Mini-Grid Market Opportunity Assessment: Nigeria

SEforALL Africa Hub

African Development Bank

Green Mini-Grid Market Development Programme: SE4ALL Africa Hub & African Development Bank

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

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

The Carbon Trust would like to thank the following Ministries and Agencies in Nigeria: Federal Ministry of Power Works and Housing (MPWH), the Rural Electrification Agency (REA), the Bulk Electricity Trading Company (NBET), the Ministry of Environment, the Nigeria Electricity Regulation Commission (NERC), the Energy Commission of Nigeria (ECN), the Federal Ministry of Science and Technology (MST), the Transmission Company of Nigeria (TCN), the Nigeria Investment Promotion Commission (NIPC), the One Stop Investment Centre (OSIC), the National Power Training Institute (NPTI), the National Agency for Science and Engineering Infrastructure (NASEI). We would also like to thank the following bilateral and multilateral donor organisations: Agence Française de Développement (AFD), the African Development Bank (AfDB), the Development Bank of Nigeria (DBN), the European Union Delegation to Nigeria and ECOWAS, Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ), Power for All, USAID Nigeria, World Bank. Finally, we would like to thank the following other organisations whom all helped contribute to this report : African Mini-Grid Developers Association (AMDA), Association of Nigerian Electricity Distributors (ANED), Clean Technology Hub, National Centre for Energy Research and Development (NCERD), International Centre for Energy, Environment and Development (ICEEED), Moriah Blessed Ventures, Odyssey, Ecobank Nigeria, Cold Hubs, Renewable Energy Association of Nigeria (REAN), Sterling Bank, Solar Energy Society of Nigeria (SESN), Tonbofa.

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PREFACE

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

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

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

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

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

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

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

This report was prepared by the Carbon Trust and the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) at the request of the AfDB. It was written by Jon Lane, William Hudson and Luke Walley of Carbon Trust and Yuri Lima Handem from ECREEE. Carbon Trust is a mission-driven organization helping businesses, governments and the public sector accelerate the move to a low carbon economy. ECREEE is a specialized agency of the Economic Community for West African States.

The content of this report was reviewed by Jeff Felten of the AfDB's GMG team and cleared by Dr. Daniel-Alexander Schroth, SEforALL Africa Hub Coordinator at the AfDB. It was edited by Kimberlee Brown.

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

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List of Acronyms

AFD	Agence Française de Développement (French Development Agency)
ANAPI	Agence Nationale pour la Promotion des Investissements (National Agency for the Promotion of Investments)
ANSER	Agence Nationale de l'Electrification et des Services Energétiques en Milieu Rural et Périurbain (National agency for the electrification of rural and peri-urban areas)
ARC	African Risk Capacity
ARE	Authorité de Régulation du secteur de l'électricité (Electricity Regulation Authority)
AREF	Africa Renewable Energy Fund
CAPP	Central Africa Power Pool
CDC	Commonwealth Development Corporation
CNE	Commission Nationale de l'Energie (National Energy Commission)
DBSA	Development Bank of South Africa
DFI	Development Finance Institution
DFID	Department for International Development
DIAGF	DFID Impact Accelerator Facility
EAIF	Emerging Africa Infrastructure Fund
EAPP	Eastern Africa Power Pool
EASE	Electricity Access Service Expansion
EDC	Electricité Du Congo (Congo Electricity)
EIB	European Investment Bank
ENK	Energie du Nord Kivu
GAP	Green Africa Power
GMG	Green Mini-Grid
HVDC	High Voltage, Direct Current
ICRC	International Committee of the Red Cross
MERH	Ministry of Energy and Hydraulic Resources
MIBA	Société Minière de Bakwanga (Bakwanga Mining Company)
PIDG	Private Infrastructure Development Group
PNSD	Plan National Stratégique de Développement 2017-2021 (National Strategic Development Plan for 2017 - 2021)
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PRG	Partial Risk Guarantee
RC	Republic of the Congo
RE	Renewable energy
SAPP	Southern Africa Power Pool
SEFA	Sustainable Energy Fund for Africa
SEforAll	Sustainable Energy for All
SENEN	Service National des Energies Nouvelles (National Service of New Energies)
SNEL	Société Nationale de Électricité (National Power Company)
SNV	Stichting Nederlandse Vrijwilligers (Netherlands Development Organisation)
SOKIMO	Société des mines d'or de Kilo-Moto (Company of the Kilo-Moto Gold Mines)
TA	Technical Assistance
UCM	Unité de Coordination et de Management des projets du ministère (Ministry's Unit for Project Coordination and Management)
UNDP	United Nations Development Programme
WB	World Bank

EXECUTIVE SUMMARY

This country report is one of a series of country reports under the Market Intelligence business line of the African Development Bank's Green Mini-Grid Market Development Programme (GMG MDP). The MDP has the ultimate objective of fostering access to electricity across Africa by promoting the development of green mini-grids where they represent a technically and economically better option than the extension of the main grid. The Market Intelligence business line aims to provide comparable, actionable data on the potential for GMGs across countries in Sub-Saharan Africa (SSA). This report provides an analysis for Nigeria. Previous country reports can be downloaded from the GMG Help Desk (http://greenminigrid.se4all-africa.org).

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

Nigeria is the most populous country in Africa, with a population exceeding 190 million people and a landmass of 923,768 km². With an annual population growth rate exceeding 2.5%, the population is projected to reach 237 million by 2030 (World Bank, 2017). The national life expectancy is 55 years for men and 56 years for women (World Health Organisation, 2016). Nigeria is bordered on the east by Cameroon, on the northeast by Chad, on the north by Niger, on the west by Benin, and on the south by the Gulf of Guinea.

In spite of a recent economic downturn, Nigeria remains Africa's largest economy, with total gross domestic product (GDP) of US $405 billion in 2016. This is down from $568 billion in 2014, a decrease of 29%. This steep fall in GDP is linked predominantly to the falling price of oil, which in 2016 accounted for over 90% of foreign income to Nigeria, but also to certain past fiscal policies including fixing the Naira to the dollar (Financial Times, 2016). GDP per capita decreased even more in percentage terms to $2,178 in 2016, 32% less than in 2014 ($3,222). The Nigerian economy relies heavily on the hydrocarbons sector, with oil and gas representing 35% of GDP and 95% of exports. As of July 2017, Nigeria exported 1.84 million barrels of oil per day. Other key sectors within the Nigerian economy are agriculture, information and communications, and manufacturing.

The Nigerian Government has made significant efforts to improve the economic environment in recent years. For the first time, Nigeria was among the top ten 'improvers' in 2016-17 according to the World Bank's 2018 Doing Business report. The country has improved according to the following indicators: starting a business, dealing with construction permits, registering property, getting credit, and paying taxes. In 2017, the economy entered recovery from the 2016 recession, with GDP growth of 0.8%. A positive outlook to 2019 is anchored in higher oil prices and production as well as stronger agricultural performance. Nonetheless poverty remains unacceptably high, with 80% of Nigeria's inhabitants living on less than $2 a day.

Slow progress has been made in Nigeria's domestic energy sector, particularly in terms of rural electrification. At present, approximately 73.6 million (73.6m) people lack access to grid electricity (13.4m in urban areas and 60.2m in rural areas), with the national electrification rate at 60.6% (86.0% in urban areas and 34.1% in rural areas) (IEA, 2017). This corresponds to an urban-to-rural electricity access divide of some 450%. The electrified population has grown around 1.4% annually since 2005 (circa. 1m people per year), inconsistent with an existing national target of achieving 90% access to electricity by 2030 (circa. 55m people to be connected in 10 years). Achieving this target will require connecting more than 1 million households per year and adding roughly 25GW of generation capacity to 2030 (World Bank, 2017). The lowest electrification rates are found in the North West states, with 12% electrification in Taraba and Jigawa, and 13% electrification in Kebbi, Sokoto and Zamfara. These communities therefore rely on candles, kerosene and torches for lighting, and traditional biomass for cooking.

Rural electrification has been limited to date by significant power deficits in Nigeria, including an overall lack of generation capacity, as well as heavy transmission and distribution losses. In 2015, according to the SE4ALL-AA (Sustainable Energy for All Action Agenda), Nigeria had a total installed capacity of over 12GW. As of May 2015, however, only 6.8GW of installed capacity was available, with only 3.9GW of capacity operating (due to variety of reasons including gas shortages, water management, breakdowns and grid constraints). These issues are compounded by deficiencies in both transmission and distribution assets. Another critical challenge for distribution companies (DisCos) is commercial losses, which can be as high as 50%. Network meters are not currently sophisticated enough to restrict illegal connections.

The potential for decentralised, renewable energy systems is very high, particularly given displacement potential for an estimated 14GW of existing decentralised diesel generator capacity. As of 2011 this translated to 1 generator for every 2.5 citizens and about 3.5 trillion Naira per year spent on diesel and petrol (30 billion USD, 45% of this by private households). Consequent vulnerability to fuel prices is set to intensify in the future. Nigeria's population is also projected to reach 267 million by 2030, with a latent generation capacity requirement of 116GW.

The Nigerian government recognises that mini-grid solutions will be the most cost effective option for certain remote settlements, given the distance to the grid and their relatively low demand loads compared to urban areas. This is evidenced by the SE4ALL Action Agenda and associated government strategies, where mini-grid generation capacity is targeted at 8.1GW by 2030 (18%). Other targets including reaching 75% national electricity access by 2020 (60% in rural environments) and 90% by 2030, compared to 40% in 2016.

On-grid and off-grid rural electrification is the responsibility of the Rural Electrification Agency (REA), under the overall sectoral responsibility of the Ministry of Power, Works and Housing. The new government has provided REA with strong backing to drive implementation of off-grid solutions in unserved and underserved areas, primarily through reducing development costs by delivering pre-development activities. This includes site identification and facilitation with local and state governments. Eleven distribution companies (DisCos) operate and are responsible for the national distribution networks for different states, and the Transmission Company of Nigeria similarly for transmission assets. Electricity generation and supply is regulated by the Nigerian Electricity Regulatory Commission.

Private developers are generally positive about the future market for mini-grids, responding to the greater clarity provided by the new Mini-Grid Regulation. The 2016 Regulation for Mini-Grids provides critical regulatory clarity, including setting out protections for grid-stranded mini-grids. Operating mini-grid developers include ACOB Lighting Technologies, Arnergy, GVE, Rubitec Solar and Waste-2-Watt. The majority of companies spoken to on behalf of this report reported plans for accelerating expansions, bolstered by this regulatory clarity and existing successful pilots. This is strengthened by the limited network expansions anticipated of the eleven distribution companies, not expected to electrify more than 5km from their existing grid within the next 5-10 years due to low tariffs and significant commercial and technical losses.

Based on current grid coverage, analysis reveals that approximately 13% of the non-electrified population would be best served by mini-grid solutions, with the highest potential in the north of Nigeria. This corresponds to 13.6 million people (7.4% of total population), dropping to 12.2 million people best served by mini-grid solutions when including planned network extensions by 2025. 164 million people already live within 15km of the grid and a further 6.2 million people are likely to be best served by solar home systems. The majority of northern states have over half a million people best served by mini-grids, particularly in the North East and North West regions where the electrification rate exceeds 20% in only a few states. The lowest potential is found in Abia, Bayelsa, Imo and Rivers states, where the entire population lives within 15km of the grid. A further nineteen of thirty-seven states have over 95% of the total population within this threshold.

Analysis reveals a total mini-grid market size of approximately $994 million annual revenue, with 92% of the mini-grid market found in the northern regions. This assumes an average annual rural household expenditure on energy of US $402, or $73 per person (5.5 people per household). Total potential in the North East, North West and North Central regions is found to be $371m, $340m and $199m annual revenue respectively, compared to $57m, $14m and $12m in the South West, South East and South South regions, respectively. The highest potential state is Borno, with an estimated annual revenue market size of $154m and 2.1 million people most economically served through mini-grids. The actual market size may be greater than the estimates given here considering decentralized solutions could also be feasible in areas in grid proximity, and given the low likelihood of near-term DisCo expansion.

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

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

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

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

The Market Development Programme is implemented by the Sustainable Energy for All (SEforALL) Africa Hub, through a grant of the Sustainable Energy Fund for Africa (SEFA). The SEforALL Africa Hub, hosted by the AfDB, is a partnership of African institutions dedicated to support the continent's progress towards the SEforALL initiative's three main objectives on energy access, renewable energies and energy efficiency.

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

2. COUNTRY AND SECTOR OVERVIEW

2.1 COUNTRY OVERVIEW

Nigeria is the most populous country in Africa, with a population exceeding 184 million people and a landmass of 923,768 km². With an annual population growth rate exceeding 2.5%, the population is projected to reach 237 million by 2030 (World Bank, 2017). The national life expectancy is 55 years for men and 56 years for women (World Health Organisation, 2016). Nigeria is bordered on the east by Cameroon, on the northeast by Chad, on the north by Niger, on the west by Benin, and on the south by the Gulf of Guinea.

Nigeria is divided into thirty-six states and one Federal Capital Territory (Abuja), which is not a state but a territory under the direct control of the Federal Government. The states are further sub-divided into 774 Local Government Areas (LGAs). Nigeria has strengthened its democratic governance after forty years of instability following independence. The President holds executive power, and a bicameral system composed by a House of Representatives and a Senate holds the legislative power.

As in most of West Africa, Nigeria's climate is characterised by strong latitudinal zones, becoming progressively drier as one moves north from the coast. Temperatures throughout Nigeria are generally high; diurnal (daily) variations are more pronounced than seasonal. The highest temperatures occur during the dry season while rains and moderate temperatures occur during the wet season. Although average temperatures of 26-28 degrees Celsius vary little from coastal to inland areas, inland areas, especially in the northeast, have greater extremes of up to 40C. Given this climatological cycle and the size of the country, there is a considerable range in total annual rainfall across Nigeria, from around 10 to 230 mm per month, both from south to north and, in some regions, from east to west Nigeria receives a fairly distributed solar radiation averaging 19.8 megajoules per meter squared per day (MJ m^2/day) and average sunshine hours of 6.0 hours per day. Average Global Horizontal Irradiance (GHI) values are highest in the North, ranging between 2,000 and 2,200 kWh/m^2 (which is comparable to other very high yield sites around the world) (World Bank, 2017).

In spite of a recent economic downturn, Nigeria remains Africa's largest economy, with total gross domestic product (GDP) of US $405 billion in 2016. This is down from $568 billion in 2014, a decrease of 29%. This steep fall in GDP is linked predominantly to the falling price of oil, which in 2016 accounted for over 90% of foreign income to Nigeria, but also to certain past fiscal policies including fixing the Naira to the dollar (Financial Times, 2016). GDP per capita decreased even more in percentage terms to $2,178 in 2016, 32% less than in 2014 ($3,222). The Nigerian economy relies heavily on the hydrocarbons sector, with oil and gas representing 35% of GDP and 95% of exports. As of July 2017, Nigeria exported 1.84 million barrels of oil per day. Other key sectors within the Nigerian economy are agriculture, information and communications, and manufacturing.

The Nigerian Government has made significant efforts to improve the economic environment in recent years. For the first time, Nigeria has been among the top ten improvers in 2016-2017 according to the World Bank's 2018 Doing Business report. The country has improved in the following indicators: starting a business, dealing with construction permits, registering property, getting credit, and paying taxes. In 2017, the economy entered recovery from the 2016 recession, with GDP growth of 0.8%. A positive outlook to 2019 is anchored in higher oil prices and production as well as stronger agricultural performance. Nonetheless poverty remains unacceptably high, with 80% of Nigeria's inhabitants living on less than $2 a day.

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lowest electrification rates are found in the North West states, with 12% electrification in Taraba and Jigawa, and 13% electrification in Kebbi, Sokoto and Zamfara. These communities therefore rely on candles, kerosene and torches for lighting, and traditional biomass for cooking.

Crop production has been one of the main contributors to non-hydrocarbon related economic growth although the agriculture sector, the main source of livelihood for most Nigerians, faces many challenges. These issues include an outdated land tenure system that constrains access to land (1.8 hectares per farming household), a very low level of irrigation development (less than 1 percent of cropped land under irrigation), poor access to credit, limited adoption of modern technologies, high cost of farm inputs, inefficient fertilizer procurement and distribution, inadequate storage facilities, high post-harvest losses and waste, and poor access to markets. These have all combined to keep agricultural productivity low, averaging 1.2 metric tonnes of cereal per hectare compared to a global average of 4.0 metric tonnes per hectare (as of 2016) (World Bank, 2016). Over the past 20 years, value-added per capita in agriculture has risen by less than 1 percent annually. It is estimated that Nigeria has lost US $10 billion in annual export opportunity from groundnut, palm oil, cocoa and cotton alone due to continuous decline in the production of those commodities, and production increases have not kept pace with population growth leading to rising food imports.

