIGURE 12

Summary of Mini-Grid Policies and Regulations in Sierra Leone and Nigeria[72]



Source: International Renewable Energy Agency.

It is important to emphasize that while the Nigerian tariff is considerably lower than the tariff in Sierra Leone, the two mini-grid markets are at different stages of development and have pursued different market planning and development approaches, which has an impact on the cost of service. In addition, the larger size of the Nigerian market (and increased scale of electricity demand) plays an important role in driving cost reductions vis-à-vis Sierra Leone, where there are fewer mini-grid customers in more sparsely populated rural villages. Household income levels are also lower in Sierra Leone (56.8 percent national poverty headcount ratio compared to 40.1 percent in Nigeria in 2018), contributing to a lower household consumption rate.[73]

71 "A Robust Mini-grid Regulatory Framework," Electrifying Economies, (2019): https://www.rockefellerfoundation.org/wp-content/uploads/2020/10/EE-Download-Solutions-CaseStudies-Minigrid-regulations.pdf

72 "Policies and Regulations for Renewable Energy Mini-Grids," International Renewable Energy Agency, (November 2018): https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_mini-grid_policies_2018.pdf

73 World Bank Global Poverty Working Group: Poverty headcount ratio at national poverty lines (% of population): https://data.worldbank.org/indicator/SI.POV.NAHC?locations=NG-SL

3 MINI-GRID REGULATORY FRAMEWORKS, TARIFFS AND SUBSIDIES IN SIERRA LEONE AND NIGERIA

3.1 Assessment of Mini-Grid Regulatory Frameworks in Sierra Leone and Nigeria

3.1.1 Tariff Framework

Tariff Setting

The affordability of energy access is a function of the price of electricity and the end user's income level.[74] A household's expenditure on electricity against its income is an indicator of the affordability of electricity. In general, a household is considered 'energy poor' if more than 10 percent of the household income is spent on fuel to maintain an adequate level of comfort.[75] Without electricity access, off-grid households will spend a higher proportion of their income on alternative forms of energy (e.g., diesel generators, kerosene lanterns, batteries etc.), which have higher costs compared to mini-grid and grid power. As a result, most customers already pay much higher rates for access using these alternatives, thus defining their willingness to pay (WTP) for mini-grid electricity.

Providing service to rural customers via a mini-grid is almost always more costly than electrifying urban customers connected to the national grid, since large utilities can average costs across a wider customer base with uniform national tariffs that effectively cross-subsidize customers who are more expensive to serve with revenue from those who are cheaper. National tariffs can often have a market-distorting effect whereby customers — particularly those in remote regions — do not understand the utility's true cost to provide service, which can set unrealistic expectations about how much they should pay for power and exacerbate tariff-setting challenges.[76] Consumer education and awareness-raising around this issue is therefore critical. This can be a challenge, especially given the relatively low level of financial literacy that is typical of rural areas. Financial literacy drives consumer decision-making and understanding of benefits and cost-savings – in this case, the savings associated with paying a higher tariff for mini-grid access in rural areas vis-à-vis the national grid baseline and/or more costly and polluting alternative energy sources.

Mini-grid operators typically sell electricity to retail consumers who are receiving power for the first time, which makes it difficult to fix or even predict revenues. Fixing other costs and risks through long-term contracts is also challenging, as a lot is still unknown about how mini-grid development and operation will evolve over the long term. Regulation plays an essential role, not only to ensure cost recovery from project development, but also to address integration with and compensation from the main grid upon its arrival.[77]

There is no standard tariff structure that can be applied to all contexts, as technology, scale, geography and customer profiles vary.[78] When determining tariff options, policymakers and regulators need to balance complex and frequently competing priorities of providing price control on electricity service in the name of social good, while also providing a means for investors to achieve sufficient returns on their investment to attract the necessary financing to the market.[79] Generally, when setting an electricity tariff, policymakers must assess trade-offs related to whether mini-grids should be allowed to

74 Bhatia, M. and Angelou, N., "Beyond Connections: Energy Access Redefined," World Bank ESMAP, (July 2015): https://openknowledge.worldbank.org/bitstream/handle/10986/24368/Beyond0connect0d000technical0report.pdf?sequence=1&isAllowed=y

75 "Lights, Power, Action: Electrifying Africa," Africa Progress Panel, (2015): https://www.africa50.com/fileadmin/uploads/africa50/Documents/Knowledge_Center/APP_Lights_Power_Action_2016__PDF.pdf

76 Reber, T., Booth, S., Cutler, D., Li, X., and Salasovich, J., "Tariff Considerations for Micro-Grids in Sub-Saharan Africa," National Renewable Energy Laboratory (NREL), USAID Power Africa, (February 2018): https://www.nrel.gov/docs/fy18osti/69044.pdf

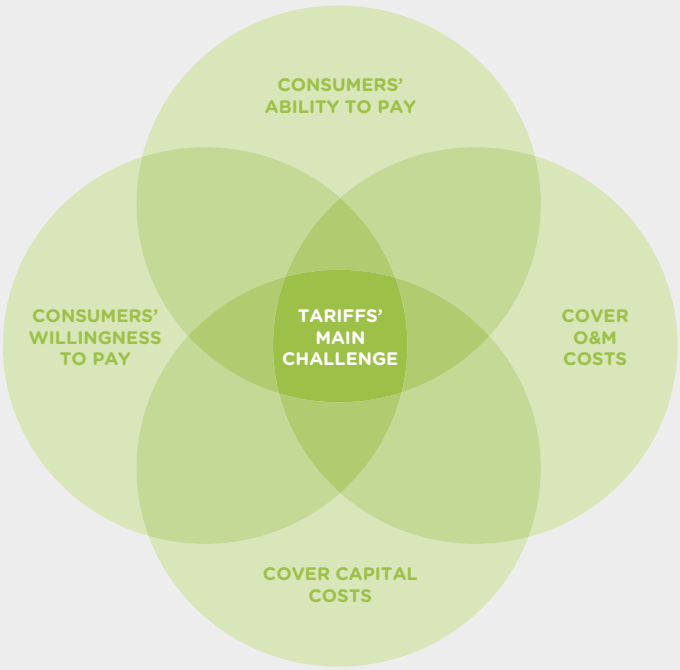
77 "Open Sourcing Infrastructure Finance for Mini-Grids," Crossboundary Energy Access, (December 2020): https://www.crossboundary.com/wp-content/uploads/2020/12/Project-Financing-Mini-Grids-Online-Pages.pdf

78 USAID: https://www.usaid.gov/energy/mini-grids/regulation/tariffs/

79 Reber et al., 2018.

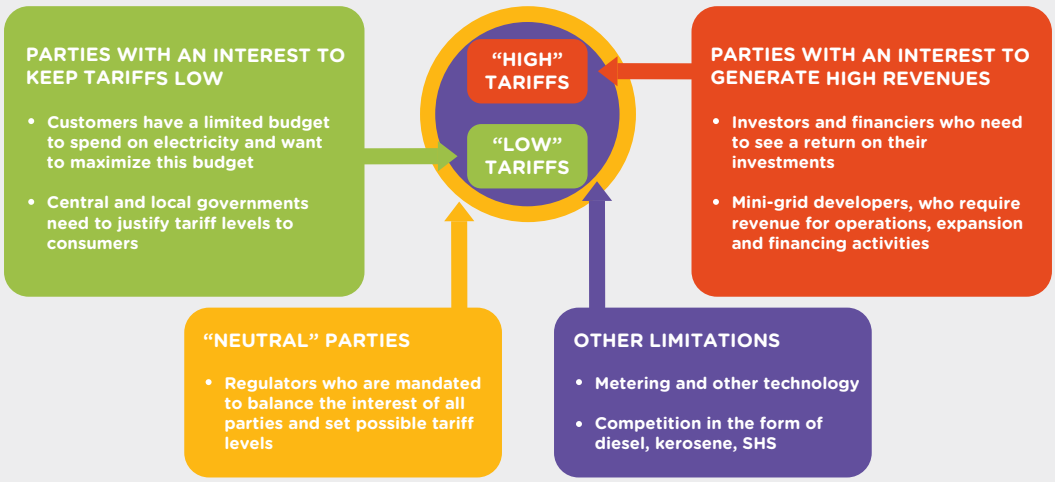
charge cost-reflective tariffs that are above the average national tariff, which has implications for the amount of subsidy required as well as for the speed of electricity access rollout. When setting tariffs, an "optimal" solution will ideally account for the interests of all key stakeholders (e.g., customers, governments, regulators and investors).[80] The key dynamics surrounding mini-grid tariff setting are illustrated in **Figure 13** and **Figure 14**.

FIGURE 13
Affordability vs. Sustainability in Tariff Setting[81]



Source: Philipp, 2014.

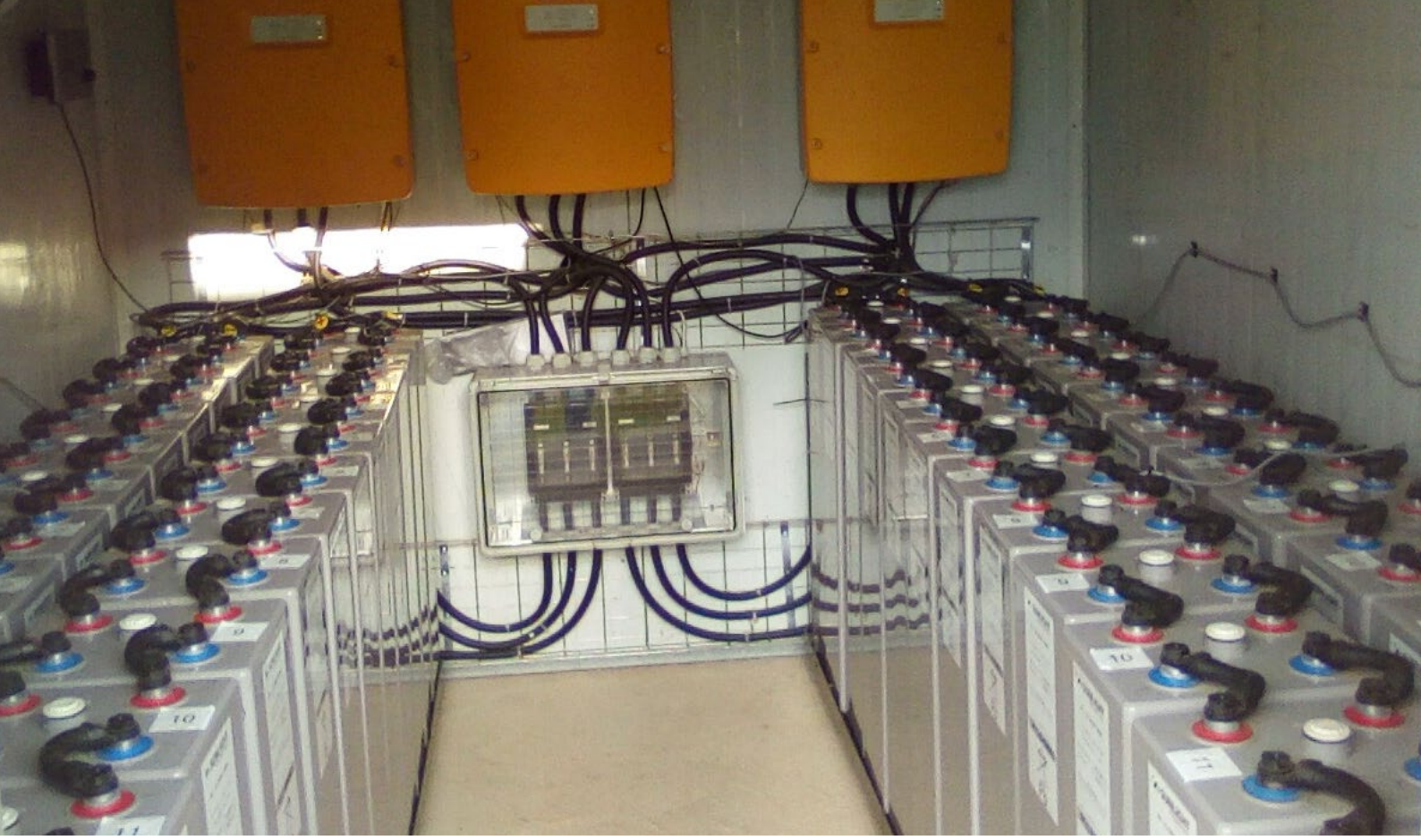
FIGURE 14
Key Stakeholders Involved in Tariff Setting



Source: Energy4Impact and INENSUS, 2019.

80 "Green Mini-Grid Help Desk: Billing, Revenue Collection and Metering Models for Mini-Grids," Energy4Impact and INENSUS, (April 2019): https://energy4impact.org/file/2098/download?token=EclaPTX_

81 Philipp, D., "Billing Models for Energy Services in Mini-Grids," GIZ Workshop on Hybrid Mini-Grids, (9 March 2014).



Cost Components

The levelized cost of electricity (LCOE) is an important indicator in tariff design, as it is equivalent to the minimum average tariff at which electricity must be sold to cover project costs (see **Key Definitions**). Mini-grid cost components can be broadly classified as capital costs (capex) and operating costs (opex):

- **Capital costs** are largely incurred at the start of project development, usually relate to fixed assets (any asset expected to last more than one year) and include the cost of replacement of an asset over the project's lifetime. Examples include power generation equipment (panels, batteries, inverters etc.) and distribution equipment (electricity poles/wiring for connections and metering). Capex also includes project planning and development costs, including costs for acquiring land and project permits, as well as costs for civil, mechanical and electrical engineering and installation.
- **Operating costs** can be **fixed** (relatively constant, irrespective of the level of output) or **variable** (proportional to output). Fixed operating costs can be present even if electricity generation output is zero and are typically incurred on a recurring basis or for the purchase of assets expected to last less than one year (e.g., staff salaries, equipment maintenance, cost of financing, cost of renting land, metering platform fees etc.). Variable operating costs are incurred only when electricity is generated and sold by the mini-grid operator and are thus proportional to output (e.g., fuel costs for a diesel generator); when there is no output, variable costs are negligible.

Tariff Components, Structures and Cross-Subsidization Schemes

Capital and operating costs for a mini-grid are funded through tariffs from customers purchasing electricity, cross-subsidies from the mini-grid operator — derived from customers based on their classification — and external subsidies from government and/or international financial institutions. Whether a cost-reflective tariff is applied to individual customers is a matter of policy choice, with important considerations for how this process will be funded. In practice, cross-subsidization can be achieved through a combination of different tariff structures in order to yield an average tariff that is cost reflective. Different tariff components can also be combined; for example, both energy/consumption-based components and capacity-based components can be used together. A summary of the various tariff structures, billing and revenue collection methods that are typically deployed by mini-grid developers is presented in **Table 2**.[82]

82 Energy4Impact and INENSUS, 2019; and Reber et al., 2018.

TABLE 2

Mini-Grid Tariff Components and Structures

Tariff Structure	Advantages	Disadvantages
CUSTOMER OR SITE CLASSIFICATION The operator categorizes different types of customers (e.g., commercial, residential, community/government) so that some pay below the level of the cost-reflective tariff, while others pay above it. This typically works in one of the following ways: • Commercial/productive users are charged more to cross-subsidize lower rates for residential users, thus stimulating demand among households with lower disposable income • Residential users are charged more to cross-subsidize lower rates for commercial/productive users, thus incentivizing more productive-use activities. Another possible form of cross-subsidy arises when an operator has multiple sites or different businesses; under this scenario, the mini-grid operator may choose to have an average tariff for a single system set below the cost-reflective level, with the intention of meeting the funding gap through the internal transfer of cash from the other sites or businesses.	• Promotes electricity access among low-income households by providing a lifeline tariff; or • Stimulates the PUE among commercial/productive-use customers	• Mini-grids are typically serving low-income customers, most of whom are receiving electricity access for the first time; the complexity of this tariff structure may therefore be difficult for customers to understand, requiring extensive community engagement/sensitization and customer education and training • Requires smart meters (and thus the availability of mobile network coverage)
ENERGY/CONSUMPTION-BASED: QUANTITY OF USE Electricity is purchased in "blocks" of kWh usage whereby the marginal tariff rate increases in a stepwise manner as a customer uses more energy. When used for cross-subsidization, additional revenue from higher-intensity users who are charged higher tariffs cross-subsidizes lower rates for a basic level of subsistence use across all customers.	• Incentivizes energy efficiency • No load limiters required • Allows for flexibility to "pay-as-you-go"	• Complexity of this tariff structure may be difficult for customers to understand, requiring extensive community engagement/sensitization and customer education and training (e.g., around proper utilization of mini-grid electricity, load capacity usage, appliance wattages/what appliances can and cannot be used etc.)
ENERGY/CONSUMPTION-BASED: TIME OF USE (TOU) Tariffs vary based on the time of day at which power is used, with higher rates charged at times when demand is highest (peak) to allow lower rates at low-demand times (off-peak). Electricity supply is often more important, especially for residential customers, during the evening hours for lighting needs; however, this also corresponds to when it is typically more expensive for solar mini-grids to produce power (relying on diesel power or battery storage). In order to increase uptake during daytime hours (i.e., when it is typically cheaper for a solar mini-grid to produce power), operators can deploy TOU-based tariffs to better manage mini-grid load profiles and increase overall system efficiency. A related TOU-based tariff is a **seasonal tariff**, in which the charge per unit of energy depends on the season (e.g., solar mini-grids may charge high tariffs during the rainy season).	• Operators can better manage mini-grid load profiles and increase overall system efficiency • Convenient for solar PV hybrid systems that can match generation with demand	• Meters used can be expensive, which adds to the cost of electricity • Complexity of this tariff structure may be difficult for customers to understand, requiring in-depth customer education to understand charges • Discouraging usage during certain times of day (or during certain seasons) may lead to customer dissatisfaction • Seasonal tariffs may not correspond to seasonal incomes of rural customers
CAPACITY-BASED Similar to a consumption-based tariff, but rather than charging different marginal rates based on use, customers pay a flat tariff rate based on their maximum peak consumption (kWp) with a higher rate for higher peaks. Tariff depends on the number of devices with a limit on power rating.	• No meter required (only load-limiter) • No bill calculation • Suitable for low-income populations • Easy to understand for customers who can either use or not use specific appliances	• Difficult to forecast demand • Discourages productive use • Does not encourage energy efficiency; may lead to high consumption levels (and corresponding difficulties in meeting demand)

Tariff Structure	Advantages	Disadvantages
SERVICE-BASED / ENERGY-AS-A-SERVICE (EaaS) Under a service-based electricity tariff scheme, electricity is sold based on the energy service provided, utilizing a combination of consumption and capacity-based tariff structures (i.e., charge per unit of energy consumed and power utilized). Customers pre-pay/subscribe on a periodic basis (daily, weekly, monthly or pay-as-you-go (PAYG)) for an electricity service with a maximum capacity (kW) and a specific allocation of energy (kWh), typically controlled by smart-metering technology. Service-based tariffs are customized to reflect the actual electricity consumption needs of consumers and can be based on the desired usage of a given energy appliance and/or TOU. Service-based tariffs can be deployed as some combination of the following: • **EaaS tariff**: tariff depends on hours of usage (ideal for developers that want to ensure electricity is used for a specific purpose) • **Time-bound tariff:** tariff depends on amount of time electricity is used by customers (combined with an energy limit applicable to the time frame)	• **Simplicity**: Customers do not need to understand the complexity of electricity tariffs. • **Improved quality of service**: Renewable energy-based mini-grids have strict limitations in terms of the energy that can be supplied daily due to the intermittent nature of renewable energy sources. The use of service-based tariffs with customer-specific energy allowances and capacity requirements facilitates the sizing of the system (minimizing risk of over/undersizing) and provides operators with predictability of demand, allowing them to better manage electricity load profiles, lower costs and improve overall quality of service and system efficiency. This expands battery life-spans and minimizes the use of diesel in the case of hybrid solar-diesel mini-grid systems. • **Predictable revenues/expenses:** This method also ensures revenue stability for the operator since the revenue can be easily forecasted, thus facilitating financial planning. On the other hand, customers also benefit from knowing in advance how much they are going to pay, as well as what they can afford (and when/ if TOU is incorporated into the business model). • **Tiers of Service:** Service-based tariffs align closely with tiers of electricity service, where the price of the power depends on the tier of service required or equipment used by the customer. The inclusion of a multi-tier approach (see **Key Definitions**) allows for adapting the tariff levels to customer willingness and capacity to pay.	Customers are not fully aware of their electricity consumption Where an EaaS tariff is deployed without a time-bound tariff, it can be difficult to enforce compliance (need a load limiter) Does not encourage energy efficiency (if a time-bound tariff is deployed without a consumption limit) Need to ensure that customers are aware that they still pay for electricity even if they do not consume any during the allocated time (may lead to customer dissatisfaction)

Source: Adapted from Energy4Impact and INENSUS, 2019 and Reber et al., 2018.

NOTES: The various pricing and tariff structures presented in **Table 2** correspond to different metering technologies and billing/revenue collection methods. A 2019 survey carried out by Energy4Impact and INENSUS found that a majority of mini-grid developers in Africa utilize some combination of pre-paid, smart metering technologies with the support of local agents who collect payments through cash or mobile money transactions (including PAYG) to operate their mini-grids. Different tariff structures can be integrated with different types of meters depending on several interrelated factors (target end users, load profiles, availability of a mobile network for the use of smart meters etc.).[83]

83 Energy4Impact and INENSUS, 2019.

3.1.1.1 Sierra Leone

With the assistance of UNOPS, in June 2019, the Electricity and Water Regulatory Commission (EWRC) approved a comprehensive mini-grid regulatory framework for Sierra Leone — the 2019 Mini-Grid Regulations — which includes regulation on market entry, cost-reflective retail tariffs, technical and service standards, and the arrival of the main grid, with different guidelines applicable to isolated and interconnected mini-grids. In addition, the Environmental Protection Agency (EPA) introduced new licensing guidelines for renewable energy projects and mini-grids, including minimum requirements for holders of a basic license and standardized criteria for projects requiring Environmental Impact Assessments (EIAs) to be undertaken and Environmental and Social Management Plans (ESMPs) to be developed.

Licensing

Mini-grid projects are regulated based on their capacity. The regulations allow for two license categories: (i) a basic mini-grid license for projects below 100 kW; and (ii) a full mini-grid license for projects between 100 kW and 10 MW for the generation, distribution and retail sale of electricity. According to the regulations stipulated by the EWRC:[84]

- A **Basic Mini-Grid License** comprises a license for generation, which authorizes the licensee to produce electricity, and a license for the sale of electricity, which authorizes the licensee to sell electricity to consumers in a designated unserved area stated in the license via a mini-grid of up to and including 100 kW of distributed power in aggregate.
- A **Full Mini-Grid License** authorizes the licensee to construct, install and operate isolated mini-grids, comprising a license for generation, a license for distribution, which authorizes the licensee to distribute electricity directly or indirectly to consumers within a designated unserved or underserved area stated in the license, and a license for the sale of electricity through a mini-grid of above 100 kW and up to and including 1MW of distributed power per site and not exceeding 10 MW in aggregate, comprising a distribution network that is built in compliance with the approved distribution code and metering devices.

A modification of the license is necessary if: (i) a new mini-grid site is being added by a mini-grid licensee; (ii) the mini-grid distribution network is extended into another community; or (iii) the mini-grid licensee is classified in a higher license fee category, due to the expansion of existing mini-grid sites. 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, who are the heads of local chiefdoms and speak on behalf of the community.

The Mini-Grid Regulations stipulate that basic mini-grid license holders (i.e., below 100 kW) can charge any tariff agreed to between the licensee and the consumer, as long as it is also approved by the appropriate community authority (usually local community chiefs). These tariffs may, however, be reviewed by the EWRC upon receipt of a petition signed by 60 percent of a community's consumers served by a basic mini-grid licensee. A full mini-grid licensee (100 kW to 10 MW) may propose retail tariffs for specific consumer categories that take into account the ability of the respective consumers to pay; or propose a retail tariff structure based on the amount of electricity sold, the number of connections or the power provided or consumed, which may be paid in installments or fully charged up front, subject to the approval of the EWRC. Where a full mini-grid licensee desires to start a new service or revise existing rates charged, or if the validity period of the tariff granted will expire within 60 days, the holder shall make an application to the Commission for that purpose, with supporting documents describing and justifying the inputs into the tariff calculation tool provided or approved by the Commission.[85]

The Rural Renewable Energy Project (RREP) was the first time this mini-grid licensing process was implemented in Sierra Leone. All three of the private operators — Winch Energy, PowerGen and Energicity — successfully obtained full mini-grid licenses from the EWRC based on a cost-reflective tariff methodology for Work Package 1 (WP-1) sites and began selling electricity to WP-1 customers at an average tariff level of USD 0.85/kWh (ranging from USD 0.82/kWh to 0.87/kWh) as of Q4 2019.[86] The most recent round of tariff negotiations, combining the WP-1 and Work Package-2 (WP-2) sites, resulted in a range of USD 0.74/kWh to 0.82/kWh, with an average tariff of USD 0.79/kWh.[87]

84 Sierra Leone Electricity and Water Regulatory Commission: Mini-Grid Regulations 2019: https://ewrc.gov.sl/mini-grid-regulations/
85 AfDB Green Mini-Grid Market Development Programme - Mini-Grid Market Opportunity Assessment: Sierra Leone, 2019.
86 Ibid.
87 Stakeholder consultations, 2021.

The tariff structure consists of a service charge and a capacity charge. Connection fees are paid prior to the installation; however, in some cases, customers can reach an agreement with the operators and pay the connection fees over a period of three months.[88] The mini-grid connection fee includes a one-time payment of USD 15 (SLL 150,000), which partially covers the external connection fee, in-house wiring, and includes three switches and three energy-efficiency lights. There are stand-alone meters mounted either on poles or affixed to households, but all of the meters are pre-paid. Recently, a standing charge at a comparable level to that of the Electricity Distribution and Supply Authority (EDSA) was introduced that reduces the per kWh payment for the energy consumption and ensures minimum payment from the consumers. Previously, the charge covered the first 2 kWh of consumption per month; for any consumption greater than this threshold, the customer would pay a uniform tariff irrespective of the amount of consumption.[89]

Some mini-grid operators in Sierra Leone currently deploy an increasing block tariff (IBT) structure – a method of apportioning costs among and within different customer classes in which a customer whose electricity usage is greater pays progressively higher rates for that usage. A cross-subsidy from high- to low-consumption customers, referred to as a 'lifeline' tariff or social tariff, is often part of an IBT tariff mechanism, whereby a lower rate is charged to customers who consume below a certain amount of electricity per period.[90] This approach is currently being deployed by at least one operator in Sierra Leone.

Market Entry

Market entry under the RREP entailed a competitive bidding process for the selection of mini-grid operators that was managed by UNOPS on behalf of the Ministry of Energy (MoE). As outlined in **Section 2.2.1**, the public-private partnerships (PPP) arrangement signed with the selected operators has two key components: (i) a Usage Rights Agreement, where the operators are required to pay an annual fee to the Governmnent of Sierra Leone (GoSL) for usage of WP-1 assets that had already been constructed; and (ii) a Project Development Agreement for the mini-grid projects that were to be co-financed and developed under WP-2.[91] The tendering process was tailored to the selection of international firms, as certain threshold requirements were put in place to ensure that bidders had the necessary resources and financial capabilities to secure adequate financing for the development of the WP-2 sites. Given the novelty of this initiative, administration of the solicitation and subsequent negotiations with the selected bidders required extensive technical assistance (TA) dedicated to providing capacity building for government/public officials involved.[92]

When interviewed, mini-grid operators expressed satisfaction with the overall quality and rigour of the selection process and noted the strong buy-in and support from all key stakeholders involved on behalf of the GoSL (i.e., MoE, EWRC, PPP Unit, UNOPS). However, operators also noted that the RREP — similar to most programmes of its size, scope and ambition — is complex in its design, involving lengthy procedures that require significant resources to manage. A simplified process was recommended, with the GoSL taking on more of an oversight role in the market to ensure electrification targets are achieved and private operators are providing affordable, reliable and quality-verified electricity service.

In addition, operators indicated that the financing mechanism adopted by the RREP — a pre-financing arrangement with only an 'in-kind' subsidy — was not necessarily their preferred approach, as it put the onus on developers to pay for the assets received under each work package (see **Section 2.2.1**), as opposed to an alternative subsidy mechanism that may have provided them with more flexibility (see **Section 3.2**).[93]

Operators pointed to the utilization of results-based financing (RBF) schemes as a possible approach to expedite market entry. A private sector-driven model such as this is simpler in its design and structure and can reduce the contractual complexity of projects, which can in turn allow for greater possibility of reducing project development costs and end-user tariffs. However, it is worth noting that RBF schemes also face challenges, as feedback from the Nigeria Rural Electrification Agency (REA) highlighted issues with developers receiving the last tranche of grants due to their inability to verify the number of connections that they indicated in their grant application, despite receiving the first and second tranches of the grant up front.

88 During the initial rollout phase, some operators experienced challenges collecting payments for this connection fee and have implemented a loan structure to allow households to pay the fee in installments.
89 Stakeholder interviews, 2020.
90 Tenenbaum et al., 2014.
91 Policies and Regulations for Renewable Energy Mini-Grids, IRENA, 2018.
92 Stakeholder interviews, 2020.
93 Stakeholder interviews, 2020.

Other aspects of the bidding design that operators flagged include adjusting funding and experience-related requirements to increase the participation of local companies in the process; and supporting the design and implementation of flexible and innovative business and financial models, including the introduction of grant support schemes, to ensure long-term sustainability. An example of this would be for the RREP (and/or future mini-grid programmes) to allow developers to suggest their own projects outside of the existing PPP framework, which will provide an opportunity for developers to test innovative business models and solutions and possibly expedite electrification – essentially to allow space for a "bottom-up" approach to coexist in the market (see **Table 1**). Overall, operators concluded that in the future, a simpler process should be implemented, as the management, resources and technical complexity associated with the current design may contribute to project delays and higher project development costs.

Cost-Reflective Tariffs

The tariff determination method stated in the EWRC Mini-Grid Regulations 2019 applies to all mini-grids equally irrespective of the operator. The revenue requirement methodology is used to determine the tariff for the provision of services by the operators. The revenue requirement is the sum of operation costs, depreciation on capital and capitalized cost, reserves for repair and replacements, taxes, a reasonable return on the privately-financed regulatory asset base (RAB) that adequately reflects the risks faced by the mini-grid operator plus a performance-related profit margin on the quantity of electricity sold if the project is heavily subsidized.

Grant-financed activity or assets are not included in calculating the revenue requirement.[94] The tariff is calculated based on historic data for the previous year and applied in the regulatory year, except for the first tariff application for which projections based on reasonable assumptions are used. Booked costs are not approved automatically and stated consumer demand is not automatically accepted; the EWRC ensures that the proposed costs for the regulated service reflect prudently-incurred costs at a reasonable level of efficiency and that the underlying consumer demand is based on either verifiable data or prudent and reasonable demand projections based on verifiable data.

The revenue requirement is determined by the following formula:[95]

$$RR = O\&M + D + T + (return \times RAB) + (PRPM * E)$$

RR = revenue requirement for the regulatory year
O&M = operation and maintenance expenses
D = depreciation expense for the year (of all regulated capital and capitalized assets)
T = taxes, duties and charges, including non-recoverable GST paid
return = rate of return
RAB = regulatory asset base (residual value of the capitalized assets, including capitalized development cost)
PRPM = performance-related profit margin (SLL/kWh) reflecting grant financing
E = electricity sold (kWh)

The RAB is determined including all privately-financed used and useful assets in the provision of regulated activity at fair value (based on the cost approach, e.g., depreciated replacement cost).
The RAB is determined by the following formula:

$$RAB = \frac{(RAB_{t-1} + RAB_{t-2})}{2}$$

The RAB at the end of year (t-1) is determined by the following formula:

$$RAB_{t-1} = RAB_{t-2} + CAPEX_{t-1} - S_{t-1} - D_{t-1}$$

RAB_{t-1} = RAB at the end of year (t-1) (previous year)
RAB_{t-2} = RAB at the beginning of year (t-1) (previous year)
$CAPEX_{t-1}$ = privately financed capital additions (tangible or intangible assets) during year (t-1)
S_{t-1} = asset disposal during year (t-1), and
D_{t-1} = depreciation in the year (t-1)

The EWRC oversees the process of determining the tariffs for both mini-grids and off-grid projects, to be revised annually based on historic data for the previous year. While the entire RREP selection process — from the tender and procurement of the operators to the negotiations — took about two years to finalize, the tariff negotiation itself took about four months, with the final negotiation having concluded in June 2019. Overall, when interviewed, operators indicated that the

94 It should be noted that these are indirectly included in the reserve account requirements of the RREP project; other projects can also include a reserve account but it is not a requirement from the EWRC.
95 Sierra Leone Electricity and Water Regulatory Commission: Mini-Grid Regulations 2019.

tariff determination methodology provides a transparent method for operators to determine the price of their services. It also instills confidence in private sector investors about the entire regulatory process, as it provides guidance beforehand on how they can recoup their investments. Operators were also pleased with the support provided by UNOPS as a key intermediary throughout the process.

There were some challenges faced internally as extensive financial modelling training of EWRC staff was necessary to utilize the tool and apply it to the tariff applications with the operators. The process of assessing the capital and operating costs of the project was difficult due to the fact that mini-grid development is novel in the country and the region and, as such, there are few benchmarks for comparison in completing these assessments. There were further challenges in estimating the electricity demands of potential customers.

The EWRC ensures that the costs incurred by service providers in providing the services and a reasonable amount of return is considered and captured in the tariff calculation process. Prior to tariff negotiations, surveys were carried out to understand customers' ability and willingness to pay. The results of this process found that average retail tariffs of USD 0.85/kWh were cheaper than the alternatives end users were currently utilizing for energy access (including for lighting, mobile phone charging and purchasing of kerosene and/or lanterns). This suggests that the inefficient use of energy from the mini-grid may have contributed to misperceptions surrounding affordability, underscoring the importance of community-sensitization efforts and effective messaging around utilizing mini-grid electricity, appliances, costs etc., especially given that many mini-grid customers are first-time electricity users.[96]

As regulations state that the tariffs must be cost reflective, the process involved a review of the financial models together with the operators and the EWRC in order to develop the appropriate tariff calculation tool. The tool was transparent, and the regulator was able to account for all the costs and variable inputs. However, stakeholder interviews suggested that the initial demand assessment failed to properly estimate/account for how many hours of electricity would be consumed by end users; as higher usage leads to higher cost, this has an impact on affordability.[97] A related complicating factor is that the mini-grid tariff was higher than the national grid tariff (which is typical of mini-grid projects), which led to misperceptions from community end users. Issues surrounding financial literacy and the benefits of cost-savings need to be carefully considered during community-sensitization efforts.

96 Stakeholder interviews, 2020.
97 It is important to consider that the demand assessment was conducted in 2016, while the systems were not turned on until 2019.

Tariff Adjustment

The tariff adjustment process adopted by the EWRC for Sierra Leone is contained in the Mini-Grid Regulations for Sierra Leone. It stipulates that tariff adjustments shall occur when the EWRC (through its representative) inspects the mini-grid facilities or conducts an audit of the accounts of the mini-grid licensee and determines that the revenues earned by the operator or costs incurred deviate from the costs and revenues stated for the tariff determination at the time of licensing.

Technical and Service Standards

The EWRC, with assistance from UNOPS and the Millennium Challenge Coordinating Unit (MCCU), set the technical standards and grid codes to guide the development and operation of mini-grids in Sierra Leone. These standards cover site selection and handover to the operators with various options including a buyout in case of grid expansion. Mini-grids are also bound to follow standards for health and safety. Government incentives are accessible on the condition that imported equipment conforms with International Electrotechnical Commission (IEC) certifications and standards.

Regulatory interventions (e.g., through the licensing framework) aim to further support service quality. This has helped make processes run more smoothly and has provided clarity in the sector surrounding standards, while also providing protection for mini-grids. A grid code is being developed by the EWRC, currently in its interim draft as of late 2020. Other standards and codes include the establishment of a grid management committee, among other plans being developed by the EWRC. Operators are being asked to take part in multiple monitoring and evaluation (M&E) frameworks (MoE, EWRC, UNOPS etc.); when interviewed, operators suggested that one consolidated/integrated M&E framework be established for them to adhere to in order to reduce the regulatory burden (IEC protocols serve as a basic guide and the ISO 9001 on the side of the suppliers).

The presence of a large informal market for solar products in Sierra Leone leads to misperceptions about equipment quality that hamper the development of the country's solar market – including the mini-grid sector. This trend makes public awareness-raising and consumer education on product quality critical. Moreover, to ensure sustainable market growth, IEC and/or regional West African (ECREEE) standards must be adopted, along with a robust enforcement mechanism to ensure compliance.

Arrival of the Main Grid

The EWRC Mini-Grid Regulations include the following stipulations for the arrival of the main grid:[98]

i. **Basic Mini-Grid License**: Where a main-grid utility or a full mini-grid licensee extends its distribution network to an area served by an isolated mini-grid under a basic mini-grid license, on request of the main-grid utility or the full mini-grid licensee, the basic mini-grid licensee has to decommission and remove all assets and equipment within three months after the main-grid utility or the full mini-grid licensee has started supplying electricity to the area. In such circumstances, the basic mini-grid licensee shall not be entitled to any refund or compensation.
ii. **Full Mini-Grid License**: Where a main-grid utility extends its network to an area served by an isolated mini-grid under a full mini-grid license, the full mini-grid licensee has the option to either convert to an interconnected mini-grid based on a mini-grid interconnection contract between the full mini-grid licensee and the main-grid utility, or to transfer all assets that the main-grid utility wishes to retain on the respective site in return for financial compensation from the main grid utility before the arrival of the distribution grid network. The total compensation is calculated as the total depreciated value of assets remaining and handed over and assets decommissioned, removed and disposed of plus compensation for the revenue generated within the last 12 months prior to the date of connection of the mini-grid to the distribution network.