Nigeria is the continent's leading consumer of rice, one of the largest producers of rice in Africa and simultaneously one of the largest rice importers in the world. As well as an important food security crop, rice is an essential cash crop for small-scale producers who commonly sell 80 per cent and consume just 20 per cent of their overall rice production. Rice generates more income for Nigerian farmers than any other cash crop in the country. In 2008, Nigeria produced approximately 2 million metric tonnes of milled rice and imported roughly 3 million metric tonnes, including the estimated 800,000 metric tonnes that is suspected to enter the country illegally on an annual basis.

Moreover, the country is the largest producer of cassava in the world, with about 50 million metric tons annually from a cultivated area of about 3.7 million ha. Nigeria accounts for cassava production of up to 20 per cent of the world, about 34 per cent of Africa's and about 46 per cent of West Africa's. The national average yield of cassava is estimated at about 13.6 metric tonnes per ha, as against potential yield of up to 40 metric tonnes per ha. Close to two-thirds (66 per cent) of total production is in the southern part of the country, while about 30 per cent is in the north-central, and 4 per cent in other parts of the north. The crop is predominantly grown by smallholders on small plots for family consumption and local sale. Large scale commercial plantations are rare.

2.2 OVERVIEW OF THE ENERGY SECTOR

The Federal Ministry of Power, Works and Housing (MPWH) is responsible for the energy sector in Nigeria, including developing policies for the provision of adequate and reliable power supply. The former monopoly utility, the National Electricity Power Authority (NEPA), was unbundled in the Electric Power Sector Reform (EPSR) Act of 2005. The new structure established under the EPSR Act, hereby referred to as the Act, is presented in Figure 1. This Act established 6 generation companies (GenCos), which each operate a generation asset, making up about half of the installed capacity of Nigeria. The full list of power plants is available in Table A-8 of GIZ NESP: The Nigerian Energy Sector, 2015. Eleven distribution companies (DisCos) operate in, and are responsible for, the national distribution networks for different states (shown in Figure 2). They retain licencing rights in areas covered by their networks. The Transmission Company of Nigeria (TCN), responsible for maintaining and developing Nigeria's transmission assets, was also established as well as the Nigerian Electricity Regulatory Commission (NERC). The Nigerian Bulk Electricity Trading (NBET) company was established as a guarantee mechanism as part of the transition initiated by the Act, guaranteeing payment for the GenCos' electricity while the DisCos become suitably reliable off-takers. Independent Power Producers (IPPs) selling electricity and ancillary services through Power Purchase Agreements (PPAs) can also do so through the NBET.

Figure 1: Structure of the electricity sector (2005 EPSR Act)

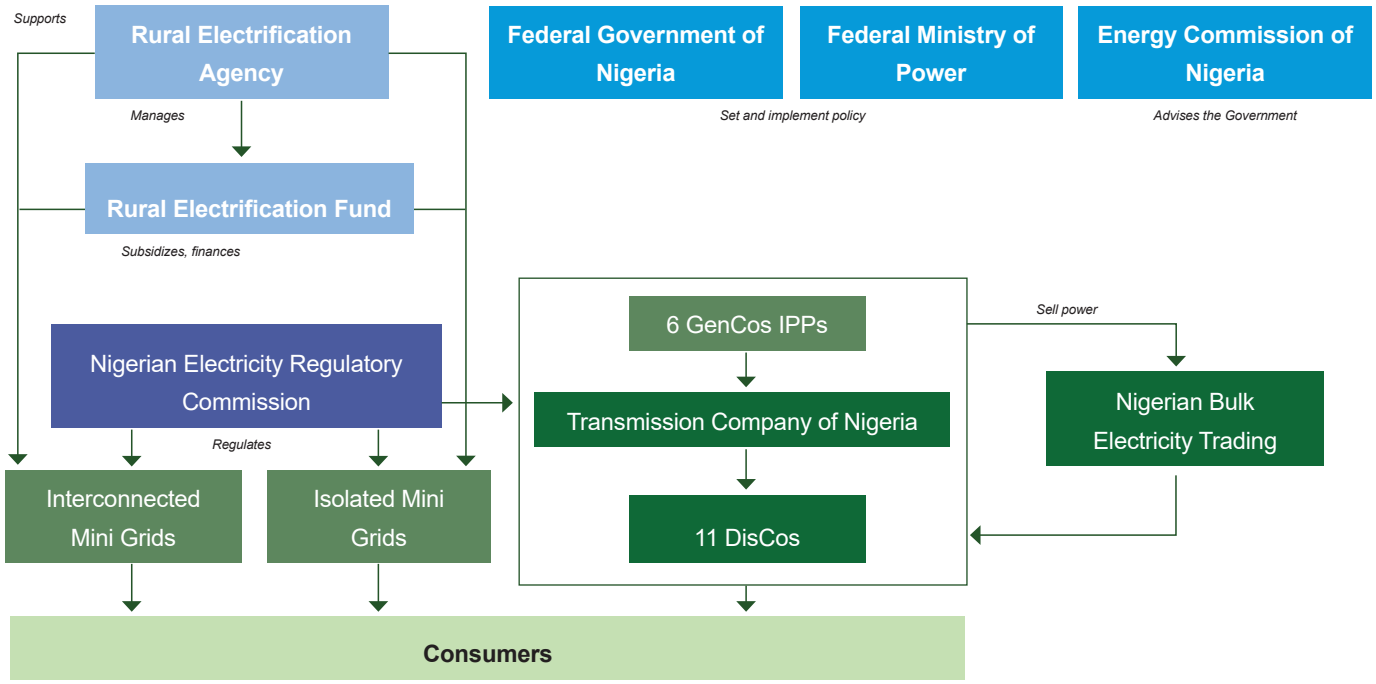
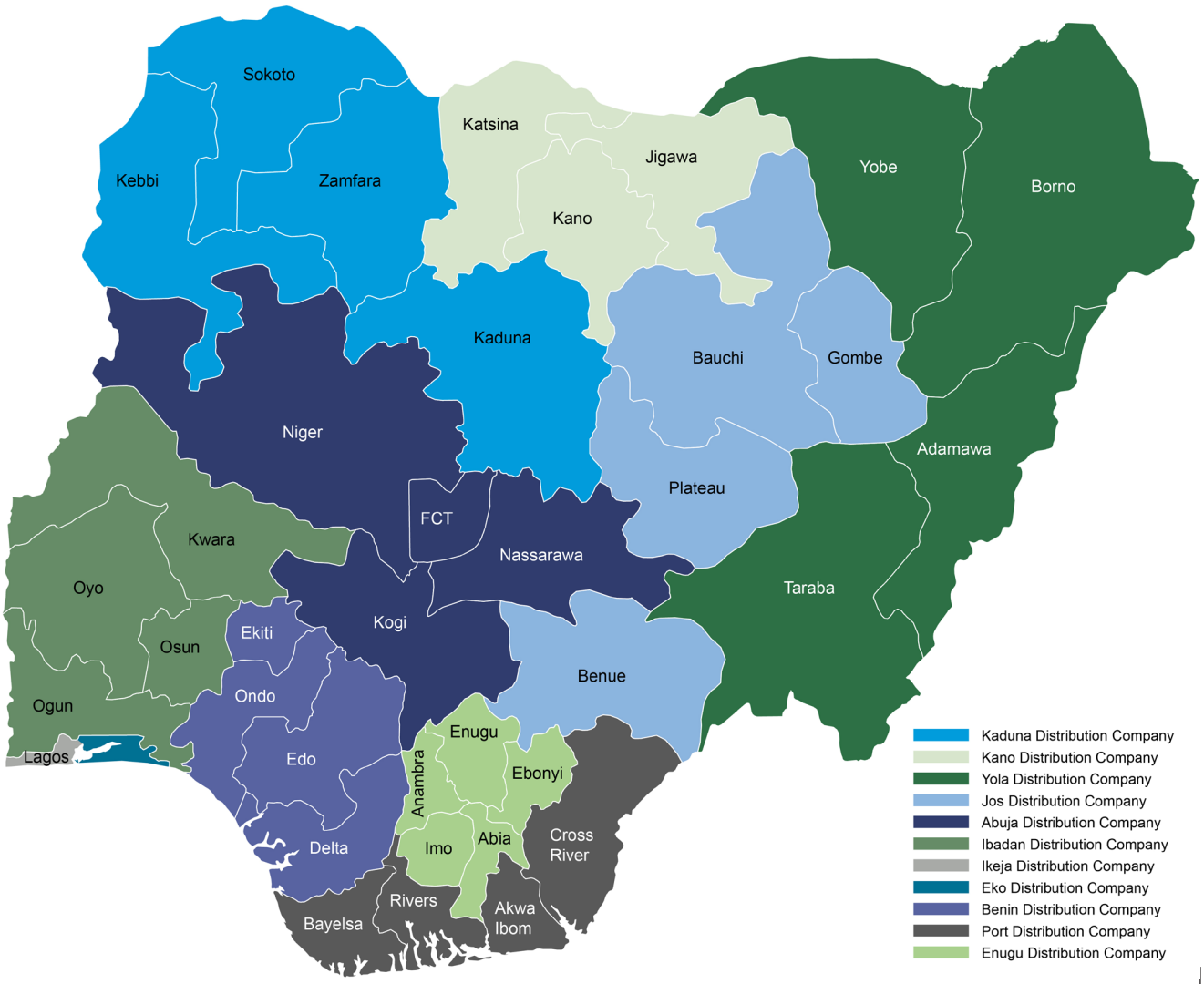


Figure 2: Map of the allocation of states amongst Nigeria's eleven Distribution Companies (DisCos)



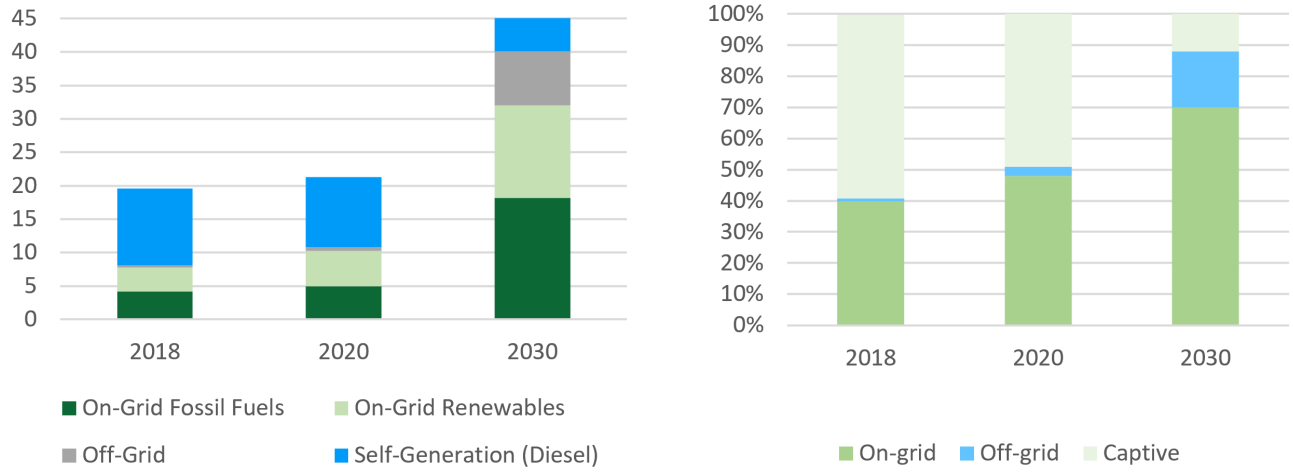
The incumbent Nigerian government, elected in 2015, sees renewable energy as an important part of Nigeria's future energy sector, diversifying beyond fossil fuel-based generation. This focus on diversification is driven by issues facing the current power network (detailed in section 1.3), including a severe deficit in on-grid generation capacity and a resultant reliance on decentralised diesel generators. A number of strategy documents and policies have been published under the incumbent government, including the National Renewable Energy and Energy Efficiency Policy (NREEEP) (Nigerian Ministry of Power, 2015), the Sustainable Energy for All Action Agenda (SE4ALL-AA) (Government of Nigeria, 2016) and the National Renewable Energy Action Plan (NREAP) (Nigerian National Council on Power, 2016).

The Nigerian government is targeting an additional 30GW of electricity generation capacity by 2030, with 30% of this capacity to come from renewable energy, as part of their Electricity Vision 30:30:30. This is contrasted to the current 5GW of available capacity where only 20% is renewable (large hydro). This target under the SE4ALL-AA (Figure 3) is in line with the overall ECOWAS target of 31% RE mix by 2030. This includes a targeted contribution from large and small hydro of 28% and 19% by 2020 and 2030 respectively, a 20% and 19% contribution by solar (PV and solar thermal) by 2020 and 2030 respectively, and a maintained contribution of 2% by wind and 3% by biomass. Total electricity generation capacity is therefore be targeted to reach 23.5GW in 2020 (including 10.5GW captive self-generation and 0.54GW off-grid generation), and 45GW by 2030 (including 8GW off-grid and 5GW captive self-generation). The marginal decrease in the renewable energy proportion reflects increased fossil fuel generation (Tunde et al, 2016).

The government also has the following energy efficiency targets:

- 40% and "almost 100%" of efficient lighting use by households by 2020 and 2030 respectively;
- 20% and 50% increase in use efficient technologies and demand side management measures in high-energy consuming sectors (transport, power and industrial sectors), over 2015 levels;
- Compulsory energy audits for high-energy consuming sectors and public buildings by 2016.

Figure 3: Nigeria Generation Capacity Targets (Electricity Vision 30:30:30)



Nigeria's Intended Nationally Determined Contribution (INDC) (UNFCCC, 2015) aims to limit per capita emissions at approximately 2 tonnes CO_2e (carbon dioxide equivalent) by 2030, compared to a business as usual trajectory of 3.4 tonnes CO_2e by 2030. This will be achieved via the following measures:

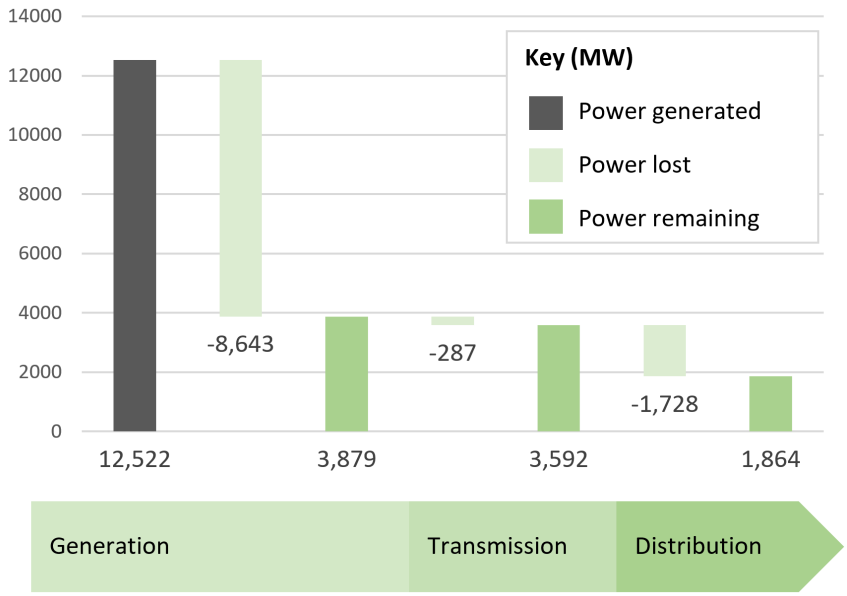
- Work towards ending gas flaring by 2030;
- Work towards off-grid solar PV of 13GW (13,000MW);
- Deployment of efficient gas generators;
- 2% per year improvements to energy efficiency (30% by 2030);
- Transport modal shift from cars to buses;
- Improvement of the electricity grid;
- Climate smart agriculture and reforestation.

2.3 OVERVIEW OF THE POWER SECTOR

There is a significant power deficit in Nigeria due to an overall lack of generation capacity. In 2015, according to the SE4ALL-AA, Nigeria had a total installed capacity of over 12GW (World Bank, 2017). This is predominantly from gas-fired power plants, with large hydropower being the only significant renewable source (20% of total). As of May 2015, however, only 6.8GW of installed capacity was available with only 3.9GW of capacity operating (due to variety of reasons including gas shortages, water management, breakdowns and grid constraints). This capacity deficit has continued at a similar level over subsequent years, ranging from 3GW to 5GW, severely at odds with Nigeria's economic size and growth rate. In 2015 power supply in Nigeria averaged 3.1GW, which was estimated to be only a third of the country's minimum demand (RECP, 2018). This lack of present-day capacity is largely due to a lack of investment capital for energy projects pre-2010, prior to the release of the Nigeria Vision 20:20:20 and Roadmap for Power Sector Reform documents. Systematic under-investment in current and new assets has resulted in poor power quality and availability.

There are also deficiencies in both transmission and distribution assets, resulting in heavy losses (low efficiency) and an inability to cover costs. The Transmission Company of Nigerian (TCN) operates a network of 5,525km of 330kV and 6,800km of 132kV of transmission lines, as of 2016. This is responsible for nearly all of the current population's electricity access, which stands at 60.6% access nationally (34.1% in rural areas). However, a 2017 review found that about 1,600 rural electrification projects, mostly concerned with grid extension, had been abandoned by contractors over the last five years (Nigeria Electricity Hub, 2016). Transmission losses average between 8% and 10% according to ICREEE and 7.4% according to NERC (NERC, 2017). Similar challenges face Nigeria's distribution assets, where DisCos are not recovering their costs. Operating losses were reported by the Association of Nigerian Electricity Distributors (ANED) for the DisCos at over 10 NGN/kWh in 2015, with an average tariff of 27 NGN/kWh against a total cost of NGN 35NGN/kWh (ANED, 2015). Combined generation, transmission and distribution losses are shown in Figure 4, showing that only 15% of the constructed capacity actually reaches power consumers. The tariff rate is agreed by each DisCo with the regulator NERC on a 5-year basis, considering both operating costs and 5-year expansion plans. These 5-year expansion plans are not made public due to perceived commercial sensitivity for the DisCos.

Figure 4: Nigeria power sector energy losses (MW) (REA, 2018)



Another critical challenge for DisCos is that of commercial losses, primarily due to a lack of appropriate metering. Commercial losses can be as high as 50%. This is primarily because of a lack of metering across their inherited networks, but also because the meters used are not sophisticated enough to restrict illegal connections. A simple meter monitors the usage from a particular household but cannot account for illegal connections onto the low voltage (LV) line that connects to the household. This means DisCos cannot account for a significant proportion of the power used on their lines, resulting in revenue losses. This has resulted in prioritisation of best paying customers with a particularly negative impact on rural

energy supply. More sophisticated meters are needed, such as those used by the largest mini-grid developer, Green Village Electricity Projects Limited (best known as GVE), which sit on the LV line itself and individually attribute all usage across the line.

Given challenges with reliability of the grid, most residential homes and 85% of businesses rely on individual diesel generators, with an estimated 14GW of decentralised diesel generation capacity. As of 2011 this translated to 1 generator for every 2.5 citizens and about 3.5 trillion Naira per year spent on diesel and petrol (approximately US $30 billion; 45% of this by private households). Fuel prices have increased significantly since 2011, with average diesel prices rising from 65 to 214 NGN per litre (18c$/l to 0.59c$/l at current exchange rates) from December 2011 to February 2018 (Nigeria Data Portal, 2018). This is contrasted with an average national grid power consumption of 250kWh/year per person for those with an electricity connection, which averages across the whole population (including those not using power) to just 143 kWh/year. This national rate is relatively consistent with other SSA countries, but is small relative to Nigeria's economy. This demonstrates the energy limitations on households and companies due to the reliance on decentralised diesel generators and other fossil fuel assets. Although Nigeria is a net exporter of fossil fuels, with about 13.6tNaira of oil exports versus 2.6tNaira of fuel imports, this still leaves it vulnerable to oil price crashes such as those seen in 2015 and 2016 (Nairametrics, 2018).

These issues will intensify in the future as Nigeria's population is projected to reach 267 million by 2030, with an associated latent demand for up to 116 GW of additional generation capacity. This is estimated by the Nigerian Population Commission based on a population growth rate of 2% and a 7% economic growth rate. This trajectory is a key driver behind the government's focus on private investment in the energy sector, and in off-grid energy, as narrowing even the current generation capacity gap is seen as reliant on private and external financing and operation.

2.4 OVERVIEW OF THE OFF-GRID SECTOR

2.4.1 ENERGY ACCESS POLICY AND PLANNING

The Nigerian government recognises that mini-grid solutions will be the most effective option for certain remote settlements, and are likely to be more cost-effective than grid extension. This is evidenced by the SE4ALL Action Agenda and associated government strategies, where mini-grid generation capacity is targeted at 8.1GW by 2030. The majority of unserved citizens live in rural areas, with about 66% of this rural population lacking access to electricity (IEA, 2017). These communities therefore rely on candles, kerosene and torches for lighting and traditional biomass for cooking. The settlement electricity access growth rate since 2005 has been approximately 5%, although this figure is much larger than the growth in household connections. The current rate of progress is therefore inconsistent with the target of achieving 90% access to electricity by 2030, which would require connecting more than 1 million households per year (3% of the population) and adding roughly 25GW of overall generation capacity (World Bank, 2017). Grid extension is unlikely to be an economical solution for many of these communities, given the distance to the grid and their relatively low demand loads compared to urban areas.

The SE4ALL Action Agenda details a number of energy access targets, including reaching 75% national electricity access by 2020 (60% in rural environments) and 90% by 2030, compared to 40% in 2016. This translates to 2% of total electricity supply to come from off-grid generation by 2020 (0.54 out of 23.5 GW total) and 18% by 2030 (8 out of 45GW total). Of this 8GW 2030 target, 5.3GW would be through mini-grids, with the remaining 2.8GW through solar home systems (this figure includes the government's targets for street lighting). Other targets include:

- Replacing 50% of traditional firewood consumption for cooking by improved cook stove technology by 2020 and 80% by 2030;
- Working together with the private sector to roll-out LPG at affordable cost for Nigerians by 2020 and subsequently up to 2030;

- By 2025 and 2030, nuclear energy is targeted to contribute about 2.5% (1GW) and 4% to available electricity mix, although no plant is yet to be commissioned[2] (IAEA, 2015);

On-grid and off-grid rural electrification is the responsibility of the Rural Electrification Agency, REA. The new government has provided the REA with strong backing to drive implementation of off-grid solutions in unserved and underserved areas[3]. REA's core support to the private off-grid sector is through reducing development costs by delivering pre-development activities, including site identification and facilitation with local and state governments. As part of this work REA maintains a GIS portal of 8,000 potential mini-grid communities, including socio-economic factors such as the locations of schools (Nigeria Rural Electrification Agency, 2018). This portal allows market estimations based on selected criteria including economic activity and distance from the national grid. REA has visited over 100 of these sites to date to verify population data and conduct community demand assessments, though the intention is to scale this significantly in coming years. The World Bank and AfDB-funded Nigeria Electrification Project (NEP), detailed in section 2.4.4, plans to electrify 300,000 households and 30,000 Small and Medium Enterprises (SMEs) via 1,000 mini grids over 5 years. It will start with the 100 pre-selected mini-grid sites clustered into bid packages, likely allocated through tender (but possibly by auction or another mechanism).

At the same time, the REA is tasked with supporting DisCos to meet their grid extension obligations, as well as:

- Energising education: providing renewable energy for 37 universities and 7 university teaching hospitals;
- Energising economies: supporting electrification of 250-300 urban markets through site identification, demand assessments and land agreement facilitation with state government;
- REA estimates an achievable total levelised cost of energy of 41c$/kWh for PV-battery mini-grids developed under this initiative over the next 3-5 years (by January 2022)[28,4]
- Energising rural communities: similar to the mini-grid work, but focused on Solar Home Systems.

There were eleven privately-owned operating mini-grids as of August 2017, with approximately 10,000 people or 1,800 customers served (table 1) (World Bank / ESMAP, 2017). A list of mini-grid project developers in Nigeria is included in the Stakeholder Directory in this report (section 4.4). The average tariff across a range of customer categories for mini-grids responding to the ESMAP report is 36c$/kWh, compared to an average grid tariff of 8c$/kWh. This corresponds to a US $2.2 per month bill at Tier 2 consumption (73-250kWh/year). The average cost of connection is $783 (not all charged to the customer), with an average subsidy per connection of $356 (45%). The reliability of service provided by these mini-grids is significantly better than the main grid. Two of the seven mini-grid respondents provided 24 hours of service, with all the others above 16 hours, compared to an average of 9 hours from the grid.

Private developers are generally positive about the future market for mini-grids, responding to the greater clarity provided by the new Mini-Grid Regulation. The mini-grid regulation, detailed in the licencing section below, provides regulatory clarity for mini-grids, including setting out protections for grid-stranded mini-grids. The majority of companies spoken to on behalf of this report reported plans for accelerating expansions, bolstered by this regulatory clarity and existing successful pilots.

Operating mini-grid developers include ACOB Lighting Technologies, Arnergy, GVE, Rubitec Solar and Waste-2-Watt, with their operating mini-grids shown in table 1 (as of August 2017). GVE is the largest, with 5 operating mini-grids and 5 more under development. A 6-phase plan targets a total of 1 million customers and 500 mini-grids, gradually increasing in size above the 100kW threshold for regulated systems. This accelerating-growth plan illustrates Nigerian developer confidence in general in their business models, existing pilot projects, the latent demand for higher-tier energy

2 Geregu in Kogi State and Itu in Akwa Ibom State were confirmed in 2015 as the two preferred sites for the country's first nuclear power plants. This followed an intergovernmental nuclear cooperation agreement with Russia in 2009, and subsequent agreements on the design, construction, operation and decommissioning of an initial plant. Details can be found in the Nigeria Atomic Energy Commission's (NAEC) Strategic Plan 2015.

3 'Underserved' is defined as a community which is around or close to an existing grid network, but not fully served by it

4 It is not known whether this estimate includes a grant funding proportion, or to what level.

in rural areas, and the positive response of communities to mini-grids over individual diesel systems. This demand means developers can sustain rural interest even at relatively high tariffs: for example, GVE charges 75c$/kWh for households and 45c$/kWh and 60c$/kWh for commercial loads during the day and night respectively.

Table 1: Privately-owned mini-grids as of August 2017 (Summary of Appendix A, ESMAP report: Mini-Grids in Nigeria (World Bank / ESMAP, 2017))

Location (State, Town)	Year	Generation Source	kW	People Served	Owner
Rivers, Egbeke	2013	Solar PV	6	480	GVE
Rivers, Egbeke	2015	Solar PV	9	720	GVE
Rivers, Egbeke	2015	Solar PV	9	720	GVE
Gombe, Kolwa	2015	Solar PV	34	1,600	GVE
Niger, Bisanti	2016	Solar PV	34	1,600	GVE
Kaduna, Dodan Karji	2017	Solar PV	16	443	ACOB Lighting Technologies
Delta, Oghriagbene	2017	Solar PV	16	N/A	ACOB Lighting Technologies
Rivers, Ihuama	2017	Solar PV	16	636	ACOB Lighting Technologies
Osun, Idi-Ata/Onimbaml	2015	Solar PV	24	1,180	Arnergy
Edo, Obayantor 1	2016	Solar PV	38	1,180	Arnergy
FCT, Rija	2017	Biogas	20	500	Waste-2-Watt
TOTAL			**246**	**10,239**	

The DisCos are not expected to electrify more than 5km from their existing grid within the next 5-10 years, but even this is limited by low tariffs and significant commercial and technical losses. Both developers and donor agencies were in agreement that DisCos were unlikely to deliver any real expansion of their networks in the near future, due to the issues discussed in section 3.3. They agreed that a 5km buffer zone would be sufficient for planning mini-grids over the next 5-10 years. In practice off-grid developers are still likely to prioritise sites that are further than this given the current wealth of choice of non-electrified settlements, but interplay between grid (DisCos) and off-grid (mini-grid developers) may later become a barrier as developers look to build closer to the grid. Permission from DisCos is currently needed to build energy systems close to their grid, with the Interconnected Mini-Grid Regulation covering PPA arrangements for the scenario in which mini-grids also sell power to the main grid (there are no examples of this having happened in Nigeria to date).

2.4.2 LICENCING

Private sector companies can get a licence for generation and distribution under the 2005 Power Sector Reform Act (EPSR Act). Mini-grids were not regulated until the 2016 Regulation for Mini-Grids (see section 4.1 for details). The new legislation provides a framework for regulating mini-grids under 1MW generating capacity. Only mini-grids can be operated in a bundled generation and distribution mode under one company. Systems above these thresholds are classed as unbundled independent power producers and independent electricity distribution networks are therefore regulated by the 2005 Act and the 2012 Regulations for Independent Electricity Distribution Networks (IEDN), section 4.1.

The 2016 Regulation for Mini-Grids differentiates licencing conditions based upon a threshold of 100kW of distributed power and whether the system is isolated from, or interconnected with, the national grid. The procedure for different systems are as follows:

- Isolated mini-grids of less than 100kW (power injected into the same distribution network as an average of any 15 min interval) – required to register only, with the regulator (NERC) giving a non-objection. May apply for a permit to enable access to compensation if the grid arrives;

- Isolated mini-grids above 100kW (distributed capacity) – must apply for a permit and have an agreement with the community[5];
- Interconnected mini-grids – 100kW threshold for registration/permit applies. In both cases there is a requirement to have a tri-partite contract with the local DisCo and the community, with the NERC approving the contract. This contract must contain an agreed purchase tariff for the community, tariff for electricity sales to the DisCo (if applicable) and the usage right for the mini-grid to use the DisCos network infrastructure.

There are a number of other documents including a certificate of incorporation, a certificate of occupancy (land permit), and building permits. The full regulation is detailed in section 4.1, and a comprehensive summary can be found in the 2017 ESMAP report, Mini-Grids in Nigeria (World Bank / ESMAP, 2017). A brief summary of some important licencing conditions include:

- Currently all projects above 100kW require an environmental impact assessment (to receive a permit), although NERC is looking to obtain an exemption for mini-grids;
- The local DisCo's consent is needed for a site chosen which lies within the geographical boundary of its five-year plan (which is submitted to NERC every five-years), even for an isolated system;
- Isolated mini-grids may obtain a 12-month exclusivity agreement with the community, which can be renewed by NERC if the site is outside the five-year plan of the local DisCo;
- A deliberate ambiguity in the Regulations enables multiple distribution systems under 100kW to be connected by feeder lines to a generation facility under 1MW and still be considered separate projects, if desired. This means that such systems can avoid the need to obtain a full permit, and register instead, which can be beneficial in certain cases;
- One benefit of obtaining a permit rather than registering, however, is the permit's provisions for protecting mini-grids upon arrival of the grid (see later section);
- A developer that is awarded a grant by the REA must reach and sign a Grant Agreement with the REA within 6 weeks of registering or receiving a permit. The Grant Agreement does not affect the registration or permit application.

2.4.3 MINI-GRID TARIFFS

NERC has published a Multi-Year Tariff Order (MYTO) tool for calculating the appropriate tariff, independent of national grid tariffs, which must be used by isolated mini-grids in order to obtain a permit. The regulation for tariff setting for isolated and interconnected systems is summarised in table 2, and in all cases the final approval lies with NERC. The tool is cost reflective, with later tariff revisions mandated if either the developer or the community raises an objection to the existing agreement.

Table 2: Summary of tariff setting requirements under the 2016 Regulation for Mini-Grids

	Registration	Permit
Isolated mini-grid	Developer sets tariff through MYTO calculation tool or agreement with the community	Developer must use MYTO calculation tool to determine tariff, and attach calculation spreadsheets to its application
Interconnected mini-grid	Developer agrees with the DisCo and the community	Developer agrees with the DisCo and the community on retail tariff, usage right for the DisCo's network infrastructure, and tariff for electricity generated by the mini grid and fed into the DisCo's network. MYTO must be used only to calculate the retail tariff, and calculation spreadsheets must be attached to the application

5 The Mini-Grid Regulation defines 'community' as a group of people within the same geographic location organized under a local leadership structure or a legally recognised corporate entity and in both cases capable of entering into contracts and being capable of suing and being sued. Where tariff agreements are concerned the regulation states that the 'community' in the agreement must represent "60% of the electricity output of that same community"

2.4.4 SUBSIDIES AND INCENTIVES

REA's financial arm is the Rural Electrification Fund (REF). In its first year of operation, the REF provides capital subsidy to qualified public and private rural electrification schemes. All mini-grid projects built to date have received some form of subsidy. The REF is funded through any surplus appropriated pursuant to the EPSR Act 2005, including any fines obtained by NERC under this Act as well as any other government or external contributions. The REF is currently reviewing 269 proposals for grant funding of renewable energy projects, under a first year budget of $10m. The grant contribution limit is $300,000 or 75% of CAPEX, whichever is less (50% of CAPEX for SHSs). The REF is also able to provide technical assistance similar to REA, mainly through project development support. Both REA and the REF recognise the need for further technical support and capacity building, especially concerning renewable energy and geospatial information systems (GIS).