For the mini-grid communities selected under the RREP, operators handling these sites have various options including buyout in the case of grid expansion to those communities. Some operators are building systems that can be integrated to the grid upon its future arrival. Interviewed operators are generally satisfied with the arrival of the main grid regulatory framework. The main concern for operators in the future is how the full compensation is to be determined and what parameters

98 Sierra Leone Electricity and Water Regulatory Commission: Mini-Grid Regulations 2019.

will determine it. As part of an evolutionary approach to mini-grid regulation (see **Table 11** in **Section 3.3**), these issues need clarification in order to reduce developer risk and uncertainty, while at the same time ensuring a smooth transition from mini-grids to the main grid for all parties involved (operators, utility and customers).

3.1.1.2 Nigeria

The 2016 Mini-Grid Regulations enacted by the Nigerian Electricity Regulatory Commission (NERC) provide comprehensive regulatory and permitting guidelines for the development and operation of mini-grids in the country. The regulations include technical standards, economic regulation (including tariff methodologies), quality of service requirements, environmental requirements, type of contractual agreements, licensing processes, and other aspects of the framework such as what happens when the national or distribution grid arrives. The regulations have allowed mini-grid operators to charge a cost-reflective tariff to customers served by their mini-grids, ensuring recovery of costs and bankability/financial sustainability.

Licensing

The NERC Regulations for Mini-Grids 2016 define mini-grids as either isolated mini-grids or interconnected mini-grids. Isolated mini-grid sites are so classified when the location is designated as unserved and has not been assigned to an electricity distribution company (DisCo), or any other mini-grid developer. The NERC Regulations define mini-grids in categories in terms of capacity and licensing requirements. Mini-grids subject to a capacity limit of 1 MW are exempt from the power generation licensing regime established by the Electric Power Sector Reform Act (2005) and administered by the NERC. The regulations identify three broad forms of mini-grids:[99]

i. Isolated mini-grids with 100 kW or less of distributed power that may simply be registered with the NERC or at the discretion of the developer, obtain a permit from the NERC
ii. Isolated mini-grids larger than 100 kW of distributed power and up to 1 MW of generation capacity that require a permit from the NERC
iii. Interconnected mini-grids that require a tripartite contract with the developer, the community and the relevant distribution licensee.

Isolated Mini-Grids

The tariff mechanism for isolated mini-grids depends on whether the developer has obtained a permit or is simply registered. For permit holders, tariffs are computed using the REA Mini-Grid Tariff Tool, which is intended to be cost reflective and subject to a cap of 10 percent for technical and non-technical losses each. For registered mini-grids, the operator is at liberty to adopt the REA's methodology or set tariffs pursuant to an agreement with its community – which must have been consented to by at least 60 percent of the customers within the community. The community has the right to intervene and adjust the tariff in the event that the return accruing to the mini-grid operator exceeds typical non-recourse local currency commercial debt interest rates by above 6 percent.

Interconnected Mini-Grids

Interconnected mini-grids are mini-grids deployed within the franchise area of a DisCo that is unable to provide electric power or provides poor quality/unreliable power to a community. Interconnected mini-grids utilize the existing electricity distribution infrastructure of the DisCo and thus enter into agreements with both the community to be served, and the DisCo that owns the distribution assets. Interconnected mini-grid tariffs comprise the generation tariff determined according to the REA Mini-Grid Tariff Tool methodology and the distribution use of service tariff that is paid to the distribution franchise owner for the use of its electricity distribution infrastructure. When interconnected mini-grid operators distribute electric power from the DisCo to the mini-grid customers in addition to the electric power from the mini-grid infrastructure, a tariff for the power supplied by the DisCo will also be charged. Tariffs are subject to approval by the NERC.

Market Entry

For developers to operate in the sector, they simply have to demonstrate their capacity through evidence of previous projects and to ensure that these projects have been built and are operational. They also have to demonstrate that they have the capacity to access financing, through debt or equity, to develop mini-grid sites. While there are also basic documentation requirements according to the regulation, the major requirements are their technical and financial capabilities.

99 Nigerian Electricity Regulatory Commission Regulation for Mini Grids 2016: http://rea.gov.ng/wp-content/uploads/2018/07/NERC-Mini-Grid-Regulation.pdf

Cost-Reflective Tariffs

In Nigeria, according to the NERC Regulations for Mini-Grids 2016, tariffs are computed using the cost-reflective NERC Mini-Grid Tariff Tool, which is the NERC's methodology for setting fair and transparent retail tariffs (see **Section 3.1.2.1**). The RAB model in Nigeria provides a detailed Excel-based tool that has pre-set categories for asset base inputs, enabling mini-grid developers to input data and receive pricing estimates. The methodology is based around allowances for three specific costs – allowed return on capital, depreciation, and efficient operating costs and overheads. There are entries available for both generation assets (solar panel, solar cables, battery bank, solar inverter, battery inverter, sub-distribution infrastructure, generation house etc.) and distribution assets (poles, grid low voltage, grid connections, customer connections and smart meters). Nigeria does not cap the rate of return that developers can earn on their RAB at a specific number but pegs it to the non-recourse commercial debt interest rate plus six percentage points.[100]

The NERC Regulations provide a methodology for tariff determination that has implications for the affordability of energy generated and consumed. The policy and regulatory framework provides for flexibility around tariff setting for mini-grids below 1 MW where companies are allowed to determine the tariffs that would allow them to achieve a sufficient return on investment, with the approval of the regulator. Most of the country's existing commercial mini-grids fall into this category and utilize an owner-operator business model funded through a mix of debt, equity and grant funding (the most common debt to equity ratio is around 70:30, with an additional variable grant component).

The Federal Government of Nigeria (FGN) has taken several steps to reduce regulatory burdens for mini-grid developers. At the end of 2019, the NERC developed a web-based tool to streamline the mini-grid registration process for developers and released a simplified, Excel-based NERC Mini-Grid Tariff Tool to help developers determine what cost-reflective tariffs to charge end users. Registered mini-grids are allowed to set their tariffs freely and are allowed, but not required, to use the NERC Mini-Grid Tariff Tool, which is publicly available on the NERC website. However, stakeholder interviews revealed that the previously available NERC tariff tool was mostly applicable for the main grid and did not necessarily provide adequate direction on tariffs for an off-grid project.[101] In 2020, under the Nigerian Energy Support Programme (NESP), GIZ supported the NERC to address this issue by preparing a tariff tool that is specific to mini-grids, which is currently available on the NERC website.[102]

The comparison of affordability is not typically based on the price of grid power, which is seen as unavailable and also not cost reflective, but on alternatives such as kerosene for lighting and diesel generators for electricity. In determining tariffs, mini-grid developers are obligated to engage with communities on tariff setting and sign agreements with community representatives and key stakeholders. During the community engagement process, developers conduct demand assessments and market analysis to determine the cost of alternative energy sources and to evaluate the purchasing power of the community.

Stakeholder interviews with Nigerian developers found that most communities are willing to pay high tariffs as long as they are lower than the alternatives. This is indeed the case in Nigeria, where current mini-grid tariffs (averaging about USD 0.50/kWh) are cost reflective, with end users experiencing savings of about 30 percent through mini-grid electrification (see **Section 2.2.2**).[103]

In Nigeria the issue of affordability has not inhibited the development of the mini-grid sector. With a robust tariff determination framework using the NERC Mini-Grid Tariff Tool methodology, the tariff allows a licensee that operates efficiently to recover the full costs of its operations, including a reasonable return on capital invested in the business. As described in **Section 2.2.2**, with the introduction of the Nigeria Electrification Project (NEP) RBF and performance-based grant (PBG) mechanism administered by the REA, mini-grid tariffs will continue to improve and enable more affordable access.

Mini-grid affordability in Nigeria is further enhanced through increased utilization of productive use of energy (PUE) applications (see **Section IV**). In some instances, developers offer productive users and commercial users (who generally consume more power) a lower tariff than residential customers. This acts as an incentive to those using power for productive use/economic generating activities as well as to those using electricity during the

100 "Exploring Africa's Mini-Grid Tariff Methodologies," National Association of Regulatory Utility Commissioners (NARUC), United States Agency for International Development, (March 2020): https://pubs.naruc.org/pub.cfm?id=A1E7A0F1-155D-0A36-319F-8CBC8BE8B342
101 Stakeholder interviews, 2020.
102 NESP Nigeria: https://twitter.com/nesp_nigeria/status/1268098896447733763?s=20
103 Stakeholder interviews, 2020.

day, when it is more affordable for the operator to produce and distribute energy. This tariff structure incentivizes others to enter the PUE market segment and stimulate electricity demand for the mini-grid, as there is cross-subsidization of productive users by residential users. Other interviewees signaled the need for more consumer awareness-raising to educate customers on the benefits and cost-savings associated with the mini-grid tariff vis-à-vis the costs expended on diesel or petrol generators.[104]

One of the ways through which tariffs can be further reduced is by providing access to affordable financing to developers in local currency, which the FGN is starting to do with the support of SEforALL. Another way is through the reduction of import duties on solar products and components. From the developer's perspective, reduction of hardware costs (through vendor financing, for example) will also contribute to reduced tariffs, as well as developing sites in larger portfolios to take advantage of economies of scale to further reduce development costs and tariffs.

Generally, operators believe the current regulatory regime on tariffs provides a comprehensive framework that supports developers, meets investor needs, and thus encourages sustainable development of the sector. Improvements can be made to the framework for interconnection of mini-grids due to the need to collaborate with distribution companies (DisCos). The way the NERC Mini-Grid Tariff Tool has been structured is through cost-reflective tariffs as a way of encouraging private sector participation in order to improve the rate of energy access in the country. From the template shared by the regulator, tariffs would have been pre-agreed with the community and signed by virtue of a commercial agreement, which is one of the requirements for applying for the permit. However, if an operator generates below 100 kW and does not want to go through the process of NEC registration and obtaining the permit, they can avoid associated regulatory coverage and are at liberty to charge any tariff agreed upon with the community.

Tariff Adjustment

The NERC Regulations include guidelines for tariff determination by the various categories of mini-grids. There is no customer classification imposed by the NERC for mini-grids, and a tariff is calculated using the NERC Mini-Grid Tariff Tool methodology for either one village, or a cluster of villages located in the same area. The actual tariff and billing model are described in the contract between the mini-grid developer and the community, or the tripartite agreement that includes the DisCo in the case of an interconnected mini-grid.

In order to amend/escalate/adjust mini-grid tariffs in Nigeria, the NERC Mini-Grid Regulations indicate that sufficient notice should be given when there is an intention to adjust the tariff, and an application to the NERC is to be made in this respect. No interval is provided in the regulations for application for tariff adjustments by the operator, and the regulations state that the NERC shall be entitled to inspect and verify the accounts of the mini-grid permit holder for the purpose of adjustment of tariffs.

Upon verification by the NERC that the actual costs or revenues incurred or received by the mini-grid operator deviate from those stated (or projected) during tariff determination with the NERC at the point of application for the permit (or approval of the tripartite agreement), the input parameters for calculating the tariff using the NERC Mini-Grid Tariff Tool methodology are to be adjusted to the actual current values. The tariffs may then be adjusted by the NERC, with the new tariffs applied within 30 days following approval. The mini-grid operator or community may request an inspection of the accounts of the mini-grid operator for the purpose of tariff adjustment; the request incurs a charge of NGN 200 per customer (USD 0.50) to be paid by the party requesting the inspection.

Technical and Service Standards

Compliance with standards varies according to the type of authorization. Registered mini-grids must apply minimum technical requirements and ensure quality of service, in accordance with their agreements with the beneficiary communities. They are recommended, but not required, to follow technical guidelines in the NERC regulations and the distribution code for registered mini-grids.

Mini-grids that hold a permit, whether isolated or connected, are bound to follow the grid code, the distribution code, and health and safety standards. Some of the standards include maintaining a stipulated frequency range, notifying users of outages at least 72 hours in advance, and reporting significant incidents to the NERC within 24 hours (defined as malfunctioning of equipment, or injury to a person or an animal due to electrical causes).[105]

104 Stakeholder interviews, 2020.
105 "Mini-Grids in Nigeria: A Case Study of a Promising Market," World Bank ESMAP, (November 2017): http://documents1.worldbank.org/curated/en/352561512394263590/pdf/ESM-dNigeriaMiniGridsCaseStudyConfEd-PUBLIC.pdf

Arrival of the Main Grid

Options for how to deal with grid expansion differ according to the type of mini-grid. Interconnected mini-grids must pay the DisCo a charge for using its network infrastructure. This charge is determined through negotiations with the DisCo and must be approved by the NERC. However, the DisCo may also take over interconnected mini-grids and re-integrate them into its network once the tripartite contract expires, on the condition of providing written proof of endorsement by the connected community, and notification to the NERC.[106]

Isolated mini-grids operating with a permit have two options:

i. Convert into an interconnected mini-grid and become a small power producer and/or a small power distributor; or
ii. Sell the isolated mini-grid's assets to the DisCo in return for compensation.

If the extension of the grid happens within five years of the commissioning of the mini-grid operator, the compensation corresponds to the remaining depreciated value of assets, including construction and development costs. If the extension of the grid happens after five years of the mini-grid being commissioned, the compensation corresponds to the remaining depreciated value of assets, excluding construction and development costs. The DisCo must also pay the mini-grid an additional compensation, whether the grid arrives before or after the five-year threshold. This additional compensation equals the revenue generated during the 12 months before the date of interconnection or buyout. This aims to provide an incentive for mini-grid developers to increase the load while preventing predatory behaviour from DisCos (e.g., where DisCos let mini-grids prove the economic viability of a location before expanding their network and taking over the mini-grids for a relatively low price.) The NERC has the final say when parties cannot agree on the amount of compensation; however, it is worth noting that the NERC has not played such a role yet. Due to the nascent stage of the market, there have not been any documented cases of such conflicts to date, as no DisCo has extended its distribution system to an area already occupied by mini-grids.

Registered mini-grids that do not have a permit are not eligible for any compensation. They must decommission and remove all their assets and equipment within two months after the DisCo has started supplying electricity to the area.

Stakeholder interviews found that operators are currently seeking out partnerships with DisCos to develop mini-grids that are in "under-grid" areas. As for the compensation offered for grid extension, some operators feel it is inadequate and as such, have engaged one of their partners to drive a policy review process that will include the Renewable Energy Association of Nigeria (REAN) for wider participation. The purpose of this collective-action approach is to undertake a review from an industry-wide perspective as opposed to an individual one.

Mini-grids in Nigeria are gradually trending towards grid parity, especially interconnected mini-grids, as DisCos may be sourcing more of their power from such projects. A survey carried out by the Rocky Mountain Institute found that although capacity utilization of mini-grids is still below average, as projects work towards the achievement of energy access goals by connecting households, revenue collections have been solid. With more focus on PUE, mini-grids in Nigeria will achieve more capacity utilization and further enhance affordability.[107]

3.1.2 Summary of Findings

3.1.2.1 Comparative Analysis of Tariff Determination Methodologies in Sierra Leone and Nigeria

Tariff Calculation

The tariff calculation methodologies in the mini-grid tariff calculation tools used by both the EWRC and the NERC calculate the average tariff as a ratio of the total allowed revenue (TAR) to the total annual demand. The tariff calculation tools used by both regulatory agencies use similar methods to determine a cost-reflective tariff for a prudently operating developer. The TAR, which is the sum of the operational costs, depreciation, etc., is used together with the total demand in calculating the tariff in both the EWRC and NERC tariff tools, as presented in **Table 3**.
Some differences in the components of the annual TAR exist in the tariff calculation tools used by the EWRC and the NERC as summarized below.

i. The NERC includes the cost of payments made to the local electricity distribution company where applicable. This applies to interconnected mini-grids that are a

106 Ibid.
107 Mini-Grid Investment Report: Scaling the Nigerian Market, Rocky Mountain Institute, 2018.

mini-grid category under the Nigerian Regulation for Mini-Grids 2016.

ii. The EWRC includes grants for cost (added as a negative to prevent the granted sums from being counted as part of the tariff), and reserves (covering repair costs, etc.) as components of the annual TAR.

The NERC tariff tool further allows for the calculation of TOU tariffs split into daytime and nighttime tariffs. TOU tariffs are calculated as a ratio of the TAR to the projected total energy consumed (kWh) during the daytime and nighttime. The NERC tariff tool also provides for the calculation of the tariff as an average flat-rate tariff, which is calculated as the ratio of the TAR to the number of customers served by the mini-grid in one month.

TABLE 3
Mini-Grid Tariff Determination Comparison[108]

Tariff Components	EWRC Tariff Tool[109]	NERC Tariff Tool[110]
Total Annual Allowed Revenue (A) in SLL or NGN	(+) Operational Costs[111]	(+) Operational Costs
	(+) Depreciation	(+) Depreciation
	(+) Average Return	(+) Average Return
	(+) Performance-Related Profit Margin	(+) Performance-Related Profit Margin
	(-) Grants for Cost (Capex)	(+) Payments made to DisCo
	(+) Reserve Account Contribution	(+) NERC Fee (NGN/year)
Total Demand (B) in kWh/year	Total Annual Demand	Total Annual Demand
Tariff (C) = $\frac{\text{Total Allowed Revenue (A)}}{\text{Total Demand (B)}}$		

Source: EWRC and NERC.

As the tariff tools used by both the EWRC and NERC use similar tariff determination methodologies based on the cost-of-service approach (whereby end-user tariffs are calculated as the ratio of the TAR to the total annual demand), any differences in a tariff calculated using either tool would be due to the differences in the individual components of the TAR, or the fact that some components of the TAR are unique to each of the tools used by the EWRC or NERC.

The regulator in Sierra Leone, through its Mini-Grid Regulations and tariff tool, allows the developer some flexibility in choosing the weighted average cost of capital (WACC) — or return on the RAB — to be used in the tariff tool (and thus tariff determination) subject to the approval of the EWRC. The NERC also allows similar flexibility in its tariff tool, and the WACC is calculated based on the cost of debt and the expected return on equity. The requirement for the NERC to approve the rate of return used to derive a tariff using the NERC tariff tool is however not mentioned in the Nigeria Regulations for Mini-Grids 2016.

The Sierra Leone Electricity and Water Regulatory Commission (SLEWRC) states in its Mini-Grid Regulations that: *"the applicant's proposed rate of return on its own invested capital shall be supported by a cost of capital analysis. The applicant shall propose and justify a capital structure which will include a discussion on cost of debt and equity for the applicant. The rate of return proposed needs to be confirmed by the Commission."*

The EWRC and NERC tariff tools and methodologies do not use the Capital Asset Pricing Model (CAPM) that aims to guide an appropriate return on equity in relation to

108 The EWRC mini-grid tariff tool includes applicable taxes in the determination of operating costs, which itself is a line item in the tariff determination calculation. The NERC mini-grid tariff tool does not consider taxes in the determination of the tariff; Nigerian mini-grid developers may thus apply a pre-tax WACC when determining a tariff in order to address this tax burden in its revenues.
109 EWRC Tariff Calculation Tool Version 9.2
110 Tariff Tool Version 4 from: https://nerc.gov.ng/index.php/component/remository/Regulations/MYTO-Mini-Grid-Model/?Itemid=591
111 Includes EWRC fees.

the risk premium on the respective equity market. This implies that potentially widely varying returns on assets (a product of the RAB and the WACC) may be proposed by developers in both Nigeria and Sierra Leone based on the prevailing market conditions and could cause wide variations in tariffs determined for either market.

3.1.2.2 Summary of Mini-Grid Tariff Frameworks in Sierra Leone and Nigeria

A summary of findings based on a review of the mini-grid tariff frameworks in Sierra Leone and Nigeria is presented in **Table 4**.

TABLE 4
Mini-Grid Tariff Frameworks in Sierra Leone and Nigeria

Indicator	Sierra Leone	Nigeria	Lessons Learned
Tariff calculation methodology	• Revenue Requirement methodology • The RAB model is defined as "the sum of all assets used and useful in providing regulated services," which gives the regulator the discretion to determine the reasonableness of entries on a case by-case basis	• Publicly-available NERC Mini-Grid Tariff Tool • Operators generating below 100kW are at liberty to set their own tariffs through a "willing buyer-willing seller" regime (must have agreement with community) • The RAB model provides a detailed Excel-based tool that has pre-set categories for asset base inputs (includes generation and distribution assets) allowed within the RAB. It also provides pricing estimates.	• The multi-year tariff order (MYTO) tool reduces regulatory burden for developers and regulators • In Nigeria, registered mini-grids have the flexibility to set their tariffs freely and/or to use the tariff calculation tool.
Average mini-grid tariffs	**RREP**:[112] • **WP-1, Year 1 (2019-20):** USD 0.82 – 0.87/kWh; average of USD 0.85/kWh • **WP-1 and WP-2, Year 2 (2020-2021):** USD 0.74/kWh – 0.82/kWh; average of USD 0.79/kWh	• **NEP and NESP I:** USD 0.39-0.79/kwh (NGN 150 – 300/kwh); average of USD 0.58/kWh (NGN 220/kWh) • **REF**: USD 0.32-0.39/kwh (NGN 120 and 150/kwh)	Some of the key similarities and differences between the tariff frameworks in Sierra Leone and Nigeria include: • The annual TAR used in tariff determination for Sierra Leone and Nigeria has certain components unique to each that could drive differences in tariffs for similar installations. • The developer is allowed to calculate its return on the RAB (subject to approval by the EWRC in Sierra Leone) allowing for potentially differing tariffs as the return on the RAB is based on the local lending rate and the return on equity proposed by the project developer. • In Sierra Leone, as operators begin to connect more customers and bring larger mini-grid systems online, project development costs are gradually decreasing. • In both countries, some mini-grid developers charge productive users a lower tariff than residential customers to incentivize PUE. • Access to finance is a key barrier for mini-grid developers in both countries; in Nigeria, developers have built up their internal capacity/expertise (under the NEP) in terms of preparing proper documentation, thus improving access to financing programmes, and in turn enabling the reduction of tariffs.

112 NOTE: These tariffs only reflect the RREP; other mini-grid projects in Sierra Leone (e.g., PRESS-D) may charge different tariffs.

Indicator	Sierra Leone	Nigeria	Lessons Learned
Market Entry	• Top-down planning approach under the RREP • Bidding process under the RREP is lengthy and complex, which leads to higher costs for developers, who must absorb these costs as overhead • The EWRC can refuse to grant a license based on reasons relating to the financial, technical and managerial capability of the applicant, or the inability to render the service for which the license is being sought	• Private sector-driven model that combines top-down and bottom-up planning approaches • Entrants are required to show technical and financial capability • The NERC can similarly refuse to grant a license based on not fulfilling these basic requirements	• The complex PPP structure of the RREP resulted in lengthy and expensive negotiation and financing processes, with delays largely attributed to extended application processes to obtain licenses and other permits, as well as to ongoing general elections in Sierra Leone in early 2018. Continuous learning by doing (by regulators, developers and communities) and the subsequent refinement and streamlining of permitting/contract negotiation processes is a key lesson learned. • Due to higher existing local capabilities in Nigeria with its more developed power sector, companies could assess the sites they want to develop themselves, carry out surveys, provide their design and submit to the REA, which carries out evaluation, checks necessary documentation and ensures that they meet the financial and technical requirements to deliver such projects. • Following a successful grant application, developers are given the NEP RBF grants subject to verification that customers have connected to the mini-grid and been provided with satisfactory service for 90 days.
Technical and Service Standards	• Set by the MoE and the EWRC • Grid code currently under development • Informal market competition requires improved enforcement standards by relevant authorities	• Set by the REA, the NERC and the Standards Organization of Nigeria • Standards vary according to type of authorization • Registered mini-grids are recommended but not required to follow the codes; mini-grid operators with permits are bound to follow the codes • Informal market competition requires improved enforcement standards by relevant authorities	• Regulators should implement measures to ensure standards/ quality (e.g., by adopting IEC and/or regional/ECREEE standards), mitigate potential difficulties in customs clearance and import logistics, as well as to oversee implementation of tax exemptions by coordinating with all agencies and regulatory bodies involved.
Ability to reduce capex development and/or opex costs	• According to interviews with operators, reductions of operational and asset costs to significant levels are not possible, as opex costs are relatively fixed, and the variable costs directly tied to revenue levels are low • Removal of import duty on IEC-certified approved solar products (excluding ancillaries such as distribution equipment, batteries, etc.) • Removal of GST from mini-grid electricity and tax holiday for mini-grid operators for 5-year period	• Distribution infrastructure and storage were the most significant cost drivers, which cannot easily be reduced due to under-grid/ energy reliability of the grid • 5% import duties and 5% VAT on imported solar components[113]	• Develop sites at scale, as the economies of scale in developing multiple mini-grid sites at once should reduce some costs (fixed costs are spread over far larger volumes of kWh sold). • Focus on optimal cost per kWh and the appropriate financing structures for this, as significantly increasing the customers/sites managed and the consumption per customer remains the best way to reduce tariffs.

113 "Policy Research on the imposition of 10% Tariff Duties on Solar Components: Making a Way for Solar in Nigeria," https://ng.boell.org/sites/default/files/uploads/2019/07/final_35_page_-_policy_research_on_the_10_duties_on_solar.pdf.pdf

Indicator	Sierra Leone	Nigeria	Lessons Learned
Arrival of the Main Grid	• Basic mini-grid licensee has to decommission and remove all assets and equipment • Full mini-grid licensee has the option to either convert to an interconnected mini-grid based on a contract between the licensee and the main-grid utility or transfer all assets in return for financial compensation	• Interconnected mini-grids pay the DisCo a charge, determined by negotiation and approved by the NERC, for using the DisCo's network infrastructure or the DisCo may take over the interconnected mini-grids and re-integrate them into its network once the tripartite contract expires • Isolated mini grids with a permit either convert into an interconnected mini-grid or sell their assets to the DisCo in return for compensation	• Arrival of the main grid/DisCo network is the single most important constraint facing mini-grid developers in Nigeria; some feel that there is unfair compensation offered for grid extension and are trying to drive a policy review process with the REA.

Source: SLEWRC Mini-Grid Regulations; NERC Mini-Grid Regulations; stakeholder interviews, 2020.

Affordability is central to mini-grid development, particularly in countries like Sierra Leone and Nigeria, where rural income levels often make it difficult for the population to afford electricity access. In the context of mini-grid electrification, affordability and WTP are directly tied to alternative energy and lighting sources that are used by off-grid communities (diesel generators, kerosene lanterns, batteries etc.), which are more expensive by comparison. Hence, most customers already pay higher rates for access using these alternatives than the tariff set by mini-grid operators.

Affordability of tariffs therefore cannot be determined based on the absolute value of a given tariff and must be examined within a broader, country-specific economic context. Domestic low voltage consumers (i.e., households) in the ECOWAS region spend about 17 percent of their income on tariffs, on average; Sierra Leone has one of the highest average low voltage (LV) domestic tariffs in the ECOWAS region with users spending up to 20 percent of their income on electricity, while domestic LV consumers in Nigeria spend about 10 percent of their income on electricity.[114] A 2015 study carried out under the EU-funded PRESSD-SL programme found that — using conventional energy sources — the cost of lighting, on average, accounted for between 10 and 15 percent of household incomes, while households using generators were found to spend upwards of 20 percent of their income on lighting.[115]

Electricity is a bit more affordable to lifeline consumers who spend an average of about 2 percent of their income on electricity. Lifeline rates refer to the subsidized rates given to customers for the first block of consumption (i.e., enough electricity access to cover basic needs), whose discounts are borne by those with higher electricity consumption. The lifeline tariff in Sierra Leone is one of the least affordable, in relative terms to the GDP per capita, as consumers of the Electricity Distribution and Supply Authority (EDSA) of Sierra Leone have to spend up to 3.2 percent of their income on electricity tariff, compared to lifeline consumers of the Abuja DisCo in Nigeria, who have to spend less than 1 percent of their income on tariff, making this one of the most affordable lifeline tariffs in the region.[116]

On average, the non-domestic low-voltage consumers (who use electricity for commercial activities) in the ECOWAS region pay 15 percent higher tariff than domestic low-voltage consumers. This figure goes up to 77 percent in Nigeria – i.e., the non-domestic consumer tariffs are 77 percent higher than domestic consumer tariffs whereas in Sierra Leone, the non-domestic tariffs are only about 30 percent higher than domestic consumer tariffs. The difference between the two tariff classes is indicative of the subsidization and/or cross-subsidization in favour of domestic consumers in each country. This trend suggests that tariffs in each country (and at the ECOWAS regional level) do not promote commercial and industrial activities.[117]

114 "Electricity Tariffs in ECOWAS Region," African Development Bank Group, Energy Policy, Regulation and Statistics Division, (September 2018): http://www.ecowrex.org/sites/default/files/pesr1_-_energy_statistics_bulletin_september_2018.pdf
115 Lai, K., Munro, P., Kebbay, M., and Thoronko, A., "Promoting Renewable Energy Services for Social Development in Sierra Leone: Baseline Data and Energy Sector Research, Final Report," European Union, (July 2015): https://pressd-sl.org
116 Electricity Tariffs in ECOWAS Region, African Development Bank, 2018.
117 Electricity Tariffs in ECOWAS Region, African Development Bank, 2018.

Stakeholder interviews in Sierra Leone indicate that in setting mini-grid tariffs, the regulator investigates capital cost, financing and more, and most operators find the current tariff cost and regulations to adequately cover all key factors. Some operators, however, view the tariff structure as overly controlling and thus preventing experimentation to optimize structure. The tariff set by the EWRC is to be reviewed after 12 months; this had yet to take place as of late 2020.

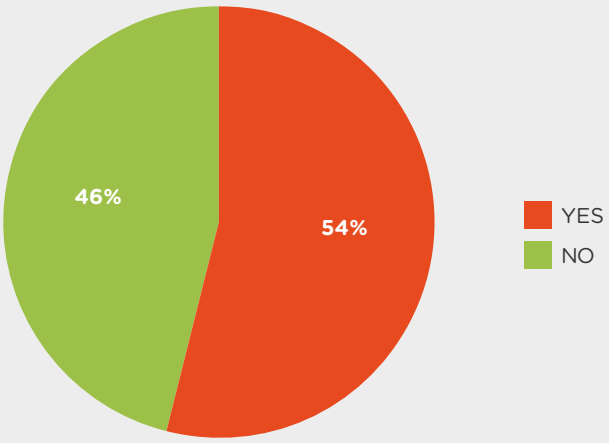
Several fiscal policies (both direct and indirect) have been taken to support the mini-grid sector. For example, the MoE and the Ministry of Health and Sanitation (MoHS) provided access to land for the development of the RREP WP-1 mini-grid sites, while the Ministry of Finance (MoF) provided incentives for the importation of mini-grid equipment that meets international standards of quality. In 2021, the GoSL approved corporate tax exemptions and a goods and services tax (GST) waiver for mini-grid projects, while the FCDO, under Work Package 7 (WP-7) of the RREP, provided a tariff subsidy (see **Section 1.1.2**).

It is important to emphasize that, even though the mini-grid tariff is considered unaffordable by many, a large number of the mini-grid customers had never used electricity in this form prior to the arrival of the mini-grid. Thus, when they first connected to the system, many customers ended up consuming more electricity than they could afford. In this context, energy expenditures in relation to income levels may take some time to level off as end users learn more about their energy usage and expenditures.

Many of these issues can be addressed through awareness-raising and community-sensitization campaigns targeting financial literacy (so that end users better understand the benefits of cost-savings), as well as energy efficiency/conservation, and appropriate use of end-use appliances to optimize energy use. Collaboration between stakeholders across varying levels, from the private and public sector, is also important to ensure understanding and inclusion. Improving understanding of these dynamics within a mini-grid community is critical to fostering sustainable growth of the mini-grid sector.

Another option may be through the application of Energy-as-a-Service (EaaS) business models, whereby mini-grid operators offer end-user services rather than selling kWh (see **Annex 1**). This has proven to be an effective approach in other nascent and early-stage mini-grid markets and would help overcome many of the above-mentioned knowledge barriers. Indeed, mini-grid community surveys found that user knowledge surrounding electricity usage from the mini-grid was relatively low (**Figure 15**).

FIGURE 15
User Knowledge of Amount Charged per kWh of Electricity



Source: WP-1 Mini-Grid Community Surveys, 2020.

With the mini-grid tariff still considered unaffordable for many rural households, companies in Sierra Leone are working to address this by providing microfinance to end users to increase uptake through PUE (see **Section 4.2**). Grant schemes and subsidies from the government and development partners can play an important role in facilitating access to financing (e.g., for the purchase of productive-use equipment), which is currently a focus of the RREP under Work Package 6 (WP-6). All surveyed operators mentioned the issue of high cost of financing as an important cost driver, with commercial banks in Sierra Leone not having much experience in the mini-grid sector and thus being understandably risk-averse. Government guarantees can ease this risk averseness to support lower-cost financing from commercial banks without significant burden to the government budget. Operators are also working with communities to better understand different classes of customers, how they manage, use, and consume energy etc. to further improve affordability.

Operators stated that various aspects of the WP-1 and WP-2 site development contributed to higher tariffs. For example, sourcing a large quantity of installation materials, and associated installation/connection labour, was identified as being particularly costly for WP-1. These costs were reduced under WP-2, however, as operators were able to make use of their own trained engineers in Sierra Leone. The biggest cost driver for WP-2 development was procurement of the power generation assets, along with having to repeatedly finance new project costs for each site; financing is extremely expensive, with legal costs up to USD 400–650 per hour to manage the preparation of various contracts and permits, particularly those related to land leasing. The lengthy and complex nature of this process led to higher costs for developers, who must absorb these costs as overhead. Operators suggested that an ideal structure would be a relatively simple framework contract that can be used on an ongoing basis.

In addition, the possibility of further standardization can be explored. Some operators explained that mini-grid projects are destined to have higher costs because they are all tailor-made projects – unlike grid extension projects. Considering this inherent characteristic, the GoSL can carefully analyze power assets and development/permitting processes that can be further standardized in order to create replicability and learning for developers, leading to further cost reductions. Developers can also explore coordinated efforts of bulk purchase of such standardized assets to pursue cost reduction via increased purchasing power. For this kind of action, however, a well-planned mini-grid development programme by the GoSL may become essential to create market certainty.

Operators mentioned equipment costs, e.g., solar batteries, as a key cost driver. In addition, the lack of locally available parts and installers greatly adds up the cost, as they need to be procured from outside of the country. There are additional logistical difficulties during the country's rainy season, which can lead to delays and increase costs.

Increasing the number of customers is also important for operational cost reductions. Operators suggested that operational and asset cost reductions are not possible to significant levels, and that cost savings on assets will simply push costs down the line into higher maintenance and poor performance – in turn resulting in reduced revenue due to downtime. Moreover, variable costs directly tied to revenue levels are about 2–4 percent; therefore, significantly increasing the customers/sites managed and the consumption per customer remains the best way to reduce tariffs, as fixed costs are spread over far larger volumes of kWh sold. This requires clearer processes for financing and deployment of larger project portfolios. As a longer-term cost reduction measure, the GoSL should invest in building local capacity to create a sustainable market with local expertise.[118]

118 Stakeholder interviews, 2020.

3.2 Assessment of Mini-Grid Subsidy Schemes in Sierra Leone and Nigeria

3.2.1 Impact of Subsidies on Project Development Costs and Electricity Tariffs

The economics of mini-grid development in Sub-Saharan Africa remain challenging, as mini-grids often have high up-front capital and operational costs and tend to serve low-income rural customers with limited ability to pay. Demand from these customers can be unpredictable, as many rely on agriculture for income. Varying weather conditions, seasonality and crop yields all directly impact the ability of customers to pay their bills. For mini-grid operators, such irregular income streams pose significant risks to revenue collection, and risk returns for their financial backers.[119] While there are some exceptions, including sites that have the right mix of loads, income levels, and proximity to transportation or urban areas, most mini-grids typically require some form of grant or subsidy to be economically viable.[120]

There are various approaches for providing subsidies. Subsidies can be delivered by either supplying certain elements to the developer directly, or by a financial transfer paid for inputs or outputs, generation or distribution outcomes, or on a capital or operational basis. Subsidies are typically provided to either: (i) consumers (i.e., customers served by a mini-grid), which are derived on the basis of a price-gap approach; or (ii) producers (i.e., mini-grid operators).[121] The two most common consumer subsidies are connection subsidies and consumption subsidies.[122] A connection subsidy is a one-time grant that allows a household, business, or public institution to connect to a mini-grid system, while a consumption subsidy (sometimes described as a quantity-based subsidy) is an ongoing subsidy that reduces a customer's cost of consuming electricity by reducing the customer's tariff.[123] Producer subsidies are administratively easier and also allow for greater flexibility in structuring the subsidy.[124] **Table 5** presents different types and sources of producer subsidies; **Table 6** presents eight basic options for structuring/disbursing subsidies for mini-grids.[125]

TABLE 5
Types and Sources of Producer Subsidies

Type	Source
Subsidies that increase revenues	
Feed-in tariffs with premiums	Government/donors/buying utility's customers
External operating subsidies	Government/donors
Tariffs that exceed costs for other customers served by the SPP or for other non-SPP electricity consumers	Other customers from within a tariff class, from other tariff classes, or from customers whose tariffs are not regulated
Subsidies that lower costs	
Connection cost grants	Government/donors/other customers
Customer contributions in aid of construction	Customers
Discounted purchase price on bulk supply tariff	National utility/government/selling utility's other customers
Waivers of import taxes	Government/donors
Concessional/soft loans	Government/donors
Production tax credit	Government
Tax holidays	Government
Guarantees on SPP loan payments	Government/donors
Guarantees that national utilities will pay for electricity supplied by the SPP	Government/donors
Loan buy-down programmes	Government/donors

Source: Tenenbaum et al., 2014.
NOTE: SPD = small power distributor; SPP = small power producer.

119 State of the Global Mini-Grids Market Report 2020.
120 Melnyk, M. and Kelly, A., "Smart Incentives for Mini-Grids through Retail Tariff and Subsidy Design: A Guide for Policymakers," African Mini-Grids Community of Practice and Electric Capital Management, (March 2019): https://southsouthnorth.org/wp-content/uploads/2019/04/Smart-Incentives-for-Mini-grids-through-Retail-Tariff-and-Subsidy-Design_-A-Guide-for-Policymakers_LEDS-GP-FWG-1.pdf
121 Ibid.
122 Consumption or usage subsidies include subsidies built into the tariff structure, such as lifeline tariffs, and subsidies paid to customers for the purchase of energy-efficient appliances and electromechanical equipment
123 Tenenbaum et al., 2014.
124 Melnyk and Kelly, 2019.
125 Excludes pre-investment subsidies, which essentially cover TA to governments and developers such as market and resource assessments, geospatial planning, prefeasibility and feasibility studies.