The three largest ongoing programmes providing capital support to mini-grids are the Bank of Industry, GIZ's Nigeria Energy Support Programme (NESP) and the World Bank's $350m contribution ($250m to mini-grids) to the Nigeria Electrification Project (NEP). All are detailed in the Stakeholder Directory in this report (section 4.4) along with other donor programmes including USAID, AfDB and Power for All. The Bank of Industry provides concessional financing (single figure rates) to micro, small and medium enterprises including to the mini-grid developer GVE. GIZ provides grants for the whole cost of the distribution assets (1m EUR in phase 1), while the World Bank aims to provide a matching grant (likely set to 75% or $300,000, whichever is less) followed by a performance-based connection subsidy, likely set at 30%. The World Bank grants will be channelled through REA's REF. The AfDB is also contributing $200m to the NEP.

There has been a strong focus under the incumbent government on improving the ease of investment in the energy sector, spearheaded by the Nigerian Investment Promotion Commission (NIPC). This includes establishment of the One Stop Investment Centre (OSIC). This investment facilitation mechanism streamlines administrative procedures relating to investment by housing in one place the 26 government agencies relating to the issuance of business approvals, permits and licenses and company incorporation (section 4.4). A comprehensive compendium of investment incentives compiled by the NIPC can be found in the Investment Incentives directory (section 4.2). Aiming to attract foreign direct investment into the power sector, this compendium of incentives includes:

- A 3-year tax holiday for energy projects, with an additional 2 years for renewable projects;
- Exemption from Duty Taxes on imported PV panels, but not other components i.e. batteries;
- Seven-year tax holiday in respect of industries located in economically disadvantaged local government areas;
- Capital & Investment Allowance which can be carried forward and used after tax holiday period;
- Manufacture of transformers, meters, control panels, switchgears, cables and other electrical related equipment are considered as pioneer products/industries. As a result, there is tax holiday of 5 to 7 years for investors who invest in these areas;
- Power plants using gas are assessed under companies income tax act at a reduced rate of 30%
- 100% foreign ownership of electricity plants allowed;
- Allowed repatriation of profit with a 5% withholding tax.

2.4.5 POWER PURCHASE AGREEMENTS

Mini-grids can sign PPAs under the Interconnected Mini-grid regulation either with a DisCo or NBET to sell power back to the grid, but none have done so to date as all have been isolated systems. NBET recently signed PPAs for 1.2GW of grid-connected solar PV at the rate of 11.5 US cents/kWh, which is expected to come online by 2018.

2.4.6 ARRIVAL OF THE GRID

The Mini-Grid Regulation provides protection for grid-overtaken (or grid-stranded) mini-grids that have a permit, although no such scenario has yet arisen in practice. Interconnected mini-grids may choose hand over assets to the DisCo once the original tripartite contract expires, on the agreement of NERC and the community. Previously isolated, grid-stranded mini-grids have three options:

1. Become an embedded generator under the DisCo and sell the distribution network to the DisCo;
2. Become an interconnected mini-grid operator under a tripartite agreement maintaining both generation and distribution assets while selling to and purchasing electricity from the DisCo in bulk;
3. Transfer the distribution assets to the DisCo, with compensation.

As an embedded generator the mini-grid sells bulk power on a tariff agreed with the local DisCo. This tariff does not have to follow the Multi-Year Tariff Order (MYTO), and neither the DisCo nor NBET is obliged to buy power. If no agreement is reached then the only option is the second scenario. Here the mini-grid operator will be compensated by the DisCo for the depreciated value of the capital assets plus one year's worth of customer revenue. If the grid arrives within five years of commissioning then the compensation will also include the value of construction and development costs. Registered mini-grids without a permit are not compensated, and must move all assets within two months of the DisCo beginning to sell electricity.

2.4.7 TECHNICAL RULES

Mini grids that hold a permit, whether isolated or connected, are bound to follow the NERC Grid Code, the NERC Distribution Code, and the Health and Safety Standards. These codes constrain the nominal operating variations in voltages across lines to ±5% below 415V and ±6% above, and the variation in frequency to between 48.5 and 51.75Hz. They also mandate the operator to notify users at least 72 hours in advance of outages and mandate reporting of serious incidents to NERC within 24 hours. Mini-grids registered with NERC have to restrict voltages to ±10% and frequency to ±20% of their nominal values.

2.4.8 MOBILE SERVICES

Nigeria has Africa's largest mobile market with approximately 142 million subscribers. The main providers are MTN Nigeria, Glo Mobile (Globacom), Bharti Airtel (formerly Zain, Celtel), 9Mobile (Etisalat Nigeria, EMTS, Mubadala), M-Tel (Nitel), Visafone, Starcomms (Capcom), Multi-Links, Reliance, InterC Network (Intercellular), Megatech Engineering (Zoda Fones), Telkom, Econet Wireless and Vodacom.

Mobile money has not achieved similar penetration despite a number of active operators, partly due to the bank-led model adopted by the Nigerian Central Bank (NCB). This bank-led approach is in contrast to successful mobile money markets like Kenya, where the telecoms companies own and are responsible for the mobile money service (also typically linked to lighter regulation). The bank-led approach in Nigeria was chosen partly to reduce money-laundering, but also due to protectionism within NCB. This has led to slower investment in mobile infrastructure as mobile money revenue has less influence over banks' larger portfolios.

2.4.9 BARRIERS AND POTENTIAL INTERVENTIONS FOR MINI-GRID DEPLOYMENT

Overall Nigeria is now the biggest and most attractive off-grid opportunity in Africa. Previously a number of mini-grid market barriers under the last government had restrained progress in the off-grid space, limiting the number of successful mini-grid developers as well as the availability of performance data on operational mini-grids. Despite this, there are a number of positive drivers contributing to the size of the current opportunity in Nigeria[9]:

- A population of approximately 184 million, with at least 70m unelectrified citizens in rural areas;
- A culture of entrepreneurship and a willingness to pay for reliable power, including in rural areas;
- A severe deficit in the actual operating capacity of the national grid (~70% deficit);

- 14GW of decentralised diesel generators and an estimated 3.5 trillion Naira spent per year on petrol, making renewable, off-grid power highly competitive even when considering the substantial fossil-fuel subsidies;
- The incumbent government's focus on off-grid solutions;
- Clear regulations for mini-grids and protections from the grid;
- Clear responsibilities and mandates of ministries and their implementing agencies.

Access to required mini-grid finance, in line with the size of the opportunity in Nigeria, is currently restricted by the lack of distribution network data availability. The DisCos consider this to be commercially sensitive. This information is therefore not available except to the regulator, NERC, which receives each DisCo's five-year business plan including all planned grid extensions over this period. This is detailed further in section 3.1.

Another remaining barrier is the need for greater facilitation and coordination across local, state and national government. Currently projects require the consent and engagement of local, state and national government to deliver a mini-grid project (including land and community agreements, licencing etc.). This can often include engaging with individuals or departments whose involvement is not strictly mandated, but who can block progress if they do not feel sufficiently engaged and considered. REA has been successfully providing this facilitation role in certain cases. Rolling out a systematic approach (or 'one stop shop') for facilitating engagement of government on behalf of developers would likely accelerate the implementation of off-grid projects.

Removing import duties and VAT exemptions for components other than solar panels would allow a reduction in the tariffs paid by mini-grid customers, potentially by as much as 15%. Components such as batteries and power electronics do not receive the same exemptions as solar panels, due to their being able to be used for other purposes. Panels only make up about a quarter of the CAPEX of a mini-grid however, so further exemptions could significantly bring down costs for developers and increasing the rate of development of off-grid projects. GVE estimates that duty waivers could deliver a 15% CAPEX saving, which could be passed directly onto customers. Further savings could also be achieved by removing the 5% VAT on all electricity sales.

A number of other potential interventions to stimulate investment in mini-grids include:

- Blended finance made available through commercial banks with the support of development finance institutions (DFIs) such as the World Bank and the African Development Bank;
- Greater deployment of mini-grids, combined with greater collection and dissemination of performance data and successful business models;
- Continued data collection of potential sites for mini-grids, and further ground-truthing and demand assessments of identified sites;
- Removing the restriction of needing an Environmental Impact Assessment to get a permit
- Greater penetration of mobile money services, ideally under a telecoms-led approach.

3. GREEN MINI-GRID POTENTIAL

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

This chapter aims to give mini-grid stakeholders an understanding of the size of the opportunity for green mini-grids in Nigeria. Market size estimates are calculated based on a number of considerations: (1) physical opportunity size according to GIS datasets (population density, load centres, existing grid, etc.), (2) existing electricity expenditure by rural households, (3) maximum customer affordability and willingness to pay, and (4) tariffs currently allowed in-country. Comparisons will be made between an existing market size, based on affordability and in-country tariff limitations, and the theoretical market size based on cost-reflective tariffs[6]. The difference between current and theoretical market size will allow an approximation of any subsidy requirement for opening the market (in percentage terms).

3.1 DATA AVAILABILITY

In Nigeria, the National Bureau of Statistics is responsible for the production of national statistics on behalf of all federal, state and local government departments and agencies. This includes the convening and publishing of socio-economic statistics such as population projections, the breakdown of annual household energy expenditure and proportional use of different energy sources (LSMS-Integrated Surveys on Agriculture – General Household Survey Panel (2015/16).

The Ministry of Power, Housing and Works is responsible for data on renewable energy resources, though no systemic studies or renewable energy atlases exist. MPHW also collected geo-referenced data on population clusters and load centres with support from GIZ. This analysis indicates an estimated 8,000 potential load centres that are suitable for mini grids, and established the potential for mini-grids as a rural electrification solution. Further potential is provided by power intensive local industries such as telecom and agriculture, as well as other productive use solutions. The 8,000 potential sites can be found geo-referenced on a GIS database maintained on REA's website.

GIZ and the World Bank are additional key data sources, through their respective Energy Sector Management Assistance Program (ESMAP) and Nigerian Energy Support Programme (NESP). Nigeria is part of countries used as a case study under the Global Facility on Mini Grids of the ESMAP program, which maintains available data on mini grids, while other information may be obtained from the IEA Electricity Access Database 2016 publication (2014 data). The GIZ-led Nigerian Energy Support Programme (NESP) developed rural electrification scenarios as part of rural electrification strategies of five states (Cross River, Niger, Ogun, Plateau and Sokoto) across three potential electrification phases - http://rrep-nigeria.integration.org/.

The largest data gap is for distribution network data, being considered commercially sensitive by each of the eleven DisCos. Each DisCo submits a five-year business plan to NERC, which includes their current networks and five-year expansion plans. A project is underway which may make these networks available on a GIS portal by around 2020,

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

but until then this information is not public (except for NESP pilot states). For now there are still many regions that are sufficiently far from the grid as to be safe from electrification (at least for many decades), but if unresolved this uncertainty may limit the scaling of mini-grids.

3.2 ASSESSING MINI-GRID POTENTIAL: METHODOLOGY

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

- Grid extension areas: defined as areas within 15km of the grid
- Mini-grid areas: defined as areas further than 15km from the grid[7], with household density greater than 50 households per km^2
- Standalone system (SHS) areas: defined as areas further than 15km from the grid, with household density less than 50 households per km^2

To understand where these different areas lie, the national grid is inferred using a combination of high voltage (HV) line GIS data and satellite mapping of night-lights, buffered by 15km to produce the grid-extension area[8]. Potential off-grid populations are outside of this grid extension area, with mini-grid populations identified based on population density greater than 50 households per km^2.

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

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

1. **Existing rural household expenditure on electricity based on other literature and sources.** This may be based on international or local studies, or local stakeholder interviews (in theory, this should yield similar results to scenario (1) above, although this may not be the case in practice).
2. **Potential rural household expenditure on electricity, estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and an average allowable tariff currently used in-country.** This approach assumes that the average rural household's electricity use would be approximately 2.2 kWh/day; according to the SE4ALL Multi-Tier Framework, this represents a supply level between Tier 3 (1kWh per day) and Tier 4 (3.4kWh per day), which allows for electrical lighting, air circulation, television and phone charging (tier 2 level), plus additional appliances that can allow for productive uses.

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

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

3. **Potential rural household expenditure on electricity, estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and a flat tariff of $0.4 / kWh.** This tariff has been chosen as the minimum tariff needed for private developers to recover their costs. Such a rate is assumed to be one which in many contexts in Sub-Saharan Africa, and in other developing countries, is cost-reflective. It has been used to allow comparisons across countries in terms of market size, but also to highlight the shortfall between feasible tariffs, and often-cost-reflective tariffs.

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

3.3 ASSESSING MINI-GRID POTENTIAL: RESULTS

Transmission grid coverage in Nigeria is reasonable across most states, comprising mainly of 330kV and 132kV lines. Analysis has been conducted using both the current power network and planned power network up to 2025. The planned network extensions were sourced from the West African Power Pool GIS database. TCN operates a network of 5,524 km of 330 kV and 6,801 km of 132kV of transmission lines, as of 2016 (Figure 5)[9]. It is responsible for nearly all of the current population's electricity access, which stands at 40% access nationally (65% urban, 28% rural)[9]. The night lights analysis conducted as part of this analysis is broadly consistent with this figure, showing a national average of 45.6% electricity access. The lowest electrification rates are found in the North West states, with 12% Taraba and Jigawa and 13% in Kebbi, Sokoto and Zamfara. The highest electrification rate is in Lagos state with 96%, followed by the southern Anambra and Oyo states (78%).

Based on current grid coverage, our analysis estimates that 13.6 million people (13% of the non-electrified population) will be best served by mini-grid solutions in Nigeria. A further 6.2 million people (6% of the non-electrified population) will be best served by solar home systems (SHS) and 86.2 million people (81% of the non-electrified population) will be best served by grid extension, based on proximity to the existing grid. The north-eastern Borno state and north-western Zamfara state have the highest potential for mini-grid solutions, with 2.1 million people (39.6%) and 1.1 million people (29.7%) most economically served by mini-grids respectively. The majority of northern states have over half a million people best served by mini-grids, with an electrification ratio above 20% in only four out of thirteen states. Lowest mini-grid potential is found in Abia, Bayelsa, Imo and Rivers states, where 100% of the total population live within 15km of the grid. A further nineteen of thirty-seven states in Nigeria have over 95% of the total population within 15km of the grid.

Note: These estimates of mini-grid potential are based on the current grid coverage only[9]; they are also likely to be conservative, as the 15km buffer zone applied (for consistency across all produced country reports) does not reflect the low likelihood of DisCo grid expansion in Nigeria.

Based on intended grid expansion to 2025, our analysis estimates that 12.2 million people (12% of the non-electrified population) would be best served by mini-grid solutions in Nigeria. This 10% reduction against present day mini-grid market size reflects a number of planned extensions as provided by the Western Power Pool (WEPP), which takes the total non-electrified population within 15km of the grid to 87.5 million people (83% of the non-electrified population). Borno remains the highest potential state for off-grid solutions, with 39% of the total population best served by mini-grids. Results from this analysis are shown graphically in Figure 8, including existing and planned renewable energy sites.