TABLE 6
Mini-Grid Subsidy Disbursement Options

Capital	Generation	Distribution (including retail)
Input-based	Paid based on the cost of the generation asset, as a percentage of the cost basis	Paid based on the cost of building out the distribution network, as a percentage of the cost basis
Output-based	Paid based on the installed capacity of the generation assets, on a /kW basis	Typically paid based on the number of connections (i.e. mini-grid connected customers Other output metrics may be possible (e.g. the distance of distribution or transmission lines extended) although not currently utilized for mini-grids
Direct supply	Selected key generation assets supplied for free	Distribution assets supplied by and built by an entity that is not the project proponent, and transferred/leased to the project proponent for long-term operation
Operational		
Output-based	Paid based on the energy delivered (/kWh)	Paid based on the number of current customers (e.g. paid on a monthly or annual basis). This has not been utilized as a subsidy mechanism for mini-grids in Africa

Source: Melnyk and Kelly, 2019.

Although a wide range of subsidies have been implemented across mini-grid markets, two main types of government subsidies have driven mini-grid project development to date – up-front capex subsidies and output-based capex subsidies often referred to as RBF. A recent study of 20 mini-grid programmes in Sub-Saharan Africa found that up-front capex subsidies provided via auction programmes are the most utilized mechanism, accounting for 62 percent of all subsidies, while RBF and auction-RBF hybrid programmes account for 24 percent and 14 percent of programmes, respectively.[126]

The value of a subsidy should be high enough to ensure that the mini-grid is sustainable and profitable, but low enough to maximize the impact of limited subsidy resources and motivate the process of cost reduction and local capacity building. Clear sunset clauses of subsidy mechanisms and/or step-by-step reduction mechanisms are important ways of incentivizing the cost reduction of subsidized assets/processes. A recent GIZ study indicated mini-grid capex subsidy needs to be between 50 percent and 80 percent.[127]

Up-front Capital Expenditure Subsidies

Up-front capex subsidies are financial support provided to developers to cover some portion of the total capex of their mini-grid projects prior to construction. This typically involves issuing grants or concessional loans to cover up-front capital costs. Grants can be distributed on an in-kind basis and typically include funding for TA or distribution, generation and metering equipment. In terms of distribution, up-front subsidies can be made available at a fixed rate on a first-come, first-served basis. They may also be disbursed through minimum subsidy tenders/auction programmes.

Up-front capex subsidy auction programmes tend to be administratively complex, requiring substantial resources to be devoted by developers to engage in them. In addition, most mini-grid markets in Sub-Saharan Africa are in their pilot phase and not mature enough to benefit from auction schemes, which are designed to prioritize competition and lower prices – an approach better suited for more mature markets with a sufficient supply of experienced developers. Nevertheless, auction programmes are still the most common type of mini-grid subsidy programmes adopted in the region, with 13 African countries (including Nigeria and Sierra Leone) having launched tenders/auctions to introduce mini-grids that include up-front subsidy components. The popularity of these mechanisms in the region seems not to be based on their ability to lower prices; rather, auctions are popular

126 Phillips, J., Attia, B., and Plutshack, V., "Balancing Competition and Subsidy: Assessing Mini-Grid Incentive Programs in Sub-Saharan Africa," Duke University Nicholas Institute for Environmental Policy Solutions, Policy Brief, (December 2020): https://nicholasinstitute.duke.edu/sites/default/files/publications/Lessons-for-Modernizing-Energy-Access-Finance-Part-2.pdf

127 Peterschmidt, N., Lopez, D., and Füss, C., "A Renewable Energy Mini-Grid Technical Assistance Guide: Take-aways from 15 years of GIZ support in mini-grid market development," Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, (April 2020): https://www.get-transform.eu/wp-content/uploads/2020/06/200602_giz_get_transform_minigrid_rz05_web-min.pdf

largely because they offer developers up-front payment, larger project sizes, and a chance to negotiate terms. Up-front payments provide critical funding that developers need to begin implementation, given that small and medium-sized developers — especially local developers — may not have access to the necessary capital to wait for back-loaded RBF payments.[128] Finally, given the early stages of nearly every mini-grid market in the region, it is likely that the sector would benefit less from competition than from clear subsidies, bankable/consistent regulation, and capacity building. This would support a scale-up phase in the market, which could bring new market entrants, drive down costs, and build the capacity of regulators to allocate market opportunity efficiently.[129]

Results-Based Financing

Results-based financing (RBF) involves payment of specified sums when projects achieve certain verifiable criteria or surpass milestones, typically the number of new connections, although the specified subsidy criteria could include a wide range of variables. The level of support, meanwhile, is usually capped at a specific point – a contract might specify an end goal of 1,000 connections, beyond which no further subsidy is paid out. While implementing RBF can face challenges, it is usually faster than up-front capex subsidies. RBF shifts the risk of project delivery to the private sector.

Commonly-cited challenges of RBF include:[130]

- Developers might still require financing support to achieve early milestones given that RBF payments are back loaded. RBF may preclude smaller/earlier-stage local companies that do not have the means to pre-finance the costs of delivery.
- RBF can introduce market distortions as developers that emerge to take advantage of the market opportunity may become dependent on the continuation of the subsidy for their sustainability.
- Setting the incentive so that it triggers the desired level of activity without (over) subsidizing activities that would have happened anyway can be tricky.
- Higher data collection and verification costs.
- RBF can be very expensive for the funders in case of high demand for it. To prevent runaway costs, countries can cap the incentives.

To date, mini-grid RBF programmes have been/are being implemented in Kenya, Nigeria, Rwanda and Tanzania, while auction-RBF hybrid programmes are being utilized in Niger, Togo and Zambia.[131] Given that most of the RBF schemes currently in operation in the mini-grid sector are new, it will take a few years before their effectiveness is properly understood.[132]

Measurement and verification of results are critical to disbursements under RBF programmes. However, determining the verification approach typically requires a balance between certainty that subsidies are only paid for actual outcomes, and effectiveness (that verification cost and capacity demands or time do not reduce the impact of the subsidy). Funders have to decide on a measurement method, determining who collects the data, when, and how. Data collection by independent third-party evaluators and larger samples typically increase the confidence in the results but are more expensive. Funders also need to choose the verification method, deciding whether to pay for observed results (observational) or results attributable to the subsidy programme (causal). Verification may include a site visit (e.g., for connections), document review (e.g., receipts for costs expended) or data provided to the granting agency (e.g., electricity production data). An analysis of the Global Partnership for Results-Based Approaches (GPRBA) RBF database indicates that observational methods are used in the majority of cases.[133] Remote verification via online platforms such as Odyssey, which leverage smart meters with remote monitoring capabilities to verify new electricity connections and quality of electricity supply, are also being utilized. The verification approach selected should be independent and rigorous enough to ensure the granting agent believes results will be accurately assessed and rewarded/penalized and therefore has the incentive to deliver on them.[134]

On the other hand, private developers face the risk that the subsidies may not be disbursed according to

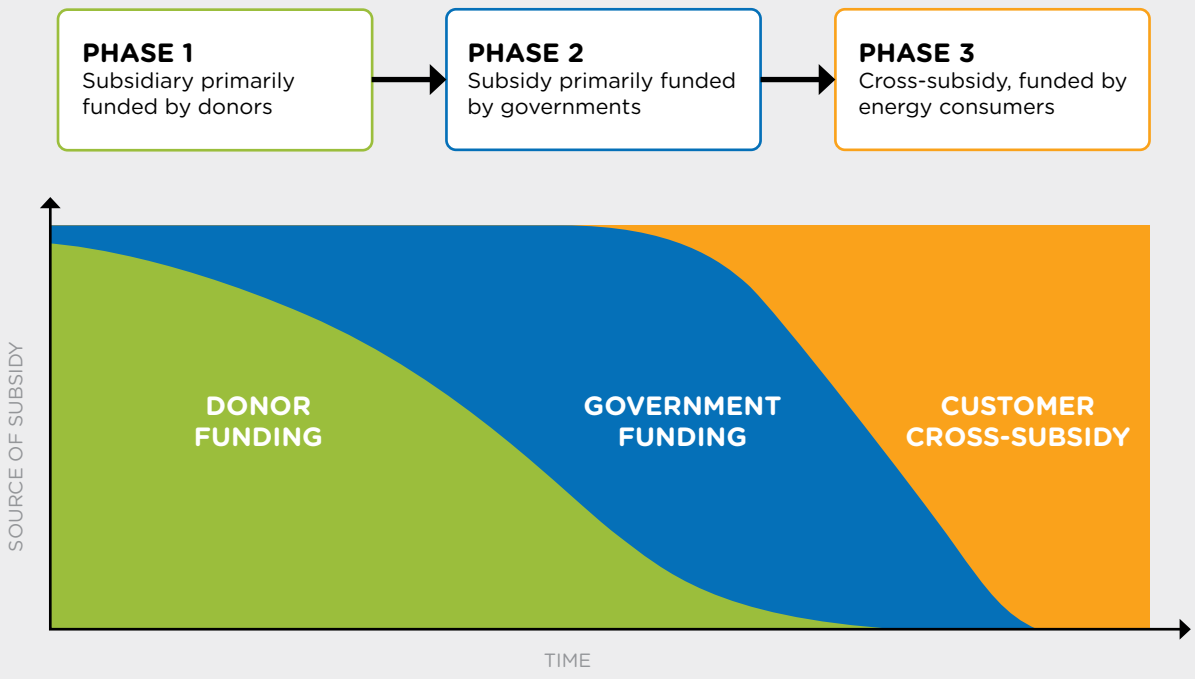
128 Phillips et al., 2020.
129 State of the Global Mini-Grids Market Report 2020.
130 "Funding the Sun: New Paradigms for Financing Off-Grid Solar Companies," World Bank ESMAP, (February 2020): https://openknowledge.worldbank.org/bitstream/handle/10986/33331/Funding-the-Sun-New-Paradigms-for-Financing-Off-Grid-Solar-Companies.pdf?sequence=6&isAllowed=y
131 Phillips et al., 2020.
132 Mini-Grids for Half a Billion People, World Bank ESMAP, 2019.
133 The GPRBA RBF database contains raw information on over 300 RBF projects in developing countries from 1993 to date, and their key characteristics
134 "A Guide for Effective Results-Based Financing Strategies," Global Partnership on Output-Based Aid (GPOBA), (2018): https://www.gprba.org/sites/gpoba.org/files/publication/downloads/2018-11/Guide_for_Effective_RBF_Strategies.pdf

the agreed payment schedules even after results are achieved and independently verified. For an RBF scheme to be effective, it is critical to ensure developers have confidence that there will be no delays in disbursements or non-payment. Otherwise, lack of confidence will result in developers discounting the value of the subsidy and treating it as a bonus, thus reducing its impact. Therefore, definite steps should be taken to build trust with developers in order to maximize the impact of the subsidy. One possible option to build trust is to implement the subsidy programme through a private, third-party agent that has a pre-existing, trusted reputation and a track record of effective and efficient programme management and capital disbursement.[135]

Phase-out Mechanism and Sunset Clause

Overall, regardless of the policy instruments through which subsidies are applied, governments that consider how subsidies will eventually be removed are more likely to propose sustainable support schemes. Timetables for phasing out subsidies following their introduction can vary. In some cases, governments communicate a phase-out plan, with support tapering off as the sector achieves greater maturity. Such reductions can be calibrated according to variables such as the number of registered mini-grids or their overall capacity.[136] A three-phase approach can be used to gradually transition towards a sustainable market (**Figure 16**.) A subsidy scheme can be initially funded by donors, and subsequently by the host government or a mix of both, before the scheme is eventually funded through sustainable cross-subsidies as the country's energy institutions mature and as its energy sector becomes financially viable. This would address concerns that donors and/or governments could get locked into funding subsidies over the long term.[137]

FIGURE 16
Transition to a Sustainable Market for Delivering Energy Access



Source: Nash and Khinmaung-Moore, 2020.

135 Melnyk and Kelly, 2019.
136 Peterschmidt et al., 2020.
137 Nash, S. and Khinmaung-Moore, J., "Designing Sustainable Subsidies to Accelerate Universal Energy Access," A briefing paper on key principles for the design of pro-poor subsidies to meet the goal of sustainable energy for all," Tearfund, (2020): https://learn.tearfund.org/~/media/files/tilz/climate_and_energy/2020-tearfund-designing-sustainable-subsidies-en.pdf

Table 7 presents a comparative analysis of different mini-grid subsidy programmes.

TABLE 7
Overview of Mini-Grid Subsidies

Subsidy Structure	Advantages	Disadvantages
Producer vs. Consumer Subsidy		
Producer Subsidies	• Producer subsidies are administratively easier and enable greater flexibility in structuring the subsidy • Increases funder's certainty that the subsidy is spent on quality energy services	• May lead to perverse incentives and undesired effects
Consumer Subsidies	• Could increase customer empowerment and builds awareness of the real cost of energy	• More complex disbursement/administrative burden
Input-based vs. Output-based Capital Subsidy vs Opex Subsidy		
Up-front Input-Based Capital Subsidy	• Could accelerate implementation, as developers need initial capital. In a business environment where access to finance is a significant barrier to mini-grid development, structuring a subsidy to include earlier disbursement tranches that are matched (timing wise) to capital expenditures can reduce the up-front financing needs of the developer (vs. disbursement upon completion) • Donor control on how implementation is to take place	• Early disbursement can increase risk of non-delivery or late delivery • Inflexibility for developers on how to achieve results • Not result-oriented • Hinders developer's innovation • Up-front capex subsidies are more likely to attract mini-grid developers that are looking at the short term • In conducting due diligence to ascertain the developer's capability and commitment to complete the mini-grid project, granting agencies often require significant documentation that takes time and is costly, both for the mini-grid developer to provide and the granting agency to review
Output-Based Capital Subsidy	• Developers are encouraged/incentivized to deliver rapid results. Less risk of non- or late delivery (compared to up-front subsidy) • Allows flexibility on how to achieve results • Innovation is encouraged • Financial risk associated with the non-delivery of results shifts from the granting agency to the recipient • Increases effectiveness • Focus on results rather than cost incurred • There is less need for detailed documentation to build granting agency confidence in the mini-grid developer	• Increasing responsibility of developers may lead to reduced delivery-quality • Developer may experience difficulties in up-front financing/lack of initial capital • Less donor control of implementation process • Mini-grid developers are wary of subsidies that may be subject to either delay in payment or have a perceived risk of non-payment • RBF is based on number of connections, is likely to encourage developers to focus on more densely populated communities so as to minimize costs (with smaller but more densely developed mini-grid systems) while retaining the same subsidy amount. Dispersed communities are thus less likely to get connected. • In general, the longer and more expensive the verification process, the less connected the subsidy is to the outcomes it is seeking as mini-grid developers will discount the value of the subsidy and deviate less from what they would have done in the absence of a subsidy. Also, the more resources spent by the granting agency to perform verification, fewer resources are available to fund the action that is being subsidized, so the subsidy programme can achieve less overall.
Output-Based Operational Subsidy	• Long-term opex subsidies are more likely to achieve long-term sustainability if the granting agency is able to remain committed to such a subsidy. Opex subsidies improve the unit economics of electricity sold, so the likelihood the mini-grid can continue to at least break even and continue to operate is higher with an opex subsidy.	• May not be feasible without cross-subsidies from grid-connected customers or taxpayers • It is risky for private project operators to place their trust in on-going public financial support given potential changes in policy, budget, and political regimes • Private investors may be reluctant to invest if they have to rely on potentially risky, long-term tariff payments from developing country governments

Source: Nash and Khinmaung-Moore, 2020; Peterschmidt et al, 2020; and Melnyk and Kelly, 2019.

3.2.1.1 Sierra Leone

There are currently no direct end-user subsidy schemes for mini-grids in Sierra Leone, as the proposed tariffs under the RREP are cost reflective.[138] The RREP business model did, however, utilize donor and government funds to cover all of WP-1 construction expenses and also provided an 'in-kind' subsidy to operators by covering the capital costs of the distribution assets under WP-2. The subsidy provided to RREP operators under WP-2 in the form of distribution materials (power cables, poles, etc.) enabled them to charge a lower connection fee to customers.[139] In 2020, the FCDO approved WP-7 to support the reduction of mini-grid tariffs through additional subsidy for non-generation, public assets (namely electricity metering and indoor connection materials) and the reserve account for replacement of WP-1 generation assets (batteries and inverters).[140]

In addition, the Finance Act of 2017 provides duty exemptions on the importation of solar equipment (excluding ancillary materials such as batteries and inverters etc.) that meets IEC global quality standards,[141] and the Finance Act of 2021 provides corporate tax exemptions and a goods and services tax (GST) waiver for mini-grid projects. While these fiscal incentives should ostensibly result in lower tariffs, the process for the 2017 tax exemption is not fully clear and requires the adoption of streamlined procedures to make it simpler for operators to apply for them.[142] The 2021 exemptions have yet to be implemented, so it is too early to draw any conclusions regarding their efficacy.

3.2.1.2 Nigeria

In Nigeria, all mini-grid related subsidies have been producer subsidies. The mini-grid component of the NEP aims to extend electricity services to 300,000 households and 30,000 enterprises in rural areas by 2023. This private sector–led component provides viability gap subsidies to mini-grid developers under two funding windows. The first window will distribute viability gap subsidies to 250 sites selected by the REA through a minimum subsidy tender to help kick-start the industry at scale. Under the second window, developers can apply for PBGs of USD 350 per connection for sites of their choice on a rolling basis.

Mini-grid end-user tariffs in Nigeria range between USD 0.39 and 0.79/kWh for 30–234 kWp solar hybrid mini-grids[143] (distinctions may exist between household and productive-use tariffs in some areas), which reflects the small scale and risk of a typical mini-grid project.[144] While these tariffs are higher than the subsidized non-cost-reflective tariff charged for on-grid electricity, they are typically less than the cost of self-generation by the mini-grid customers and are less than they would otherwise be without the availability of subsidies. These mini-grid tariff levels are possible due to the availability of subsidies, which reduce capital expenditure and unlock financing for mini-grid projects.

Funding in the form of subsidies provided under ongoing programmes such as the World Bank and the African Development Bank (AfDB)-funded NEP, the REA's Rural Electrification Fund (REF), the GIZ-funded Nigerian Energy Support Programme (NESP), the Mini-Grid Acceleration Scheme (MAS), and the Interconnected Mini-Grid Acceleration Scheme (IMAS) among others, supports the development and installation of mini-grids across Nigeria, allowing operators to charge more affordable tariffs.

Table 8 presents a summary of previous and ongoing mini-grid subsidy programmes in Nigeria.

138 AfDB Green Mini-Grid Market Development Programme - Mini-Grid Market Opportunity Assessment: Sierra Leone, 2019.
139 Stakeholder interviews, 2020.
140 http://www.energy.gov.sl/wp-content/uploads/2020/10/Fact-sheet_RREP-Updated-September-2020.pdf
141 AfDB Green Mini-Grid Market Development Programme - Mini-Grid Market Opportunity Assessment: Sierra Leone, 2019.
142 "Sierra Leone: Unlock the Potential for Grid-Connected Solar Power through Private Sector Investment – gap analysis of legal and regulatory framework for solar IPPs," World Bank, (July 2019): http://documents1.worldbank.org/curated/en/794951581398413275/text/Sierra-Leone-Unlock-the-Potential-for-Grid-Connected-Solar-Power-through-Private-Sector-Investment-Gap-Analysis-of-Legal-and-Regulatory-Framework-for-Solar-IPPs.txt
143 NGN 200/kWh [1 USD = 380 NGN]
144 Mini-Grid Investment Report: Scaling the Nigerian Market, Rocky Mountain Institute, 2018.

TABLE 8

Summary of Previous and Ongoing Mini-Grid Subsidy Programmes in Nigeria

Subsidy Programme	Description	Type of Subsidy	Funding Source	Impact & Lessons Learned
Nigeria Electrification Project (NEP) (2018–2023) [145]	**Minimum Subsidy Tender Programme (first window under NEP):** Under this component, with a budget of USD 140 million, the REA has invited private developers to bid for minimum capital cost subsidies to electrify 250 pre-selected (by the REA) communities that have high economic growth potential, thereby providing 110,000 new connections. Mini-grid developers will compete on the basis of quality and price to build, own, and operate solar hybrid mini grids. The grant amount will be determined competitively through the tender. The grant can be above or below the PBG amount of USD 350 per new connection. The grant is expected to be paid out 3 months after the project is commissioned and developers can prove to the REA that the end users are receiving reliable power from their mini-grids.	RBF	World Bank Group, AfDB and Africa Growing Together Fund (AGTF)	As of October 2019, the original list of 64 bidding developers had been culled to 16. It is currently unclear what the subsidy amount resulting from the tender will be and what the resulting tariffs for consumers will be.[146] However, Nigerian developers informed BNEF that they prefer the minimum subsidy tender since the 250 sites are already defined for them, reducing up-front project development costs. All the developers need to do is to validate the information that the REA has given them regarding the predetermined mini-grid sites. Discussions with the REA in December 2020 revealed that there has been a delay in issuing an RFP under the programme because the REA wanted to increase the number of sites from an initial 57 to over 130. The RFP is now scheduled to be issued by the end of January 2021. REA also disclosed that the procurement process has taken a very long time due to discussions with the DisCos operating in the locations that had been identified during the initial data collection process. Some of these locations have existing grid infrastructure (owned by the DisCos), which have not been utilized for the past 10—20 years. In order to avoid litigation in the development of the isolated mini-grids, the REA had to engage the DisCos to obtain data (not always readily available) and ensure the proposed sites were not part of their expansion plans. No mini-grid has been installed under the MST programme to date, so it is too early to draw clear lessons. It remains to be seen if this auction-based approach will improve value for money and encourage innovation to drive down costs.
	Performance-based Grant (PBG) Programme (second window under NEP): Under this component, USD 80 million of IDA funds is allocated to providing PBGs to developers to electrify communities of their choice. The programme, administered by the REA, aims to deploy 580 mini-grids, delivering 230,000 new connections. Developers are required to carry out geospatial studies, energy audits and community surveys to select their proposed viable sites. Grants of USD 350 per new connection are available on a first-come, first-served basis, with a minimum total grant request of USD 10,000 per mini-grid (with about 29 connections per mini-grid at minimum). The grants will be disbursed upon verification that customers have been connected to the network and have been provided satisfactory service.	RBF	World Bank Group, AfDB and Africa Growing Together Fund (AGTF)	Interviews with the REA revealed that as of December 2020, of the 29 developers that have gotten to the evaluation stage of the programme, 20 have been approved (8 of these have signed grant agreements, while 12 are yet to sign), while 6 are under review and 3 are awaiting clarifications. In addition, 14 out of the 20 approved developers have submitted a total of 144 sites to be vetted by the REA. Of these, 71 have been approved, 12 are under active review, 34 are awaiting clarification, 23 have become inactive while 4 were rejected. To date, grant agreements have been signed for 59 out of the 71 approved sites. The REA also disclosed that, of the 59 sites, 6 solar hybrid mini-grids with a total capacity of about 500 kWp providing 3,000 connections, have been commissioned in Niger, Plateau, Bayelsa and Ondo states by 4 developers.[147] Tariffs charged by these mini-grids range between NGN 150/kWh and 300/kWh (USD 0.39-0.79/kWh), with an average of about NGN 220/kWh (USD 0.58/kwh). According to the REA, there have been minimal complaints from the communities regarding tariff affordability, with operators recording 90–95% collections, and it is believed that as consumers become more aware, they will learn to adjust their usage patterns to minimize their energy costs. To date, access to finance, exacerbated by exchange rate fluctuations, has been a key challenge. Initially, the grants were to be paid out after 90 days of satisfactory operation of the mini-grids, however, in order to provide some cushion — especially in light of the COVID-19 pandemic — the developers now get 40% of the grants up front, while the balance is paid after 90 days according to the original payment schedule. This is also being addressed by the newly-introduced Solar Connection Intervention Facility, which provides long term low-interest credit facilities to developers.[148] In addition to the access-to-finance barrier, some of the developers lacked the capacity to prepare proper documentation required to access the grants. Technical support is being provided in this regard to build the capacity of these companies. In addition, the REA has the developers' meters synced with its system on Odyssey, enabling remote monitoring of the mini-grid installations. This potentially reduces the cost of verification. As of now, the programme is far behind schedule with only 3,323 connections against a first-year target of 30,000 connections, which can be partly attributed to reduced activity during the months of COVID-19 lockdown. However, the REA expects to get back on track in 2021 with 35,000 connections in the pipeline. Overall, the programme is still at an early stage of implementation, so it is not yet possible to draw clear conclusions and lessons from it.[149]

145 In response to COVID-19, a third mini-grid component has been created under the NEP aimed at electrifying primary healthcare centres. In April 2020, four solar hybrid mini-grids were handed over to authorities at COVID-19 health facilities in the country. *See*: https://rea.gov.ng/press-release-rea-electrifies-four-covid-19-health-facilities-solar-hybrid-mini-grids/

146 Peterschmidt et al, 2020.

147 These include a 64 kW mini-grid installed by PowerGen; two 67 kW mini-grids installed by Renewvia; a 234 kW mini-grid installed by GVE; and two other mini-grids installed by A4&T.

148 https://rea.gov.ng/solar-power-naija/

149 Stakeholder interviews, 2020.

Subsidy Programme	Description	Type of Subsidy	Funding Source	Impact & Lessons Learned
Rural Electrification Fund (REF)	The REF, administered by the REA, provides capital grants and technical support to rural mini-grid developers selected through an open competitive bidding process.[150] For isolated or interconnected mini-grids up to 1 MW, selected developers will receive grants ranging between USD 10,000 and 300,000 or 75% of the total capital costs[151] of the project (whichever is less) through the REF, to support deployment under commercial PPP arrangements towards accelerating access to electricity to rural and underserved areas across Nigeria. The grants will be disbursed in 3 installments prefaced on verifiable milestones as follows: 35% mobilization after signing a RBF Grant Agreement; 35% after verification of delivery of equipment at project site; and final 30% after verification of customer connections and quality of service. The grants shall be calculated based on the number of planned connections and the quality of electricity service that the grant beneficiary plans to provide to the beneficiary community in line with the SE4ALL Multi-Tier Framework for Measuring Energy Access. The selected developers will own the projects as they would be responsible for providing the remaining project capital cost both in the form of equity and debt.[152] The REF issued its first grant call in December 2017, and a total of approx. USD 2.5 million (NGN 956.9 million) was approved for 12 mini-grids ranging between 30kw and 100kw, electrifying 5,528 households with a total installed capacity of 1,016kW.[153] The second grant call (request for EoIs) was issued in July 2020, and the request for proposals (RFP) stage was expected to close by January 2021.[154]	Up-front Capital Subsidy & RBF	FGN	According to the REA, the REF supports only projects that would have been economically unviable without the grant support. As of December 2020, 11 of the 12 mini-grids had been completed,[155] while the last one is at 90% completion and expected to be commissioned in early 2021. Tariffs charged by the 11 solar hybrid mini-grids deployed to date range between NGN 120 and 150/kwh (USD 0.32–0.39/kwh). According to the REA, the tariffs are within reasonable limits and the communities are generally positive about the service provided. The complaints on tariffs so far have been mainly from 3-phase users (using heavier equipment). Currently, the capacity utilization rate of the completed projects ranges mainly between 30% and 60%, with one project below 30%, showing that the mini-grids are underutilized. To date, only one out of all the completed projects has been able to access the final tranche of the grant payment, which is based on achieving the number of connections stated in the grant agreement. The successful developer commissioned the project in 2019 and went the extra mile to stimulate demand by building a rice processing plant, pumping water and providing milling/grinding machines on a pay-as-you-go (PAYG) basis, thereby enhancing the purchasing power of the community. On the other hand, most of the other developers simply installed mini-grids without stimulating demand, leading some to lose connections rather than gain them. This clearly underscores the need for TA to developers in stimulating end-user demand. In addition, while all selected bidders signed grant agreements on the same day in January 2019, the implementation speed varied with some mini-grids deployed in 2019, some in 2020 and the final one will only be completed in 2021. The delays can be attributed to several factors. The developers that had access to finance from development finance institutions (DFIs) were able to move faster than others. Some of the projects were also affected by the border closure and the COVID-19 crisis, while others faced regulatory challenges from local authorities and community delays.
Nigerian Energy Support Programme I (NESP I) (2013–2018)	NESP I, implemented by GIZ, piloted the development of 6 off-grid solar mini-grids (50-100 kWp) in collaboration with 5 local private companies in 2017–2018 using a PPP and split-asset model. Through this model, the developers own the power generation systems (power plant) while the communities/states own the distribution assets, which are funded by capital grants provided by GIZ and account for roughly half of the total project capital expenses. In addition, the capital costs of the initial end-user connections were also covered by the capital subsidy.[156] On the other hand, the private companies covered the remaining 50% of the project's capital costs (for movable assets) with their own equity and project finance. In collaboration with the USAID REEEP, the NESP also provided TA in unlocking access to finance for the projects.[157]	Up-front Capital Subsidy	EU and the German Government	The 6 mini-grid projects are currently operational and are providing nearly 16,000 people (3,147 households) with reliable access to electricity. The tariff structure of these projects as of July 2018 is shown in **Table 9**.[158] The end-user tariffs for these projects range widely from NGN 150-300/kWh (USD 0.39-0.79/kWh). Interviews with Rubitec, one of the developers under the programme, revealed that GIZ provided a grant of EUR 200,000 that covered 42% of the total capital cost of its 85kW mini-grid. The programme also experienced delays as an economic collapse in the country and devaluation of the naira in 2015 practically halted the programme for 2 years and the projects could not access financing. Rubitec had initially planned to commission its mini-grid in September 2016; however, the project was not commissioned until February 2018. It is worth noting that the TA provided to the developers in accessing finance was critical in resolving this issue. Furthermore, in order to stimulate demand and improve the capacity utilization of its mini-grid, Rubitec has also had to provide some equipment financing for PUE.[159]

150 Mini-Grid Investment Report: Scaling the Nigerian Market, Rocky Mountain Institute, 2018.
151 Capital costs include hard and soft costs such as project development and logistics costs.
152 Rural Electrification Fund Operational Guidelines 2017, REA, October 2017.
153 Ohiare, S., "Look to Africa, the mini-grid market is competitive," ESI Africa, (March 5, 2020): https://www.esi-africa.com/industry-sectors/renewable-energy/look-to-africa-the-mini-grid-market-is-competitive/
154 Nigeria REA: https://rea.gov.ng/addendum-request-expression-interest-ref-grant-2020-ppp-model/
155 Ten of these have been commissioned while one (already operational) was set to be commissioned by the end of December 2020.
156 Stakeholder interviews, 2020.
157 Mini-Grid Investment Report: Scaling the Nigerian Market, Rocky Mountain Institute, 2018; and Warren, 2018.
158 GIZ Nigerian Energy Support Programme II: https://www.giz.de/en/worldwide/26374.html
159 Warren, 2018; and Stakeholder interviews, 2020.

Subsidy Programme	Description	Type of Subsidy	Funding Source	Impact & Lessons Learned
Mini-Grid Acceleration Scheme (MAS)	MAS is a nationwide, non-site-specific, open competitive tender implemented by the REA designed to select mini-grid companies to construct isolated mini-grids up to 1 MW, providing 21,000 new connections. The MAS tender aims to promote productive-use business models for mini-grids to be operated on a commercial, public-private partnership basis. The REA announced the results of the MAS in October 2019. The 4 winners of the tender will be supported in deploying their proposed mini-grid projects with an in-kind partial capital grant – in the form of distribution and metering equipment – and TA valuing a total of EUR 6 million. All assets (granted and privately financed) will be installed and tested by the selected bidders.	In-Kind Up-front Capital Subsidy	EU and the German Government through the Nigerian Energy Support Programme II (NESP II)	According to the REA, the mini-grids will be delivered at an affordable tariff that would have been economically unviable without the scheme.[160] The REA initially aimed to get these projects online by the end of July 2020, however, no project has been installed to date. The REA team disclosed that the scheme has been significantly delayed because the selected developers realized that the grants provided would be inadequate so they decided to change the delivery mode from isolated mini-grids to interconnected mini-grids. Consequently, the required DisCo negotiations have delayed the process. As of now, the scheme is in the techno-economic assessment stage under which the sites proposed by the selected bidders are being vetted by the REA prior to implementation. While it is too early to draw conclusions, a key takeaway so far from this scheme is that it is important to ensure the value of the subsidy provided is high enough to achieve programme goals.
Interconnected Mini-Grid Acceleration Scheme (IMAS)	Similar to the MAS, the IMAS is a nationwide non-site-specific open competitive tender implemented by the REA targeted at selecting developers to design, construct, commission and operate interconnected solar-based mini-grids of up to 1MW serving 15,000 customers (in grid-connected but poorly-served communities in Nigeria) on a commercial public-private partnership basis, in partnership with interested DisCos. In April 2020, the REA announced the results of its IMAS tender and 7 developers were selected to partner with 7 DisCos. The winners will be supported in deploying their proposed interconnected mini-grid projects with in-kind partial capital grants totaling EUR 3 million covering meters and up to 50% of grid refurbishment/ extension (cables and poles) in addition to TA. Selected bidders under the IMAS will install all assets (granted and privately financed) and test them.[161]	In-Kind Up-front Capital Subsidy	EU and the German Government through the Nigerian Energy Support Programme II (NESP II)	The REA initially aimed to get these projects online by the end of September 2020, providing end users with affordable electricity tariffs. However, no project has been deployed under the scheme to date. Presently, the scheme is in the TA phase where developers work closely with the DisCos to fine tune the project, get approvals, work on tariffs, distribution use of service charge, etc. The 7 developers are currently at different stages, with a couple well ahead of the others and almost ready to proceed to implementation. It is thus too early to draw any conclusions/lessons learned.

Source: Nash and Khinmaung-Moore, 2020; Peterschmidt et al, 2020; State of the Global Mini-Grids Market Report 2020; and stakeholder interviews.

160 State of the Global Mini-Grids Market Report 2020.
161 Ohiare, 2020.

TABLE 9

Nigerian Energy Support Programme I: Mini-Grid Project Overview

Developer	Location (Community)	Local Government Area	State	kW capacity[162]	Number of connections	Tariff Structure (NGN/kWh) [163]	O&M (NGN/ month)	Capacity Utilization (%)[164]
CREDC	Umon Island	Biase	Cross River	50	100	200 (USD 0.53)	140,000	5
Nayo Tropical Technology Ltd.	Tungan Jika	Magama	Niger	100	300[165]	140 (USD 0.37)[166]	50,000	20
Rubitec Solar Ltd.	Gbamu Gbamu	Ijebu-East	Ogun	85	500	180 (USD 0.47)	125,000	47
GVE Projects Ltd.	(i) Angwan Rina (ii) Demshin	Shendam	Plateau	100	250	288 (USD 0.76)	32,500	9
GoSolar	Kurdula	Gudu	Sokoto	80	500	200/300 (USD 0.53/0.79)[167]	80,000	80

Source: Rocky Mountain Institute, 2018.

Interviews with the REA revealed that the developers prefer up-front grant disbursements (not in-kind), particularly in an environment where access to finance is a major barrier. The REA opines that both up-front capital subsidies and RBF have their merits depending on desired results. It stated that in order to achieve accelerated deployment of systems, which is the objective of the MAS and the IMAS programmes, up-front capital subsidies are the best option, as developers need initial capital. Yet the actual experience from the implementation of the MAS, IMAS and REF programmes so far seems to prove this is not always the case as there have been significant delays due to various factors. In order to achieve the best standard and quality of service, an RBF mechanism is preferred, as developers must meet predetermined performance standards in order to access the subsidy. As an implementing agency seeking sustainable results and aiming to gradually shift the sector away from reliance on grants, the REA has a preference for RBF.[168]

The NEP is still at an early stage of implementation, so it is not yet possible to draw clear conclusions and lessons learned from the programme. Nevertheless, lessons from other RBF programmes show that a lack of foresight in addressing long-term maintenance requirements has undermined many schemes. This is evident in the UK-funded RBF scheme in Tanzania, where two service providers benefitting from the programme have left the market, and institutional systems installed under the programme have suffered from technical system failures, with poor maintenance provision highlighted as a challenge.[169]

3.2.2 Summary of Findings

Table 10 presents a comparative analysis of previous and ongoing mini-grid subsidy programmes in Sierra Leone and Nigeria.

162 Five of these projects use 100% solar generation with battery storage, while one project is a solar-diesel-battery hybrid.
163 Based on an exchange rate of 1 USD = 380 NGN.
164 Based on number of connections as of July 2018; several projects were only recently commissioned at the time and are expected to have significantly increased their capacity utilization over the past two years.
165 Subsequently expanded to 765 connections.
166 Fixed tariff is NGN 140 per kW with option of variable tariff of NGN 120 daytime and NGN 200 nighttime. https://www.esmap.org/sites/default/files/Presentations/ENGAGING%20THE%20STATE_WORLD%20BANK%20MINIGRID%20ACTION%20LEARNING%20%20EVENT_PPT.pdf
167 Tariff structure differentiated by commercial and household users, respectively.
168 Stakeholder interviews, 2020.
169 Peterschmidt et al, 2020.

TABLE 10

Mini-Grid Subsidy Schemes: Summary of Findings

Indicator	Sierra Leone (RREP)	Nigeria (Multiple Programmes)	Lessons Learned
Speed of delivery	Similar to most programmes of its size, scope and ambition – the RREP is complex in its design, involving lengthy and expensive negotiation and financing processes that require significant resources to manage (both for developers and regulators)	• **NEP**: The first mini-grid deployed under the NEP was commissioned in December 2019 just 3 months after the project's grant agreement signing under the PBG programme and 9 months after it was launched. However, it is worth noting that as of now, the programme as a whole is way behind schedule. • **REF**: The first grant call was issued in December 2017 and grant signing did not occur until January 2019, while most of the projects were not built until 2020. • **MAS/IMAS**: The tender results for the MAS and IMAS were announced in October 2019 and April 2020 respectively. However, both are still yet to enter the implementation phase. • **NESP I:** The programme received proposals in 2015, however, the mini-grids were not built until 2018.	**Sierra Leone:** • Programme delays were largely attributed to extended application processes to obtain licenses and other permits, as well as to ongoing general elections in Sierra Leone in early 2018. • Continuous learning by doing (by regulators, developers and communities) and the subsequent refinement and streamlining of permitting/contract negotiation processes is a key lesson learned. **Nigeria:** • According to the REA, the transparency and speed of the NEP process is due to the e-procurement method utilized in collaboration with Odyssey.[170] This could not have been achieved through traditional manual methods.[171] Nevertheless, the NEP has faced delays due to other factors besides COVID-19 such as lack of access to finance, developers' limited capacity and engagement with DisCos. • One of the key takeaways from the experience so far in Nigeria is the need for some early disbursement of subsidies as was done under the NEP PBG to reduce delays due to financing difficulties. Also, there is a need for provision of concessional local currency loans as well as TA to support developers in accessing the finance needed to cover the portion of capex not covered by subsidies. • In addition, the experience with the various auction programmes in Nigeria (MST, MAS, IMAS, REF) just like the RREP shows that the auction structure is more prone to delays.
Tariff Reduction	**RREP**:[172] • **WP-1, Year 1 (2019-20):** USD 0.82 – 0.87/kWh; average of USD 0.85/kWh • **WP-1 and WP-2, Year 2 (2020-2021):** USD 0.74/kWh – 0.82/kWh; average of USD 0.79/kWh	• **NEP and NESP I:** USD 0.39-0.79/kwh (NGN 150 – 300/kwh); average of USD 0.58/kWh (NGN 220/kWh) • **REF**: USD 0.32-0.39/kwh (NGN 120 and 150/kwh)	• In Sierra Leone, WP-7 was approved by the FCDO in 2020 to support the reduction of mini-grid tariffs through additional subsidy for non-generation, public assets (electricity metering and indoor connection materials), and the reserve account for replacement of WP-1 generation assets (batteries and inverters). • In the case of Nigeria, there is a direct correlation between the level of subsidy and tariffs. A comparison of the REF and NEP PBG programmes shows that REF subsidies cover 50-70% of capex while the NEP PBG covers only about 30%. As a result, tariffs for NEP sites are between 25% and 108% higher. It is worth noting that there are other factors that influence tariffs, including location, presence of productive uses, cost of financing, site accessibility etc.

170 Odyssey Energy Solutions is a web-based data platform to simplify, streamline, and reduce the costs of developing and financing mini-grids in emerging markets.

171 "Case Study: Nigeria Electrification Project," Odyssey, (18 December 18 2019): https://www.odysseyenergysolutions.com/2019/12/18/nigeria-electrification-project/

172 NOTE: These tariffs only reflect the RREP; other mini-grid projects in Sierra Leone (e.g., PRESS-D) may charge different tariffs.

Indicator	Sierra Leone (RREP)	Nigeria (Multiple Programmes)	Lessons Learned
Economies of Scale	• Projects planned and financed on a one-off basis	• Under the NEP MST, each winning bidder will potentially develop and finance 40–50 mini-grids	• Operators in Sierra Leone opined that the RREP did not allow them to take advantage of economies of scale. • In Nigeria, discussions with the REA revealed that it would like to see the private companies develop 20–30 mini-grid sites to realize economies of scale that can potentially lead to a reduction in tariffs. This led to the consideration to allow winning bidders under the NEP MST to develop 40–50 sites together. The cost reduction impacts of this mechanism are yet to be assessed.
Construction Quality	• WP-1 systems not installed by operators; for WP-2 developers will procure and install generation assets	• Under all programmes, all assets (granted and privately financed) are installed and tested by operators in accordance with the technical and safety standards and guidelines set forth in the NERC Regulation for Mini-Grids	• In contrast to the RREP programme in Sierra Leone, subsidy recipients under the various programmes in Nigeria were responsible for installing and testing all assets.[173] • In Sierra Leone, there was a substantial delay between the time the systems were installed and the sites were electrified (mainly due to delays in the tendering process), which led to the capacity reduction of batteries. The MoE and UNOPS have since worked with the operators to address this.

Source: Nigeria REA; State of the Global Mini-Grids Market Report 2020; and stakeholder interviews.

3.3 Recommendations for Sierra Leone

RREP Programme Design/Structure

- **Introduce Subsidy Schemes and other Supportive Financing Arrangements:** Serving rural low-income customers who typically use very little electricity requires some form of subsidization; rural community surveys indicated that tariff affordability was a key barrier. It is recommended that the GoSL and its development partners therefore consider implementing appropriate subsidy schemes (see **Section 2.4**) to ensure that rural customers achieve access.

  When interviewed, operators indicated that the pre-financing mechanism under the RREP was not necessarily their preferred approach, as they would have preferred an alternative structure that may have provided them with more flexibility.[174]

  › A traditional Design-Build-Operate (DBO) model (see **Key Definitions**) would have been preferred by the operators vis-à-vis the approach taken by the RREP, which engaged with national contractors to complete WP-1 construction works.[175] While the logic behind this approach is sound — i.e., the desire to increase local participation in mini-grid sector development — it led to challenges for the operators. Going forward, a recommendation would therefore be to instead follow a more conventional DBO approach — whereby government finances the construction through a direct capital subsidy to the international developer — and to subsequently take measures to develop local mini-grid sector capacity following successful implementation of a pilot phase fully implemented by international firms, thus ensuring best international practices and associated knowledge transfer.

  › Providing government guarantees to support mini-grid project developers is another recommended approach to ease the cost of project financing. The GoSL, with support from its development partners, could provide concessional loans in local currency to offset a portion of costs (perhaps through a revolving fund mechanism). Government involvement in pre-financing can also seek to lower risk premiums from the commercial banking sector, which can provide access to affordable financing in local currency, and in turn reduce the need for subsidies and grants and encourage long-term commercial sustainability of the sector.

173 http://rea.gov.ng/wp-content/uploads/2019/05/Overview-of-IMAS-CfP.pdf
174 Stakeholder interviews, 2020.
175 Ministry of Energy - Rural Renewable Energy Project: http://www.energy.gov.sl/home/rural-renewable-energy-project/

- **Reduce Programme Complexity**: When interviewed, operators suggested that the RREP — similar to most programmes of its size, scope and ambition — is complex in its design, involving lengthy procedures that require significant resources to manage. A simplified process was recommended, with the GoSL taking on more of an oversight role in the market to ensure electrification targets are achieved and private operators are providing affordable, reliable and quality-verified electricity service. Recent and ongoing experience from the Nigerian market also highlights the importance of streamlining processes through the use of data analytics and e-procurement tools.

Tariff Affordability

- The results of the UNOPS community survey process found that average retail tariffs of USD 0.85/kWh were cheaper than the alternatives end users were currently utilizing for energy access (including for lighting, mobile phone charging and purchasing of kerosene and/or lanterns). Hence, the inefficient use of energy from the mini-grid likely contributed to misperceptions surrounding affordability, which suggests that more resources and efforts need to be made by both the public and private sector to sensitize communities, raise awareness, and educate consumers around energy consumption and electricity usage (especially vis-à-vis monthly expenditures), the benefits and cost-savings of mini-grid electrification etc.

Subsidies

- **Up-front Grant/RBF Scheme**: While the subsidy design approach utilized under the RREP may have been necessitated by the nascent stage of the market, the absence of established private sector players, and the lack of data on usage patterns, operators suggested that up-front capital (not in-kind) grants/subsidies (per kWh or percentage of capex) or an RBF scheme should be adopted going forward.[176] These are considered to be simpler and less time-consuming approaches (as seen in the fast implementation of some of the projects supported by the NEP PBG programme), which would in turn allow for greater possibility of reducing project development costs and lowering end-user tariffs, while also providing clarity to private partners and clear benchmarks for GoSL on costs of decentralized vs. central grid expansion. A private sector-driven model such as this is much simpler in its design and structure than the top-down approach adopted by the RREP. Such an approach would drastically reduce the contractual complexity of the existing PPP arrangements. Taking into consideration lessons from the NEP PBG programme, where some portion of the RBF payments have been converted to up-front payments, it is recommended that an up-front capex subsidy-RBF hybrid model be adopted, ensuring that the value of the subsidy is high enough to achieve tariff reduction. This should be structured such that all construction and procurement is carried out by private partners with approval from a TA partner such as UNOPS. It was also suggested by one of the operators that in the long term, this becomes a rolling fund to support sustainable market development.

Cost Reductions[177]

- According to several operators, the complex PPP contract structure — particularly permits associated with land leasing — results in a lengthy/expensive negotiation and financing process and creates more likelihood of project delays, which leads to higher costs as wages have to be paid regardless. Adopting a simplified and consistent framework/process across the relevant public agencies will reduce costs.
- Another suggestion was to increase the number of sites managed per operator to further reduce costs and tariff levels, as fixed costs are spread over far larger volumes of kWh sold. Operational costs are fixed with only approximately one-third of costs having a degree of variability driven by the number of sites/customers.
- There is also a greater need for proper customer demand estimation as an inadequate assessment of power demand led to underutilization, thus driving up costs.

Applicable Lessons/ Recommendations from Nigeria

- One of the ways through which tariffs can be reduced is by providing access to affordable financing to

176 It is worth noting that developers would generally prefer up-front capital grants to an RBF scheme due to difficulties in financing the full costs of delivery up front. However, in cases where the up-front subsidy schemes are too complex resulting in higher costs (such as the RREP) the developers interviewed would prefer a simpler mechanism such as RBF.

177 It should be noted that there is no single, silver bullet to reducing costs and increasing tariff affordability in a nascent mini-grid sector. While subsidies can be an important market driver, all of the measures listed here are important and play a role in reducing costs and risks across mini-grid project value chain activities – from planning, engineering, finance, development and installation, to operation. As mini-grid markets develop, initial subsidy measures need to be revised or replaced to meet the evolving demands of a more independent and mature sector.

developers in local currency, which the FGN is starting to do with the support of SEforALL.

- Mini-grid developers in Nigeria focus heavily on PUE. Technical and financial assistance can be provided to mini-grid developers to stimulate PUE and revenue-generating activities in mini-grid communities (e.g., in the form of equipment financing).[178]
- In Nigeria, the REA is collaborating with developers to find innovative ways of reducing costs and improving service. Opportunities include reduced import duties on solar products and components, integrated hardware and software packages, improvements in modular capacity, development of specialized local project development and management expertise, aggregated financing solutions, and a focus on end-use service instead of power consumption.[179]

178 This is already being pursued under WP-6 of the RREP with funding from the FCDO.
179 Carlin, K., "Growing the Mini-Grid Market in Sub-Saharan Africa," Rocky Mountain Institute, (20 March 2017): https://rmi.org/growing-minigrid-market-sub-saharan-africa/

Long-term Vision and Market Certainty

- Going forward, with support from UNOPS, the FCDO and other development partners, it is recommended that the GoSL develops and implements a coherent long-term strategy that builds upon the strong foundation of the RREP and the existing regulatory framework and aligns the priorities of all market actors — government, developers, end users, and financiers — to expand mini-grid electrification in the country. This can be in the form of a *master plan* but should include clear national targets for mini-grid expansion in the long term. This will provide clarity and predictability to mini-grid market players – notably for investors and companies who need to consider multi-year plans involving significant capital expenditure or borrowing.
- Sierra Leone has already established a strong and supportive policy and regulatory framework, and developers have praised the country's robust enabling environment. Yet a long-term vision is needed to provide further market certainty, foster private sector participation, de-risk and mobilize mini-grid financing, and stimulate market development.
- Given that a lack of access to affordable financing is a recurring challenge in the market, it is also recommended that future mini-grid programme designs incorporate TA for developers to help them access capital and also work with the commercial banking sector in Sierra Leone to develop mini-grid lending capacity in local currency. This effort can build on the USAID-funded Climate Economic Analysis for Development, Investment, and Resilience (CEADIR) programme, which engaged with local commercial banks from 2016 to 2018 to develop their clean energy lending capacity, with a focus on the stand-alone solar and mini-grid market segments.[180]

Evolutionary Regulation

Evolutionary regulation involves designing a regulatory framework that evolves as the market develops. This includes defining the market growth phases and spelling out, in advance, the regulations that will apply at each stage. This approach allows operators greater initial freedom through light-handed regulation, with regulation gradually becoming more stringent as the market matures.[181] Sierra Leone should consider adopting a flexible and evolutionary approach to mini-grid development (**Table 11**).

TABLE 11
Evolutionary Regulation for Mini-Grid Market Development

STAGE 1: START-UP PHASE	STAGE 2: GROWTH PHASE	STAGE 3: MATURE or LOCALIZED MARKET DOMINANCE PHASE
• Light-handed regulation is applied • Only registration is required • Operators to set their tariff freely, under a "*willing buyer, willing seller*" regime • Regulation of technical standards is limited to that of safety and grid-compatibility • Government may consider implicit subsidies and viability-gap subsidies e.g., the use of capital subsidy, tax exemptions etc.	• Regulator notes that existing mini-grids are gaining 'market power' and more developers are coming online; this is when tighter regulation of tariffs and service standards will kick in • Market entry regulation will still be through simple registration • Regulator can now set tariffs at a level estimated to be the cost of service of an efficient new entrant/operator (similar to incentive and benchmark regulation) • Regulator may set minimum service levels but leave the regulation of technical standards unchanged • Government may provide capital-cost and connection subsidies	• Characterized by regulation of tariffs and further tightening of service standards • Regulator uses individual and specific, cost-based tariff limits, because an efficient new-entrant price could lead to monopoly pricing and rent • Regulator may opt for grid-level service standards to ensure that service for all customers is equal • Government may continue to provide connection subsidies for low-income customers • Government may decide to provide energy subsidies to reduce the cost of electricity for all mini-grid customers or align mini-grid tariffs with the national grid tariff (e.g., national uniform tariff)

Source: World Bank, 2019.

180 USAID CEADIR: https://www.climatelinks.org/resources/renewable-energy-lending-west-africa
181 "Ensuring that Regulations Evolve as Mini-Grids Mature," World Bank Energy Sector Management Assistance Program, (2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31773/Ensuring-That-Regulations-Evolve-as-Mini-Grids-Mature.pdf?sequence=1&amp%3BisAllowed=y

Table 12 provides a summary of recommendations in relation to mini-grid policy and regulatory framework development, tariff-setting and subsidy mechanism design.

TABLE 12

Recommended Regulatory, Tariff-Setting and Subsidy Mechanisms for Sierra Leone

Indicator	Summary of Recommendations
GoSL policymakers should…	
Policy and Regulatory Framework	• Develop and implement a coherent **long-term strategy** that builds upon the strong foundation of the RREP and the existing regulatory framework and aligns the priorities of all market actors — government, developers, end users, and financiers — to de-risk and mobilize mini-grid financing and expand mini-grid electrification in the country. This can be in the form of a '**master plan**' but should include **clear national targets for mini-grid expansion in the long term**. This will foster private sector participation and provide clarity and predictability to mini-grid market players, notably for investors and companies who need to consider multi-year plans involving significant capital expenditure or borrowing. • **Expand internal capacity of the MoE** and/or create either a separate **directorate within the MoE** or an entirely new **rural electrification agency** dedicated to managing the rollout of a national mini-grid programme, with a long-term vision and targets in order to provide clarity and predictability to mini-grid market players • Adopt policy and planning approaches that create opportunities for developers to take advantage of **economies of scale** (with fixed costs spread over far larger volumes of kWh sold) to reduce costs and expedite market development (i.e., allow for a **bottom-up approach** to coexist in the market) • Develop and implement programmes providing technical and financial support to mini-grid developers to stimulate **PUE** and revenue-generating activities in mini-grid communities, which provides anchor clients for mini-grid power supply and increases customer income levels and purchasing power (see **Section IV**) • **Streamline import duty exemptions** for solar equipment, including the adoption of clear guidelines for all relevant public institutions; consider expanding the existing import duty exemptions to cover ancillary equipment such as distribution equipment, inverters and batteries to further reduce development costs • Implement policy measures to **ensure standards/quality** of equipment in the off-grid/mini-grid sector • Support local market growth through collaboration with the Renewable Energy Association of Sierra Leone (**REASL)** (e.g., to certify and train local entrepreneurs), as the use of local suppliers and engineers will reduce project development costs
Tariff Setting	• Utilize available supporting data to propose a **benchmark return** on equity based on existing market conditions in Sierra Leone (or financing opportunities for mini-grids internationally) to simplify the tariff review process and provide a **clear market signal to developers** on the profitability of their potential investments • Make explicit the required subsidy to reach a certain tariff (e.g., via RBF, per kWh or % capex subsidies), that would provide clarity to the private sector and clear benchmarks for government on costs of decentralized electrification vs. central grid expansion
Subsidy Mechanisms	• Adopt an **up-front cash grant/RBF hybrid scheme** (as opposed to an 'in-kind' subsidy) to reduce project development costs and potentially lower tariffs; the hybrid structure will reduce developers' up-front capital constraints while also ensuring quality of service as developers are fully paid based on the deployment and verification of the connections; the value of the subsidy should be high enough to achieve tariff reduction • Adopt a **simplified, streamlined and consistent process** across all relevant public agencies to **reduce complexity** and the amount of time/resources required of developers • Adopt a **framework contract** that can be used on an ongoing basis to streamline project approvals and save time and reduce project delays/costs • Design subsidy programmes to **ensure quality of construction** by making developers/subsidy recipients responsible for installing and testing all mini-grid assets (under the RREP, issues during the construction phase of WP-1 sites led to an increase in O&M and project development costs) • Incorporate **long-term maintenance** of mini-grids in subsidy design • Provide **TA** to developers to help them access available financing • Utilize **data analytics and e-procurement** to increase transparency and speed of project delivery • Consider how subsidies will eventually be removed; a **3-phase approach** can be adopted to gradually transition towards a sustainable market (see **Figure 16**)
Long-term Market Sustainability	• Develop and launch a long-term rolling fund providing **local currency debt financing** to the market (much like the Nigeria Infrastructure Debt Fund), which will help address access-to-financing challenges and enable mini-grid businesses to grow/reduce tariffs. • Provide **TA and capacity building for the local commercial banking sector in Sierra Leone** to develop mini-grid lending capacity in local currency. This effort can build on the USAID-funded CEADIR programme, which engaged with local commercial banks from 2016 to 2018 to develop their clean energy lending capabilities, with a focus on the stand-alone solar and mini-grid market segments. • Promote **EaaS** business models, which have proven to be effective in other nascent and early-stage mini-grid markets. Under the EaaS approach, mini-grid operators offer end-user energy services rather than focusing on power consumption/selling kWh, with service-based tariffs customized to reflect the actual electricity consumption needs of consumers based on the desired usage of a given energy appliance and/or time of use. There are wide-ranging benefits to this approach, including its simplicity, improved quality of service and predictability of revenues and expenses, among others (see **Annex 1**).

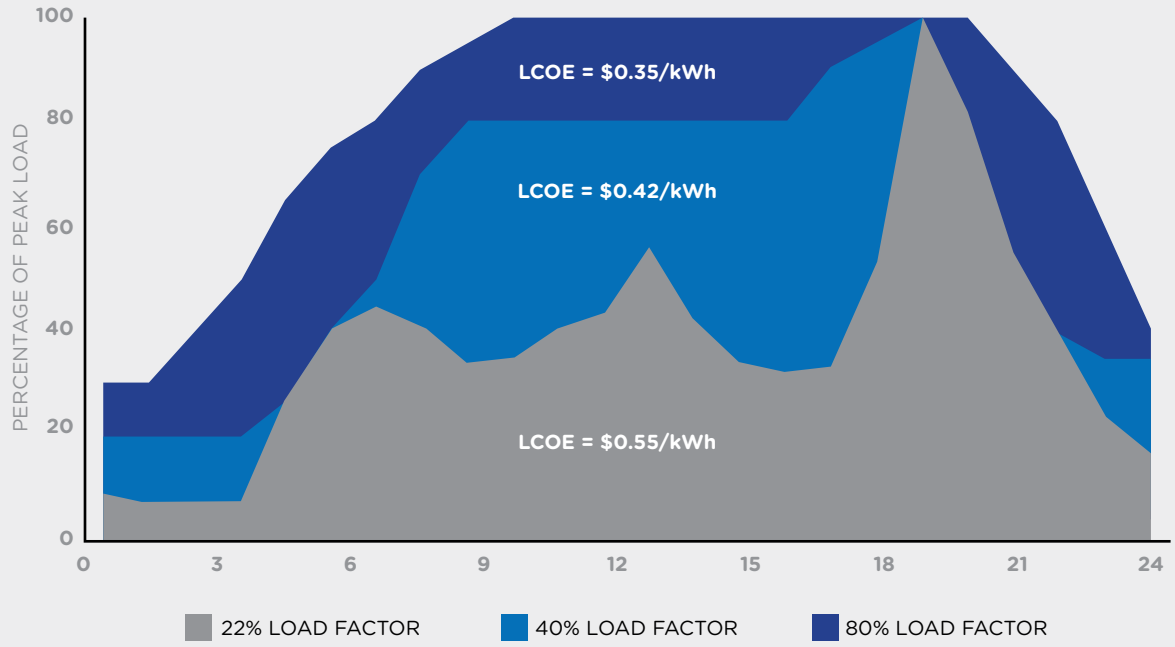
PART II
PRODUCTIVE USE OF ENERGY AND SITE SELECTION

4 PRODUCTIVE USE OF ENERGY AND MINI-GRIDS

4.1 Productive-Use Applications and Business Models in the Mini-Grid Sector

For mini-grid developers, generation capacity utilization remains an ongoing challenge. Sustained economic activity that relies on greater capacity utilization ensures more stable revenues for mini-grid operators; hence, operators often try to arrange funding to support productive use of energy (PUE) applications that will stimulate electricity demand (e.g., to finance the purchase of new agricultural processing equipment, water pumps, etc.). During the site selection process for new mini-grids, developers typically prioritize sites with 'anchor loads' or those that have productive users of electricity able to meet set minimum demand thresholds.[182] As illustrated in **Figure 17**, as the PUE increases, it becomes more economical for mini-grid operators to produce electricity, thus improving the long-term financial viability of the project. Moreover, local businesses benefit from switching from expensive diesel generators to more affordable mini-grid electricity.[183]

FIGURE 17
Change in Daily Load Profile and LCOE from Increases in the Productive Use of Electricity



Source: World Bank ESMAP.
NOTE: LCOE = Levelized Cost of Electricity

182 Agenbroad, J. et al., "Mini-Grids in the Money: Six Ways to Reduce Mini-Grid Costs for Rural Electrification," Rocky Mountain Institute, (2018): https://rmi.org/wp-content/uploads/2018/12/rmi-seeds-minigrid-report.pdf
183 Mini-Grids for Half a Billion People, World Bank ESMAP, 2019.

Increasing the average revenue per user (ARPU) of a mini-grid is crucial in improving its economic returns and subsequently attracting private investment. However, this is difficult in rural areas where low generation capacity utilization remains an ongoing challenge due to residential customers' limited power demand and ability to pay. To address this, developers are increasingly targeting PUE customers such as small businesses and industrial users with higher and more predictable power demands than residential customers.[184] Revenue from these productive-use activities can also generate local economic development and growth, which in turn improves communities' ability to pay for electricity provided by the mini-grid.[185]

In Sierra Leone, where most of the population lives in rural areas and engages in subsistence agriculture, mini-grids can power rural agricultural productivity and create new businesses or expand existing ones linked to the agricultural value chain. To date, the most common rural productive-use activities powered by mini-grids in Sub-Saharan Africa include local industries (agriculture, livestock and fishing), light manufacturing (welding, carpentry, etc.), commercial and retail services (lighting, entertainment, barbering and tailoring), and medium-scale production from small factories or intensive agricultural processing (drying, grinding, milling and threshing). It is worth noting that even with inexpensive solar power available, many of these agricultural processing functions may not be cost-effective solutions in rural areas due to supply chain and other logistical constraints.[186] Developers are adopting various business models to incorporate and/or stimulate such productive uses of electricity.

The Energy and Environment Partnership Trust Fund (EEP Africa), a clean energy financing facility managed by the Nordic Development Fund (NDF), has categorized three main types of PUE business models (**Figure 18**):[187]

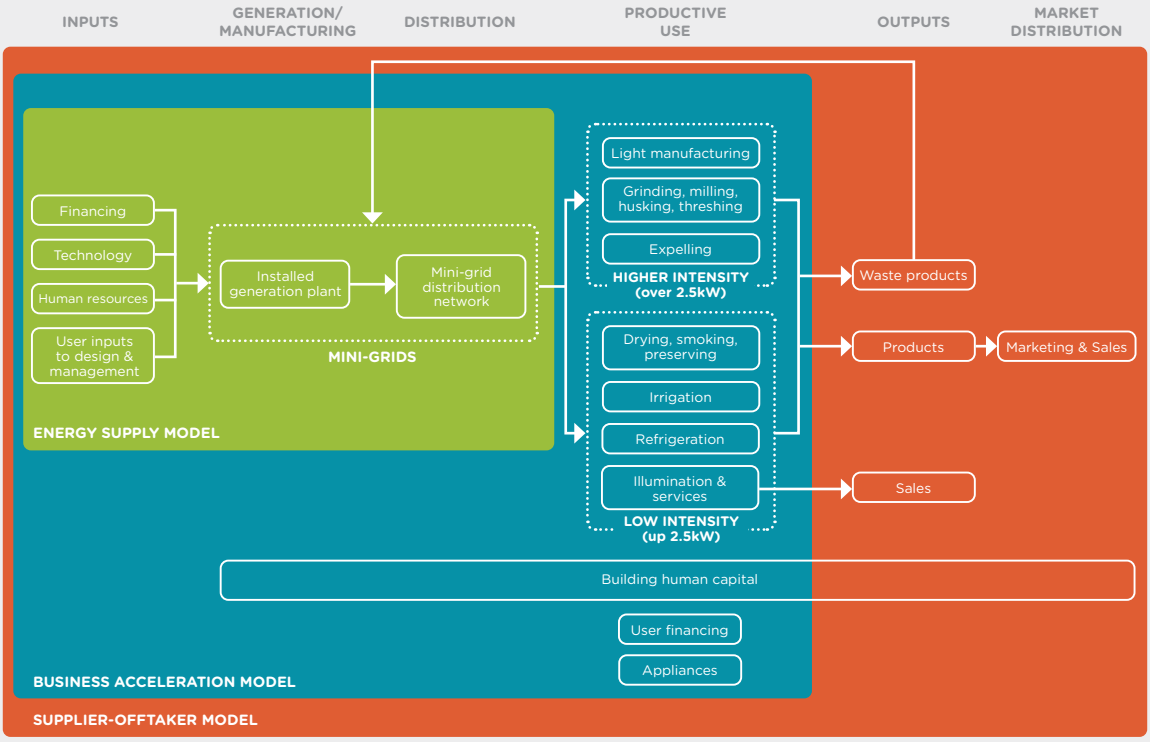
- **Energy Supply Model:** This is the simplest model in which mini-grid developers only supply electricity to productive-use customers. Operators often design mini-grids to accommodate a primary offtaker or to convert existing users from diesel to electricity.
- **Business Acceleration Model:** Under this model, the mini-grid developer combines electricity supply with the provision of appliances and equipment through direct sales or financing to customers. In some cases, this can also include business development support associated with the productive-use application. This approach

184 State of the Global Mini-Grids Market Report 2020.
185 Borgstein, E., Wade, K., and Mekonnen, D., "Capturing the Productive Use Dividend," Rocky Mountain Institute, (April 2020): https://rmi.org/insight/ethiopia-productive-use/
186 Avila, E., "Productive Use Report: Productive Use Report: Evaluation of Solar Powered Agricultural Technologies for Productive Use Applications," Access to Energy Institute (A2EI), 2020: https://a2ei.org/resources/uploads/2020/09/A2EI_Productive_Use_Report_Agricultural_Technologies.pdf
187 "Powering Productivity: Lessons in Green Growth from the EEP Africa Portfolio," EEP Africa and Nordic Development Fund, (2020): https://eepafrica.org/wp-content/uploads/2019/12/EEP_PUE_Digital-new.pdf

has proven to boost revenue generation for both the developer and the end user. For example, in Nigeria, Green Village Electricity (GVE) has experimented with financing productive-use equipment such as grinder motors and has been able to increase utilization to 74 percent of peak capacity for its mini-grid by providing loans for soft-start electric motors, and the company expects further adoption will raise that to 90 percent.[188]

- **Supplier-Offtaker Model:** Under this model, mini-grid developers fill the demand gap by establishing and operating commercial and/or industrial activities, serving as the primary offtaker. Initiating a productive activity based on a local commodity (such as producing ice for fisherman) that supports revenue generation can be more profitable for the energy supplier than providing energy to consumers.

FIGURE 18
Mini-Grid Developer Productive-Use Business Models



Source: Energy and Environment Partnership Trust Fund (EEP Africa).

4.2 Expanding Mini-Grids and Promoting Electricity Access for Productive Use

The success of the pay-as-you-go (PAYG) business model in the off-grid market for stand-alone systems has extended beyond household ownership and is being adapted for use in mini-grids with businesses now adapting the model to serve other rural and off-grid sectors. This includes commercial and industrial sectors, such as agriculture, where payments for solar irrigation pumps (powered by solar mini-grids) can be tailored to agricultural output, making the improved technology more affordable without the need for large capital investments. The business model also provides a secure customer for mini-grid developers, creating regular income and leaving open the opportunity for additional services and access to be provided to the local community from excess energy supplies.[189]

As Sierra Leone's mini-grid sector continues to evolve, PUE will be increasingly important to its growth and long-term commercial sustainability. Once fully operational, mini-grids can provide a wide range of income-generating opportunities. Trade is facilitated

188 Agenbroad, J. et al., "Mini-Grids in the Money: Six Ways to Reduce Mini-Grid Costs for Rural Electrification," Rocky Mountain Institute, (2018): https://rmi.org/wp-content/uploads/2018/12/rmi-seeds-minigrid-report.pdf
189 "Off-Grid Electricity in Africa: Market Review and Opportunities," ITP Energised, (August 2019): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/Off-Grid-Electricity-Access-in-SSA-Japan-and-UK-Opportunities.pdf

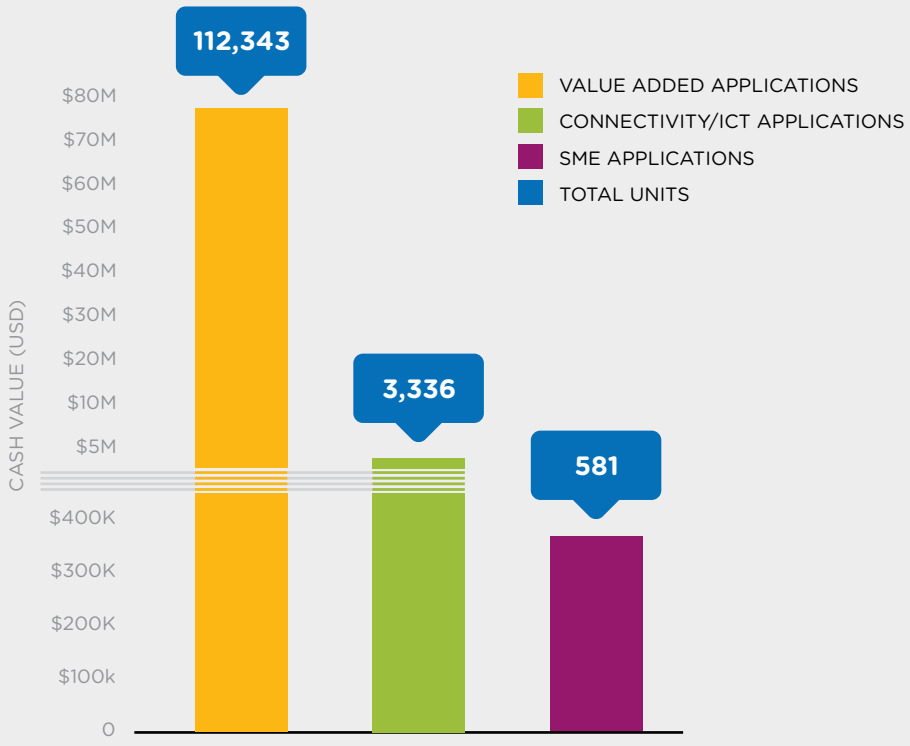
greatly by the availability of electricity, as retail shops can be open longer hours and sell more products. Local entrepreneurs can utilize power to develop and grow rural enterprises in areas such as agricultural productive use, rural cold chains in food and health systems, and Information and Communications Technology (ICT) such as mobile phone charging and internet access services, among others.

Under Work Package 6 (WP-6), the Rural Renewable Energy Project (RREP) focuses on private sector development and PUE as a key driver of electricity demand in rural mini-grid communities, with grant funding made available by the FCDO for this purpose. Following substantial outreach to communities, a request for proposals that closed in March 2020 received nearly 50 applications across five categories – Inclusive Business (large companies), Rural Based Businesses, Community Group Enterprises, Youth Groups, and Training/Business Development Service Providers.[190]

Winch Energy has formed several key partnerships to develop local enterprises and expand productive-use applications in its Work Package 1 (WP-1) mini-grid communities. For example, the company has partnered with EasySolar to offer consumers electrical appliances available on microcredit and is working with the telecommunications operator Orange to expand access to mobile money services in its communities. In addition, Winch Energy has installed Mobile Power (MOPO) battery systems (**Box 1**) to benefit people in the community who have yet to be connected to the mini-grids and plans to pilot an electric vehicle programme using this technology in Q1 2021.[191]

FIGURE 19

Estimated Off-Grid Solar Cash Market Potential for the Productive-Use Sector in Sierra Leone



Source: GreenMax Capital Advisors; World Bank-ECREEE Regional Off-Grid Electrification Project: Sierra Leone Report, 2019.
NOTE: The estimated cash value and number of units are annualized to reflect typical lifespan of off-grid solar systems. Value added applications: smallholder solar pumping/agricultural irrigation, solar milling and solar-powered refrigeration
Connectivity/ICT applications: mobile phone charging enterprises
SME applications: barbering and tailoring rural microenterprises

190 Hunt, S., "5 years on from the launch of Green Mini-Grids Africa – what's been achieved, and what have we learned?" Mini-Grids Partnership Newsletter, (May 12, 2020): https://minigrids.org/5-years-on-from-the-launch-of-green-mini-grids-africa-whats-been-achieved-and-what-have-we-learned/

191 "Winch Energy celebrates project success in Sierra Leone," African Review, (26 October 2020): https://www.africanreview.com/energy-a-power/renewables/winch-energy-celebrates-project-success-in-sierra-leone

BOX 1

Mobile Power Battery Rental Platform

Mobile Power (MOPO) is a UK-based company that develops and operates portable energy distribution systems for the off-grid market in Sub-Saharan Africa. It has developed a pay-per-charge rental model to supply battery power at a price affordable to low-income households and businesses. The rental platform requires no deposit, has no credit checks, requires no fixed payment structure, and batteries can be rented on a daily basis. The approach consists of selling and deploying MOPO hubs (typically powered by solar panels) where batteries are charged and then field agents take care of distributing them to customers. The field agents pre-purchase activation credits from MOPO using mobile money, while customers pay the agent using cash, mobile money etc. The agent uses the credits to activate the battery, and once the rental period is complete, the agent collects the battery and returns it to the hub for a new cycle. In Sierra Leone, MOPO hubs are already being used to supply electricity to schools in off-grid areas, while Winch Energy plans to pilot an electric vehicle programme using the technology in Q1 2021.[192]

Source: Mobile Power.

4.3 Assessment of Agricultural Productive Use in Sierra Leone and Nigeria

The agriculture-energy nexus is critical to supporting rural economic development. Off-grid solar applications can support a wide range of productive applications (e.g., solar water pumping, agricultural processing, milling equipment, refrigeration etc.) to generate economic activity, increase productivity and transform rural livelihoods. This is particularly true in Sierra Leone, where a majority of the population lives in rural areas and two-thirds of the country's labour force engages in subsistence agriculture.

Agricultural practices, especially for smallholder farmers, can benefit from a wide range of off-grid solar technologies, including in water pumping and irrigation, agricultural processing and cold storage. Improved irrigation increases yields and smallholder farmer income. Solar-powered refrigeration and cooling equipment can serve multiple purposes, including ice production for a wide range of industries and cold storage of agricultural produce, which can reduce losses and increase output. Cereal crops like maize, sorghum, millet and rice provide an opportunity for value addition through hulling or milling, while solar drying of coffee and cocoa and palm oil processing are productive-use applications that can greatly benefit rural farmers.[193] Off-grid communities typically use equipment that is powered by diesel generators; thus, there is a need for policy and financial interventions in order to raise awareness of the benefits and long-term cost savings associated with switching to equipment powered by clean energy, as well as to finance the up-front cost of purchasing equipment.

4.3.1 Sierra Leone

In 2019, UNOPS commissioned a feasibility study led by INENSUS GmbH (using its KeyMaker Model (KMM)) to identify productive-use hotspots (30 kW systems and above), such as food processing, cold storage applications and fisheries, with the objective of helping RREP operators identify anchor tenants to support the long-term sustainability of their operations. The KMM is a concept developed by INENSUS aiming to improve the economics of a mini-grid project by unlocking local market potential. Under the KMM, operators typically procure raw materials from the local community, process them to produce final goods using the electricity from their mini-grids, and sell them to a given market, usually in urban areas where demand is high.[194] The virtue of the concept relies on leveraging the stable supply of electricity from a mini-grid and establishing mini-grid project management structures in order to enter an agriculture/farm product's value chain, usually at the processing and trading stages (see **Figure 18**).