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

Figure 5: Existing electricity grid with planned network up to 2025 in Nigeria (dotted lines) (Western Power Pool)

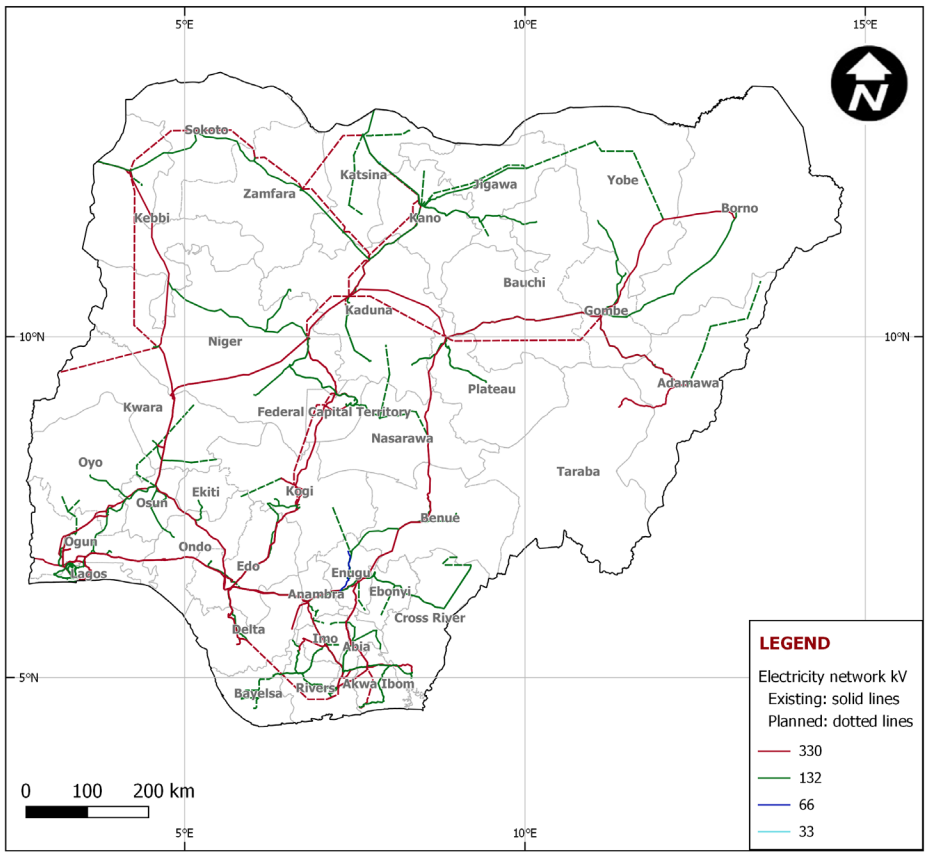


Figure 6: Population density in Nigeria

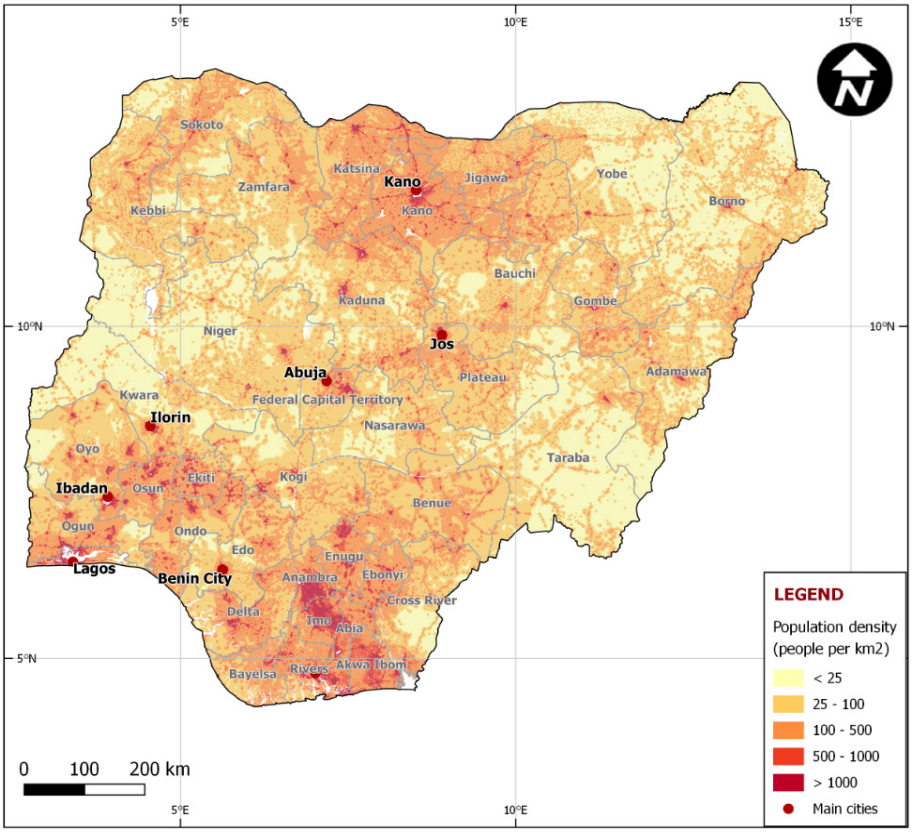


Figure 7: Regions best served by grid extension, mini-grid and standalone systems, shown with major and minor population centres (dotted lines are planned grid extensions up to 2025) (Carbon Trust analysis)

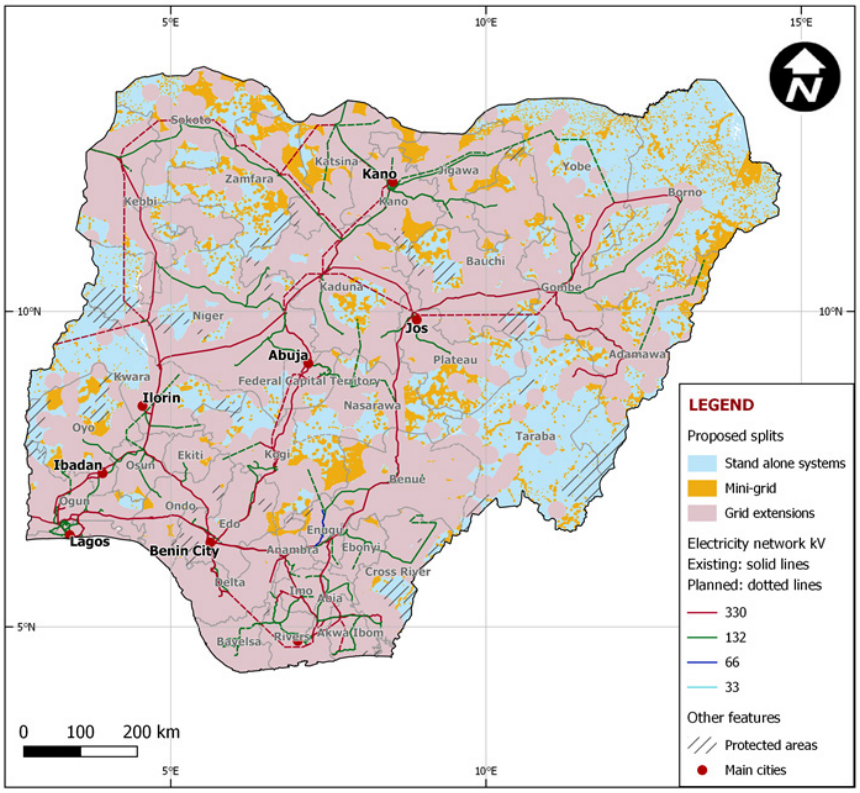
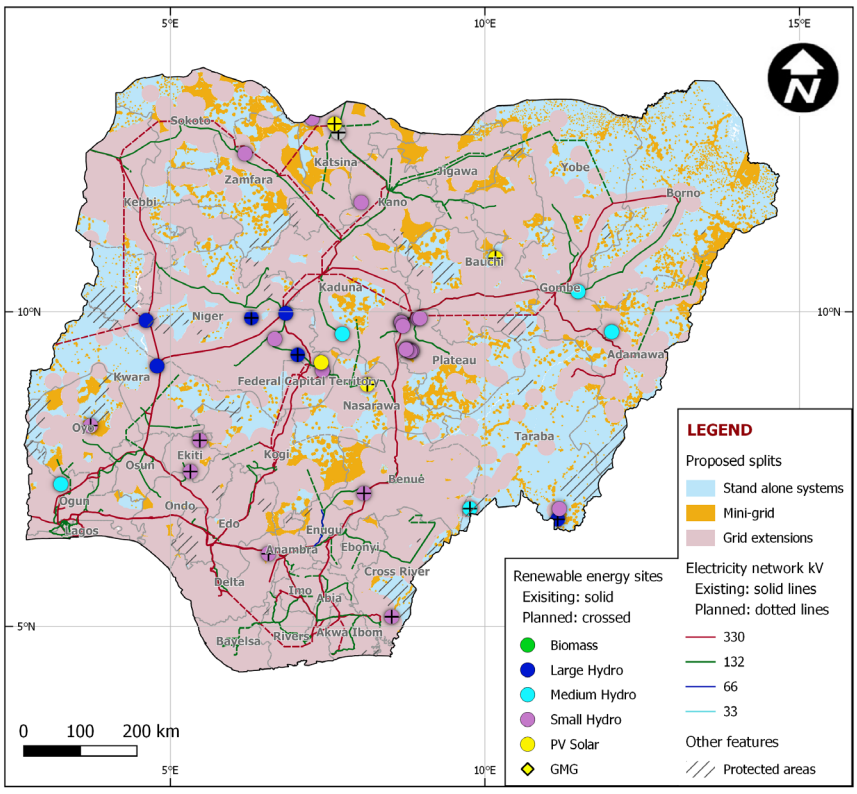


Figure 8: Regions best served by grid extension, mini-grid and standalone systems, shown with existing and planned renewable energy sites (dotted lines are planned grid extensions up to 2025) (ECOWREX data portal, Carbon Trust analysis)



In terms of potential revenue, the size of the market based on 13.6 million potential customers varies according to the four electricity expenditure scenarios described in section 3.2:

1. **Existing rural household expenditure on electricity from the World Bank Global Consumption Database:** according to this database, average rural household spend on energy consumption in Nigeria is $281 annually. To convert this to expenditure on electricity, we use two assumptions: (1) that around 60% of household energy spend is on electricity, and (2) that household spending comprises 60% of the total revenue of a mini-grid (when including revenue from businesses and community buildings). Given that the average number of persons per household in Nigeria is 5.5 (United Nations, 2017), this translates to per capita electricity expenditure of approximately $30.60 annually, or an overall market size of $417m annually (assuming 13.6 million customers). Based on grid expansion projections to 2025, this market size will drop to $374m (assuming 12.2 million customers) (World Bank, 2019).
2. **Existing rural household expenditure on electricity based on other reports / literature:** based on a separate World Bank report, average mini-grid demand in Nigeria is given as 25 kWh per month per household, with residential tariffs of $0.75/kWh. This translates to per capita electricity expenditure of $40.91 annually or an overall market size of $557m annually (assuming 13.6 million customers). Based on grid expansion projections to 2025, this market size will drop to $500m (assuming 12.2 million customers) (World Bank, 2018).
3. **Potential rural household expenditure on electricity,** estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and an average allowable tariff currently used in-country: annual cost of electricity from a mini-grid was estimated based on forward-looking household electricity consumption of 2.2 kWh per day, represents annual per capita electricity demand of 146 kWh (5.5 persons per household). The average off-grid tariff (<50MW) in Nigeria is assumed to be around $0.5 / kWh (based on stakeholder interviews), giving an average annual electricity expenditure of USD $73 per person and an overall annual mini-grid market size of $994m (assuming 13.2 million customers). Based on grid expansion projections to 2025, this market size will drop to $893m (assuming 12.2 million customers).
4. **Potential rural household expenditure on electricity,** estimated based on a bottom-up calculation of what would be required to deliver SE4ALL Tier 2/3 energy access nationwide, and a flat tariff of $0.4 / kWh: this tariff is assumed to be cost reflective.

Based on annual electricity demand of 146kWh per capita, a tariff of $0.4 / kWh gives an average annual electricity expenditure of USD $58.40 per capita: an overall annual mini-grid market size of $795m given a mini-grid population of 13.2 million. Based on grid expansion projections to 2025, this market size will drop to $714m (assuming 12.2 million customers)

A summary of these four market size estimates is shown in table 3.

Table 3: Market Size Estimates for the Four Scenarios

Scenario	Estimated per capita annual costs for GMG ($)	Market Size given current GMG population ($m)	Market Size of GMG population (given planned grid extension)
1 World Bank Database	$30.60	$417m	$374m
2 Other Donor Reports	$40.91	$557m	$500m
3 'Bottom-up' + existing tariff	$73.00	$994m	$893m
4 'Bottom-up' + theoretical tariff	$58.40	$795m	$714m

Scenarios (1) and (2) reveal electricity demand which is significantly below that needed to deliver Tier 2/3 energy access in Nigeria. For this reason, scenario (3) is chosen as the most realistic estimate of the size of the market required to drive productive use of electricity in Nigeria.

In summary, this report estimates an annual mini-grid market size of USD $994 million in Nigeria based on an average mini-grid tariff of USD $0.5/kWh, and average household demand per day of 2.2kWh. This implies per capita annual electricity expenditure of $73.00 within the population best served by mini-grids. Based on an estimated cost-reflective tariff of $0.4/kWh across SSA, it is therefore estimated that project costs would not require any subsidy contribution to open up the mini-grid market to developers (lifetime project costs – with subsidy covering both CAPEX and OPEX).

The actual market size may be greater than the estimates given here considering decentralized solutions could also be feasible in areas in grid proximity. As already highlighted, local distribution companies maintain their licence when they are connected to the grid. Thus, the connection to the grid, rather than reducing the market, may actually increase it, creating the potential to sell excess power to DisCos or NBET.

Table 4: Estimated household market size for off-grid solutions (analysis using the existing and planned network up to 2025)

State	Current grid network					Planned grid network to 2025			
	Electrification rate	Non-electrified population ('000s)			Mini-Grid Market ($m)	Non-electrified population ('000s)			Mini-Grid Market ($m)
		< 15km of grid	Mini-Grid	SHS		< 15km of grid	Mini-Grid	SHS	
NORTH WEST		**30,254**	**4,668**	**1,121**	**340.8**	**30,935**	**3,922**	**997**	**286.3**
JIGAWA	12%	4,076	721	22	52.6	4,116	679	18	49.6
KADUNA	43%	4,146	471	170	34.4	4,252	341	114	24.9
KANO	32%	7,969	502	16	36.6	7,972	497	16	36.3
KATSINA	14%	5,567	787	40	57.5	5,772	566	21	41.3
KEBBI	13%	3,214	213	170	15.5	3,247	182	156	13.3
SOKOTO	13%	3,069	830	315	60.6	3,133	763	297	55.7
ZAMFARA	13%	2,213	1,145	389	83.6	2,443	895	375	65.3
NORTH EAST		**12,245**	**5,085**	**3,112**	**371.2**	**12,661**	**4,622**	**2,993**	**337.4**
ADAMAWA	35%	1,812	920	323	67.2	2,021	619	301	45.2
BAUCHI	17%	4,093	651	256	47.5	4,145	614	230	44.8
BORNO	34%	1,330	2,105	1,180	153.7	1,346	2,081	1,178	151.9
GOMBE	17%	2,416	88	37	6.4	2,428	79	31	5.8
TARABA	12%	1,183	645	820	47.1	1,183	645	820	47.1
YOBE	19%	1,411	677	496	49.4	1,538	583	433	42.6
NORTH CENTRAL		**13,104**	**2,725**	**1,555**	**198.9**	**13,226**	**2,623**	**1,407**	**191.5**
BENUE	17%	4,191	367	58	26.8	4,191	367	58	26.8
FCT ABUJA	71%	520	35	34	2.6	523	35	25	2.6
KOGI	50%	1,579	802	237	58.5	1,586	798	226	58.3
KWARA	68%	839	214	317	15.6	864	178	274	13.0
NASARAWA	31%	1,133	412	305	30.1	1,146	404	294	29.5
NIGER	42%	2,554	284	397	20.7	2,627	230	324	16.8
PLATEAU	31%	2,288	611	207	44.6	2,289	610	207	44.5
SOUTH WEST		**6,873**	**784**	**306**	**57.2**	**6,887**	**710**	**299**	**51.8**
EKITI	72%	836	72	0	5.3	836	72	0	5.3
LAGOS	96%	584	0	0	-	583	0	0	-
OGUN	72%	1,381	34	39	2.5	1,378	34	39	2.5
ONDO	72%	1,229	105	9	7.7	1,229	105	9	7.7
OSUN	71%	1,303	36	14	2.6	1,303	36	14	2.6
OYO	78%	1,540	536	244	39.1	1,558	462	237	33.7
SOUTH EAST		**10,181**	**191**	**1**	**13.9**	**10,181**	**191**	**1**	**13.9**

ABIA	52%	1,830	-	-	-	1,830	-	-	-
ANAMBRA	78%	1,208	94	-	6.9	1,208	94	-	6.9
EBONYI	25%	2,052	35	-	2.6	2,052	35	-	2.6
ENUGU	25%	3,144	62	1	4.5	3,144	62	1	4.5
IMO	61%	1,947	-	-	-	1,947	-	-	-
SOUTH SOUTH		**13,558**	**166**	**84**	**12.1**	**13,559**	**163**	**84**	**11.9**
AKWA IBOM	36%	3,188	3	-	0.2	3,190	-	-	-
BAYELSA	52%	1,035	-	-	-	1,035	-	-	-
CROSS									
RIVER	29%	2,494	97	80	7.1	2,493	97	80	7.1
DELTA	62%	2,006	12	0	0.9	2,006	12	0	0.9
EDO	63%	1,613	54	4	3.9	1,613	54	4	3.9
RIVERS	52%	3,222	-	-	-	3,222	-	-	-
	Total	**86,215**	**13,619**	**6,178**	**994.2**	**87,449**	**12,231**	**5,780**	**892.9**

3.4 RENEWABLE ENERGY POTENTIAL FOR MINI-GRIDS

3.3.1 HYDRO

Hydropower has been a cornerstone of grid-powered generation in Nigeria for decades, constituting 15% of current power generation in the country. There is currently 1,900 MW hydropower installed in 3 large power plants located at large dams at the following locations: Kainji (760M); Jebba (570MW); and Shiroro: (600MW), although only half of it is operational (GIZ, 2015). A multitude of river systems, providing a total of 70 micro dams, 126 mini dam and 86 small sites, supply a technically exploitable large hydropower potential, estimated to be about 11,250 MW. Under recent circumstances, only 17% is being tapped (RECP Nigeria, 2018). By 2020, the Nigerian government aims to have increased the hydroelectricity generation capacity to 5,690 MW. This projection shall be met through an upgrade of old hydroelectricity plants and the installation of new hydro power plants (Table 5). Potential large investments in some significant hydropower sources, such as the dam for the Mambilla plateau in eastern Nigeria, have been struggling due to large investment costs and lead times needed (GIZ, 2015).