A stable supply of electricity can directly increase the quality of processed agricultural products while reducing

192 https://www.mobile-power.co.uk/#home; and "Off-Grid Electricity in Africa: Market Review and Opportunities," ITP Energised, (August 2019): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/Off-Grid-Electricity-Access-in-SSA-Japan-and-UK-Opportunities.pdf

193 Kyriakarakos, G., Balafoutis, A., and Bochtis, D., "Proposing a Paradigm Shift in Rural Electrification Investments in Sub-Saharan Africa Through Agriculture," *Sustainability*, 12, (2020): https://www.mdpi.com/journal/sustainability

194 Cabanero, A., Nolting, L., and Praktiknjo, A., "Mini-Grids for the Sustainable Electrification of Rural Areas in Sub-Saharan Africa: Assessing the Potential of KeyMaker Models," *Energies*, 13, (2020): https://www.mdpi.com/1996-1073/13/23/6350

their transport costs. Mini-grid operators are also able to secure demand for mini-grid energy consumption if farmers establish local agricultural-processing projects. Such projects not only create an end market for the local farmers to sell their produce, but also create an additional income stream for the mini-grid operators, while driving them to operate more cost-efficiently and sustainably.

The KMM has been tested by a subsidiary in Tanzania, the mini-grid operator JUMEME Rural Power Supply Ltd.[195] In 2019, INENSUS supported the RREP through an assessment of potential PUE revenue streams for rural mini-grids across several key agricultural sectors of Sierra Leone.[196] Some of the key findings from these studies are summarized in **Table 13**.

TABLE 13

INENSUS KMM Feasibility Assessment of Agricultural PUE Applications in Sierra Leone, 2019

PUE Activity	Location	Work Package	Business Scenario	Expected Results
Rice milling and processing	Mathoir	WP-2	Purchasing a small-scale mill at the capacity of 25.33 MWh/year. The mill would operate 8 hours/day, 7 days/week, 9 months/year.	• 1.3 tons of milled rice daily with a small-scale processing capacity of 300 kg/hour. • Increase the market value of rice from USD 0.29/kg (farmgate rice) to the price of USD 0.76/kg (processed rice for wholesale).
Palm oil Production	Masiaka	WP-2	Implementing a plant of 5 tons of FFB/day processing capacity, supplying 173 tons of Masankey crude palm oil per year.	• 20-year project IRR of 16.5% with a pay-back period of 10 years. • Annual net profits of USD 13,600 once the plant is running at full capacity in year 6.
Cassava Processing	Foredugu	WP-2	Re-start of an already installed 10 ton/day of raw cassava processing plant.	• 20-year project IRR of 39.4% and a pay-back period of 3 years. • Annual net profits of USD 33,300 once the plant is operating at full capacity in year 4.
Refrigeration for cold fish storage	Conakry Dee, Shenge, Foredugu and Moyamba	WP-2	The productive use of mini-grid electricity to support the establishment of a fish cold storage chain. The cold storage chain is designed to have 6 air blast freezer cold storage rooms (-30°C) of 20 ft.	• 20-year project IRR of 18.9%, pay-back period of 10 years. • Net profits of USD 6,500 from the fifth year of operation.

Source: Inensus GmbH.

NOTE: KMM = KeyMaker Model

RREP Mini-Grid Community Field Surveys

In October and November 2020, the GreenMax consultant team carried out a survey activity of nine RREP mini-grid communities across both WP-1 and WP-2 sites, involving interviews and consultations with community representatives (chiefs), residential households, productive users (farmers, fishermen, traders, technicians), health workers, and representatives of religious institutions, youth groups, and other community organizations. The surveys found that the mini-grid projects are capable of supporting increased productivity, particularly in the agricultural sector, namely rice processing, palm oil production, and refrigeration for food processing and storage. Field surveys with farmers collected information on potential productive-use applications of mini-grid electricity to support their activities.

A total of 11 farmers were interviewed across the various communities, including five interviewees served by WP-1 and six interviewees served by WP-2.[197] Interviewees were asked a variety of questions related to the productive-use activities they engaged in and how they felt mini-grid electrification could support their agricultural value chain activities. They were also asked about barriers related to expanding PUE through the mini-grids (e.g.,

195 "JUMEME's business model for mini-grids reaping multiple benefits in Tanzania", Sustainable Energy for All, (27 May 2020): https://www.seforall.org/news/jumemes-business-model-for-mini-grids-reaping-multiple-benefits-in-tanzania

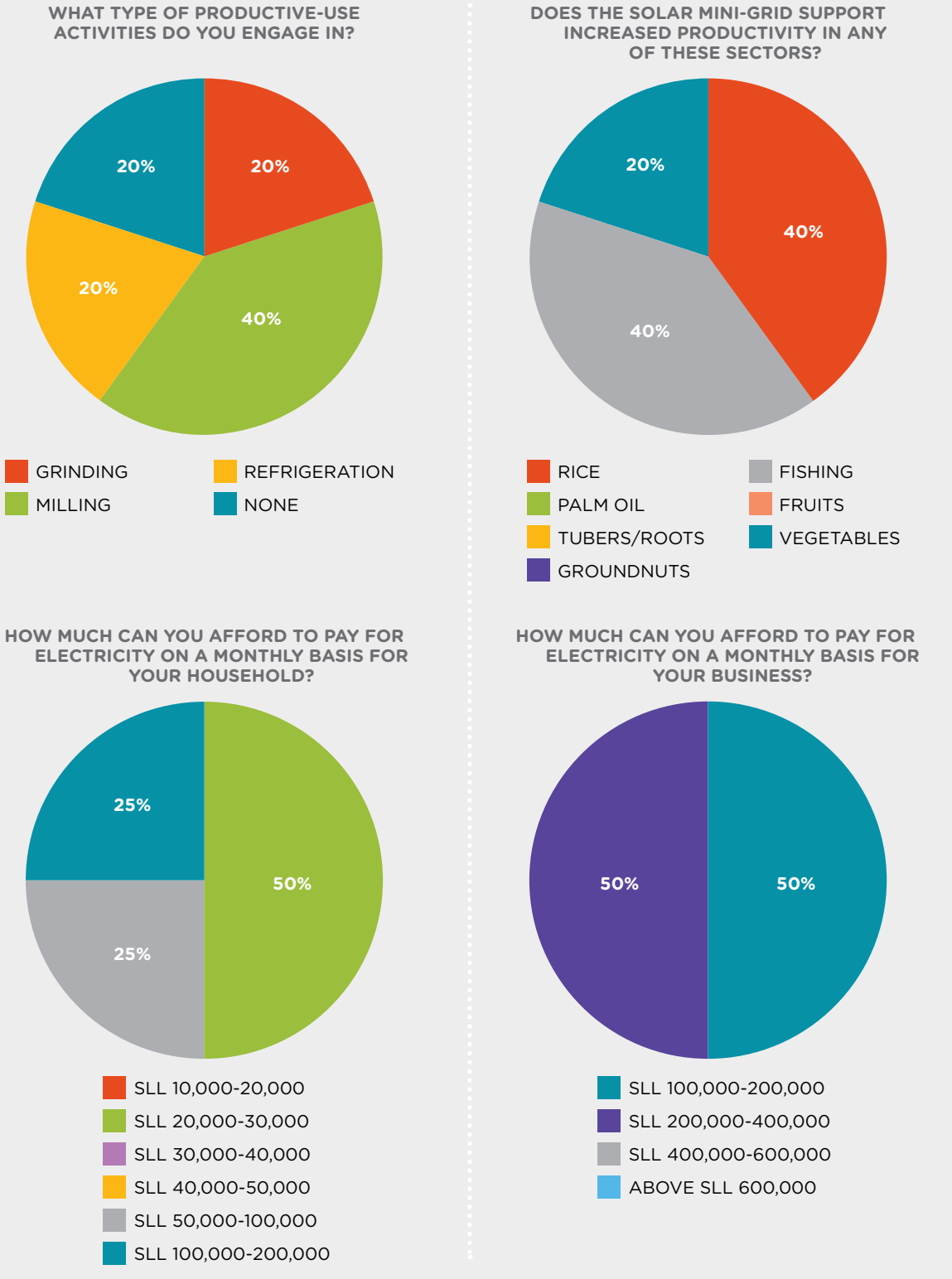
196 "Rural Renewable Energy Project - Productive Use Facilitation: Value Chain Assessment for Operator 1 – PowerGen Limited," Inensus GmbH, (2 December 2019). "Rural Renewable Energy Project - Productive Use Facilitation: Assessment of potential productive use applications for Operator 2 – Winch Energy Limited," Inensus GmbH, (27 December 2019); and "Rural Renewable Energy Project - Productive Use Facilitation: Assessment of potential productive use applications for Operator 3 – Power Leone (SL) Ltd.," Inensus GmbH, (27 December 2019).

197 **NOTE**: The distinction between WP-1 and WP-2 sites is noteworthy, as only WP-1 mini-grids were in operation during the time of this survey activity (WP-2 sites were still under construction); see **Annex 2** for more details.

vis-à-vis the use of alternative sources of power such as diesel generators). The results of this survey activity are presented in **Figure 20** and **Figure 21**. Due to the small sample size, survey results are not representative and should only be considered as a baseline for future research.

FIGURE 20

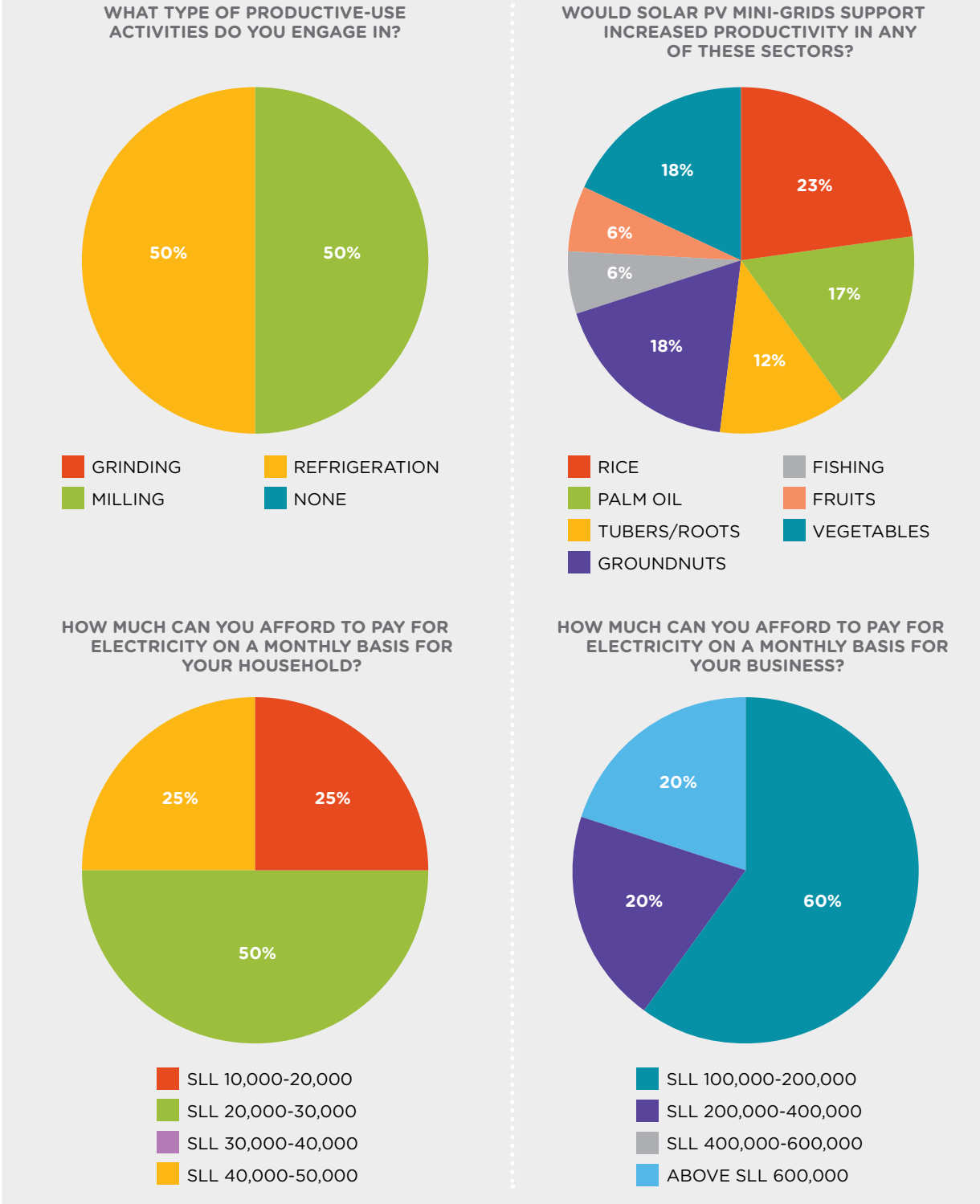
Mini-Grid Community Productive Use Survey Results (WP-1)[198]



198 NOTE: 1 USD = SLL 10,000

FIGURE 21

Mini-Grid Community Productive Use Survey Results (WP-2)[199]



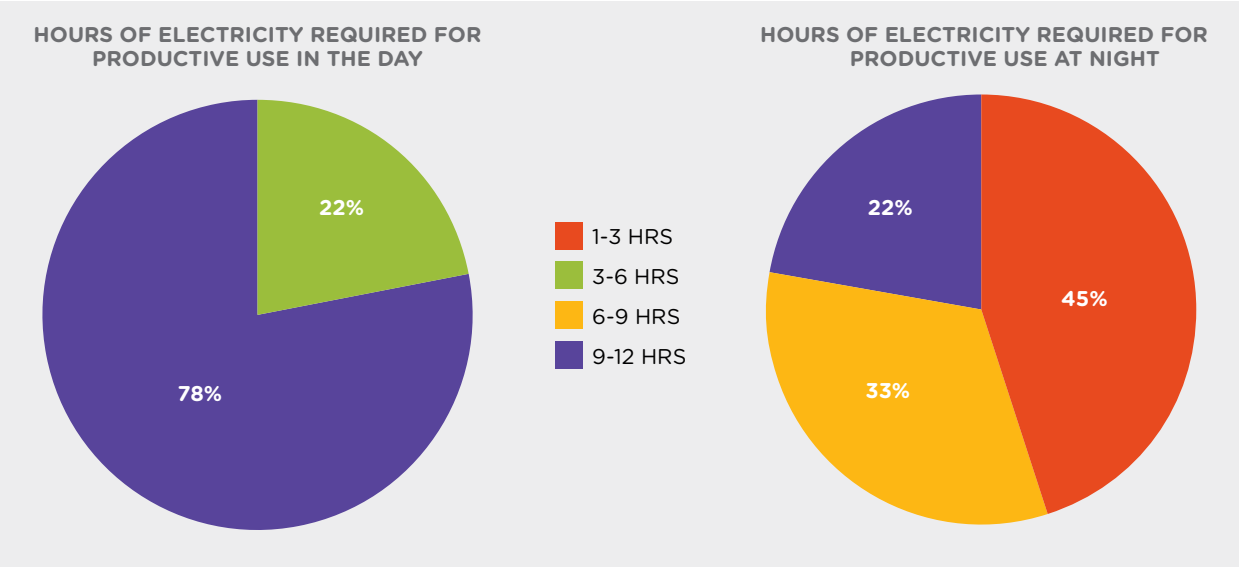
Consultations with rural mini-grid community stakeholders in Sierra Leone found that milling and refrigeration are among the most common productive-use applications, while solar mini-grid electrification can support increased productivity across a variety of agricultural sectors, led by rice, palm oil, fish, vegetables and groundnuts via agricultural processing and cold storage applications.

Under WP-1, no subsidies were provided to encourage productive use. Productive use is, however, being

199 NOTE: 1 USD = SLL 10,000

considered for WP-2 sites under WP-6 of the RREP (see **Section 1.1.2**). The FCDO is currently working with UNOPS to provide funding and resources to reduce connection fees for potential productive-use customers and to subsidize the purchase of productive-use equipment for local communities. In this context, responses from mini-grid community interviewees served by WP-1 differed from WP-2 community respondents, given the increased emphasis on PUE for WP-2 site development.

When asked about what factors discouraged new productive-use customers from connecting to a subsidized mini-grid, WP-1 community end users indicated that high tariffs were the main barrier. Some productive users also stated that the mini-grid connection point was far from where they perform agricultural activities, which posed logistical challenges. In contrast, WP-2 community end users viewed tariffs as largely appropriate and were generally more positive about the prospect of using mini-grid power to supply their productive activities. Instead, their main concerns were surrounding equipment financing and training needed to expand PUE applications.



Both WP-1 and WP-2 end users expressed a desire for an increase in the hours of electricity supply, suggesting that perhaps more hours of electricity supply would be necessary to support productive-use applications. This was particularly true for evening hours, where electricity not only provides lighting but also refrigeration. The challenge, of course, is that solar mini-grids must rely on battery storage and/or diesel fuel to provide service at night (which is more expensive).

A summary of the key findings from the WP-1 and WP-2 mini-grid community surveys is presented in **Table 14**.

TABLE 14

RREP Mini-Grid Community Field Surveys

Indicator	Feedback from Stakeholder Interviews		Lessons Learned	Recommendations
	Work Package 1	Work Package 2		
PUE activities	• **Rice milling and processing:** Interviewees engaged in rice milling indicated that while mini-grids and/or off-grid electrification could support increased productivity in rice milling, they were not currently using the electricity supplied by mini-grid to support productive use due to the high tariff	• **Fish processing:** Respondents indicated that they anticipated commencing fish processing and storage once the mini-grids expanded to support the fisheries value chain • **Refrigeration for food storage:** Respondents indicated that once the mini-grid was developed, solar-powered cold rooms could support various agricultural sectors, such as fisheries, cassava and potato harvesting, fruit and vegetable storage, etc. • **Palm Oil:** WP-2 respondents anticipated that palm oil processing could potentially utilize mini-grid electricity	• **Rice milling and processing:** The INENSUS GmbH study indicates that regions with large-scale rice production would achieve reasonable financial returns from investing in mini-grid-powered rice mill. • **Fish processing:** In Tanzania, JUMEME Ltd. piloted a KMM project in the fishing sector. The project involved building the mini-grid to offer power to local residents, but also running a business that bought fish from local fishermen, processing and freezing them on-site using its own electricity, and then selling the frozen fish to distributors for sale across Tanzania.[200] Mini-grid operators in Sierra Leone are considering a similar programme. • **Food storage:** The Cooling-as-a-Service (CaaS) model[201] currently implemented in Nigeria shows that solar-powered refrigeration and cold rooms can cut food waste by 50% and save 460 tons of CO_2 emissions per year. CaaS can also be deployed in Sierra Leone's rural energy market.	• **Rice Processing and milling:** Provide PUE equipment financing to rural farmers to support electricity uptake and invest in mini-grid-powered mills for farmers. The community expressed interest but lacks the up-front capital to access the machinery. A lease-to-own model could overcome this barrier. • **Fish processing:** Provide financing to support design and implementation of KMM pilot project to demonstrate viability of PUE applications in the fishing sector (e.g., fish drying; cold storage etc.) • **Refrigeration:** Ensure that the mini-grid can provide enough hours of electricity supply for refrigeration; provide financing for community-owned freezer that can be utilized by farming and fishing communities for cold storage • **Palm Oil:** Make the investment in the processing business and refocus efforts to improve the yields of existing farms
Electricity tariff	• Tariff is seen as too high and a barrier to PUE • No subsidies available to reduce tariff	• Customers are expecting to commence new productive-use activities once mini-grid electricity is available • WP-2 customers see no barriers to switching their PUE applications from diesel fuel to mini-grid power (potential barrier from operator perspective; e.g., starting current for diesel-powered milling machines might be problematic for the mini-grid to handle) • WP-2 customers are interested in equipment-financing support to help transition their current PUE applications to mini-grid supply	• WP-2 interviewees had more community sensitization around PUE vis-à-vis WP-1. • WP-2 productive-use customers needed financing support for equipment and necessary training in order to mechanize previous small-scale productive-use activities into business activities that could generate additional revenue.	• Ensure that future mini-grid development includes extensive community engagement and sensitization around issue of PUE • Provide equipment financing and training for productive-use customers

200 "JUMEME's business model for mini-grids reaping multiple benefits in Tanzania", Sustainable Energy for All, (27 May 2020): https://www.seforall.org/news/jumemes-business-model-for-mini-grids-reaping-multiple-benefits-in-tanzania

201 "What is servitization, and how can it help save the planet?" World Economic Forum, (20 November 2020): https://www.weforum.org/agenda/2020/11/what-is-servitization-and-how-can-it-help-save-the-planet/

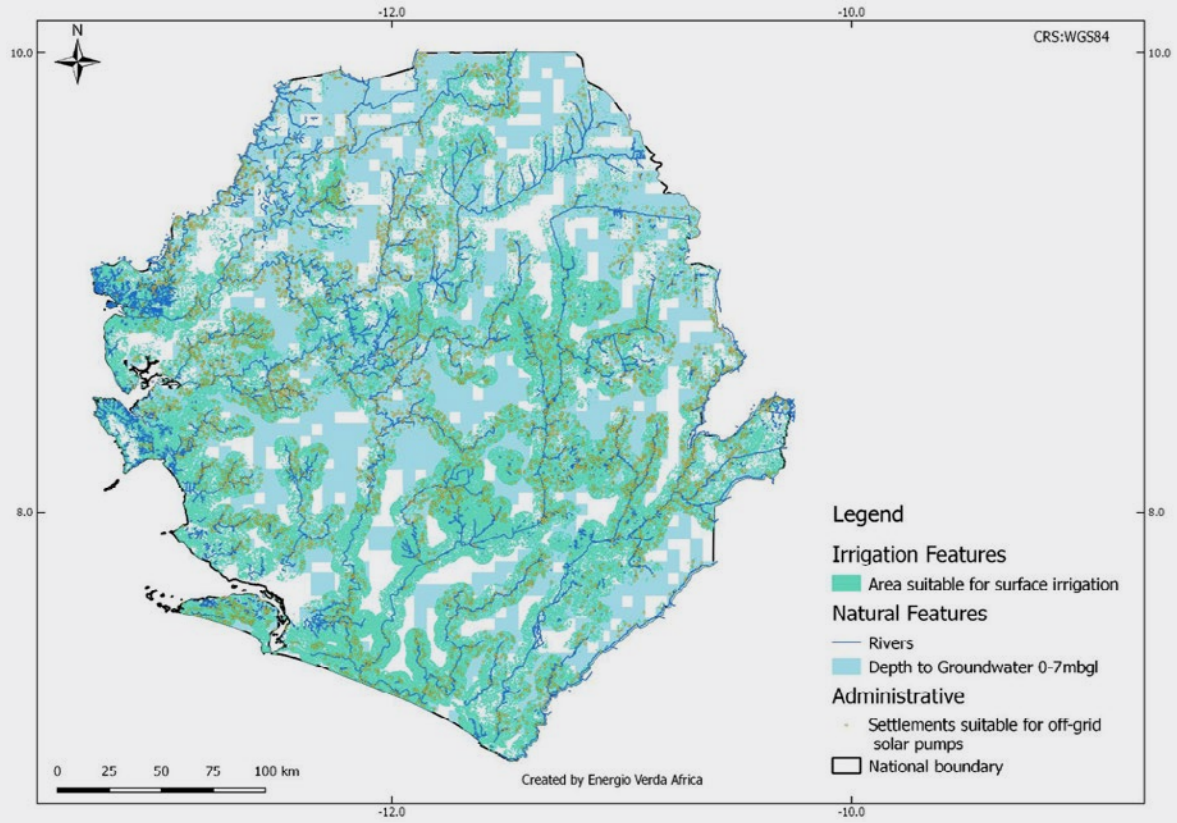
4.3.1.1 Smallholder Water Pumping and Irrigation

Solar-powered irrigation technology allows smallholder farmers to switch from expensive and polluting diesel-powered pumps to sustainable, renewable power. Sierra Leone suffers from poor water access, particularly in the dry season from December to April. Irrigated agriculture is limited by low awareness and knowledge of improved agronomic practices, which has in turn limited the uptake of mechanized tools and equipment such as solar water pumps. While there has been a recent shift towards solar water pumping technology at the institutional level, the domestic market is still largely dominated by low-quality water pumps.[202] The relatively high cost of mini-grid-powered solar pumping systems is a key barrier that inhibits uptake of this technology among smallholder farmers. Moreover, awareness-raising campaigns and associated training is badly needed at the rural farm level, which is hard to sustain without support, e.g., from organizations such as the International Fund for Agricultural Development (IFAD).

A GIS study undertaken in 2019 for the World Bank Regional Off-Grid Electrification Project (ROGEP)[203] found that there is widespread access to the water table for surface irrigation in Sierra Leone (**Figure 22**). To date, this vast irrigation potential remains almost entirely untapped.

FIGURE 22

Area Suitable for Surface Irrigation and Identified Settlements Suitable for Off-Grid Solar Pumps



Source: Energio Verda Africa GIS analysis; Sierra Leone Wash Data Portal; British Geological Survey Bureau of Statistics; World Database on Protected Areas.
World Bank-ECREEE Regional Off-Grid Electrification Project: Sierra Leone Report, 2019.

202 "Off- and Weak-Grid Solar Appliance Market: Sierra Leone Country Profile," Efficiency for Access, (September 2020): https://storage.googleapis.com/e4a-website-assets/EForA_CountryProfile_SierraLeone.pdf
203 World Bank Regional Off-Grid Electrification Project (ROGEP): Sierra Leone Report, ECREEE, 2019.

A case study in Uganda **(Box 2**) found that there was a strong economic case for small- to large-scale farmers to adopt solar irrigation in order to grow high value crops. Regular, consistent watering with an irrigation system can improve yields, and allows farmers to capitalize on higher market prices that occur during dry seasons. Pilot projects demonstrated that solar water pumping for irrigation enables higher yields for horticultural crops that have shorter-term growing cycles, such as tomatoes, kale, cabbage, beans and onions. Solar irrigation enables such crops to utilize the high temperature of dry seasons, allowing farmers to have three harvest cycles in a year when using solar irrigation. As a result, operators to date have mainly sold to medium- to large-scale farmers, or to smallholder farmers who grow high-value horticultural crops as opposed to smallholder farmers who grow staple crops such as maize.

BOX 2

Solar Irrigation for Ugandan Farmers

Increased instances of erratic and unpredictable weather patterns due to climate change (e.g., drought, heavy rainfall, changing growing seasons etc.) reduce farmer productivity, particularly at the smallholder level. In Uganda, this trend has prompted the government to focus development initiatives on providing sustainable and affordable irrigation for off-grid rural smallholder farmers, who make up 80 percent of farmers in the country. With decreasing capital costs, solar water pumps are gradually becoming a cost-effective and sustainable solution for rural farmers to reduce their reliance on rain-fed agriculture and diesel alternatives. Although most solar water pumping systems to date have functioned as stand-alone systems, solar water pumping and irrigation technologies that are suited for commercial and industrial applications can benefit from mini-grid power.[204]

Source: Uganda Off-Grid Energy Market Accelerator and USAID Power Africa.

4.3.1.2 Agricultural Processing

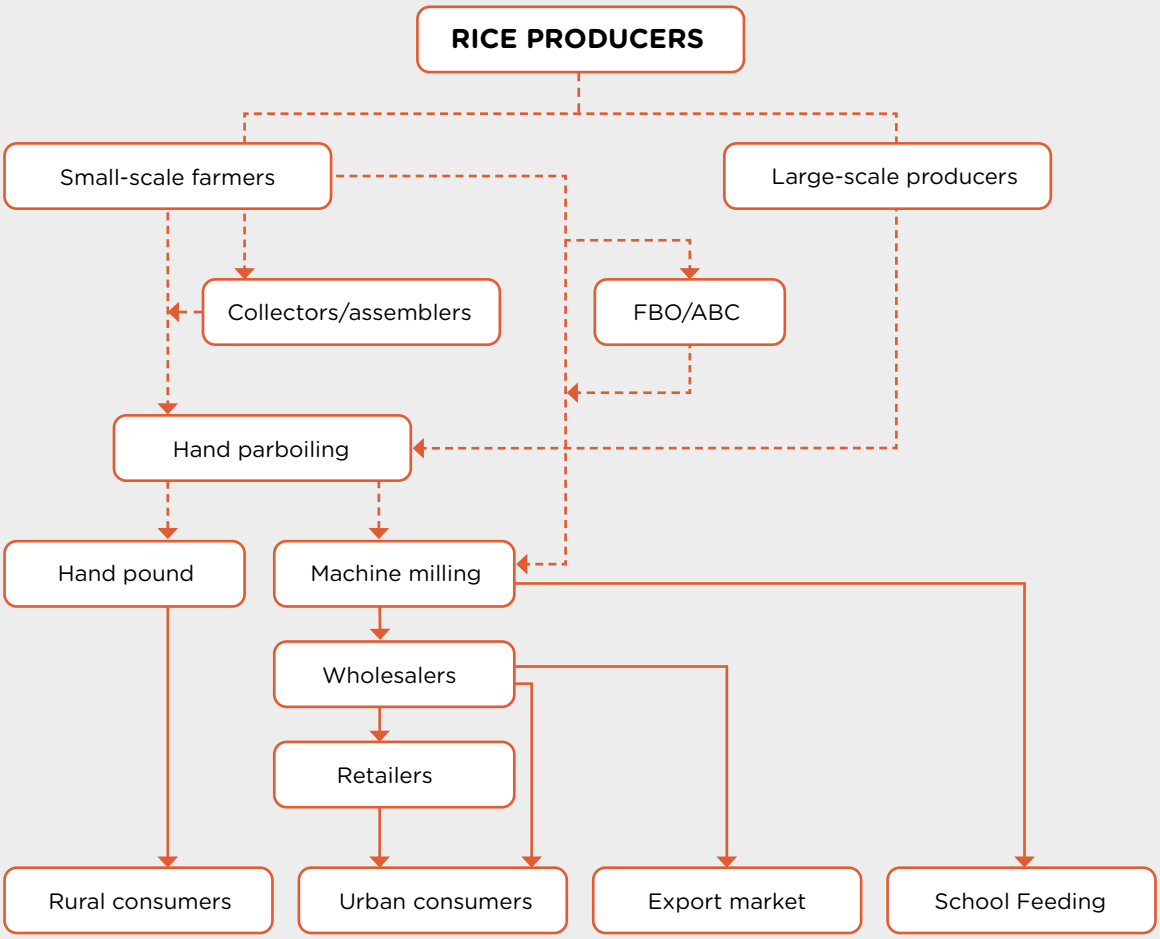
Using mini-grids in agricultural value chains provides an opportunity for rural communities to boost local economies. Some agricultural activities have shown great potential to effectively benefit from mini-grids in Sierra Leone, such as milling, palm oil processing, cassava root production and cold storage.[205]

Rice Milling

While Sierra Leone has a comparative advantage in rice production relative to other neighbouring countries, it lacks the infrastructure to ensure high-quality rice processing. As a result, the country is traditionally an importer of rice due to the low quantity of locally processed rice (which is manually processed by small-scale farmers). The INENSUS GmbH study indicates that regions with large-scale rice production would achieve reasonable financial returns from investing in mini-grid powered rice mills, when reasonable assumptions are considered. The KMM business case identified Mathoir as a strategic location to consider future establishment of a rice processing enterprise. The mini-grid system to be developed would allow access to electricity to power the load implied by a KMM operating eight hours/day, seven days/week, nine months/year, producing an estimated 1.3 tons of milled rice daily with a small-scale processing capacity of 300 kg/hour. On top of the additional revenue stream from the rice value chain enabled by the PUE, there are the added benefits of reduced transport costs and savings in time. This would help Sierra Leone achieve economies of scale in product trade, as well as facilitate linkages between rural and urban centres and help it to outperform metropolitan or international competitors.[206] A summary of the KMM feasibility assessment of this rice milling business case study is presented in **Figure 23**.

204 "Productive Use of Energy in Uganda: Learning from the Uganda Off-Grid Energy Market Accelerator (UOMA)," Uganda Off-Grid Energy Market Accelerator; USAID, (October 2020): https://uoma.ug/wp-content/uploads/2020/10/UOMA-PUE-white-paper.pdf
205 Power for All Factsheet: Mini-grids productive use of energy (PUE) in agriculture: https://www.powerforall.org/application/files/9615/9302/4971/FS_Mini-grids_productive_use_of_energy_PUE_in_agriculture3.pdf
206 "Rural Renewable Energy Project - Productive Use Facilitation: Assessment of potential productive use applications for Operator 2 – Winch Energy Limited," Inensus GmbH, (27 December 2019).

FIGURE 23
Rice Milling Value Chain



Source: INENSUS GmbH.

Palm Oil Processing

Palm oil processing is a commercial industry in Sierra Leone that is already benefitting from mini-grid power (**Box 3**). The INENSUS study identified Masiaka as a community with the highest potential for a palm oil KMM project. Field interviews conducted with rural farm owners in Masiaka who own 150 acres of palm fruit farms revealed significant interest in the development of a palm oil pressing business that could be electrified by a mini-grid. At present, annual yields in Sierra Leone of 7.6 tons/hectare would allow for the 150-acre farmland to produce approximately 50.5 tons of fresh fruit bunch (FFB)/year, which would not produce enough of a return to cover the large up-front capital investment (given operational costs, it is estimated that approximately 9,600 tons of FFB would need to be sourced on an annual basis to present a viable business case). The palm oil business is one of relatively low margins, and thus requires large-scale capacities to lead to profitable outcomes.[207] A summary of the KMM feasibility assessment on the palm oil business case study is presented in **Table 13**.

207 "Rural Renewable Energy Project - Productive Use Facilitation: Assessment of potential productive use applications for Operator 3 – Power Leone (SL) Ltd.," Inensus GmbH, (27 December 2019).

BOX 3

Mini-Hydro Palm Oil Processing Plant in Sierra Leone

In the town of Yele in the Tonkolini District, Sierra Leone, a 250 kWp mini-hydropower system powers a palm oil processing plant along with a community of 300 households. The palm oil plant has improved the financial case for the power plant as an anchor client, buying one-third of the electricity generated. The power plant has created several permanent local jobs and supplies affordable power to the local community.[208]

Source: TU Delft Technology, Policy and Management.

Cassava Value Chain

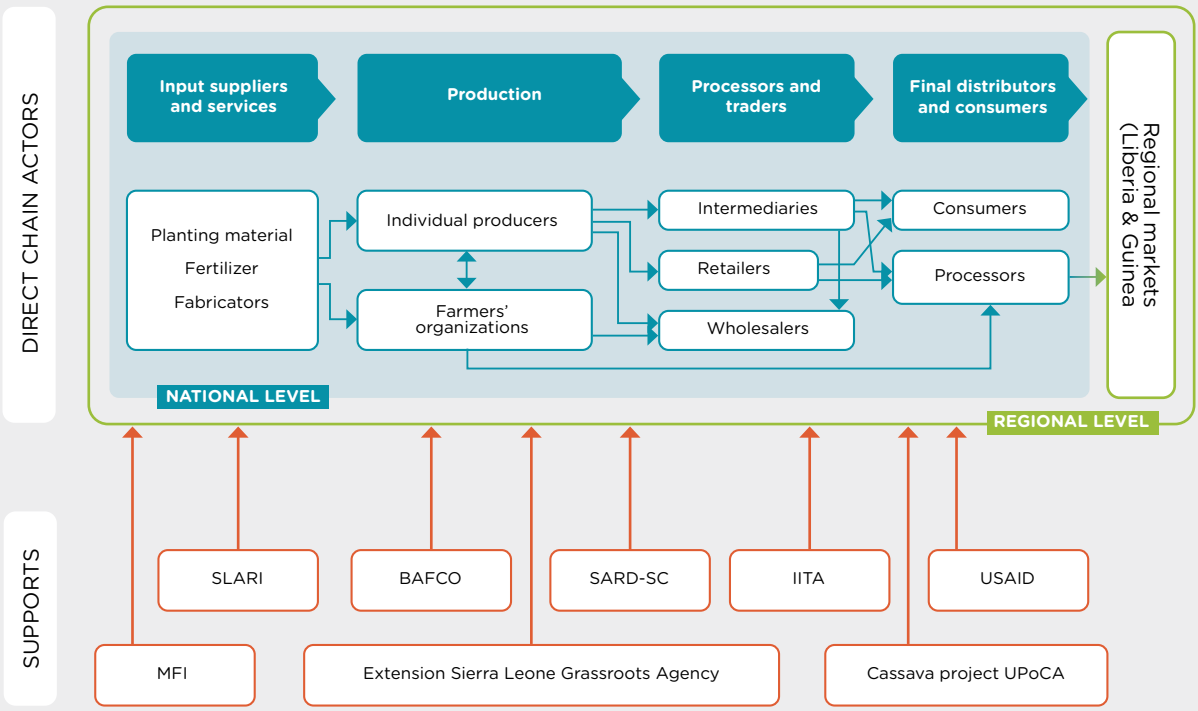
Cassava and its derived products have been identified by the Government of Sierra Leone (GoSL) as a key crop to increase export-based revenues for the country. Increasing cassava root production in recent years has led to Sierra Leone becoming a net exporter of cassava and its derivatives across the West African region. The produce is exported either as food, starch or animal feed. Cassava production (in tons/year) is generally highest in the districts of Moyamba, Bo and Bonthe, while yields peak in Bonthe at more than 800 kg/year, followed by Moyamba, Bo, Tonkolili and Pujehun (between 400 and 800 kg/year). The corresponding values are generally between 200 and 400 kg/year in Port Loko and Kambia, and the lowest in the districts of Bombali and Kono at below 200 kg/year.

Processing and transporting cassava products (**Figure 24**) in Sierra Leone remain an expensive business due to a widespread lack of suitable processing machinery, small-processing capacities and poor road conditions. Since the raw cassava root cannot be stored for more than two or three days, a lack of large-scale or automatic processing equipment means that farmers must generally rely on small-scale diesel-powered machines to process part of the root and gari in order to be able to store it.

INENSUS identified the possibility of supporting a large-scale cassava processing project at a strategic location selected to trail the route used by traders of gari and other cassava derivatives from the epicentres of gari in the country. With a processing capacity of 10 tons of cassava root processing per day, it is designed to operate eight hours/day, six days/week and twelve months/year. While a promising business opportunity, the project is likely to require the participation of an external investor with access to financing. Although mini-grid electricity will not directly feed the processing plant, the local presence of Power Leone in Foredugu would allow for the overhead and management cost-sharing structures between the electricity and agro-processing projects that characterize the KMM approach. Alternatively, the project can be considered as a stand-alone commercial and industrial solar project.[209] A summary of the KMM feasibility assessment of the cassava processing business case study is presented in **Table 13**.