Nigeria holds potential for hydro-powered mini-grids due to a landscape with numerous river systems and dams; however, seasonal flow patterns may affect economic viability. In all parts of Nigeria, potential sites for unexploited small hydropower plants exist, as the country is reasonably endowed with large rivers and natural falls. The total capacity for small hydropower is estimated at 3,500 MW, of which about 64.2 MW of this is being exploited. The potential for small hydro-powered plants lie mostly in the southern and central parts of the country (Figure 8). Large seasonal variation in flow patterns between the wet and dry season may limit the economic potential of hydropower, especially for small and mini hydro plants (GIZ, 2015). NESP attempted to find micro-hydro mini-grid opportunities across its five target states in phase 1, but chose solar-battery hybrid solutions in all states due to this seasonality.

Table 5: Hydropower plants under development

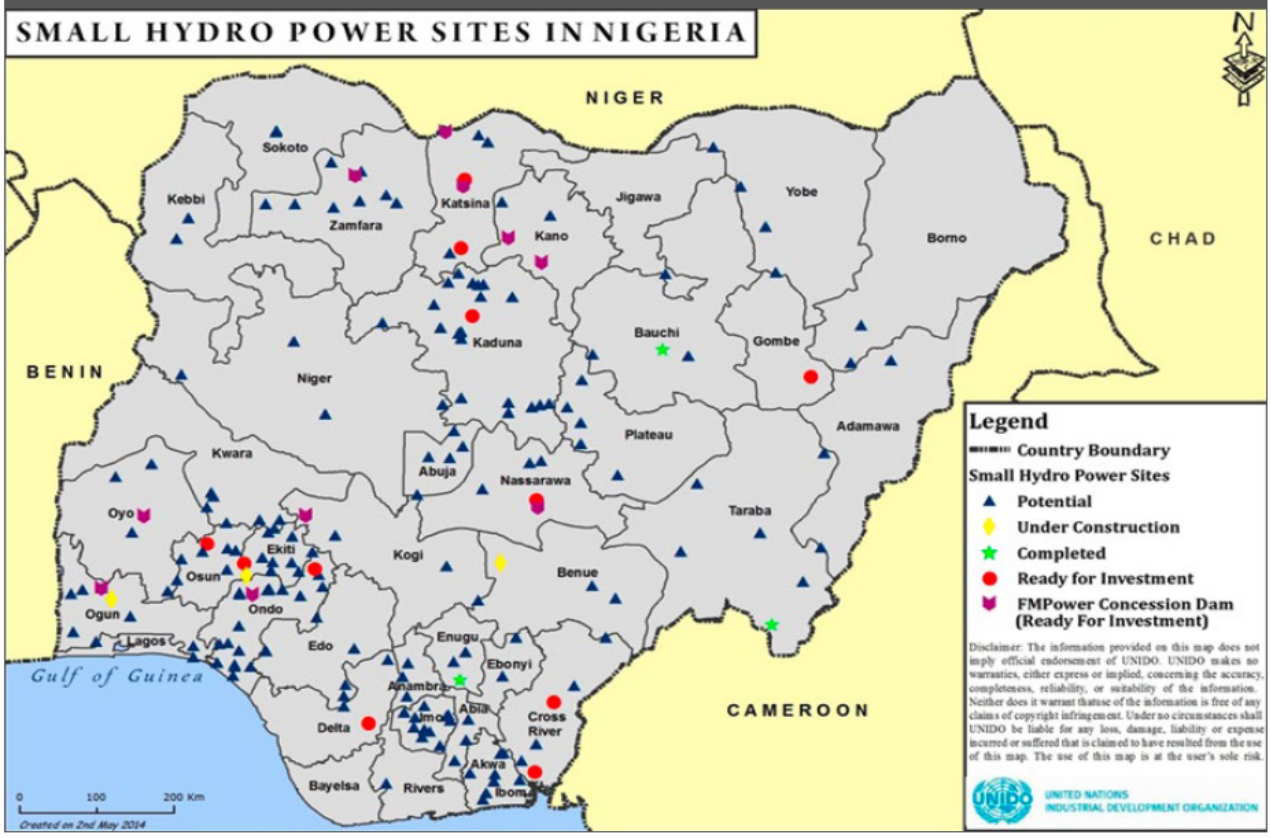
Power Station	Capacity (MW)	State	Geographical location
Zungeru project*	700	Niger	North Central
Mambilla Project	3,050	Taraba	North East
Gurara II Project	360	Niger	North Central
Gurara I Project	30	Niger	North Central
Itisi Project	40	Kaduna	North West
Kashimbilla Project	40	Taraba	North East

*Financing secured

Source: *Federal Ministry of Power, 2014*

Figure 8: Small Hydro power sites in Nigeria

FIGURE 8 – 1:
SMALL HYDRO POWER SITES IN NIGERIA



Source: *Nna, C.D & Gbadegesin, A.O. & Lawal, Kamilu. (2016). A decentralized, renewable-energy-powered business hub for rural areas: A case study of Ilakan community, Nigeria. 1-7. 10.*

3.3.2 BIOMASS

Nigeria has significant biomass potential and a range of various biomass feedstock sources. Biomass is widely spread across the central to southern region of the country (Figure 9). Nigeria has various potential biomass resources which includes agricultural crops and residues, forestry resources and animal and municipal solid waste. Crops such as cassava, sugar cane, rice and maize are the most promising feedstock for biofuel production (GIZ, 2015). Nigeria is the world's largest producer of cassava and is the largest producer and consumer of rice in Africa, which translates into large quantities of available biomass feedstock. The potential of residues from these agricultural crops has been summarised in Table 6. Nigeria has significant amounts of animal and municipal wastes. According to estimates, the daily production of animal waste in Nigeria is about 227,500 tons, which could lead to about 6.8 million m^3 of biogas (RECP, 2018). Bioenergy programmes that are under development under the Renewable Energy Programme include: the development of a biofuel production complex in the northern part of Ekiti State by Global Biofuels Ltd.; the development of sugarcane based biofuel plants in Girei and Demsa Local Government Areas of Adamawa State; the development of an integrated Rice Processing and Power Generating facilitator by Carbon Quest and Adamawa State.

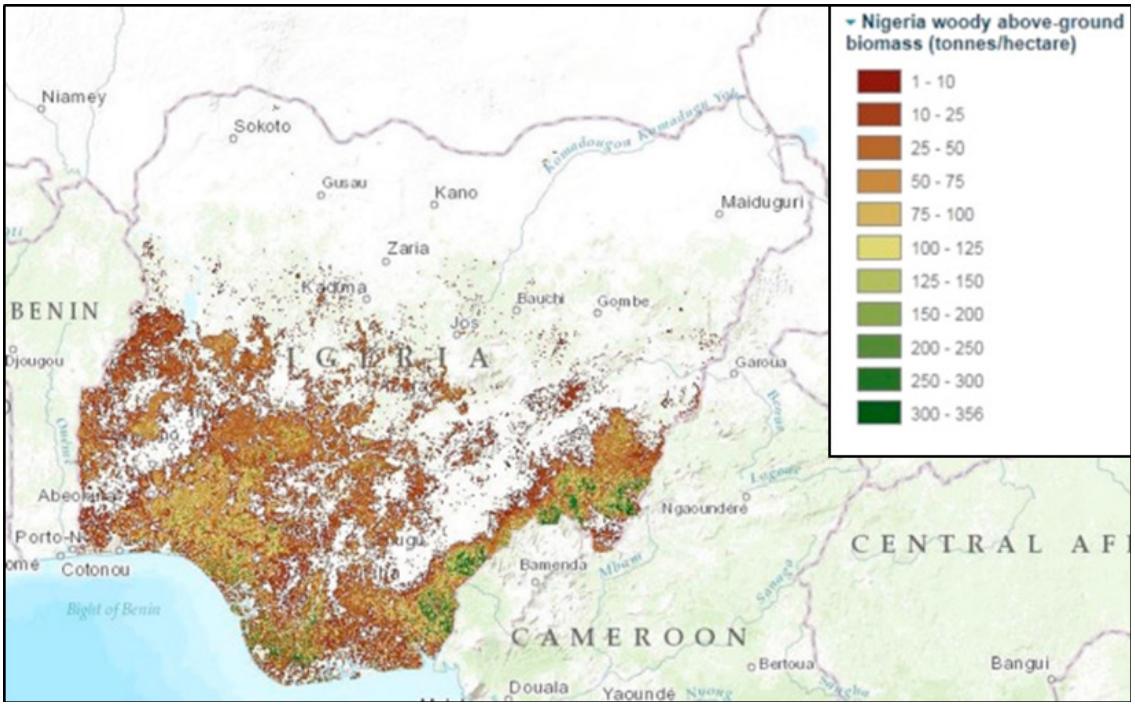
Table 6: Residues estimate from agricultural crops, 2010

Crop	Production ('000 t)	Component	Weight available in million tons	Total energy available (PJ)
Rice	3,368	Straw	7.9	126.0
		Husk	1.2	23.0
Maize	7,677	Stalk	10.8	211.4
		Cob	2.1	34.2
		Husk	0.9	14.3
Cassava	42,533	Stalks	17.0	297.7
		Peelings	76.6	812.3

Sugar Cane	481	Bagasse	0.1	2.0
		Tops/Leaves	0.1	2.2

Source: *Simonyan, K.J. & Fasina, O.; The Challenge of Food Security in Nigeria, 2013*

Figure 9: Above ground woody biomass



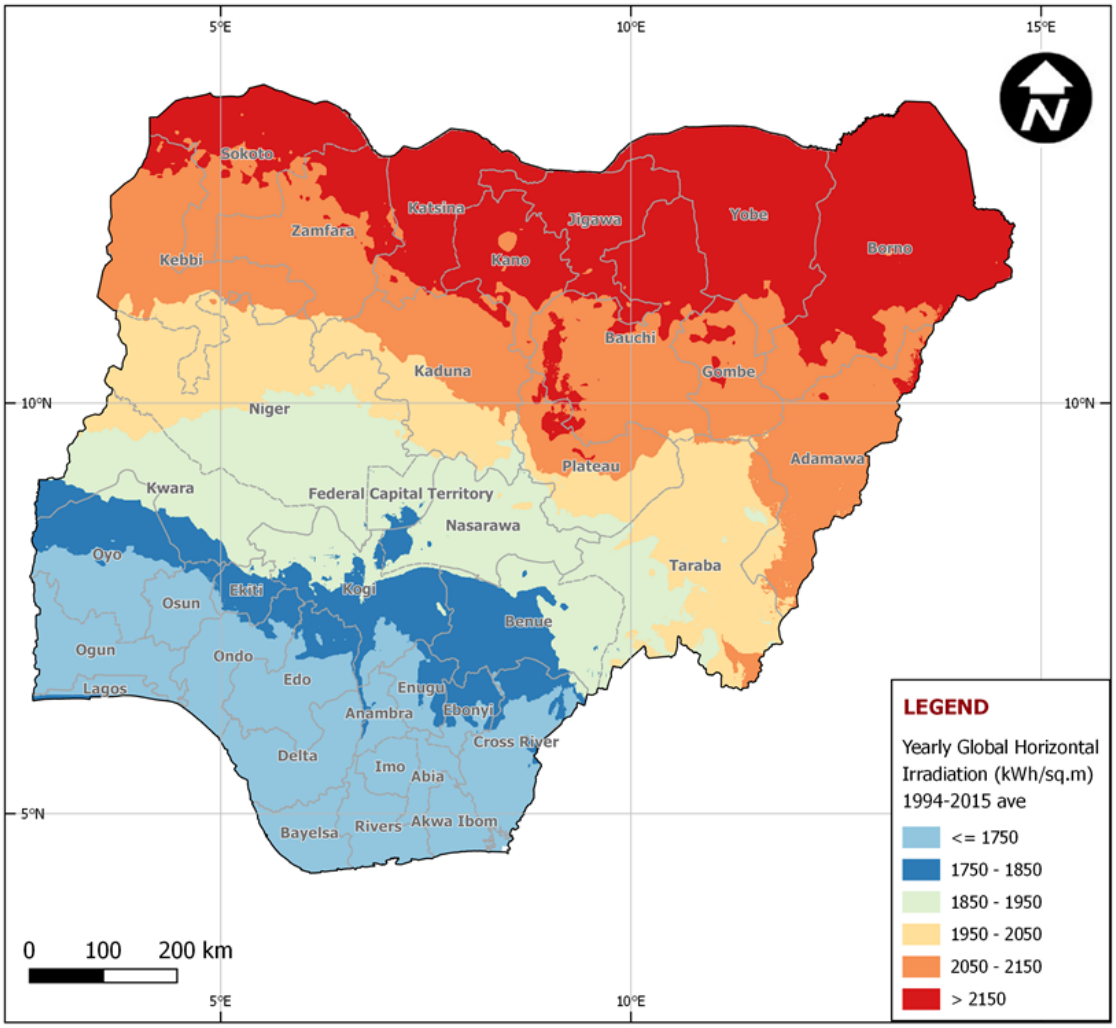
Source: *Longhurst, Philip & Iwo, Juliet & Manovic, Vasilije. (2016). Biomass resources and biofuels potential for the production of transportation fuels in Nigeria. Renewable and Sustainable Energy Reviews. 2016. 172-179. 10.*

3.3.4 Solar

High radiation indexes coupled with competitive economic viability provides great potential for solar powered mini-grids. Nigeria has significant solar energy potential, with distributed solar radiation averaging 19.8 MJm^2/day and average sunshine hours of 6h/day (RECP Nigeria, 2018). The total assumed potential for concentrated solar power and photovoltaic generation is around 427,000 MW. The best potential for solar power lies in the northern region of the country, where the average GHI values in these areas range between 2,000 and 2,200 kWh/m^2 (Figure 10). This is comparable to other high-yielding sites around the world such as Southern Spain and Australia (GIZ, 2015). Solar PV plants in Nigeria produce power at a comparable levelised cost of energy when compared to petrol and diesel generators. Petrol and diesel generators produced power at a levelised cost of energy (LCOE) between US$0.23 and US$0.42 per kWh as of June 2015. The cost of electricity from PV was around US$0.30 per kWh during the same period[5]. The cost of petrol and diesel has increased by 75% and 36% since 2015, respectively, whereas the cost of Solar PV technologies generally decreases with time. In July 2016, 14 Greenfield Independent photovoltaic (PV) power projects with a capacity of 1,125MW had their PPAs signed by the Federal Government, owned by the Nigerian Bulk Electricity Trading Plc (NBET) (RECP, 2018). The government is planning on increasing mini-grid capacity from approximately 50 MWh in 2016 to 5,314 MWh in 2030 as

part of the Electricity Vision 30:30:30. It is expected that this will mostly be comprised of solar energy. The government is aiming to achieve a 20% contribution of solar energy (PV and Solar thermal) to the national electricity generation mix by 2030 (Government of Nigeria, 2016).