208 Janse, 2019.
209 "Rural Renewable Energy Project - Productive Use Facilitation: Assessment of potential productive use applications for Operator 3 – Power Leone (SL) Ltd.," Inensus GmbH, (27 December 2019).

FIGURE 24
Cassava Value Chain



Source: INENSUS GmbH.

4.3.1.3 Cold Storage and Refrigeration

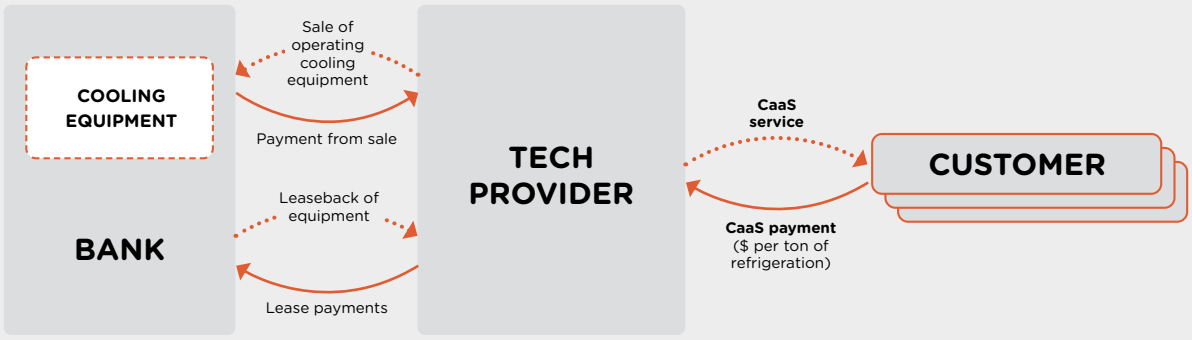
The provision of rural cold chains has very high economic development co-benefits. Rural cold chain projects can improve the income of smallholder farmers (or fishermen) by reducing waste and can improve access to health services by securing economic delivery of medicines and vaccines. Case studies have found that solar-powered refrigeration and cold rooms have the potential to cut food waste by 50 percent and save 460 tons of CO_2 emissions per year. Cooling systems integrated with community mini-grids can also be used where larger cold chain applications exist, such as for ice manufacture.

Cooling-as-a-Service

Cooling-as-a-Service (CaaS) is a pay-per-service model for clean cooling systems that eliminates the up-front cost of clean cooling equipment for customers, who instead pay per unit of cooling they consume. The technology provider installs, maintains and operates cooling equipment, recovering costs through periodic payments made by the customer.[210] End users are thus incentivized to consume energy efficiently, while technology providers are incentivized to install and maintain the most efficient equipment possible. Moreover, financial service providers have the security of owning an operating asset under a CaaS contract with a customer. The CaaS business model (**Figure 25**) is cheap for customers, profitable for technology providers and reduces harmful refrigerant emissions.[211]

210 CaaS Factsheet: http://countoncooling.eu/wp-content/uploads/2020/01/CaaS_Factsheet.pdf
211 Global Innovation Lab for Climate Finance – Cooling as a Service: https://www.climatefinancelab.org/project/cooling-service/

FIGURE 25
Cooling-as-a-Service Business Model



Source: Global Innovation Lab for Climate Finance.

It is estimated that the CaaS model can save customers more than 20 percent of cooling costs, while reducing emissions from electricity use and coolant leakage by up to 49 percent. The model also opens up vast market opportunities for technology and finance providers. To date, the Kigali Cooling Efficiency Programme (K-CEP) and Basel Agency for Sustainable Energy (BASE) have made significant progress towards initial implementation of the CaaS business model in the Dominican Republic and Jamaica and are pursuing three to four larger flagship implementation projects in India, Mexico and South Africa.[212] Nigeria is also piloting a CaaS business model whereby farmers can use cooling equipment provided by the mini-grid service provider.[213]

Rural Cold Chains in Agriculture and Fishing

Solar refrigeration, cooling and processing equipment also enables traders and livestock farmers to sell dairy products, while cold storage of agricultural produce can reduce losses and increase output (**Box 4**). Cold rooms and ice production are also valuable investments for the fishing industry (**Box 5**); in Sierra Leone, RREP mini-grid operators are currently exploring options to launch a freezer-leasing programme to help mini-grid customers store fish in order to enter the sector.

BOX 4
Cold Chain Solutions for Indian Banana Farmers

India is the global leader in banana cultivation. In 2013, Danfoss, a Danish multinational manufacturing firm that offers energy system management services, partnered with the Indian government and the Confederation of Indian Industry to form a task force that aimed to deliver cold chain solutions to banana farmers in order to reduce postharvest losses. With support from local industry associations, the task force conducted a feasibility study of the banana sector to assess how cold chains could be utilized to reduce losses and boost export revenue. The study's findings helped educate farmers on cold chain infrastructure and technologies, resulting in a 300 percent increase in farmer income and a 20 percent reduction in postharvest losses. By 2018, India began exporting bananas to Europe. India's government is now exploring how cold chain solutions can be applied to support other agricultural crops/sectors.[214]

Source: Danfoss.

212 Ibid.
213 "What is servitisation, and how can it help save the planet?" World Economic Forum, (20 November 2020): https://www.weforum.org/agenda/2020/11/what-is-servitization-and-how-can-it-help-save-the-planet/
214 "The World's Banana Giant is Awake," Danfoss, (26 February 2019): https://www.danfoss.com/en/about-danfoss/news/cf/the-world-s-banana-giant-is-awake/

BOX 5

JUMEME Fishing Industry Pilot Project in Tanzania

In Tanzania, JUMEME Ltd. piloted a KeyMaker Model (KMM) project in the fishing sector. The project involved building the mini-grid to offer power to local residents, but also running a business that bought fish from local fishermen, processing and freezing the fish on-site using the business's own electricity, and then selling the frozen fish to distributors for sale across Tanzania. Using lessons from the pilot, JUMEME has expanded and now has 12 mini-grids in operation on Lake Victoria islands, connecting roughly 5,000 customers and supplying an area of roughly 80,000 people with electricity. A further 11 mini-grids are currently being completed, providing a further 5,300 connections, and the company is planning a third scaling phase that it hopes will start construction by the end of 2020.[215]

Source: Sustainable Energy for All.

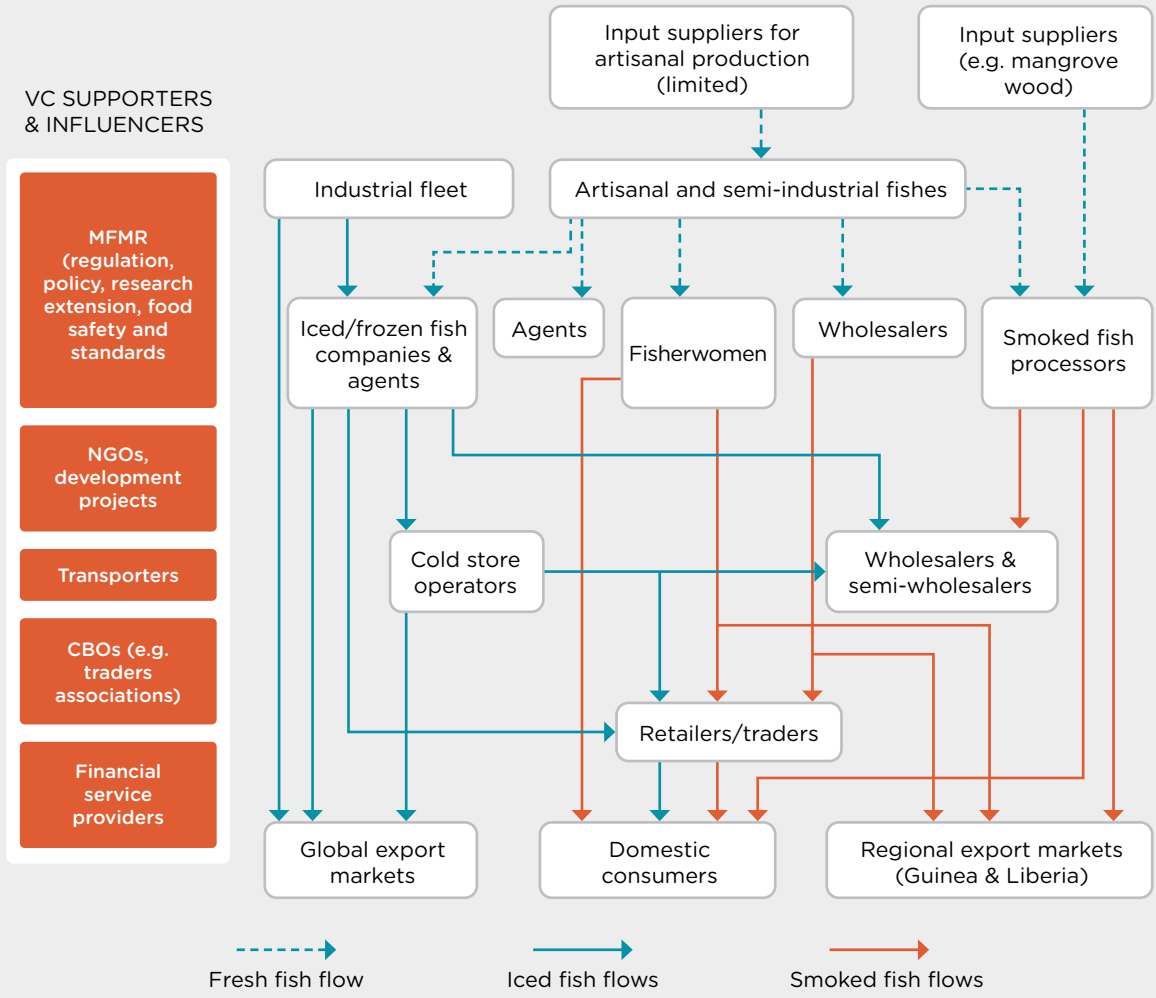
The prevailing challenges across the fisheries value chain (**Figure 26**) in Sierra Leone are as a result of poor management of fisheries and input supplies, high postharvest losses due to inefficient processing methods and lack of cold storage (with estimates stating that up to 50 percent of caught fish is lost), transport challenges, uneven market information between fishermen, cold storage owners and traders, and limited access to credit. The artisanal fish value chain is where losses are the highest. About 80 percent of the fish is sold raw and traders smoke it on-site or keep it fresh depending on the distance to their next selling point.[216]

215 "JUMEME's business model for mini-grids reaping multiple benefits in Tanzania", Sustainable Energy for All, (27 May 2020): https://www.seforall.org/news/jumemes-business-model-for-mini-grids-reaping-multiple-benefits-in-tanzania

216 "Rural Renewable Energy Project - Productive Use Facilitation: Assessment of potential productive use applications for Operator 3 – Power Leone (SL) Ltd.," Inensus GmbH, (27 December 2019).

FIGURE 26

Cold Storage for the Fisheries Value Chain



Source: INENSUS GmbH.

Studies carried out by INENSUS analyzed the feasibility of a cold storage business plan in Sierra Leone's fisheries sector. The business case study estimates that a cold storage room of 20 ft. (providing approximately 30m^3 of cold storage capacity) capable of maintaining indoor temperatures at -30°C would cost approximately USD 5,846. With a shipment cost of USD 2,500, the required up-front capital would be USD 8,346. By applying the annuity method with some assumptions, an annual leasing fee of USD 1,505 would have to be paid by the community to the mini-grid operator and the ownership of the cold room would be transferred to the community by year six. Assuming 1 ton of meat/fish can be stored per m^3 of space and assuming a rotation of one week, 1,440 tons of meat/fish could be stored throughout the year. Such a cold storage room has a daily electrical consumption of 59 kWh. Provided it runs 24/7, this leads to 21.6 MWh of mini-grid electricity consumption per year. At a tariff of USD 0.51/kWh, cold storage would generate a yearly additional revenue stream of about USD 30,000.[217] A summary of the KMM feasibility assessment of this cold storage business case study is presented in **Table 13**.

4.3.2 Nigeria

There are several ongoing programmes and initiatives targeting PUE in Nigeria:

- The **Energizing Economies Initiative (EEI)**, launched in 2017, is a Federal Government of NIgeria (FGN)

217 "Rural Renewable Energy Project - Productive Use Facilitation: Assessment of potential productive use applications for Operator 2 – Winch Energy Limited," Inensus GmbH, (27 December 2019).

initiative implemented by the Rural Electrification Agency (REA) that aims to support the deployment of off-grid electricity solutions to micro, small and medium enterprises (MSMEs) in economic clusters (markets, shopping centres and agricultural/industrial complexes) through private sector developers. In the now completed pilot phase of this initiative, using specific industry indicators such as population density, trade, employment sustainability etc., the REA identified and selected three catchment areas throughout Nigeria for immediate intervention. Major activities taking place in the selected clusters include clothing and shoes production, printing and fabrication of tools and mechanical parts, mid-scale manufacturing and distribution companies (DisCos). The REA details end-to-end best practice for electrifying economic clusters that can be summarized in five key steps: (i) identify the opportunity; (ii) assess feasibility; (iii) set up structure; (iv) build; and (v) operate.[218]

- The **Nigeria Electrification Project (NEP)** has a mini-grid component that aims to support the development of private sector mini-grids in unserved areas with targets to electrify 300,000 households and 30,000 local enterprises.[219] In December 2019, the first mini-grid was commissioned under the NEP (by PowerGen Renewable Energy) in Rokota, a farming community in Niger state whose economic activities include shea butter farming, palm fruit farming and small trade.[220] The NEP mini-grid programme can be described as a supply-side initiative, because it directly assists suppliers of electricity and assumes that benefits (in the form of increased affordability) will trickle down to consumers. In a survey conducted in Gbamu Gbamu, a village in Ogun State where a mini-grid went online in February 2018, members of the population indicated that equipment financing was the one thing that would enable them to take further advantage of the clean, reliable electricity. The African Development Bank (AfDB)-funded side of the programme recognizes the importance of helping rural communities increase their electricity consumption, and in the second component of the Bank's collaboration with the REA, allocated USD 20 million to performance-based grants (PBGs) that will encourage energy access companies to distribute appliances. A few examples of the approved appliances include maize shellers, egg incubators, sewing machines and salon haircutting kits.[221]

The REA also plans to introduce an Energizing Agriculture Programme focused on the productive use of renewable energy in the agricultural sector. The initiative is still in its planning stages.[222]

Several off-grid solar companies are already providing PUE products in Nigeria; for example, Rubitec Solar Ltd. is currently providing solar-powered irrigation solutions to its customers.[223] Local banks including the First Community Monument Bank (FCMB) are also taking an interest in this market segment. In November 2019, the REA, in collaboration with FCMB, GIZ and Power For All, organized a two-day Energy-Agriculture Nexus Workshop, with the aim of engaging with stakeholders on best practices/approaches to stimulate economic growth in the rural agricultural sector through off-grid solar infrastructure development.[224] In addition to solar, waste-to-energy opportunities are also being explored by renewable energy developers in food processing plants such as cassava and palm oil.[225]

Stakeholder consultations with mini-grid developers in Nigeria revealed that prior to the project development stage, the number of commercial users in a given community was first determined as they were the potential anchor customers able to provide the necessary income for the mini-grid to operate. In cases where there was an insufficient number of commercial users, more people were encouraged to take up productive-use activities through incentives such as equipment financing to expedite the purchase of productive-use appliances and offering the lowest tariff plans to the highest users of energy. Appliance financing-programmes have been an effective mechanism to balance load by increasing daytime energy demand and energy efficiency. This financing scheme helps the mini-grid operator optimize daytime load, electricity demand and capacity

218 Energizing Economies: http://rea.gov.ng/wp-content/uploads/2019/02/EEI-Executive-Summary.pdf
219 Nigeria Electrification Project (NEP) Solar Hybrid Mini-Grids Component: https://rea.gov.ng/minigrids/
220 "Nigeria Electrification Project: Rokota Community Shines Bright with Rural Electrification Solar Hybrid Mini-Grid Project," Rural Electrification Agency, (December 7, 2019): https://rea.gov.ng/press-release-rokota-community-shines-bright-rural-electrification-solar-hybrid-mini-grid-project/
221 Dhingra, R., "How Can Nigeria Use its Mini-Grid Power Supply to Empower Rural Residents?" Clean Energy Finance Forum, (July 22, 2020): https://cleanenergyfinanceforum.com/2020/07/22/how-can-nigeria-use-its-mini-grid-power-supply-to-empower-rural-residents-second-of-two
222 Rural Electrification Agency: https://rea.gov.ng/interview-look-africa-mini-grid-market-competitive/
223 https://rea.gov.ng/ref-energy-agric-nexus/Bolade-Soremekun-RUBITEC-AGROSOLAR.pdf
224 https://rea.gov.ng/energy-agric-nexus-workshop/; https://rea.gov.ng/energy-agric-nexus-workshop-27th-november-2019/
225 https://www.nsenergybusiness.com/features/electricity-in-nigeria-pyrogenesys/

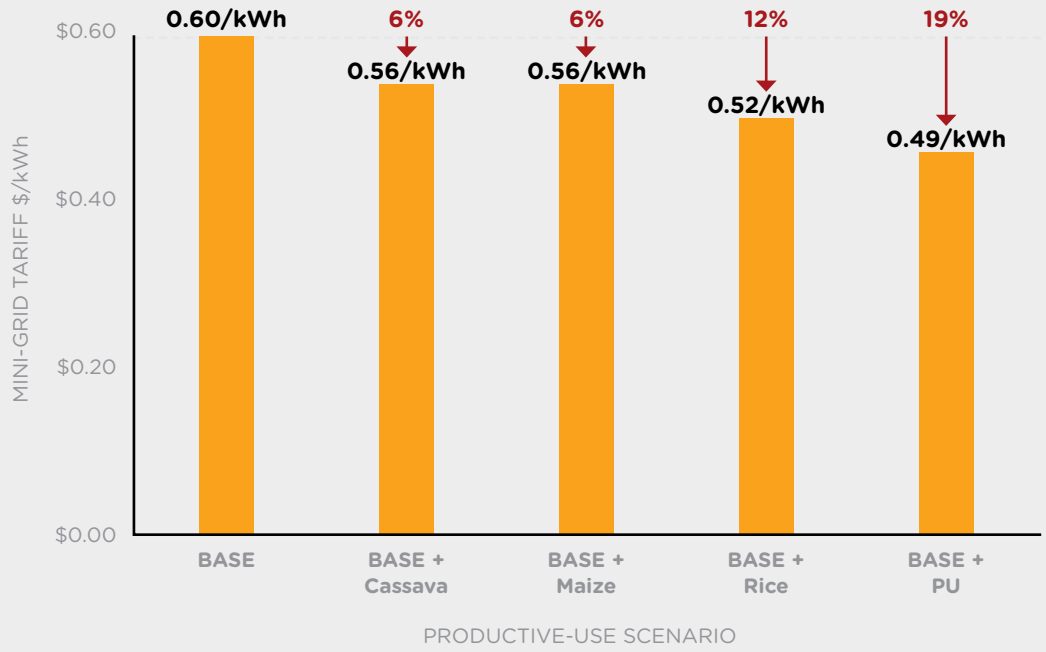
utilization.[226] GVE in particular uses company funds and donor funds to provide equipment financing as a pilot scheme to build a business case that will encourage local microfinance institutions to participate.

A 2020 study conducted under the Nigeria Power Sector Programme (NPSP) assessed 12 agricultural value chains across Kaduna and Cross River states through more than 250 field interviews with farmers, processors, and traders in over 40 rural communities to identify priority electrification opportunities within key agricultural value chains. The study showed that expected loads from Tier 1 productive-use activities including cassava grating, rice milling and flour milling can improve mini-grid economics and enable lower cost-reflective tariffs for customers. Additional productive-use loads (Tier 2 and 3) improve the mini-grid's economics by increasing the system utilization rate and increasing sales. The analysis also found that there is a positive and compelling economic case for each Tier 1 activity analyzed, and with reasonable assumptions all cases can demonstrate positive net present value (NPV). While results are consistently positive, the degree of economic viability is most contingent on the volume of crops processed.

Figure 27 shows that, relative to a baseline scenario with a 77 kWp solar PV-diesel hybrid mini-grid without added productive use, mini-grid electricity tariffs in communities with electrified cassava grating, rice milling and maize flour milling can be 8–14 percent lower, while still earning a 15 percent internal rate of return (IRR) for mini-grid investors.

FIGURE 27

Mini-Grid Tariff to Achieve 15% IRR Under Different Productive-Use Scenarios



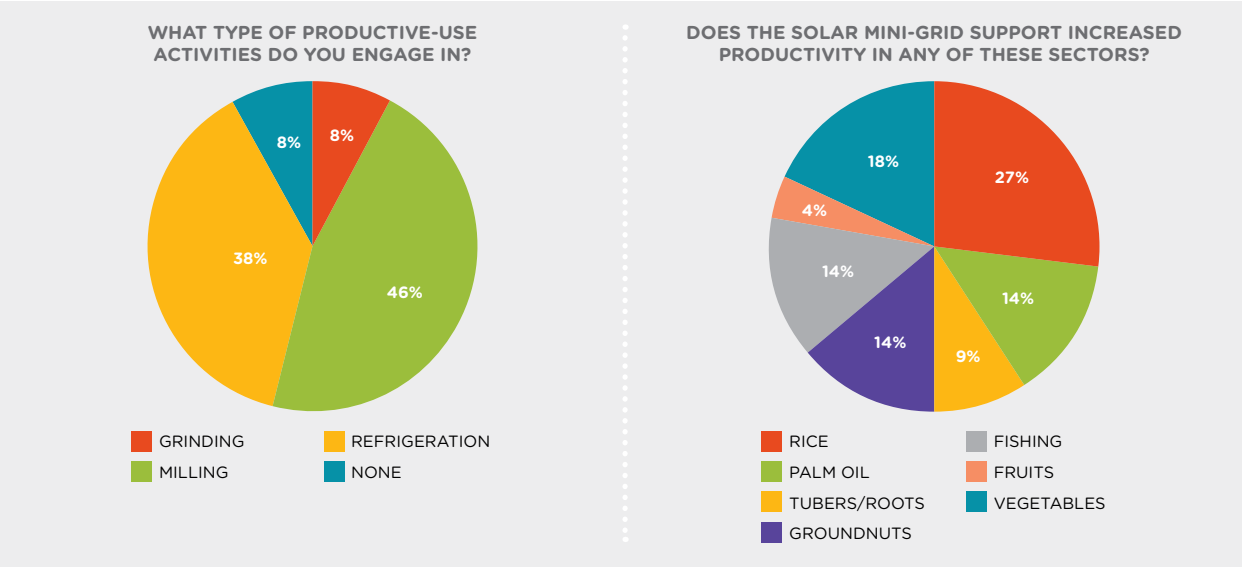
Source: USAID Nigeria Power Sector Programme.

4.4 Summary of Findings

Consultations with rural mini-grid farmers and community stakeholders in Sierra Leone found that milling and refrigeration are among the most common productive-use applications, while solar mini-grid electrification can support increased productivity across a variety of agricultural sectors, including rice, palm oil, fishing, vegetables and groundnuts. Mini-grid electricity would mainly be applied to agricultural processing and cold storage applications in these market segments.

In Sierra Leone, the ability to pay for mini-grid electrification among rural agrarian communities is highly dependent upon the seasonality of income, crop yield etc. This makes the utilization of PUE a critical tool going forward, as it can provide a steady source of income and help increase the purchasing power of communities in the long term.

226 Mini-Grid Investment Report: Scaling the Nigerian Market, Rocky Mountain Institute, 2018.



Operators will also need the support of key public and private sector partners to expand PUE. Several interviewed operators stated that their preference would be to focus on their core competence as electricity providers, while other partners in the agriculture sector should be engaged to support the sale of productive-use machinery/equipment and development of associated value chains at the local level. These private sector partnerships and financing arrangements are already being pursued under Work Package 6 (WP-6) of the RREP with funding from the FCDO.

Barriers to Market Growth

- **Affordability/high up-front equipment costs**: Generally, the biggest barrier to widespread deployment of productive-use applications in Sub-Saharan Africa is the high up-front capital cost of the equipment/machinery and the low purchasing power of rural end consumers and entrepreneurs. This is particularly true in Sierra Leone due to low-income levels among the rural population.[227]
- **Access to finance for equipment purchase:** A vast majority of Sierra Leoneans lack access to financial services, as the country's financial system is underdeveloped and characterized by extremely low levels of credit penetration. Lending is largely concentrated on corporate entities and trade, as banks are less willing to lend to small and medium-sized enterprises (SMEs) and the agricultural sector due to their high perceived risk. Furthermore, most potential end users do not have verifiable credit history.
- **High tariffs/electricity costs**: Even in cases where consumers/micro-enterprises are able to afford productive-use equipment, they may not be able to afford the electricity to use it. High mini-grid tariffs may make investments in equipment financially unviable, discouraging investment. An inadequate assessment of power demand can lead to underuse of the mini-grid, which drives up costs.
- **Access to equipment/unavailability of equipment in remote areas**: End users in remote locations are often unable to access the right equipment – energy-efficient and high-quality equipment that meets their needs in cost, performance, durability and power requirements. Moreover, equipment suppliers often prefer not to serve low-income rural markets due to the higher costs of serving customers in remote locations combined with uncertainty about demand size and ability to pay.
- **Limited Technical Capacity**: Local technical knowledge and skills are critical to take advantage of electric equipment for productive-use applications and projects. However, local entrepreneurs in rural areas often lack the skills to run a business, while mini-grid developers lack adequate knowledge of local rural agriculture value chains.[228] As a relatively new market segment for the off-grid sector, the market dynamics of the PUE market are not yet well understood. There is also limited availability of qualified technicians to maintain systems across various locations.[229]

227 McCall, M. and Santana, S., "Closing the Circuit: Stimulating End-Use Demand for Rural Electrification," Rocky Mountain Institute, (October 2018), https://rmi.org/insight/closing-the-circuit/
228 Power for All Factsheet: Mini-grids productive use of energy (PUE) in agriculture: https://www.powerforall.org/application/files/9615/9302/4971/FS_Mini-grids_productive_use_of_energy_PUE_in_agriculture3.pdf
229 "Nigeria Power Sector Programme (NPSP) Productive Use Stimulation In Nigeria: Value Chain & Mini-Grid Feasibility Study," United States Agency for International Development, (July 2020): http://rean.org.ng/media/img/PA-NPSP_Agriculture_Productive_Use_Stimulation_20200728.pdf

- **Access to Markets**: Productive-use businesses cannot grow beyond a certain size if they do not have access to a wider market for their products beyond their communities. This will require extensive coordination and technical and financial support from various public agencies (e.g., agriculture ministries, energy, infrastructure, planning etc.) as well as private sector partners.

Drivers of Market Growth

- **Cost Reduction/Fuel Switching**: Stakeholder interviews found that productive-use/commercial customers will opt to connect to mini-grids if the mini-grid tariff per kWh is lower than the cost of electricity generated by diesel generators. The resultant reduction in the customers' aggregate cost of energy will increase profitability and enable the productive-use customers to focus on their core businesses with less focus on power generation management.
- **Reliability/Quality of Service**: Reliable power supply is key for commercial customers, otherwise, they will continue to use diesel generators. Therefore, mini-grid systems must be designed to serve productive-use loads while maintaining power quality, reliability and availability. A three-phase distribution system is necessary for PUE compared to single phase networks that have lower capital costs, but higher power losses.[230]
- **Community Engagement and Incentives Schemes**: The provision of well-designed incentives is crucial to stimulating PUE during off-peak hours, thereby increasing the efficiency of the mini-grids. Some recommended incentives for Sierra Leone include:[231]
  - **On-Bill Equipment Financing**: To stimulate productive uses of electricity (grain mills, welders, etc.), low-cost loans should be provided by the mini-grid operator to support end users/local entrepreneurs in acquiring electrical productive-use equipment and machinery and start-up of new businesses. The loans are paid off over time through a surcharge on the customers' electricity bills.
  - **Time of Use/Flexible Tariffs**: PUE during daytime/off-peak hours should be incentivized by flexible time-of-use (TOU)-based tariffs to manage load profiles and ensure the efficiency of the mini-grid.
  - **Awareness Campaigns and Education**: Creating awareness and education for would-be equipment purchasers/local entrepreneurs and accessible market information for mini-grid providers is crucial. Potential end users should be educated to opt for energy-efficient and soft-start appliances (appliances with motors that require less electricity to start up and to run) that reduce peak loads and operational costs of the system.

4.5 Recommendations for Sierra Leone

A 2019 study carried out by Dalberg Advisors and the World Bank of the market opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa identified eight areas in which governments, development partners and the private sector can work together to build the off-grid solar productive-use market (**Figure 28**).[232] The GoSL, with assistance from its development partners and together with the private sector, should develop and implement policies and programmes to pursue these interventions and spurt growth of the productive-use sector. Rolling out PUE in mini-grid communities on a large scale will require extensive coordination across various public agencies (Ministry of Energy (MoE), Ministry of Agriculture and Forestry, Ministry of Planning and Economic Development, Ministry of Local Government and Rural Development (MLGRD)) as well as private sector partners, including in the local financial sector (e.g., Sierra Leone Association of Microfinance Institutions) to improve access to local currency financing for the PUE sector.

Local operator Winch Energy has already formed several key partnerships to develop local enterprises and expand PUE in its WP-1 mini-grid communities. The company has partnered with EasySolar to offer consumers electrical appliances available on microcredit and is working with the telecommunications operator Orange to expand access to mobile money services in its communities.[233]

230 Janse, S., "Affordable and reliable mini-grids in Sierra Leone," TU Delft Technology, Policy and Management, (May 2019): https://repository.tudelft.nl/islandora/object/uuid%3Ab98a7726-bb05-430f-832c-53282130edeb; and Power for All Factsheet: Mini-grids productive use of energy (PUE) in agriculture: https://www.powerforall.org/application/files/9615/9302/4971/FS_Mini-grids_productive_use_of_energy_PUE_in_agriculture3.pdf

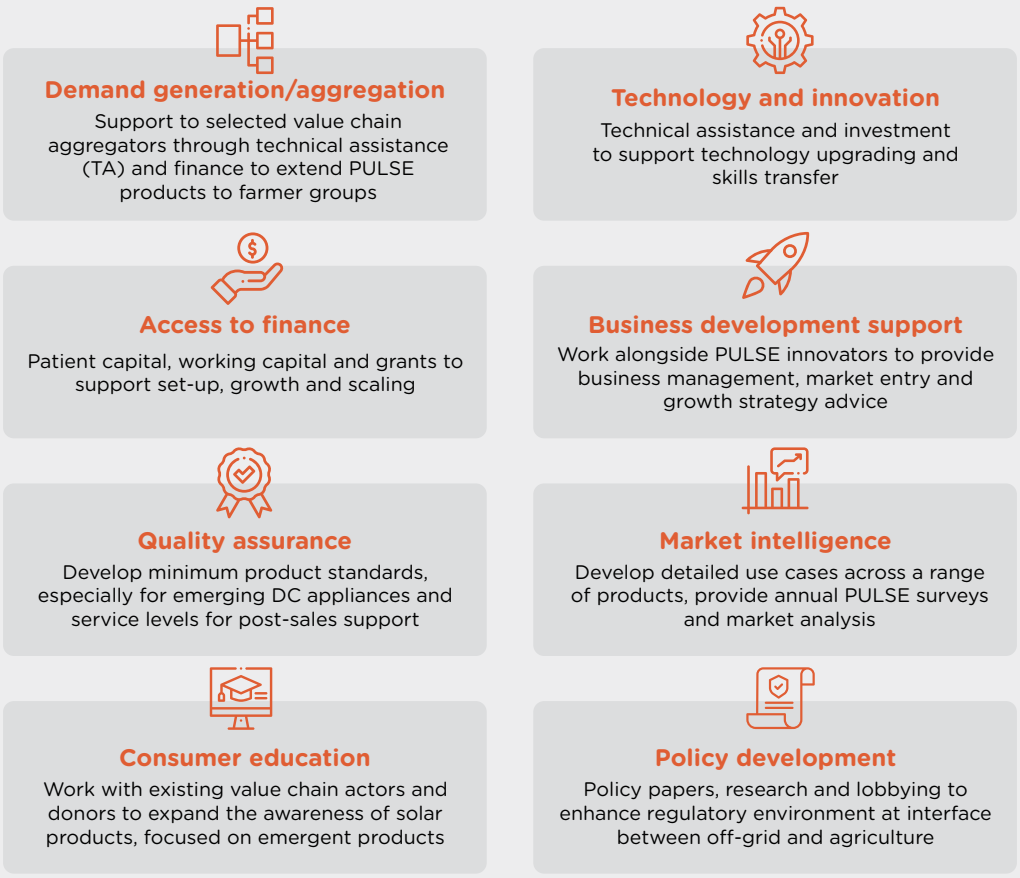
231 Janse, 2019; McCall and Santana, 2018; State of the Global Mini-Grids Market Report 2020; and "Nigeria Power Sector Programme (NPSP) Productive Use Stimulation In Nigeria: Value Chain & Mini-Grid Feasibility Study," United States Agency for International Development, (July 2020): http://rean.org.ng/media/img/PA-NPSP_Agriculture_Productive_Use_Stimulation_20200728.pdf

232 "The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa," Dalberg Advisors, Lighting Global and World Bank, (2019): https://www.lightingglobal.org/wp-content/uploads/2019/09/PULSE-Report.pdf

233 "Winch Energy celebrates project success in Sierra Leone," African Review, (26 October 2020): https://www.africanreview.com/energy-a-power/renewables/winch-energy-celebrates-project-success-in-sierra-leone

FIGURE 28

Key Interventions to Support Development of the Productive-Use Sector



Source: Dalberg Advisors, Lighting Global and World Bank.

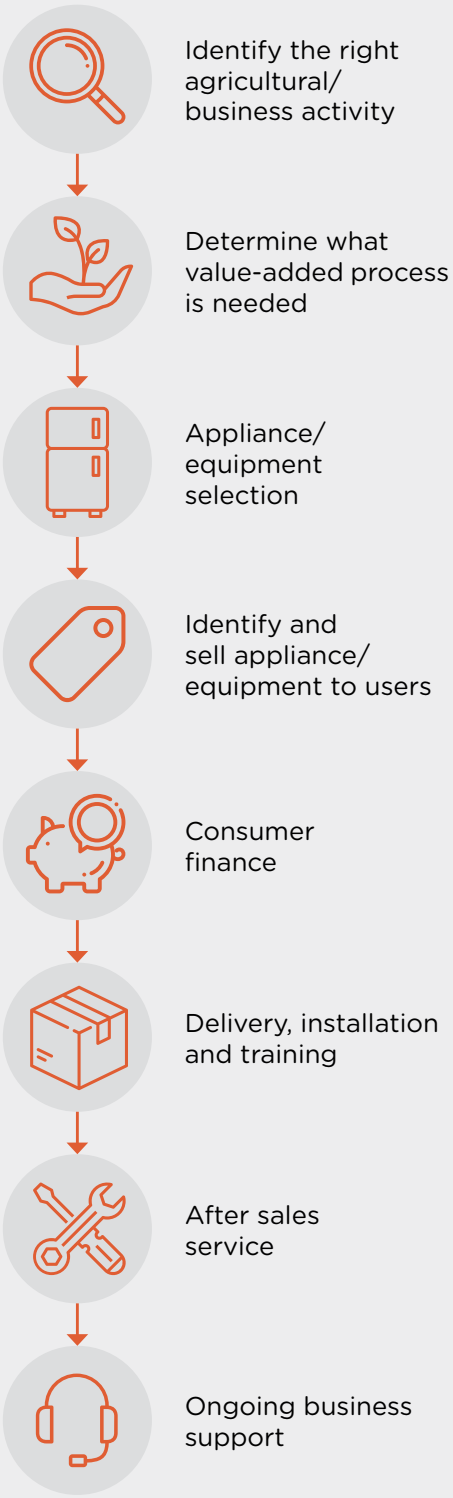
Applicable Lessons/ Recommendations from Nigeria

- **Nigeria EEI and NEP:** Under the Energizing Economies Initiative (EEI), Nigeria's REA pursued an end-to-end approach for electrifying commercial hubs/economic clusters; under the NEP, the REA and its development partners rolled out a successful PUE equipment-financing scheme (in partnership with PowerGen). Together, the EEI and the NEP offer a blueprint the GoSL can follow to identify suitable commercial and/or agricultural hubs that could benefit from mini-grid electrification, followed by the selection and careful integration of appropriate PUE equipment through an appliance-financing mechanism with ongoing business development support (**Figure 29**).
- **Community Sensitization and Engagement:** Community engagement is a key feature of the NEP. Future mini-grid development in Sierra Leone will require extensive community engagement and sensitization around productive-use applications, including consumer education on what/how appliances interface with the mini-grid, as well as financing for equipment and associated training on PUE products and services.
- **Tariff Structure**: In Nigeria, some developers offer productive users and commercial users (who generally consume more power) a lower tariff than residential customers as an incentive to increase electricity uptake and PUE activities, particularly during the day when it is more affordable for solar mini-grid operators to produce and distribute energy.[234]
- **Need for Financing and Technical Assistance (TA)**: There is generally a much greater need for targeted financing and TA interventions to scale-up PUE, particularly to help local businesses grow and expand their access to a wider market for their products beyond their communities.

234 A similar approach has been considered for WP-2 sites in Sierra Leone.

FIGURE 29

Roadmap for PUE Equipment and Appliance Integration into Mini-Grid Development[235]



Source: Kenya Green Mini-Grid Facility.