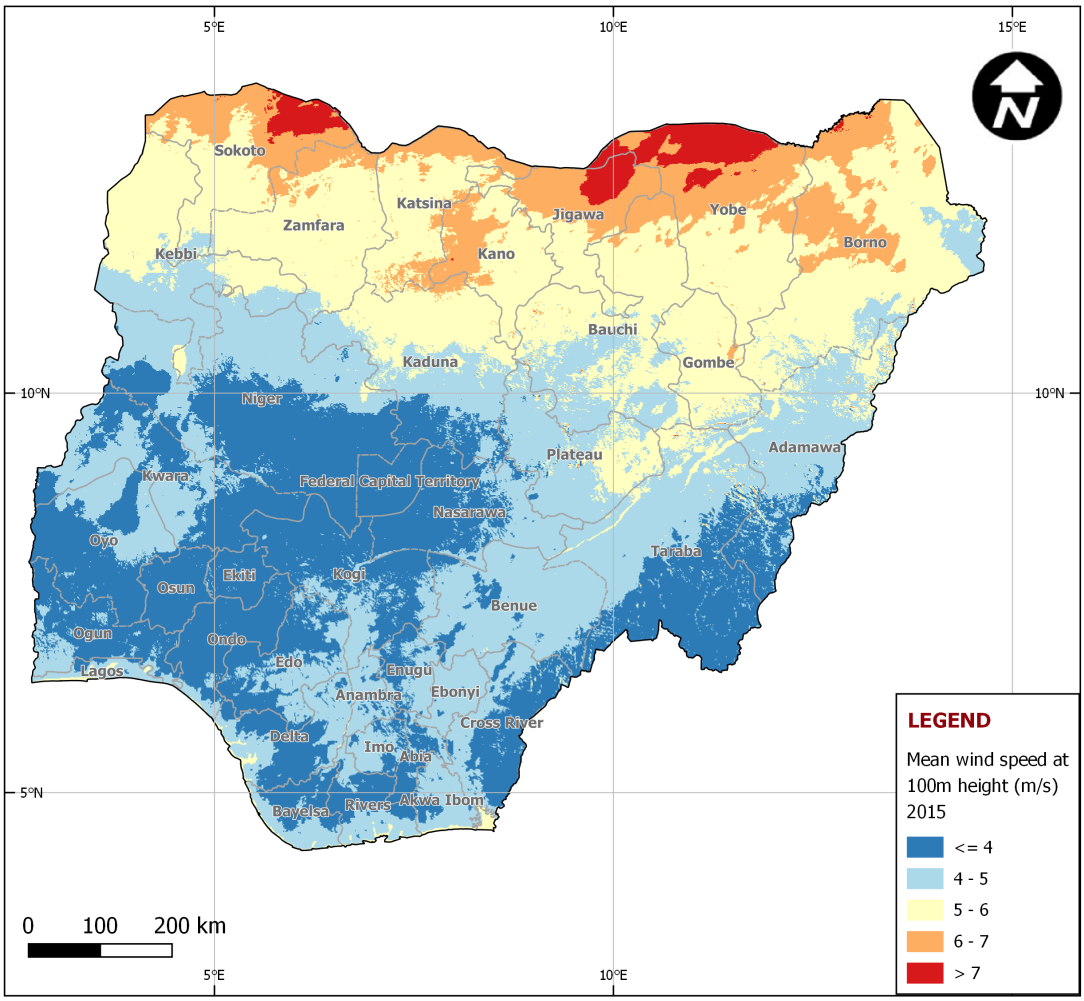
Figure 10: Yearly Global Horizontal Irradiation (kWh/sq.m). 1994-2015 ave.



3.3.5 WIND

Nigeria has a low to moderate potential for wind power with only a few selected areas reaching speeds sufficient for electricity generation. Based on the wind energy resource mapping carried out by the Ministry of Science and Technology (MST), majority of the country has annual average wind speeds of between 2.0 m/s - 4.0 m/s at 80m above the ground. These speeds are best suited for water pumping rather than electricity generation. In the most suitable locations, wind speeds of up to 5m/s were recorded, which may have electricity generating potential. Only in the northmost of the country do speeds exceed 7m/s, in the Sokoto region, the Jos Plateau, Gembu and Kano/Funtua (Figure 11). The MST study also indicated fair wind speeds, sufficient for energy generation by wind farms, in Maiduguri, Lagos, Enugu, the western shoreline and the Mambila Plateau (RECP, 2018). A 10MW wind farm located in the north of Nigeria in Katsina, is expected to be completed in 2018. It will be the first wind farm in Nigeria (ECREEE, 2018). A 100MW wind farm in the Plateau State, developed by JBS Wind Power Limited, is in the process of obtaining environmental authorisation and has received a provisional Independent Power Producer license from NERC. The completion date for this wind farm is not yet known at the time of writing this report (JBS Windpower, 2018). Government aims to achieve and maintain a 2% wind energy contribution to the national electricity generation mix by 2020 until 2030 (Government of Nigeria, 2016).

Figure 11: Mean wind speed at 100m height (m/s), 2015



4. DIRECTORY

4.1 ENERGY SECTOR POLICIES AND REGULATORY FRAMEWORKS DIRECTORY

Regulation for Mini Grids (no. NER/-R-110/17), 2016
http://nercng.org/index.php/library/documents/Regulations/NERC-Mini-Grid-Regulation/

This regulation shall apply to all Mini-Grids with Generation Capacity of up to 1MW, the owners, operators and users of the Mini-Grids as well as all other private or public stakeholders such as the Distribution Licensees or any federal or state institution or agency as the case may be interacting with Mini-Grid owners, operators and users in Nigeria. This regulation is detailed extensively in section 1.4.

Sustainable Energy for All Action Agenda (SE4ALL-AA), 2016
http://power.gov.ng/Press%20Release/SUSTAINABLE%20ENERGY%20FOR%20ALL%20ACTION%20AGENDA%20(SEE4ALL-AA).pdf

Building upon the NREAP (below), this document updates the government's renewable energy, energy efficiency and energy access targets in line the broader SE4ALL targets for 2020 and 2030. Named as Nigeria's Electricity Vision 30:30:30, the primary renewable target is for 30GW of new generating capacity by 2030 with 30% of this being renewable. The main energy access target is for 90% electrification by 2030, reaching 75% (60% rural) by 2020.

Rural Electrification Strategy and Implementation Plan (RESIP), 2016
http://rea.gov.ng/inc/uploads/2017/09/RESIP.pdf

Prepared by the Ministry of Power, Works and Housing for implementation by REA, this document complements the Nigerian Rural Electrification Policy in setting out the planned approach for implementing rural electrification through both on-grid and off-grid initiatives. This includes primarily the establishing of the REA and its Rural Electrification Fund (REF).

National Renewable Energy Action Plan (NREAP, 2015 -2030), 2016
http://www.power.gov.ng/Press%20Release/NATIONAL%20RENEWABLE%20ENERGY%20ACTION%20PLANS%20(NREAP).pdf

The National RE Action Plan was released in 2016 by Inter-Ministerial Committee on Renewable Energy and Energy Efficiency (ICREEE). It details the anticipated development of renewable energy in Nigeria between 2015 and 2030, including aligning the Nigerian renewable energy and energy efficiency policies with the ECOWAS Renewable Energy Policy (EREP) and Energy Efficiency Policy (EEEP). This document is a foundation for the subsequent Sustainable Energy for All Action Agenda (SE4ALL-AA), also released by ICREEE in 2016, which contains updated renewable energy targets for 2020 and 2030.

National Renewable Energy and Energy Efficiency Policy (NREEEP), 2015
http://www.pwh.gov.ng/download/NREEEPOLICY2015-FECAPPROVEDCOPY.pdf

National Renewable Energy and Energy Efficiency Policy (NREEEP). One key output of this report is predicted population of 267m by 2030, with an associated latent demand of 116GW, based on current population and economic growth rates of 2% and 7% respectively.

Nigeria Intended Nationally Determined Contributions (INDCs), 2015.
http://www4.unfccc.int/submissions/INDC/Published%20Documents/Nigeria/1/Approved%20Nigeria%27s%20INDC_271115.pdf

This document outlines Nigeria's Intended Nationally Determined Contributions (INDCs), which aim to sustain per capita emissions at approximately 2 tonnes CO2e by 2030, compared to a business as usual trajectory reaching 3.4 tonnes CO2e.

Regulations for Independent Electricity Distribution Network (IEDN), 2012
http://www.nercng.org/nercdocs/NERC-Regulation-for-IEDN-2012.pdf

The Regulations for Independent Electricity Distribution Network (IEDN) outlines the regulations for IEDNs, which includes mini-grids systems above 1MW whether they are isolated or interconnected. This includes conditions for the granting and maintaining of licenses, operating the distribution network, commercial arrangements and other arrangements such as dispute resolution. It also prohibits an operator from generating and distributing in the same system.

Electric Power Sector Reform Act (EPSR), 2005
http://nercng.org/index.php/library/documents/Regulations/Electric-Power-Sector-Reform-Act-(EPSR)-2005/

The Electric Power Sector Reform Act liberalises the power sector of Nigeria, unbundling the previous monopoly of the national utility National Electricity Power Authority (NEPA). This Act established 6 generation companies (GenCos), which operate different generation assets, as well as eleven distribution companies (DisCos) that operate in, and are responsible for, the national distribution networks for different states. Also established was the Transmission Company of Nigeria (TCN), responsible for maintaining and developing Nigeria's transmission assets, and the Nigerian Electricity Regulatory Commission (NERC). Nigerian Bulk Electricity Trading (NBET) was established as a guarantee mechanism as part of the transition initiated by the Act, guaranteeing payment for the GenCos until the DisCos become suitably reliable off-takers.

National Grid and Distribution Codes, 2005
http://nerc.gov.ng/index.php/library/documents/Codes-Standards-and-Manuals/

The National Grid and Distribution Codes, published by the regulator NERC, detail the technical specifications for electricity systems operating in Nigeria. There are a number of relevant codes such as the Metering Code and Health and Safety Code. A full repository of regulations and other energy sector documents can be found on the NERC website.

4.2 INVESTMENT INCENTIVES DIRECTORY

Compendium of Investment Incentives in Nigeria, 2017
https://www.invest-nigeria.com/?mdocs-file=12302

The Compendium is a highly useful streamlined compilation of all legally supported fiscal incentives in Nigerian tax laws and sector-wide fiscal concessions, developed by the NIPC and the Federal Inland Revenue Service. The full documentation for each incentive listed in the compendium can be found on the website of the relevant administering agency. This compendium is part of a concerted effort to reduce investment barriers in Nigeria, and will be updated in 2108 to reflect Nigeria's fiscal policy in line with the release of the 2018 national budget.

The Nigerian Power Sector Investment Opportunities and Guidelines, 2016
http://www.pwh.gov.ng/download/NIGERIANPOWERSECTORINVESTMENTOPPORTUNITIESANDGUIDELINES.pdf
This draft document by the Ministry of Power, Works and Housing aims to close the information gap to investment in the power sector. This includes a summary of the power sector and Nigeria in general, a more detailed breakdown of the power sector and potential investment opportunities, as well as a stakeholder directory.

Nigerian Investment Promotion Commission Act (Chapter N117, Decree No 16), 1995
http://www.nipc.gov.ng/NIPCACT.pdf?lbisphpreq=1

This Act sets out the establishment of the NIPC, its functions and powers, governance structure and staffing, financial provisions and provisions for investment.

4.3 DATA SOURCES DIRECTORY

This methodology was developed during the first phase of this project, the Green Mini-Grids Market Development Program - Market Intelligence business line, which is also available via the African Development Bank. The two methodology papers are published on the AfDB's Green Mini-Grid Help Desk.

This analysis, the results of which are provided in Section 3, considers the potential for mini-grids by segmenting the countries into two areas: grid and off-grid areas. This split is based on the distance of 15km from the power network. We have used the planned power network for up to 2025. The GIS sources used in this analysis are detailed below.

Existing Power Network and Planned Extensions up to 2025
Source: Western African Power Pool (WAPP) GIS database, distributed by ECREEE.
Link: https://energydata.info/dataset/transmission-grid-ecowas-region

Population Density
Source: World Pop data portal
Link: http://www.worldpop.org.uk/data/data_sources/

Renewable Energy Power Plants
Source: ECOWAS observatory for Renewable Energy and Energy Efficiency (ECOWREX) database
Link: http://ecowrex.org:8080/geonetwork/srv/eng/catalog.search#/metadata/57db0a4b-e225-42d9-a493-3932824d69f8

Operational Clean Energy Mini-Grids
Source: ECOWAS observatory for Renewable Energy and Energy Efficiency (ECOWREX) database
Link: http://www.ecowrex.org:8080/geonetwork/srv/eng/catalog.search#/metadata/46e36312-5ee9-4363-8fbc-e93acb50e43a

Nightlights
Source: Earth Observations Group at NOAA
Link: https://datacatalog.worldbank.org/dataset/world-night-light-annual-composite-2015

Administrative Boundaries
Source: ECOWAS observatory for Renewable Energy and Energy Efficiency (ECOWREX) database
Link: https://energydata.info/dataset/nigeria-administrative-boundaries-2017

Wind: Mean Wind Speed at 100m Height
Source: DTU, IRENA
Link: https://irena.masdar.ac.ae/gallery/#gallery

Solar: Annual Total Global Horizontal Irradiation (GHI)
Source: DTU, IRENA
Link: http://globalsolaratlas.info/downloads/nigeria

4.4 STAKEHOLDER DIRECTORY

4.4.1 GOVERNMENT AND AGENCIES

Federal Ministry of Power Works and Housing (MPWH)

Contact: Engr. Faruk Yusuf (Director of Renewable Energy)
Link: http://www.pwh.gov.ng/index.php

Brief description: To generate, distribute and transmit electricity nationwide, facilitate the provision of adequate and affordable housing for all Nigerian in both urban and rural area in secure, healthy and decent environment through access to a functional Nigerian road all the time.

Rural Electrification Agency (REA)

Contact: Damilola Ogunbiyi (Managing Director and CEO)
Link: http://rea.gov.ng/

Brief description: Established under the EPSR Act in 2006 (Section 88) under the Ministry of Power, Works and Housing, the agency was not fully operationalised until 2016. REA's mandate includes;

- Promoting Rural Electrification in the Country,
- Co-ordinating the Rural Electrification Programmes in the country, and
- Administering the Rural Electrification Fund (REF) to promote, support and provide rural electrification through Public and Private Sector Participation.

Originally extending rural access only through on-grid solutions, and still tasked with supporting DisCos to meet their grid extension obligations, the new government has provided REA with strong backing to drive implementation of off-grid solutions. REA is also tasked with encouraging the participation of the private sector in the electricity market, ensuring that regulations which encourage profitable pricing and effective competition among market players are developed and implemented; ensuring that appropriate codes of conduct and rules of engagement are also enforced to ensure an efficient and investor friendly market; and monitors industry operators and prevent abuse of the market.

Nigeria Bulk Electricity Trading Company (NBET)

Contact: Dr Merilyn Amobi (Managing Director Chief Executive)
Link: http://nbet.com.ng/

Brief description: Nigeria Bulk Electricity Trading Plc is a wholly Federal Government of Nigeria owned company incorporated on July 29 2010 as part of the roadmap for power sector reform towards the full implementation of the Electric Power Sector Reform (EPSR) Act.

Federal Ministry of Environment

Contact: Dr. Shehu Mahmud Usman (Permanent Secretary)
Link: http://environment.gov.ng/

Brief description: The Federal Ministry of Environment is responsible for environmental policy awareness, enforcement and intervention in the areas of Desertification and Deforestation; Pollution and Waste Management; Climate Change and Clean Energy; Flood, Erosion and Coastal Management; and Environmental Standards & Regulations. This includes ensuring environmental compliance of energy projects including Environmental Impact Assessment (EIA) studies.

Nigeria Electricity Regulation Commission (NERC)

Contact: Abdussalam Yusuf
Link: http://www.nercng.org/

Brief description: The Nigerian Electricity Regulatory Commission (NERC) is an independent regulatory agency which was inaugurated on 31st October 2005 as provided in the Electric Power Sector Reform Act 2005. The Commission is mandated to carry out:

- The monitoring and regulation of the electricity industry

- Issuance of licences to market participants, and
- Ensure compliance with market rules and operating guidelines.

Energy Commission of Nigeria (ECN)

Contact: Prof. Eli Jidere Bala (Director General)
Link: http://energy.gov.ng/

Brief description: The Energy Commission of Nigeria is charged with the responsibility for the strategic planning and coordination of national policies in the field of energy in all its ramifications.

Federal Ministry of Science and Technology (MST)

Contact: Abbas Abubakar Gummi (Director, Renewable and Conventional Energy Technology)
Link: http://scienceandtech.gov.ng/

Brief description: The Federal Ministry of Science and Technology, Nigeria is one of the strategic Ministries of Government saddled with the responsibility of facilitating the development and deployment of Science, Technology and Innovation to enhance the pace of Socio-economic development of the country.