235 "Productive Use, Access to Finance and Partnerships," Kenya Green Mini-Grid Facility, (10 December 2020): https://www.gmgfacilitykenya.org/index.php/news-media/item/85-invitation-to-productive-use-access-to-finance-and-partnerships-webinar

5 MINI-GRID SITE SELECTION

5.1 Site Selection Criteria

The selection of sites for developing mini-grid projects varies by country and is subject to the objectives and focus of electrification policy and regulation. Several approaches exist, including public/government-led, private sector-led, or public-private partnership (PPP) schemes (see **Section 2.1**), with the collective aim of increasing energy access connections, stimulating the productive use of energy (PUE) and promoting rural economic development.

Most public sector-led mini-grid programmes focus on meeting electrification targets and are typically funded either through government budgets and/or with support from development agencies and partners. As such, the primary energy access indicators from the public sector perspective include the number of beneficiaries of a given programme, the number of household connections achieved, and the extent to which electrification has improved development outcomes (e.g., economic, health, sustainable/low-carbon growth etc.)

Private sector-led initiatives are commercially driven, with more attention on cost recovery in order to service project debt obligations while also seeking a return on investments. Hence, private developers focus more on selecting sites that will ensure sufficient electricity demand through potential anchor customers, household connections, and PUE to provide the necessary income for the mini-grid to operate sustainably.

5.1.1 Sierra Leone

In Sierra Leone, the Rural Renewable Energy Project (RREP) beneficiary communities were selected in 2016 by a steering committee led by the Ministry of Energy (MoE) based on a nationwide list of villages with community health centres (CHCs) provided by the Ministry of Health and Sanitation (MoHS) in the wake of the Ebola crisis (see **Section 1.1.2**).[236] The steering committee approved the final sites according to a series of predefined technical criteria to ensure an equitable distribution per district nationwide. The criteria considered for the selection of sites included:[237]

- Existence of a CHC
- Size of the community with respect to households, businesses and population density (a minimum of 250 structures was required in order to ensure economic viability)
- The distance of the community to the CHC (to reduce the cost of using medium voltage lines)
- The distance of the community to any existing or planned transmission lines and/or the existence or plan for any other electrification project.

The criteria for selecting mini-grid sites were the same for both Work Package 1 (WP-1) and Work Package 2 (WP-2); however, the WP-2 sites were planned to be served by larger mini-grid systems (between 36 and 200 kW) as an incentive to the operators financing this part of the project. Solar irradiance is mostly uniform throughout Sierra Leone so the most critical determinants for site selection were population density and planned future grid electrification.

Recognizing the need for a consultative approach to the implementation of the RREP, a formal Inter-Ministerial Cooperation Agreement was signed between the MoE, MoHS, and the Ministry of Local Government and Rural Development (MLGRD). This Agreement provides for collaboration on oversight activities, including monitoring and evaluation of programme outputs and results and the establishment of local by-laws and regulations to ensure local support for rural electrification.

236 Ministry of Energy - Rural Renewable Energy Project: http://www.energy.gov.sl/home/rural-renewable-energy-project/
237 Stakeholder interviews, 2020.


An important takeaway from the mini-grid site selection process in Sierra Leone is that less emphasis was placed on demand-side considerations during initial (WP-1) site selection, which prioritized supplying electricity to the CHCs. In contrast, WP-2 focused more on PUE opportunities, with several studies commissioned by UNOPS to support the three operators in this regard.

When interviewed, mini-grid operators highlighted the importance of identifying productive users when assessing electricity demand in a given community, with particular focus on the energy end-use activities of the businesses in the community. Generally, operators also focus on community accessibility, income levels and purchasing power of residents, population size and density, relative security, and level of support from local authorities and stakeholders. Above all, operators seek to identify anchor clients or customers who rely on power to carry out daily activities and are already using alternative sources of energy (e.g., diesel generators), as this represents an opportunity for fuel switching and cost savings.

5.1.2 Nigeria

The Federal Government of Nigeria (FGN) has adopted a decentralized, private sector-led approach to electrify the country's rural and unserved population. Under the Nigeria Electrification Project (NEP) mini-grid component, a results-based financing (RBF) mechanism (see **Section 2.2.2**) provides financial incentives for the development of identified off-grid sites with high customer density characteristics that are best suited for mini-grid electrification. The Rural Electrification Authority (REA) site selection process promotes private sector development of these sites by providing clarity and reducing risk for operators. At the commencement of the mini grid programme in 2017, the REA supported a detailed survey that prioritized over 200 sites with demand of at least 100 kW across five states. The assessment utilized georeferenced data to assess the following key parameters for site selection:[238]

- Sufficient load/density
- Productive-use, daytime, and flexible loads
- Supportive local and state government
- Community engagement
- Accessibility

Among 10,000 sites identified for potential mini-grid electrification, an initial 500 sites were shortlisted, and then 200 sites (with at least 100 kW of demand) were prioritized for subsequent analysis based on these criteria. Detailed surveys were then carried out in these communities using a computer-aided personal interview app on a mobile device. The REA surveys assessed community/institutional, household and commercial end users and covered a wide range of data/indicators (**Figure 30**).

Following the supply-side analysis, the REA led a robust community-engagement process to analyze demand factors, as well as to secure the buy-in of community stakeholder groups. These included community leaders, women's groups, youth groups, schools, healthcare facilities, religious organizations, community service organizations and electricity users associations. The community survey examined productive-use potential and associated load profiles, existing energy sources/type of self-generation (e.g., diesel generation) and levels of community income and willingness to pay (WTP). The REA also embarked on community awareness-raising campaigns to mobilize and sensitize rural communities across the country to form Electricity Users Cooperative Societies (EUCSs). Communities are expected to own, operate and maintain their electricity networks in collaboration with private companies providing the know-how required to operate such systems effectively and efficiently.[239]

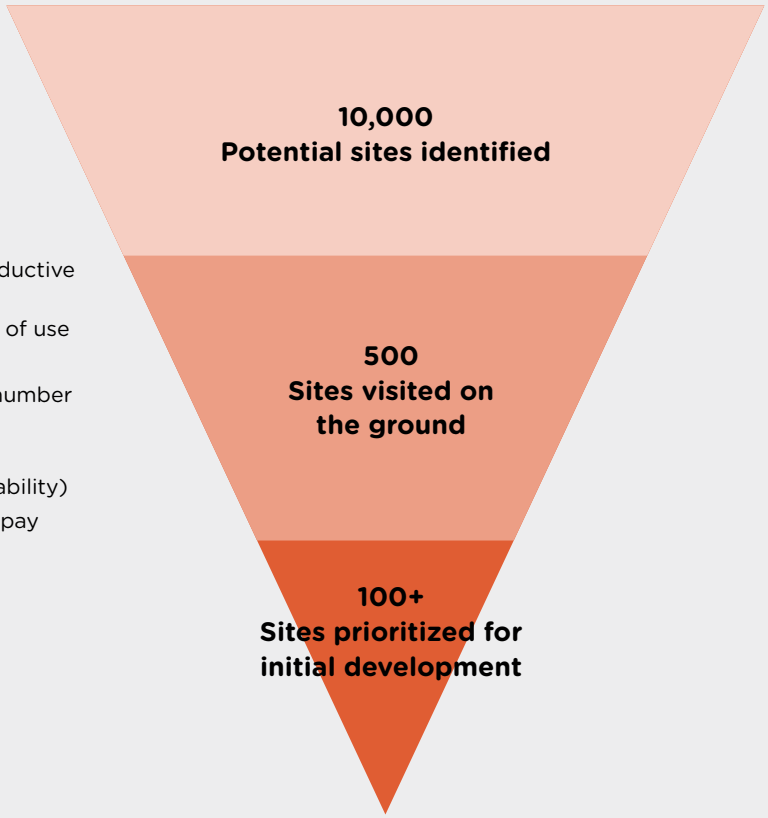
238 Babamanu, 2019.
239 Ibid.

FIGURE 30

Mini-Grid Site Selection under the Nigeria Electrification Project

REA survey data includes:

- Number of households, shops, productive loads, and other institutions
- Appliances, productive loads, time of use
- Estimated load profile
- Existing self generation (size and number of units)
- Fuel price and availability
- Cellular service (providers and reliability)
- Current income and willingness to pay
- GIS data for villages and potential customers



Source: Nigeria Rural Electrification Agency.

When interviewed, private developers indicated that the NEP provided sufficient consideration for the commercial viability of sites, and that with the REA's support, they have been able to successfully streamline sites for development. A key consideration in site selection for developers in Nigeria is proximity to the national grid. Developers want to ensure the potential mini-grid site is reasonably far away from the main grid (average of minimum 10–15km) and also not part of the current expansion plans of distribution companies (DisCos), which have control of the territories. This will ensure that a reasonable amount of time will pass for developers to recoup their investments and avoid a quick evacuation of sites due to grid extensions to the potential community.

Following the first rollout of mini-grids in Nigeria supported by GIZ in collaboration with the REA, most developers now take into careful consideration the potential commercial activities that a community can undertake to increase electricity demand and generate income. Developers now carry out detailed surveys of potential mini-grid communities to assess what productive activities exist, particularly in the agricultural sector. Surveys considered agricultural practices, including what kind of crops are planted; whether an anchor business or client can be served in the community; whether any relevant cooperatives exist in the community (e.g., for farmers, electricity user associations etc.); willingness and capacity of users to pay for power generated; and how readily accessible and secure a site is for logistics and movement of assets.[240]

5.2 Summary of Findings

A summary of findings, covering both demand-side and supply-side factors in mini-grid site selection is presented in **Table 15**.

240 Stakeholder interviews.

TABLE 15

Mini-Grid Site Selection Criteria

Mini-Grid Site Selection Approach	Lessons Learned	Recommendations
Sierra Leone (RREP) • The GoSL Project Steering Committee was established to select RREP sites based on the following criteria: › Existence of CHCs › Size of the community with respect to households, businesses and population density (min. 250 structures) › The distance of the community to the CHC (to reduce cost of using medium voltage lines) › The distance of the community to any existing or planned transmission lines and/or the existence or plan for any other electrification project • Demand assessment carried out by MoE/UNOPS in 2016 across 68 communities yielded 1,950 respondents, providing sufficient data to indicate affordability • RREP project developers identified the following key indicators when assessing the commercial viability of potential mini-grid sites (under WP-2): › Population density › Community accessibility › Income levels and purchasing power of residents › Opportunities for PUE based on energy end use of businesses in community › Level of support from local authorities and community stakeholders	**Sierra Leone (RREP)** • An important lesson from this process is that less emphasis was placed on demand-side considerations during initial (WP-1) site selection, which prioritized supplying electricity to rural CHCs in the wake of the Ebola crisis. While the provision of electricity to critical social services is important, strategies to mitigate high tariffs may be needed if these sites have low demand. • In contrast, WP-2 focused more on PUE opportunities, with several studies commissioned by UNOPS to support the 3 operators in this regard	• Governments should seek to select optimal sites to maximize financial viability by pursuing the following measures: • Adopt an IEP approach[241] to design and implement robust and methodical mini-grid site selection criteria (and make this available to developers) • Utilize GIS/georeferenced data and other consumer and market intelligence tools to identify densely populated areas with highest potential for electricity demand • Conduct extensive community-level engagement to properly assess local economic activity, raise awareness and sensitize communities • Analyze existing expenditure on energy sources/alternatives to determine ability and WTP for mini-grid access • Engage with local community to focus on potential opportunities for PUE • Adopt geo-tag survey methods as well as other data management tools (e.g., to provide demand forecasting information to developers) • Consider support of local/district and state government authorities to identify possible areas where sites can be clustered to benefit from economies of scale in construction and operations • Solicit input from wide range of community stakeholders, including women's groups, youth groups, and other associations of local entrepreneurs
Nigeria (NEP) • The REA identified 10,000 potential sites using GIS data to assess the following: › Sufficient load/density › Productive-use, daytime, and flexible loads › Supportive local and state government › Community engagement › Accessibility • Next, the REA carried out detailed surveys of 200 communities with at least 100 kW of demand, using a mobile app to assess the following: › Number of households, shops, productive loads, and other institutions › Appliances, productive loads, TOU › Estimated load profile › Existing self-generation (size and number of units) › Fuel price and availability › Cellular service (providers and reliability) › Current income and WTP › GIS data for villages and potential customers › Geo-tag survey • Finally, the REA led a comprehensive effort to raise awareness among identified communities and to mobilize and sensitize rural communities across the country to form the EUCS • The REA utilized the Odyssey data management platform as a tool for tracking hundreds of feasibility studies, connections and project performance, and providing demand-forecasting information to developers	**Nigeria (NEP)** • Project developers identified the following key indicators when assessing the commercial viability of potential mini-grid sites: › Distance from the main grid (at least 10–15km) › Exclusion from the expansion plans of DisCos for at least 5 years › Level of PUE /income-generating activities in the community › Existing energy sources and type of self-generation (diesel generator) › Affordability and WTP tariffs	

Source: Sierra Leone Ministry of Energy; Nigeria Rural Electrification Agency; stakeholder interviews.

241 See: https://www.seforall.org/interventions/electricity-for-all-in-africa/integrated-electrification-pathways

5.3 Recommendations for Sierra Leone

The Nigerian mini-grid sector offers a promising case study for mini-grid development, as it is currently witnessing rapid growth, driven by the private sector. The REA's focus on commercial viability of mini-grids and the flexibility for project developers to collaborate with it and provide inputs into site-selection criteria is driving expansion and investment into the sector. The NEP is also working hard to engage with and sensitize communities, including to promote productive activities, increasing employment and income and in turn enabling local capacity and WTP.[242]

Sierra Leone can adopt a similar model to support private sector-led growth and expansion of the mini-grid sector, with a focus on both connections and the commercial viability of sites. The MoE and the Electricity and Water Regulatory Commission (EWRC) can seek to expand their internal capacity and/or create a separate REA to manage the rollout of a national mini-grid programme, including detailed site assessments and community-sensitization initiatives as they were conducted under the NEP. Some of the key innovations from mini-grid selection in Nigeria that Sierra Leone can adopt include the utilization of GIS/georeferenced data and other consumer and market-intelligence tools,[243] and the implementation of a national data management platform (e.g., Odyssey) to provide information to developers (e.g., demand forecasting, tariff calculation etc.).

On the demand side, more emphasis should be placed on productive activities to support the end use of mini-grid electricity. Electricity demand assessments currently focus more on personal consumption at the household level (e.g., lighting and phone charging etc.), which may lead to lower levels of electricity uptake for projects. Developers need both financial and technical assistance from the government and/or development partners to support robust assessments of productive-use potential during the site selection process.

There is also the need to consider incorporating appliance financing for households and small and medium-sized enterprises (SMEs) into mini-grid business models to ensure proper use of the electricity provided. Furthermore, providing business support services to SMEs on the use of appliances will increase productive activities, stimulate electricity demand, and thus increase their overall capacity to pay for electricity consumed. Rather than only selling kWh, the Energy-as-a-Service (EaaS) business model (see **Annex 1**) can enhance the commercial viability of mini-grid projects, but also requires an increased focus on community awareness and sensitization.[244]

In 2019, SEforALL launched the Integrated Electrification Pathways (IEP) initiative – a set of integrated planning approaches and policy measures that support using grid, mini-grid and off-grid technologies to provide electricity access. The four IEP principles include:[245]

- Place access to electricity in the context of sustainable development and human needs
- Consider all technological approaches and delivery models
- Rely on high-level commitment and support for an inclusive, coordinated planning process
- Include supportive policy measures that facilitate investment and are market enabling

By adopting an IEP, Sierra Leone can support mini-grid development by adding transparency on where the grid is likely to extend, and by pursuing a rigorous, data-driven analysis of where mini-grids are most appropriate compared to alternatives.

242 Mini-Grid Investment Report: Scaling the Nigerian Market, Rocky Mountain Institute, 2018.
243 Off-grid energy services companies are increasingly making more demand-side data available through customer and market insights. For example, Nithio provides data on customer creditworthiness, expenditure patterns; Fraym offers advanced geospatial data solutions (see: http://www.nithio.com and https://fraym.io)
244 The NEP achieved this by establishing an Electricity User Cooperative Society in each mini-grid community.
245 Integrated Electrification Pathways: https://www.seforall.org/interventions/electricity-for-all-in-africa/integrated-electrification-pathways

6 RECOMMENDATIONS FOR FURTHER RESEARCH

In addition to the recommendations and lessons learned shared in this report, a few areas/topics recommended for further research to support mini-grid market development in Sierra Leone are included below.

- **Database of mini-grid market information**: Mini-grid electrification requires detailed quantifying of energy supply and demand. Currently available data do not include an exhaustive list of projects or project details sufficient to establish an accurate baseline for this purpose. To scale up mini-grid development, the Government of Sierra Leone (GoSL) can support the development of a database of existing off-grid electricity projects that includes details related to electricity supply (e.g., peak available capacity and service potential; information on fixed and variable project costs, execution details, and operating constraints such as intermittent power generation from renewable energy sources), corresponding electricity demand (end-user demand profiles, willingness/ability to pay etc.), and technology options. The database can be part of a broader Ministry of Energy (MoE) initiative to promote the publication of open, easily accessible, and up-to-date market information. This can also serve to help the Electricity and Water Regulatory Commission (EWRC) monitor and track tariff levels by conducting benchmarking exercises of service prices in different service areas to analyze how tariffs evolve over time and in turn to prevent service providers from overcharging mini-grid communities. The GoSL can seek out support from regional partners, such as ECREEE, which has developed a similar database (ECOWREX). Once the database is established, it would need to be routinely updated (e.g., by the MoE) as new market data become available.

- **Support pre-feasibility studies and community-engagement campaigns to further expedite market development:** The GoSL and its development partners can provide funding for detailed pre-feasibility studies on mini-grid sites to support their prioritization (including data sheets and interactive databases that can be made available to the private sector). Studies should focus on increasing outreach and engagement with rural communities in order to analyze average ability and willingness to pay (WTP) based on end-user groups (e.g., households, small and medium-sized enterprises (SMEs) and productive users) across different service areas. The objective of this research will be to provide better information to prospective developers on the electricity demand profile of communities (and to identify potential anchor clients and/or productive-use energy (PUE) opportunities), what kind of financial support is needed by which end users, and what corresponding funding may be available either directly provided by the GoSL and its development partners or through partnerships with the local financial sector (e.g., concessional loans, credit lines, guarantees etc.).

- **Crossboundary Energy Access** recently launched an open-source approach to increase investment in infrastructure capital for mini-grids in Africa through a new project financing model.[246] This is an innovative area of knowledge-sharing that can be explored further.

246 https://www.crossboundary.com/category/energy-access-news/open-source/

ANNEX

ANNEX 1

MINI-GRID BUSINESS MODELS

Overview of Mini-Grid Ownership and Business Models

Ownership/Business Model	Impact on Government/Utility	Impact on Private Sector	Impact on Retail Customers	Advantages	Disadvantages
PUBLIC OWNERSHIP MODEL Government/national utility is designated as the owner and operator of all mini-grid assets, responsible for generation, distribution and retail sales	• Government typically relies on cross-subsidies from national grid customers to finance mini-grid development	• No significant role for the private sector (unless a Build-Operate-Transfer (BOT) model is utilized)	• Lower cost of electricity than alternatives (e.g., kerosene, diesel generator) for mini-grid customers • Higher tariff for national grid customers due to cross-subsidies	• Lower tariffs for mini-grid customers due to cross-subsidies • Public utility has proven technical expertise from operating the national grid • Public utility has access to government funding for mini-grid development in remote areas • Public utility is already known to customers	• Requires larger subsidies and/or higher tariffs for national grid customers • Can create a financial burden for utility due to high cost of operating mini-grids in remote areas • Can slow the pace of mini-grid electrification (speed of delivery depends on capacity of public utility)
PRIVATE AND COMMUNITY OWNERSHIP MODELS Mini-grids are owned and operated solely by private sector or community actors	• Business model requires light-handed government regulation (in line with regulatory regimes that promote privatization) • Government can provide public grants, subsidies, and loan guarantees to support private sector development • If tariff is cost-reflective, eases burden on public funds or cross-subsidies, but tariff affordability is an issue	• First movers needed as private sector interest to service remote areas may be limited without some form of government support • Bankability is a concern due to high transaction costs (permits, licensing, procurement etc.) • High revenue risk exposure (tariff negotiation, non-payment)	• More expensive electricity • Private sector to encourage greater PUE • If mini-grid is community-owned, requires extensive ongoing involvement of community	• Private sector is more efficient; can accelerate the pace of mini-grid electrification • Lower subsidy required • If mini-grid is community-owned, can generate jobs for local entrepreneurs and community members	• Higher tariffs for customers • Rarely commercially viable in rural areas without funding support from government • Requires significant regulatory capacity to manage/oversee • If mini-grid is community-owned, challenges related to lack of local technical and managerial capacity necessary to operate and maintain mini-grid system

Ownership/Business Model		Impact on Government/Utility	Impact on Private Sector	Impact on Retail Customers	Advantages	Disadvantages
HYBRID OR MIXED OWNERSHIP MODELS Public and private sector actors own and operate mini-grids through public-private partnership (PPP) arrangements	**Hybrid Model 1: Public Ownership/Private Management Model** Government/utility plans, finances and implements a mini-grid project up to the commissioning stage; operation is then outsourced to the private sector through a concession or management contract, in which the private developer is responsible for the management and operation of the mini-grid system, including generation, distribution and retail sales of electricity to mini-grid customers	• If there is O&M by concession, then there is opportunity for cost-reflective tariffs, which would ease burden on public funds or cross-subsidies	• Does not need to recover capital investment • May be exposed to revenue risk from collection of tariffs	• Tariffs potentially lower (vs. fully private model) because government will develop and own the infrastructure assets	• Encourages the participation of private sector actors that may not necessarily have the capacity to develop mini-grid projects independently • Effective method of distributing responsibilities to optimize government and private sector capacities (and thus overcome limitations associated with other models) • Lower cost of capital and hence slightly lower tariffs	• Possible conflicts over large capital maintenance works, reinvestments and upgrades
	Hybrid Model 2: Private Generation/Public Distribution Model (PPA Model) Private sector builds, owns and operates mini-grid generation assets and sells power to the public utility under a Power Purchase Agreement (PPA); public utility owns and operates the distribution assets and retail sales of electricity to mini-grid customers	• If utility charges below cost-reflective tariff to customers, will require subsidies from the government or cross-subsidies from national grid customers to finance mini-grid development • Private generation is expected to be more efficient and hence cheaper due to incentive of fixed PPA tariff	• PPA reduces revenue risk • Lower operating costs and potentially easier permitting and licensing procedures make projects bankable • Potentially lengthy contractual processes associated with PPA can be mitigated by standardized PPA developed by regulator	• Lower cost of electricity than alternatives (e.g., kerosene, diesel generator) for mini-grid customers • Higher tariff for national grid customers due to cross-subsidies • Retail customers must rely fully on public utility (limited interaction between the private sector and end users/demand side)	• Encourages the participation of private sector actors that may not necessarily have the capacity to develop mini-grid projects independently • Effective method of distributing responsibilities to optimize government and private sector capacities (and thus overcome limitations associated with other models) • Easiest and quickest way to involve private sector	• No precedent of PPAs for suppliers to mini-grids • Requires significant regulatory capacity to develop interconnection rules, a standardized PPA for mini-grid sector etc.
	Hybrid Model 3: Split-Asset Model Government procures and owns the distribution assets of the mini-grid, while the private developer owns the generation assets and is responsible for the management and operation of the mini-grid system, including generation, distribution and retail sales of electricity to mini-grid customers	• Functionally the same as a fully private model, with the potential for lower cost-recovery due to government funding the distribution network capex	• Split of distribution and generation assets reduces the investment costs for the developer	• Tariffs potentially lower (vs. fully private model) because government will fund the distribution network capex • Private sector to encourage greater PUE	• Private sector is more efficient; can accelerate the pace of mini-grid electrification • Lower subsidy required • Lower cost of capital (vs. fully private model) should lead to lower tariffs	• Requires significant regulatory capacity to manage/oversee • Possible conflicts over large capital maintenance works, reinvestments and upgrades

ANNEX 2 MINI-GRID POLICY, REGULATORY AND INSTITUTIONAL LANDSCAPE IN SIERRA LEONE AND NIGERIA

Government of Sierra Leone Institutional Landscape of the Mini-Grid Sector

Key Role(s): Policy Formulation, Policy Implementation, Regulation, and Administration	Institution Name	Description
Policy Formulation	Ministry of Energy (MoE)	• The MoE develops and implements energy sector policies, projects and programmes and oversees functions across the entire energy supply chain
	Ministry of Finance (MoF)	• The MoF oversees management of the revenue and finances of the GoSL
	Environmental Protection Agency (EPA)	• The EPA was established to protect the environment of Sierra Leone and effectively manage its natural resources. In 2019, the agency released the Guidelines for Environmental and Social Impact Assessments of Renewable Energy Technologies and Mini-Grids
	National Public Procurement Authority (NPPA)	• The NPPA performs oversight functions and advises the GoSL on Public Procurement management
Regulation	Sierra Leone Electricity and Water Regulatory Commission (SLEWRC)	• Established by the Sierra Leone Electricity and Water Regulatory Commission Act, the SLEWRC regulates the utility service providers in the electricity and water sectors; developed the mini-grid regulations[247]
Implementation	Public-Private Partnership (PPP) Unit	• The PPP Unit's mandate is to promote, facilitate and streamline the inception, negotiations and implementation of all public-private partnership agreements between public authorities and private partners

247 In particular, the EWRC is responsibility for granting licenses to any entity engaged in the following activities in the electricity sector: the sale, provision, arrangement or otherwise supply of access to electricity; construction, installation or operation of any facility for the sale, provision or supply of electricity; transmission, wholesale supply, distribution or sale of electricity.

Summary of Mini-Grid Policies, Laws and Regulations in Sierra Leone

Name	Type	Description	Originating Agency
National Energy Policy, 2009	Policy	• This outlines the policies required to achieve the GoSL's goal to provide modern energy services for its citizens.	Ministry of Energy and Water Resources
National Electricity Act, 2011	Act	• Revoked the previous National Power Authority (NPA) Act of 1982 and unbundled the National Power Authority into 2 new entities – the Electricity Generation and Transmission Company (EGTC) responsible for generation and transmission at high voltage levels (161kV), and the Electricity Distribution and Supply Authority (EDSA) responsible for electricity distribution and transmission at lower voltage levels of 33kV and below. EDSA also acts as the sole offtaker for electricity from IPPs and enters into PPAs (backed by the MoF).	GoSL
Sierra Leone Electricity and Water Regulatory Commission Act, 2011	Act	• EWRC's mandate as the industry regulator includes generation licensing, tariff determination, and the development of regulations for the electricity and water sectors in Sierra Leone. It developed and achieved the ratification of the mini-grid regulations.[248]	GoSL
National Renewable Energy Action Plan (NREAP), 2015	Plan	• NREAP sets out steps to achieve the renewable energy targets of the Government of Sierra Leone.	MoE (with support from ECREEE)
Renewable Energy Policy, 2016	Policy	• The Renewable Energy Policy defines among others, targets for renewable energy contribution to the generation mix. It also recommends off-grid generation as the preferred electrification solutions for rural areas with low demand density.[249]	MoE
Energy Revolution, 2016	NA	• Government initiative (supported by the FCDO and UNOPS to promote the solar home system (SHS) market.	GoSL
Finance Act 2017	Act	• Provides for (among others) elimination of import duties for qualifying solar equipment, and tax waivers for solar and energy-saving equipment that meet the relevant International Electrotechnical Commission (IEC) global quality standards.[250]	GoSL
Electric Sector Reform Roadmap (2017–30), 2017	Roadmap	• Sets out a roadmap to achieve the various energy policies already developed by the Ministry. It aims to identify the most important actions required in the short, medium and long term that will successfully develop the electricity sector and expand electricity generation and access in order to support GoSL policy goals.[251]	MoE
Mini-Grid Regulations ratified, 2019	Regulations	• Draft regulations were issued by the EWRC in 2017 and ratified in 2019. The regulations provide guidance for participants and intending participants in the local mini-grid sector.	EWRC
EPA Guidelines for Renewable Energy Technologies and Mini-Grids, 2019	Guidelines	• Guidelines issued by the EPA in 2019 that establish simplified licensing procedures for renewable energy projects and mini-grids, including reduced costs for EPA licenses for mini-grid projects (depending on the size of the project).[252]	EPA

248 AfDB Green Mini-Grid Market Development Programme - Mini-Grid Market Opportunity Assessment: Sierra Leone, 2019.
249 Renewable Energy Policy of Sierra Leone, 2016.
250 The Finance Act 2017, Government of Sierra Leone, 2017.
251 Sierra Leone Electricity Sector Reform Roadmap, 2017-2030.
252 "Guidelines for Environmental and Social Impact Assessments of Renewable Energy Technologies and Mini-Grids," Environmental Protection Agency Sierra Leone, (May 2019): http://epa.gov.sl/wp-content/uploads/2019/09/EPA-RE-and-mini-grid-guidelines_DRAFT.pdf

Federal Government of Nigeria Institutional Landscape of the Mini-Grid Sector

Key Role(s): Policy Formulation, Policy Implementation, Regulation, and Administration	Institution Name	Description
Policy Formulation	Federal Ministry of Power	• Policymaking arm of the Federal Government with the responsibility for the provision of power in the country
	Federal Ministry of Environment	• Develops environmental regulations, acts and policies
	Energy Commission of Nigeria	• Carries out overall energy sector planning and policy implementation
	Federal Ministry of Finance	• Government body responsible for managing the finances of the FGN; as this Ministry has supervisory oversight of the Nigerian Customs Service, it also ultimately determines the import duty policies that impact the off-grid/mini-grid sector
Regulation	Nigerian Electricity Regulatory Commission (NERC)	• Independent regulatory body authorized to regulate the electric power industry in Nigeria; developed the mini-grid regulations
Implementation	Nigerian Electricity Management Services Agency (NEMSA)	• Carries out the functions of enforcement of technical standards and regulations, technical inspection, testing and certification of all categories of electrical installations, electricity meters and instruments.
	Rural Electrification Agency (REA)	• Implementing agency of the FGN tasked with electrification of rural and unserved communities; administers the Rural Electrification Fund (REF) with its mandate to fund rural electrification, and develops programmes and supporting frameworks such as the Environmental and Social Management Framework (ESMF) for the World Bank NEP Program

Summary of Mini-Grid Policies, Laws and Regulations in Nigeria

Name	Type	Description	Originating Agency
National Electric Power Policy (NEPP), 2001	Policy	• The goal of the NEPP was the establishment of an efficient electricity market in Nigeria through the transfer of the ownership and management of the infrastructure and assets of the electricity industry to the private sector.[253] It also identified the primary objective of the Nigeria Rural Electrification Programme as the expansion of access to electricity as rapidly as can be afforded in a cost-effective manner.[254] The NEPP set the agenda for the 2005 EPSRA.	FGN
National Energy Policy, 2003	Policy	• Defined as the blueprint for the sustainable development, supply and use of energy resources within the economy.[255] • Identified solar and small hydro as having potential to power rural communities as well as encouraged the use of off-grid generation solutions to supply power in remote or isolated areas. It recommended the creation of an REF to facilitate electrification in rural areas.	Energy Commission of Nigeria
Electric Power Sector Reform Act 2005	Act	• The Act provides for the formation of companies to take over the obligations of the defunct National Electric Power Authority with the aim of developing a competitive power market.[256] It established the NERC, and the REA with its Rural Electrification Fund (REF).	FGN
Rural Electrification Policy, 2005	Policy	• Defines the Nigerian government's policies, goals and objectives regarding rural electrification. The Policy sets energy access targets and timelines.	FGN
Power Sector Reform Roadmap, 2010	Roadmap	• The Roadmap outlined the government's plan to accelerate the reforms mandated under the EPSRA 2005. It was primarily on-grid focused and targeted power generation from coal, hydro and natural gas.	The Presidency – Federal Republic of Nigeria: Presidential Action Committee on Power (PACP) and Presidential Taskforce on Power
National Policy on Renewable Energy and Energy Efficiency (NREEEP), 2015	Policy	• The aims of the NREEEP include the creation of a framework to address the challenges of inclusive access to modern and clean energy resources, improved energy security and climate objectives, and setting timelines and goals for renewable energy contribution to the country's energy mix and targets for energy efficiency.	Federal Ministry of Power
Regulation for Mini-Grids, 2016	Regulation	• Regulations guiding and defining the mini grid market in Nigeria and its various categories.	NERC
Rural Electrification Strategy & Implementation Plan (RESIP), 2016	Plan	• Sets out the plan for a rural electrification market that is centrally coordinated [by the REA], demand driven and market oriented.[257] • The RESIP proposes a framework to be implemented by the REA for developing and financing rural electrification including mini-grids. It encourages private participation and public-private partnerships.	Federal Ministry of Power, Works and Housing
Rural Electrification Fund (REF) – Operational Guidelines, 2017.	Guidelines	• Defines the operational guidelines for the REF pursuant to the EPSRA 2005. It sets out a framework to award grants for renewable energy projects by the Fund and defines the list of technologies eligible for funding by the REF.	REA

253 Nigeria Energy Regulatory Commission: https://nerc.gov.ng/index.php/home/nesi/401-history
254 Rural Electrification Strategy and Implementation Plan (RESIP), 2016.
255 National Energy Policy, 2003.
256 Electric Power Sector Reform Act 2005.
257 Rural Electrification Strategy & Implementation Plan (RESIP), 2016.

ANNEX 3

MINI-GRID COMMUNITY ENGAGEMENT

The objective of the mini-grid community survey was to better understand the perspectives and experience of each RREP community, to learn about their views regarding the benefits of mini-grid electrification within the context of productive use and development, and to identify barriers that currently exist so that strategies can be developed to overcome challenges and apply lessons learned going forward.

Community survey activities included focus group meetings with village chiefs and various members of the community, combined with direct observations of the mini-grid site and surrounding homes, businesses and productive-use applications. The sites were split into four geographical lots. Off Grid Power (SL Limited) — now a partnership between World Hope International and PowerGen — was awarded two lots, and Winch Energy and Energicity were awarded one lot each. A total of nine communities were surveyed across six districts during October 2020.

No.	Region	District	Chiefdom	Community	Operator	RREP Work Package	No. of customers	Productive-use activities
1	SOUTH	PUJEHUN	SOWA	BANDAJUMA SOWA	PowerGen	1	138	1
2	SOUTH	PUJEHUN	PEJEWA	FUTA PEJEH	PowerGen	1	64	0
3	SOUTH	BO	BUMPE NAGWA	BUMPEH	PowerGen	1	194	4
4	SOUTH	BO	TIKONKO	TIKONKO	PowerGen	2	172	No data
5	EAST	KONO	SANDOR	KAYIMA	PowerGen	1	161	7
6	NORTH	PORT LOKO	KAFFU BULLOM	CONAKRY DEE	Energicity	1	201	3
7	NORTH	KAMBIA	MAGBEMA	ROKUPR	Energicity	2	No data	No data
8	NORTH	TONKOLILI	MALAL MARA	MARA	Winch Energy	1	108	No data
9	NORTH	TONKOLILI	YONI	MATHOIR	Winch Energy	2	No data	No data

Summary of Findings:

The Work Package 1 (WP-1) installations of the mini-grids were viewed as generally successful. Their role was clearly defined by UNOPS and overall, community end users wish to continue having access to the power. Local operators have developed strong relationships with their communities and customers, which enable them to operate, repair and maintain the systems. Payment collection is managed on pre-paid meters and processed via a mobile app. The main barriers operators face relate to the sizing of the mini-grid that they inherited and tariff structuring, which is regulated.

The Work Package 2 (WP-2) installations of the mini-grids are better suited for higher-consuming customers, as their larger size will provide a more feasible electrification option. The tariff cost remains the main concern for these end users, although it is worth noting that with the exception of the mini-grid at Tikonko in Bo District, which was commissioned by PowerGen in October 2020,[258] all WP-2 sites were still under construction during the survey activity (only WP-1 sites were in operation).

Some of the main **benefits** identified by surveyed communities include:

- Development benefits such as improvement in healthcare (e.g., emergency operations that can happen through the night) and education (lighting for schools allows classes to take place later in the day).
- Job creation and business opportunities.

258 https://twitter.com/InfracoAfrica/status/1318870360910139397

- Economic benefits such as small traders can now sell cold drinks; food preservation now exists.
- Cost savings, improved health outcomes and pollution mitigation from replacement of kerosene, diesel generators and batteries, as well as reduction in deforestation (bioenergy).
- Social benefits such as providing entertainment nights, social gatherings can now happen later, religious gatherings can happen earlier, e.g., early morning prayers.

Some of the key **challenges** identified by surveyed communities include:

- Economic constraints as the mini-grids are serving very low-income customers, most of whom are receiving electricity access for the first time; affordability of tariff was the most common challenge identified.
- It was noted that the cost is considerably higher than for grid-connected customers (e.g., some businesses indicated that they could not afford to use the power from the mini-grid to run their freezers as it was too expensive).
- Socio-cultural and financial literacy constraints highlighted the need for continued sensitization, community engagement and effective messaging on how to utilize electricity from the mini-grid system, an understanding of load capacity usage, what appliances can and should not be used and appliance wattage loads etc. (e.g., no irons, microwaves).
- Technical constraints such as varying weather conditions, battery replacements etc. can impact quality of service (i.e., downtime of the system), which can vary from a few hours to a few days.
- Seasonality and crop yields all directly impact the ability of customers to pay their bills.
- More capacity building is needed on the topic of PUE; anchor loads that use daytime energy can be catalysts for expanding the size and economic impact of mini grid-systems (specifically with WP-1) sites.

Community diversity such as different home sizes and businesses results in varying requirements, which in turn affects the availability of power the mini-grid can provide within its storage capacity (which can lead to downtime for the mini-grid to recharge).

KEY	
No.	Community
1	BANDAJUMA SOWA
2	FUTA PEJEH
3	BUMPEH
4	TIKONKO
5	KAYIMA
6	CONAKRY DEE
7	ROKUPR
8	MARA
9	MATHOIR

Source: Adapted from Map of Sierra Leone (Political), Worldometer.

ANNEX 4 RESEARCH METHODOLOGY AND ANALYTIC FRAMEWORK

SIERRA LEONE					
Activity	Deliverable	Research questions → Analysis	Research methods/sources of data	Preliminary list of topics to address in questionnaires	Key informants/interviewees
Existing mini-grid programmes (including tariff- forming methodologies and structures, tariff levels, productive-use performance, and drivers and barriers for expansion)	Questionnaire and interviewee list; evaluation criteria of the results to assess existing mini-grid programmes in Sierra Leone	Does the current energy policy and institutional framework support further mini-grid and off-grid project expansion? • Are mini-grid and off-grid development supported by a national policy framework? **Analysis:** Analyze off-grid regulatory framework. Investigate the national framework of mini-grid and off-grid electrification	• World Bank RISE database[259] • ECREEE-ROGEP Sierra Leone report[260] • Surveys and interviews of mini-grid stakeholders (developers/operators, industry experts, donors/financiers, policymakers and regulators) to be administered via teleconference interviews • Survey of rural mini-grid community end users in the districts where mini-grids are currently in operation (RREP)[261] in order to assess whether the quality of service meets energy needs of the communities, including for productive-use applications	• Consumer protection • Due diligence • Regulatory capacity • Regulatory oversight • Availability/lack of appropriate data for decision-making etc. • National-level tariff setting • Regulation/oversight of developer-proposed tariffs • Regulate rates only in the case of customer disputes • Other policy and regulatory issues	**Public sector stakeholders:** • Ministry of Energy (MoE) • National Power Authority (NPA) • Sierra Leone Electricity and Water Regulatory Commission (SLEWRC) • Electricity Generation and Transmission Company (EGTC) • Electricity Distribution and Supply Authority (EDSA) • Public Private Partnership (PPP) Unit (Office of the President) • Renewable Energy Association of Sierra Leone (REASL) • Ministry of Agriculture, Forestry and Food Security **Private sector/other stakeholders:** RREP mini-grid operators (Winch Energy, PowerGen and Energicity) Other international mini-grid developers active in the market Local off-grid/mini-grid industry experts
		Are the current mini-grid tariffs considered too high or at an appropriate level? Why? What kind of measures are taken to alleviate the cost issue? What are the barriers to achieving lower tariffs? What are the successful aspects of the current mini-grid programme and its policymaking process? What aspects can be improved further? **Analysis:** Investigate lessons learned from the current programme and the past policymaking process and what are drivers and barriers for improvement in general • Does the current regulatory oversight mechanism contribute to high tariffs or does it alleviate the cost issue/ lower the costs? • **Analysis:** Investigate the current regulatory oversight method, its pros and cons, and compare to alternatives • Do the current tariff formula and methodologies contribute to high tariffs or do they alleviate the cost issue/lower the costs? • **Analysis:** Investigate the current tariff-setting method, its pros and cons and compare to alternatives	• Interviews of public officials, policymakers, and regulators • Surveys and interviews of mini-grid stakeholders • Survey of rural mini-grid end users in RREP communities	• Consumer protection • Due diligence • Regulatory capacity • Regulatory oversight • Availability/lack of appropriate data for decision-making; etc. • National-level tariff setting • Regulation/oversight of developer-proposed tariffs • Regulate rates only in the case of customer disputes • Restrictions on tariff levels • National tariff setting methodology (uniform national tariff method; avoided-cost tariff method; cost-reflective tariff method by project category/class; cost-reflective tariff method by project (cost-plus method) • Capex - product costs; capex - process/ development costs; capex – EPC/supplier selection; capex - installation costs; opex; risk premium; permitted return; lack of real cost data/information	

259 https://rise.worldbank.org/country/sierra-leone
260 http://www.ecreee.org/sites/default/files/ecreee_rogep_sierra_leone_final_report.pdf
261 https://www.unops.org/news-and-stories/stories/access-to-energy-giving-sierra-leone-the-power-to-change

SIERRA LEONE					
Activity	Deliverable	Research questions → Analysis	Research methods/sources of data	Preliminary list of topics to address in questionnaires	Key informants/interviewees
		• Do high costs of mini-grid development contribute to high tariffs? Which components of the costs need to be reduced and what are the barriers? • **Analysis:** Investigate and compare cost structure and component costs of the existing mini-grid projects in Sierra Leone and Nigeria, and examine possible causes and components of high costs • Does payment structure of tariffs contribute to high tariffs or does it alleviate the cost issue/lower the costs? • **Analysis:** Investigate if any parts of payments are excessive in tariffs, and whether payment structures are aligned with real consumption patterns		• Energy-based payments (kWh); demand-based payments (kW); flat/fixed payments regardless of consumption; pay-as-you-go (PAYG) payments (pre-charge)	
		Is the mini-grid performing well? • Does the mini-grid deliver satisfactory quantity of power? • **Analysis:** Investigate whether the existing mini-grid provides services to satisfy Tier 2 (min 4 hours/day, min 50W, min 200Wh/day) and above • Does the mini-grid deliver satisfactory quality of power? • **Analysis:** Investigate whether the existing mini-grid provides services to satisfy Tier 2 and above (number of guaranteed hours per day; duration of the electricity; frequency of outages; SAIDI; SAIFI) • Do the mini-grid usages fit community needs/demands and how productive are they? What are their productive-use impacts? • **Analysis:** Investigate whether the current mini-grid projects fit real needs/demands of users • Is the current bidding process contributing to lower cost and better-quality services of mini-grid? Did you encounter any difficulties and/or barriers in the bidding process? If so, what kinds? • **Analysis:** Investigate the benefits and issues of the current bidding/selection (EPC/OEM/developers) process • Are there any quality assurance schemes, policy or regulations for the mini-grid development process as well as operation process (technical standards such as grid codes, safety standards and monitoring and evaluation framework)? • **Analysis:** Investigate any quality assurance schemes (technical standards such as grid codes, safety standards and M&E framework) that exist to make the projects to be developed and operated to offer Tier 2 and above services and productive-use impacts • What kind of criteria/metrics are used to choose mini-grid project sites? Do they consider productive-use and other demand-side factors? • **Analysis:** Investigate both supply-side and demand-side factors used to choose mini-grid sites	• Surveys and interviews of public officials (policymakers and regulators) and other mini-grid stakeholders (developers/ suppliers, operators, end users and industry experts)	• Technical issues, including quality of equipment, project design and planning, engineering, installation and operation • Standards and oversight on products and services (lack of) • Misfit between supply and demands in terms of both quantity and required usages • Bidding design and implementation of the provider selection are less than optimal due to: lack of participants; lack of technical standards and licensing; mismatch between local product/ service providers with required levels of qualifications; lack of local industry capacity, etc. • Lack of due diligence over the bidding process • Risk allocation after project commissions • Lack of auditing schemes	

SIERRA LEONE					
Activity	Deliverable	Research questions → Analysis	Research methods/sources of data	Preliminary list of topics to address in questionnaires	Key informants/interviewees
		Does the current policy/regulatory framework consider long-term grid integration? • Are there any policy and regulatory considerations to account for when the grid network arrives? How are mini-grid and off-grid projects integrated? • **Analysis:** Investigate whether economic, technical and safety regulations such as tariffs and grid codes etc. consider smooth integration of mini-grid and off-grid projects into network in the future	• Surveys and interviews of mini-grid stakeholders (developers, operators, and policymakers and regulators)	• Regulatory provisions in place to address arrival of grid	
		What are the drivers and barriers of mini-grid development and utilization to achieve Tier 2 and above access and create productive-use impacts? **Analysis:** Investigate what factors are perceived as drivers and barriers from both supply and demand sides	• Surveys and interviews of public officials (policymakers and regulators) and other mini-grid stakeholders (developers/ suppliers, operators, end users and industry experts)	• Lack of quantity of power services • Low quality of services • Low usability • Complex process of development • Complex process of connection	
Survey to assess the existing subsidies offered to mini-grid players for their respective projects in Sierra Leone	Questionnaire and interviewee list; evaluation criteria of the results to assess the existing subsidies offered to mini-grid operators for their respective projects in Sierra Leone	Do their subsidies alleviate high costs and high tariffs of mini-grid enough? • Do any producer subsidies in place help reduce high costs and high tariff impacts? • **Analysis:** Investigate whether any kind of producer subsidies, and if so, whether they are effective to alleviate high costs and high tariffs • Do any consumer subsidies in place help reduce high tariff impacts? • **Analysis:** Investigate whether any kind of consumer subsidies, and if so, whether they are effective to alleviate high tariffs	• Surveys and interviews of public officials (policymakers and regulators) and other mini-grid stakeholders (developers/ suppliers, operators, end users and industry experts)	• Direct grants to reduce costs (assets; technology-specific; location-specific; capacity building) • Non-grant subsidies (tax breaks; import duty exemption; accelerated depreciation of assets, soft loan; and loan guarantees) • RBF • Connection subsidy • Consumption subsidy • Cross-subsidies between mini-grid customers and national grid customers • Cross-subsidies between different segments of mini-grid customers • Tariff subsidies	
		What do the existing subsidies target? • Do the subsidies target generation assets/costs or distribution assets/costs or both? • **Analysis:** Investigate which part of the cost reduction that the subsidies target and evaluate whether the targets align with high costs parts	• Surveys and interviews of policymakers, regulators, mini-grid developers/ operators and industry experts)		
		Are the existing subsidies sustainable? • What are the funding sources of any existing subsidies? • **Analysis:** Investigate whether the existing subsidy programmes have long-term sustainability • Are there any sunset clauses for the existing subsidies? If so, what kind of clauses are attached? • **Analysis:** Investigate whether the existing subsidy programmes have long-term sustainability • Do the existing subsidies affect/distort the market and price signals? • **Analysis:** Investigate whether the existing subsidies can affect market formation/transformation negatively or positively through pricing signal modification	• Surveys and interviews of public officials (policymakers and regulators) and other mini-grid stakeholders (developers/ suppliers, operators, end users and industry experts)		

SIERRA LEONE					
Activity	Deliverable	Research questions → Analysis	Research methods/sources of data	Preliminary list of topics to address in questionnaires	Key informants/interviewees
		Have the existing producer and consumer subsidies supported to create access to Tier 2 or above and productive-use impacts? • What are the drivers and barriers to achieve these 2 elements? • **Analysis:** Investigate the impacts of the existing subsidies on productive usages	• Surveys and interviews of public officials (policymakers and regulators) and other mini-grid stakeholders (developers/ suppliers, operators, end users and industry experts)		

Concise desk research, survey and interviews of practitioners regarding mini-grids with solar PV used for agricultural usages		What types of agricultural usages can be promoted by mini-grid and off-grid with solar PV?
		• Which agricultural sectors can increase productivity by mini-grid or off-grid PV electrification?
		• **Analysis:** Investigate general agricultural usage examples in Africa and their user context
		• Can any of the following sectors increase productivity by mini-grid or off-grid PV electrification? If so, which value chain activities (cultivation and harvest, production (postharvest), processing, and marketing) can benefit?
		  • Rice
		  • Palm oil
		  • Cocoa
		  • Coffee
		  • Cassava
		  • Groundnuts
		  • Peppers
		  • Vegetables
		  • Fruits
		  • Livestock
		• **Analysis:** Investigate Sierra Leone's agricultural sector structure and characteristics and their fits to mini-grid and off-grid electrification; investigate real needs and demands for electrification in Sierra Leone's agricultural sector
		• **Analysis:** Investigate the existing mini-grid community for successful agricultural productive usages and issues
		• Are there any other sectors that may benefit from mini-grid and off-grid electrification? If so, which value chain activities can be supported (cultivation and harvest, production, postharvest, processing, and marketing)?
			• Desktop research and literature review
			• Surveys and interviews of agricultural sector stakeholders (mini-grid community agricultural producers, general crop producers, public officials, industry associations etc.)
			• Publications such as WB, UN, SEforALL and other organizations, development agencies, and NGOs etc.		

		• Which agricultural usages have been enhanced by mini-grid and off-grid solar PV projects? • Which value chain activities in which agricultural sector have benefitted and how? • **Analysis:** Investigate the existing productive usages enhanced by mini-grid projects and their impacts	• Surveys and interviews of agricultural sector stakeholders (mini-grid community agricultural producers, general crop producers, Sierra Leone officials, industry associations) • RREP project dashboards		
		What is required to advance agricultural PUE? What are the current barriers? • What are the (minimum) technical, financial and knowledge requirements to introduce electrification into those value chains identified above? What are the barriers? • **Analysis:** Investigate key specs needed to advance mini-grid and off-grid electrification, what is currently missing to implement them and how to overcome the barriers?	• Surveys and interviews of agricultural sector stakeholders (mini-grid community agricultural producers, general crop producers, Sierra Leone officials, industry associations) • Desktop research and literature review	• Lack of power specs • Lack of funding and financing mechanisms • Lack of policy support and incentives • Lack of local capacity • Lack of means to access potential demand • Lack of market/demand/ industry sizes; lack of supply chain, need to enhance the entire value chain not one or a few activities, etc.	

SIERRA LEONE					
Activity	Deliverable	Research questions → Analysis	Research methods/sources of data	Preliminary list of topics to address in questionnaires	Key informants/interviewees
		What are the drivers to advance their PUE in those potential sectors? • What are the important factors to drive faster introduction of electrification into those sectors/value chains identified above? • **Analysis:** Investigate key drivers and barriers for electrification and productive usages	• Surveys and interviews of agricultural sector stakeholders (mini-grid community agricultural producers, general crop producers, public officials, industry associations) • Desktop research and literature review		

NIGERIA					
Activity	Deliverable	Research questions → Analysis	Research methods/sources of data	Preliminary list of topics to address in questionnaires	Key informants/interviewees (see Section III for contact information)

Existing mini-grid programmes (including tariff-forming methodologies and structures, tariff levels, productive-use performance, and drivers and barriers for expansion)	Questionnaire and interviewee list; evaluation criteria of the results to assess existing mini-grid programmes in Nigeria	Does the current energy policy and institutional framework support further mini-grid and off-grid project expansion?
		• Are mini-grid and off-grid development supported by a national policy framework?
		• **Analysis:** Analyze off-grid regulatory framework. Investigate the national framework of mini-grid and off-grid electrification
			• World Bank RISE database[262]
			• ECREEE-ROGEP Nigeria report[263]
			• Surveys and interviews of mini-grid stakeholders (developers/operators, industry experts, donors/financiers, policymakers and regulators) to be administered via teleconference interviews
				• Consumer protection
				• Due diligence
				• Regulatory capacity
				• Regulatory oversight
				• Availability/lack of appropriate data for decision-making; etc.
				• National-level tariff setting
				• Regulation/oversight of developer-proposed tariffs
				• Regulate rates only in the case of customer disputes
				• Other policy and regulatory issues
					Public sector stakeholders:
					• Rural Electrification Agency (REA)
					• Nigeria Electricity Regulatory Commission (NERC)
					• Energy Commission of Nigeria (ECN)
					• Federal Ministry of Power (FMP)
					• Advisory Power Team (APT)
					• Federal Ministry of Environment (FME)
					• Transmission Company of Nigeria (TCN)
					• Nigeria Bulk Electricity Trader (NBET)
					• National Power Training Institute of Nigeria (NAPTIN)
					• Standards Organization of Nigeria (SON)
					• Nigerian Electricity Management Services Agency (NEMSA)
					• National Environmental Standards and Regulations Enforcement Agency (NESREA)
					
					Private sector/other stakeholders:
					• Mini-grid developers in Nigeria (including members of the Mini-Grid Developers Association):
					  • A4&T Power Solutions
					  • ACOB Lighting
					  • Arnergy
					  • Ajima Farms
					  • CREDC
					  • Darway Coast
					  • GVE Projects Ltd.
					  • GOSolar Africa
					  • Havenhill Synergy Ltd.
					  • Nayo Tropical Technology Ltd.
					  • Rubitec Solar Ltd.
					  • Wavelength IPS
					  • CESEL
					  • Trust Synergy Infrastructures
					• Other international mini-grid developers active in the market
					• Local off-grid/mini-grid industry experts
					• NGOs/Foundations e.g., Heinrich Boell
					• Renewable Energy Association of Nigeria (REAN)
					• Distribution Companies (DisCos)
					• Generation Companies (GenCos)

		Are the current mini-grid tariffs considered too high or at an appropriate level? Why? What kind of measures are taken to alleviate the cost issue? What are the barriers to achieving lower tariffs? What are the successful aspects of the current mini-grid programme and its policymaking process? What aspects can be improved further? **Analysis:** Investigate the learning from the current programme and the past policymaking process and what are drivers and barriers for improvement in general • Does the current regulatory oversight mechanism contribute to high tariffs or does it alleviate the cost issue/ lower the costs? • **Analysis:** Investigate the current regulatory oversight method, its pros and cons, and compare to alternatives • Do the current tariff formula and methodologies contribute to high tariffs or do they alleviate the cost issue/lower the costs? • **Analysis:** Investigate the current tariff setting method its pros,and cons and compare to alternatives • Do high costs of mini-grid development contribute to high tariffs? Which components of the costs need to be reduced and what are the barriers? • **Analysis:** Investigate and compare cost structure and component costs of the existing mini-grid projects in Sierra Leone and Nigeria, and examine possible causes and components of high costs • Does payment structure of tariffs contribute to high tariffs or does it alleviate the cost issue/lower the costs? • **Analysis:** Investigate if any parts of payments are excessive in tariffs, and whether payment structures are aligned with real consumption patterns	• Interviews of public officials, policymakers and regulators • Surveys and interviews of mini-grid stakeholders	• Consumer protection • Due diligence • Regulatory capacity • Regulatory oversight • Availability/lack of appropriate data for decision-making; etc. • National-level tariff setting • Regulation/oversight of developer-proposed tariffs • Regulate rates only in the case of customer disputes • Restrictions on tariff levels • National tariff setting methodology (uniform national tariff method; avoided-cost tariff method; cost-reflective tariff method by project category/class; cost-reflective tariff method by project (cost-plus method) • Capex - product costs; capex - process/ development costs; capex – EPC / supplier selection; capex - installation costs; opex; risk premium; permitted return; lack of real cost data/information • Energy-based payments (kWh); demand-based payments (kW); flat/fixed payments regardless consumption; pay-as-you-go (PAYG) payments (pre-charge)	

262 https://rise.worldbank.org/country/nigeria
263 http://www.ecreee.org/sites/default/files/ecreee_rogep_nigeria_final_report_.pdf

NIGERIA					
Activity	Deliverable	Research questions → Analysis	Research methods/sources of data	Preliminary list of topics to address in questionnaires	Key informants/interviewees (see Section III for contact information)
		Is the mini-grid performing well? • Does the mini-grid deliver satisfactory quantity of power? • **Analysis:** Investigate whether the existing mini-grid provides services to satisfy Tier 2 (min 4 hours/day, min 50W, min 200Wh/day) and above • Does the mini-grid deliver satisfactory quality of power? • **Analysis:** Investigate whether the existing mini-grid provides services to satisfy Tier 2 and above (number of guaranteed hours per day; duration of the electricity; frequency of outages; SAIDI; SAIFI) • Do the mini-grid usages fit community needs/demands and how productive are they? What are their productive-use impacts? • **Analysis:** Investigate whether the current mini-grid projects fit real needs/demands of users • Is the current bidding process contributing to lower cost and better-quality services of the mini-grid? Did you encounter any difficulties and barriers in the bidding process? If so, what kinds? • **Analysis:** Investigate the benefits and issues of the current bidding/selection (EPC/OEM/developers) process • Are there any quality assurance schemes, policy and regulations for mini-grid development process as well as operation process (technical standards such as grid codes, safety standards and monitoring and evaluation framework)? • **Analysis:** Investigate any quality assurance schemes (technical standards such as grid codes, safety standards and monitoring and evaluation framework) that exist to make the projects to be developed and operated to offer Tier 2 and above services and productive-use impacts • What kind of criteria/metrics are used to choose mini-grid project sites? Do they consider productive-use and other demand-side factors? • **Analysis:** Investigate both supply-side and demand-side factors used to choose mini-grid sites	• Surveys and interviews of public officials (policymakers and regulators) and other mini-grid stakeholders (developers/suppliers, operators, end users and industry experts)	• Technical issues, including quality of equipment, project design and planning, engineering, installation, and operation • Standards and oversight on products and services (lack of) • Misfit between supply and demands in terms of both quantity and required usages • Bidding design and implementation of the provider selection are less than optimal due to: lack of participants; lack of technical standards and licensing; mismatch between local product/service providers with required levels of qualifications; lack of local industry capacity, etc. • Lack of due diligence over bidding process • Risk allocation after project commissions • Lack of auditing schemes	
		Does the current policy/regulatory framework consider long-term grid-integration? • Are there any policy and regulatory considerations to account for when the grid network arrives? How are mini-grid and off-grid projects integrated? • **Analysis:** Investigate whether economic, technical and safety regulations such as tariffs and grid codes etc. consider smooth integration of mini-grid and off-grid projects into network in the future	• Surveys and interviews of mini-grid stakeholders (developers, operators, and policy makers and regulators)	• Regulatory provisions in place to address arrival of grid	
		What are the drivers and barriers of mini-grid development and utilization to achieve Tier 2 and above access and create productive-use impacts? **Analysis:** Investigate what factors are perceived as drivers and barriers from both supply and demand sides	• Surveys and interviews of public officials (policymakers and regulators) and other mini-grid stakeholders (developers/suppliers, operators and end users)	• Lack of quantity of power services • Low quality of services • Low usability • Complex process of development • Complex process of connection	

Indicator/Evaluation Criteria	Description	Scoring Methodology	Scoring
Affordability	Are current policy and regulations affordable for • Policymakers and regulators (i.e., can they sustain a healthy government budget)?	Strongly Agree Agree Disagree	Sample size (respondents) = n Assigned Scores: Strongly Agree(a_1) = 10 = Max Score Agree(a_2) = 5 Disagree(a_3) = 0 Number of respondents with assigned score $a_1 = n_{a_1}$ Number of respondents with assigned score $a_2 = n_{a_2}$ Number of respondents with assigned score $a_3 = n_{a_3}$ **Score (relative to Max Score)** = $\frac{\sum_{i=1}^{3}(a_i \times n_{a_i})}{(n \times \text{Max Score})}$
	Are current policy and regulations affordable for • Suppliers (can they sustain a profitable business)?	Strongly Agree Agree Disagree	
	Are current policy and regulations affordable for • End users (are they affordable for energy users)?	Strongly Agree Agree Disagree	
Cost Effectiveness and Efficiency	Do current policy and regulations do enough to incentivize: • Policymakers and regulators to be conscious about project development costs?	Strongly Agree Agree Disagree	
	Do current policy and regulations do enough to incentivize: • Suppliers to lower their project/product?	Strongly Agree Agree Disagree	
	Do current policy and regulations do enough to incentivize: • End users to use less energy?	Strongly Agree Agree Disagree	
Equity and Fairness	Do current policies and regulations address equity concerns across: • Spatial/geographical areas such as rural vs. urban?	Strongly Agree Agree Disagree	
	Do current policies and regulations address equity concerns across: • Social class (income class)?	Strongly Agree Agree Disagree	
	Do current policies and regulations address equity concerns across: • Gender?	Strongly Agree Agree Disagree	
Drive/Incentivize Market Development	Do current policies and regulations do enough to incentivize: • Suppliers to enter the sector and provide quality projects/products/services?	Strongly Agree Agree Disagree	
	Do current policies and regulations do enough to incentivize: • Energy users to connect or switch to a mini-grid/off-grid project	Strongly Agree Agree Disagree	

Indicator/Evaluation Criteria	Description	Scoring Methodology	Scoring
Level and Quality of Services	• Do the current policy and regulations encourage higher quantity of service?	Strongly Agree Agree Disagree	
	• Do the current policy and regulations encourage higher quality of service?	Strongly Agree Agree Disagree	
Productive-Use Applications	• Do these services also provide electricity to support productive-use applications?	Strongly Agree Agree Disagree	
	• Does the advent of solar electricity from the mini-grid system improve value chain activities (cultivation and harvest, production, processing, storage and marketing) of the agricultural sector?	Strongly Agree Agree Disagree	
Simplicity (easiness or burden to design in terms of amount of additional workload of staff; amount of information required; the number of separate processes and decisions; standardization etc.)	Are current policy and regulations easy for • Policymakers and regulators to design?	Strongly Agree Agree Disagree	
	Are current policy and regulations easy for • Suppliers to design tariff proposal (if it is required by regulators)?	Strongly Agree Agree Disagree	
Simplicity (easiness or burden to implement, in terms of the amount of additional workload of staff; amount of information required; the number of separate processes and decisions; standardization etc.)	Are current policy and regulations easy for • Policymakers and regulators to implement, manage and supervise?	Strongly Agree Agree Disagree	
	Are current policy and regulations easy for • Suppliers to implement and monitor projects/products/services?	Strongly Agree Agree Disagree	
Technological Neutrality/Business Flexibility	Do current policy and regulations: • Encourage diverse business models?	Strongly Agree Agree Disagree	
	Do current policy and regulations: • Encourage diverse technologies or discourage certain types of technologies such as high capex renewable projects?	Strongly Agree Agree Disagree	
Long-term Predictability	Do current policy and regulations provide long-term certainty and predictability of: • Policy and regulatory environment to supply-side players and energy users?	Strongly Agree Agree Disagree	
	Do current policy and regulations provide long-term certainty and predictability of: • Business to users?	Strongly Agree Agree Disagree	

Indicator/Evaluation Criteria	Description	Scoring Methodology	Scoring
Transparency and Clarity	Do current policy and regulations provide transparency and clarity of: • Policy and regulatory environment to supply-side players and energy users?	Strongly Agree Agree Disagree	
	Do current policy and regulations provide transparency and clarity of: • Business to users?	Strongly Agree Agree Disagree	
Integration with National Grid Network	Do current policy and regulations pose difficulty to integrate the mini-grid projects with the arrival of the national electricity network, for: • Policymakers and regulators to need to change regulations?	Strongly Agree Agree Disagree	
	Do current policy and regulations pose difficulty to integrate the mini-grid projects with the arrival of the national electricity network, for: • Suppliers to need to change tariff charges, billing and metering mechanism(s)?	Strongly Agree Agree Disagree	
	Do current policy and regulations pose difficulty to integrate the mini-grid projects with the arrival of the national electricity network, for: • End-users' need to accept changes/increase of tariffs?	Strongly Agree Agree Disagree	
Gender Considerations	Gender inclusiveness: • Do current policies and regulations specifically address gender mainstreaming?	Strongly Agree Agree Disagree	
	Gender inclusiveness: • Do current policies and regulations specifically address gender inclusion?	Strongly Agree Agree Disagree	
Standards and Quality	Standards and safety: • Do current policies and regulations specifically address disposal of solar system components?	Strongly Agree Agree Disagree	
	Standards and safety: • Do current policies and regulations specifically address safety standards for mini-grids (e.g., overcurrent protection, system control etc.)?	Strongly Agree Agree Disagree	

ANNEX 5 STAKEHOLDER CONTACT LIST

Below is a list of all of the key stakeholders that the report's team consulted with during the course of the assignment in Sierra Leone and Nigeria.

SIERRA LEONE		
Organization	Name of Contact	Position/Title
Ministry of Energy	Robin Mansaray	Head, Renewable Energy and Energy Efficiency
	Ngozi Beckley-Lines	Project Manager
Electricity and Water Regulatory Commission (EWRC)	Brima Bah	Head, Economic Regulation
	Kelcise Sesay	Head, Electricity Regulation
United Nations Office for Project Services (UNOPS)	Jasmin Roberts	Team Leader, Technical Assistance and Capacity Building
	Eunice Dahn	Programme Analyst
	Ezekiel Kamangulu	Technical Team Leader
	Leslie Mhara	Senior Project Manager, RREP
	Ariful Islam	Monitoring and Evaluation Specialist
	Nicholas M. Gardner	Sierra Leone Country Manager
Winch Energy	Pierre Johnson	Country Manager, Sierra Leone
PowerGen Renewable Energy/Off-Grid Power (OGP)	Michael Corbishley	New Market Implementation, Sierra Leone
	Femi Coker	Country Manager, Sierra Leone
Energicity	Joe Philip	VP of Engineering and Operations
	Samuel Kamanda	Project Manager, Energicity SL
Western Africa Off-Grid - REASL	Samuel Zoker	CEO
FLS Group - REASL	Leah Fatmatta Suma	Director of Operations
Pujehun District Chief	PC Lahai AK Sowa 2	Paramount Chief, Bandajuma Sowa
Pujehum District Chief	PC Suliman B Koroma	Paramount Chief, Futa Pejuh
Bo District Chief	Augustine L.Moiwo	Chief, Tikonko
Bo District Chief	PC Joseph Tommy Kposawa	Paramount Chief, Bumpeh
Kambia District Chief	Pa. Alimamy Kamara	Chiefdom Speaker, Rokupr
Port Loko District Chief	Pa Adikalie Sorie Suma	Town Chief, Conakry Dee
Tonkolili District Chief	Pa Almamy James Fulah	Section Chief, Mara
Tonkolili District Chief	Alimami Koroma	Town Chief, Mathoir
Kono District Chief	Amadu Sokoyama	Section Chief, Sandor Kayima

NIGERIA		
Organization	Name of Contact	Position/Title
Rural Electrification Agency (REA)	Ahmad Salihijo	Managing Director
	Suleiman Babamanu	NEP Project Leader
Nigeria Electricity Regulatory Commission (NERC)	Dr. Abdusallam Yusuf	Assistant General Manager
GVE Projects	Ifeanyi B. Orajaka	Managing Director
Rubitec Solar	Bolade Soremekun	CEO
A4&T Integrated	Ayodeji Ademilua	CEO

KEY DEFINITIONS

BUILD-OWN-OPERATE (BOO): A public-private partnership (PPP) agreement in which the government grants the right to a private company to design, build, operate and maintain a project. The private company retains ownership of the project and is not required to transfer the project back to the government. Although the government typically does not provide direct funding for the project under this model, it may offer other financial incentives to the private company (e.g., tax exemptions, subsidies etc.).

BUILD-OPERATE-TRANSFER (BOT): A PPP agreement in which the government grants the right to a private company to design, build, operate and maintain a project for a given number of years, after which the project is transferred back to the government. In the context of mini-grid project development, under the BOT model, the mini-grid operator obtains revenues either through a fee charged to the government/utility or through tariffs charged to customers depending on which business/ownership model is applied (see **Annex 1**).

CONCESSION: A concession agreement is a contract that is typically awarded to a private company through a competitive bidding process that grants the company rights to finance, design, build, operate and maintain a project within a government's jurisdiction, subject to particular terms. Concession contracts are usually focused on outputs (i.e., the delivery of a service in accordance with performance standards) and cover an entire infrastructure system, in which the concessionaire may take over existing assets as well as build and operate new assets. The concessionaire will pay a concession fee to the government, which will usually be ring-fenced and put towards asset replacement and expansion. In the context of mini-grid project development, the government (regulator) delineates the service area to be covered by a mini-grid license — the concession — and grants the licensee exclusive rights to develop, operate and maintain assets for the generation, distribution and retail sale of electricity to end users in the designated service area for a given number of years (usually about 20 years, or long enough to fully amortize all assets under the specified tariff regime). The concession usually comes with favourable terms, such as financial incentives, preferential tariff arrangements, or a guarantee that no other entities will be allowed to operate mini-grids in the same area. Regulators can also issue competitive bids for concession schemes, which allow developers to bid for larger and/or multiple service areas and to aggregate mini-grid projects. Such flexibility can help developers reduce costs and improve profitability by increasing efficiency in a number of areas, including planning, financing, administration, equipment supply, and operation and maintenance (O&M). Asset ownership typically rests with the government, although this varies depending on which business/ownership model is applied (see **Annex 1**). At the end of the concession period, all rights in respect to project assets typically revert to the government; alternatively, developers may have the option for renewal of the concession at the regulator's discretion.[264]

COST-REFLECTIVE TARIFF: A tariff that reflects the full cost of providing electricity to customers, including the installation, maintenance and operation of a mini-grid. Cost-reflective tariffs enable operators to recover their full costs and earn a reasonable return on their investments. Cost-reflective tariffs can also be supported with subsidies (e.g., in the form of a connection subsidy for end users, a capital subsidy for mini-grid operators, or a cross-subsidy scheme). This topic is examined in **Section III** of this report.

DESIGN-BUILD-OPERATE (DBO): A PPP agreement in which the government grants the right to a private company

264 World Bank Public Private Partnership Legal Resource Center: https://ppp.worldbank.org/public-private-partnership/agreements/concessions-bots-dbos#BOT_Projects; and "Practical Guide to the Regulatory Treatment of Mini-Grids," National Association of Regulatory Utility Commissioners (NARUC), United States Agency for International Development (USAID), 2017: https://pubs.naruc.org/pub/E1A6363A-A51D-0046-C341-DADE9EBAA6E3

to design, build, operate and maintain a project – with the government retaining legal ownership of the assets. DBO projects differ from concession agreements in that they do not require the private company to finance the project or to bear its commercial risk. In the context of mini-grid project development, the DBO model is similar to the BOT model, with the key difference being that the government finances the initial construction of the mini-grid, thus significantly reducing risk for the private developer. The documentation for a DBO is also simpler than a BOT or a concession agreement, essentially comprising a turnkey construction contract plus an operating contract, without any financing documents required.[265]

ELECTRICITY ACCESS: There is no universal definition of electricity access. The Multi-Tier Framework (MTF) developed by the World Bank is used to measure electricity access along a continuum of service levels (tiers), rather than as a household connection to an electricity grid. As illustrated in the figure below, the MTF categorizes access according to a series of indicators, including capacity, availability/duration of supply, reliability, quality, affordability, legality and health/safety.[266] The focus of this study is on Tier 2 access (and above) – defined as a minimum of four hours of electricity/day, 50W and 200Wh/day.

Multi-tier Matrix for Measuring Access to Household Electricity Supply

ATTRIBUTES			TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
	1. Peak Capacity	Power capacity ratings[28] (in W or daily Wh)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
				Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
		OR Services		Lighting of 1,000 lmhr/ day	Electrical lighting, air circulation, television, and phone charging are possible			
	2. Availability (Duration)	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
	3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration <2 hrs
	4. Quality						Voltage problems do not affect the use of desired appliances	
	5. Afford-ability					Cost of a standard consumption package of 365 kWh/year < 5% of household income		
	6. Legality						Bill is paid to the utility, pre-paid card seller, or authorized representative	
	7. Health & Safety						Absence of past accidents and perception of high risk in the future	

Source: World Bank Energy Sector Management Assistance Program (ESMAP).

ENERGY-AS-A-SERVICE (EaaS): EaaS is a business model whereby customers pay for an energy service without having to make any up-front capital investment. EaaS models usually take the form of a subscription for electrical devices owned by a service company or management of energy usage to deliver the desired energy service.[267]

LEVELIZED COST OF ELECTRICITY (LCOE): The LCOE combines a mini-grid's capital and operating costs into a single cost per unit of energy (typically expressed in USD/kWh). LCOE provides a valuable and appropriate benchmark for assessing the cost of mini-grid electricity, as it considers initial costs (such as equipment and installation

265 World Bank Public Private Partnership Legal Resource Center.
266 "Multi-Tier Framework for Measuring Energy Access," World Bank ESMAP: https://www.esmap.org/node/55526
267 Cleary, K. and Palmer, K., "Energy-as-a-Service: A Business Model for Expanding Deployment of Low-Carbon Technologies," Resources for the Future, (December 18, 2019): https://www.rff.org/publications/issue-briefs/energy-service-business-model-expanding-deployment-low-carbon-technologies/

costs), operations costs (such as staff and fuel costs), and equipment replacement over the lifetime of the mini-grid. The LCOE is equivalent to the minimum average tariff at which electricity must be sold to cover project costs.[268]

MINI-GRID: A mini-grid (or micro-grid) is a power generation system that is able to supply a small community with electricity through a distribution network and typically includes an energy storage device (battery), power conversion equipment (inverter) and can operate in conjunction with a diesel generator. Mini-grids can be powered by renewable energy sources (solar, wind, hydropower, bioenergy etc.), diesel fuel, or some hybrid of these technologies. By maximizing the use of renewable energy sources, mini-grids can reduce energy costs and improve the reliability of energy access in remote or isolated areas. Mini-grids offer an alternative to costly grid extensions and are often the cheapest electrification option for densely populated areas not near the grid. Mini-grids can be designed to deliver different levels of service and can be **isolated**/stand-alone systems or **interconnected** with the main grid. The International Energy Agency estimates that mini-grids can provide electricity access to approximately one-third of the population in Sub-Saharan Africa currently without electricity through 2030.[269]

PRODUCTIVE USE: Productive-use energy (PUE) can broadly be defined as the utilization of energy in agricultural, commercial and industrial applications to produce goods or provide services. In an off-grid community, energy can be used either for consumption (by households or for community purposes) or for productive uses. PUE has the potential to increase the impact of electrification by enhancing productivity and improving income generation for rural communities. In the context of mini-grid electrification, PUE stimulates electricity demand and leads to higher electricity consumption, which increases the viability of mini-grids by helping them operate more efficiently, cost effectively and sustainably – especially where higher consumption has no major effect on investment costs.[270] PUE also increases local income generation by allowing mini-grid communities to produce value-added products, preserve goods from spoilage and increase crop yields, among other benefits.[271] The primary focus of this report is on **agricultural PUE**, given that a majority of the population in Sierra Leone is engaged in the agricultural sector. Mini-grids can power rural agricultural productivity and create new businesses or expand existing ones linked to the agricultural value chain. This topic is examined in detail in **Section IV** of this report.

268 "Mini-Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers," World Bank ESMAP, (June 2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31926/Mini-Grids-for-Half-a-Billion-People-Market-Outlook-and-Handbook-for-Decision-Makers-Executive-Summary.pdf?sequence=1&isAllowed=y

269 Tracking SDG7: The Energy Progress Report 2020: https://www.irena.org/publications/2020/May/Tracking-SDG7-The-Energy-Progress-Report-2020

270 Mayer-Tasch, L., "Promoting Productive Use of Energy in the Framework of Energy Access Programmes," GIZ, (4 December 2013): https://sustainabledevelopment.un.org/content/documents/4738mayer.pdf

271 "Productive Use of Energy Applications in Off-Grid Energy Systems: Workshop," Green Mini-Grid Facility Kenya, Innovation Energie Développement, AFD and UK AID, (2 July 2019): https://www.gmgfacilitykenya.org/index.php/gmgreources

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