Transmission Company of Nigeria (TCN)

Contact: Mr. Usman Gur MOHAMMED (Interim MC/CEO)
Link: www.tcnorg.com

Brief description: The Transmission Company of Nigeria (TCN) was incorporated in November 2005, and is responsible for developing, operating and maintaining the transmission grid of Nigeria. It has a number of targets that include to:

- create adequate network redundancies to ensure at least 99.9% reliability;
- reduce transmission loss to 5%; and
- pursue interconnection with neighbouring countries for power exchange with associated cost savings from the sharing of reserve capacity and energy resources.

Nigeria Investment Promotion Commission (NIPC)

Contact: Reuben Kifasi (Director, Strategic Communications)
Link: www.nipc.gov.ng

Brief description: The Nigerian Investment Promotion Commission (NIPC) was established to promote and coordinate the strong focus under the new government of encouraging investment in the Nigerian Economy. NIPC's work has included the establishment of the One Stop Investment Centre (OSIC), and the publication of a comprehensive compendium of investment incentives (Investment Incentives directory, section 4.2).

One Stop Investment Centre (OSIC)

Contact: Lovina Kayode (Assistant Director)
Link: https://www.invest-nigeria.com/agencies-at-osic/

Brief description: Based within the NIPC, the One Stop Investment Centre (OSIC) is an investment facilitation mechanism to streamline administrative procedures relating to investment. 26 government agencies relating to the issuance of business approvals, permits and licenses and company incorporation have a desk within the OSIC, including the Immigration Service, Customs Service, Corporate Affairs Commission and Federal Inland Revenue Service. This enables a business or investor to tackle multiple administrative steps in one day and from a single building.

National Power Training Institute (NPTI)

Contact: Ahmed Bolaji Nagode (Director General)
Link: http://www.naptin.gov.ng/

Brief description: The primary purpose of the National Power Training Institute (NPTI) is to provide training for power sector personnel and coordinate training activities in the sector. In pursuit of this mandate, NAPTIN has taken over the management of existing seven regional training centres of PHCN.

National Agency for Science and Engineering Infrastructure (NASEI)

Contact: Prof. Mohammed Sani HARUNA (Executive Vice Chairman)
Link: www.naseni.org

Brief description: The mission of NASENI is to establish and nurture appropriate and dynamic Science and Engineering Infrastructure-base for achieving home-initiated and home-sustained industrialization through the development of relevant processes, capital goods and equipment necessary for job creation, national economic well-being and progress.

4.4.2 MINI-GRID PRACTITIONERS AND PRODUCT DEVELOPERS

Arnergy

Contact: Kunle Odebunmi (Co-Founder and COO)
Link: http://arnergy.com/

Brief description: Arnergy provides pay-as-you-go solution solar subscription services to homes and businesses in Africa, with over 2000 systems deployed between 300Wp to 27kWp. They operate two commercial 40kWp mini-grids in Oshu and Edu, utilising a modular design.

Asolar Nigeria

Contact: Saratu Usman (General Manager)
Link: http://asolarnig.com/

Brief description: Asolar is a licensed distributor of Azuri technologies in Nigeria, with solar home systems serving over 9000 people.

Asteven International Company Limited

Link: https://www.astevenltd.com

Brief description: Asteven Solar is renewable energy solutions provider, delivering a portfolio of smart off-grid solutions: smart PV solutions, pay as you go solutions, micro- and mini-grid solutions.

Atlantic Waste Power System (WSPS) Renewable Energy ltd

Contact: Christopher Onwuasoanya (President)
Link: http://atlanticwastepower.com/

Brief description: AWPS renewable energy ltd is one of Nigeria's largest solar PV service providers, and a subsidiary of Atlantic Waste Power System Inc. (USA).

Blue Camel Energy Limited

Contact: Suleiman Yusuf (CEO)
Link: http://bluecamelenergy.com.ng/

Brief description: Blue Camel Energy design and integrate renewable energy solutions across all level of energy demands from small household solar and hybrid systems to mini solar grid systems for rural electrification and industrial power backup systems.

Creeds Energy

Contact: Hannah Kabir (Managing Director)
Email: hannah.kabir@creedsenergy.com
Link: www.creedenergy.com

Brief description: Creeds Energy is a professional renewable energy company delivering solar solutions for residential, commercial and community properties.

Consistent Energy Limited / SolarDirect

Contact: Segun Abaju (Chief Energizing Officer)
Link: www.consistent-energy.com

Brief description: Consistent Energy Limited, a stand-alone rooftop solar energy company incorporated in January 2015. The company owns and promotes the SolarDirect brand aimed at displacing generators through rooftop solar projects for SMEs on a lease-to-own model, predominantly in urban and peri-urban areas.

Gelon Nigeria Limited

Link: www.gelonnigeria.com

Brief description: Gelon Nigeria limited is a renewable energy service companies focused on solar solutions, from financing and energy audits to retrofitting and maintenance.

GVE Projects Ltd

Contact: Ifeanyi Orajaka (CEO)
Link: www.gve-group.com

Brief description: Nigeria's biggest mini-grid developer, with 12 in operation (500kW cumulative capacity) and 5 more under development to take them to 1MW total capacity. With ongoing support from the Bank of Industry they have a 6-phase expansion plan to take them to 500 mini-grids and a total of 1 million customers.

Havenhill Synergy

Link: http://havenhillsynergy.com/

Brief description: Havenhill Synergy Limited is a renewable energy service organisation focused on solar solutions in urban and rural areas. They operate a 20kW solar mini-grid in Kigbe, Abuja, with the support of USAID, Power Africa, Diamond Development Initiative and the AfDB's Green Mini-Grid Help Desk.

ICIMI

Link: http://www.icimi.com/

Brief description: ICIMI is a UK- based energy company specialised in delivering low- emission energy solutions globally, developing solar power plants in Nigeria, with a presence in Africa, parts of Asia and the Americas.

Jua Energy

Contact: Abel Zhang (Country Manager, Nigeria)
Link: www.juaenergy.com

Brief description: With its headquarters in Kenya, Jua Energy designs and manufacture solar-powered systems, from SHS to mini-grids, as well as technological electronic accessories.

Lumos Global

Contact: Nir Marom (Co-Founder)
Link: http://www.lumos-global.com/

Brief description: Lumos is a solar home systems provider operating a pay-GO model through mobile providers. The Lumos system is 80W, able power lights, cell phones, fans and other small electronics.

Oginni Ever Increasing ENT. (OEIE) (NIG.) Limited

Link: http://www.oeiesolar.com/

Brief description: OEIESOLAR is a renewable energy engineering company, with deals on design, manufacture and installation of solar energy schemes.

Protergia Nigeria Limited

Contact: Ayodeji O' Deji (CEO)
Link: www.protergiaenergy.com

Brief description: Protergia Energy is a renewable energy project development company based in Abuja, Nigeria, delivering solar PV, wind and biomass solutions. Part of their portfolio is Dynovate Research Limited that, in partnership with GeoSUN Africa, offers a variety of services relating to the solar energy industry; they specialize in specifying, installing and monitoring on-site solar and weather stations in SSA for CSP, CPV and PV clients.

Roncho Energy

Contact: Ikenna Bruce Efika (Director, Technology)
Link: http://www.ronchoenergy.com/

Brief description: Roncho Energy is an energy, ICT and engineering services company. It provides solar standalone and backup solutions, mini-grids and grid extension services.

Rubitek Solar

Contact: Bolade A. Soremekun (CEO)
Link: http://www.rubitecsolar.com/

Brief description: Rubitek works as both a mini-grid project developer and consulting firm. Rubitek developed one of five Stage I Nigeria Energy Support Program (NESP) mini-grids, as well as installing 65 off-grid ATMs.

Rubycom Technologies Limited

Contact: Osaze Ize-Iyamu (Managing Director)
Link: www.rubycomtech.com

Brief description: Solar service provider, from design to manufacture and operation. Solutions include rural electrification projects, commercial installations, solar products (i.e. borehole pumps and fridges) and turnkey solutions.

SchimaticBlue Energy Limited

Contact: Chima Muoneke (Founder and CEO)
Link: www.sbe.ng

Brief description: SchimaticBlue Energy is an Energy Service Company (ESCO) providing a range of energy efficiency services, products and solutions. This includes design and implementation of energy saving projects; facility retrofitting, energy conservation programs, energy infrastructure outsourcing, demand and supply side management, power generation and energy supply technologies.

Smarter Grid International

Contact: Heather Onoh (CEO)
Link: www.smartergridint.com

Brief description: Smarter Grid International is a Nigerian solar home systems manufacturer and distributer.

SolarCentric Technologies Limited

Contact: Adetunji Iromini (Founder and CEO)
Link: http://www.solarcentrictech.com/

Brief description: SolarCentric Technologies is a project development and energy services company, which for renewable energy is focused mainly on on-grid solar projects.

Solarmate Engineering Limited

Contact: Dotun Tokun (Managing Director)
Link: www.solarmateng.com

Brief description: Solarmate Engineering Limited are an engineering firm that undertakes the design, supply, installation and maintenance of renewable energy system for various sectors.

SOSAI Renewable Energies Company

Contact: Habiba Ali (CEO)
Link: http://www.sosairen.org/

Brief description: A retailer of SHS, solar lanterns, water purification filters and cook stoves, with two mini-grids established with financing for three more. SOSAI also work as consultants on renewable energy and distribution.

VAYA Energy Solutions Limited

Contact: Stanley Vandu (Managing Director)
Link: www.vaya-energy.com

Brief description: VAYA Energy Solutions Limited is a renewable energy company focused on the deployment of solar-generated electricity solutions for utility, commercial, residential and rural customers.

Wedotebary Nigerian Limited

Contact: Yohanna Daliyop (Chairman)

Brief description: Wedotebary Nigeria Limited operates a 5MW solar power plant in Jos, Plateau State.

4.4.3 BILATERAL AND MULTILATERAL DONOR ORGANISATIONS

Agence Française de Développement (AFD)

Contact: ADEMOLA Adesoji (Project Officer- Energy/ Transportation)
Link: https://www.afd.fr/en/page-region-pays/nigeria

Brief description: AFD has been supporting Nigeria since 2008, with a focus on finance for supporting the private sector and reducing Nigeria's reliance on oil. A selection of relevant areas of support include a) development of rural roads to facilitate the sale of production, b) credit lines to extend access for SMEs to medium and long-term credit, c) a partnership with the Development Bank of Nigeria (DBN) and d) supporting the energy industry to move away from a total reliance on oil.

AfDB

Contact: Dozie Okpalaobieri (Energy Complex Consultant)
Link: https://www.afdb.org/en/countries/west-africa/nigeria/

Brief description: In addition to transnational programmes such as the African Development Fund, AfDB is a funder of Nigeria's Power Sector Recovery Programme (PSRP). PSRP aims to promote rural energy access through transmission grid expansion, innovative financing products and the provision of technical assistance to improve the revenue generation of the DisCos. AfDB is also contributing $200m toward the World Bank funded NEP. The AfDB is reportedly planning to continue support to the PSRP in three primary areas; operational and technical intervention, governance issues and policy-based support. The AfDB's previous strategy for 2013-17 is laid out in its Country Strategy Paper.

Development Bank of Nigeria (DBN)

Contact: Tony Okpanachi (Managing Director/CEO)
Link: http://www.devbankng.com/home.php

Brief description: The Development Bank of Nigeria (DBN) exists to address financing constraints faced by micro to medium-scale enterprises and small corporates. Supported by the World Bank, AFD, AfDB, European Investment Bank and KfW, the DBN does this by providing technical assistance, wholesale lending and partial credit risk guarantees to participating financial institutions.

European Union Delegation to Nigeria & ECOWAS

Contact: Nadia Cannata (Head of Section, Economic Cooperation & Energy)
Link: https://eeas.europa.eu/delegations/nigeria_en

Brief description: The National Indicative Programme for Nigeria outlines the main focal sectors of the EU cooperation with the country during the period 2014-20 under the 11th European Development Fund, with total supported expected to reach € 512m over this period. €150m is to be allocated to 'sustainable energy and access to electricity'. The energy theme will centre on strengthening the capacity of relevant government agencies, especially in the least developed States in the North. It also plans to improve the enabling environment for the electricity sector and the development of renewable sources, including through vocational training and by strengthening the oversight capacity of non-state actors.

GIZ

Contact: INA HOMMER (Head GIZ-NESP)
Link: https://www.giz.de/en/worldwide/1902.html

Brief description: GIZ is one of the key actors in Nigeria, with longstanding support to the energy sector especially through its Nigeria Energy Support Programme (NESP). The first phase of NESP ended in 2017, and targeted greater investment in the energy sector through four themes: (1) Policy Reform and on-grid Renewable Energy, (2) Energy Efficiency, (3) Rural Electrification and Sustainable Energy Access, (4) Capacity Development and Training (cross-cutting across the first three). In the Rural Electrification and Sustainable Energy Access theme there were a number of key achievements, grouped into three workstreams:

- Policy frameworks
    - Supported the government to review and approve a number of documents stalled under the last government
    - Developed new policies and regulations including the mini-grid regulation
- Data, electrification planning and GIS
    - Data collection focused on five states - Sokoto, Niger, Plateau, Cross River, Ogun
    - Supported the development of a three-phase plan/roadmap for 100% electrification in each of these five states
- Mini-grid project development
    - 6 pilot solar PV projects in the above five states, with 100-200 households each. In addition to project development support, grant funding was provided under a 'split-asset' model where the fixed assets, i.e. distribution system, were grant funded. Movable assets were financed through private equity and debt

The second phase of NESP will continue to work with Sokoto, Niger, Plateau, Cross River and Ogun states, helping them to scale up to around 20 mini-grids reaching 100k people. They will also continuing to monitor and test the existing pilots, and begin to establish similar relationships with other states.

Power for All

Contact: Chibuikem Agbaegbu (Head, Market Access)
Link: http://www.powerforall.org/nigeria

Brief description: Power for All is a global organisation specialising in advocacy, communications and market development. In Nigeria Power for All focuses on market development through support to a) government, b) donor agencies and c) the private sector. Recent programmes have included supporting the Renewable Energy Association of Nigeria (REAN) to represent the private sector, conducting demand estimation in rural communities to identify opportunities for SHSs and mini-grids, awareness raising of the off-grid sector and facilitating coordination between key stakeholders.

USAID Nigeria

Contact: Roseann Casey (Director, Economic Growth & Environment)
Link: https://www.usaid.gov/nigeria

Brief description: A total of $351.6m of foreign assistance to Nigeria is planned by the US in 2019, focused around democratic stability and poverty reduction. The Power Africa programme is the focal programme for energy (mainly on-grid), while the Beyond the Grid programme focuses on off-grid energy. Through this programme they have supported REA to improve the clarify of mini-grid regulation and on the development of REA's electrification master plan, as well as coordinating a Task Force of off-grid stakeholders with Power for All. The recently completed Renewable Energy and Energy Efficiency Project (REEEP) aimed to facilitate access to finance through technical assistance to banks and developers, combined with promotion of policy changes to improve the business environment. USAID's Development Credit Authority (DCA) also ran a guarantee fund with Ecobank, but found limited engagement from developers due to the remaining loan terms.

World Bank

Contact: Jianping Zhao (Team Leader, Energy)
Link: http://www.worldbank.org/en/country/nigeria

Brief description: The World Bank, working with the Ministry of Power, Works and Housing, plans to contribute 350m$ (250m$ to mini-grids) to the Nigeria Electrification Project (NEP). Through this the World Bank aims to provide 250m$ to solar mini-grids in phase 1 (5-10 years away from any DisCo networks) through a $70m matching grant (likely set to 75% or 300,000$, whichever is less) followed by an $80m performance-based connection subsidy (likely 30%). They are working with REA and the Odyssey platform to standardise the application and procurement process. The World Bank also has a number of other projects:

- NG-Electricity Transmission Project (486m$) – Transmission network reinforcement including upgrading 48 existing substations and conductor replacement along 13 132kV lines
- Kaduna State Economic Transformation Program-for-Results (350m$) – Improving the business enabling environment and fiscal management and accountability in Kaduna State

4.4.4 OTHER RELEVANT ORGANISATIONS AND INITIATIVES

African Mini-Grid Developers Association (AMDA)

Contact: Aaron Leopold (CEO)
Link: http://africamda.org/

Brief description: The African Mini-Grid Developers Association is an advocacy group consisting of private sector developers of AC mini-grids in Africa, aiming to address core barriers to unlocking scale for the mini-grid market. A Nigerian chapter of AMDA has been recently established, in addition to existing ones in Kenya and Tanzania.

Association of Nigerian Electricity Distributors (ANED)

Contact: Azu Obiaya (CEO)
Link: http://www.anedng.com/

Brief description: ANED is an association of the eleven electricity distribution companies (DisCos) in Nigeria that is dedicated to advocacy on behalf of the Nigerian electricity supply industry, facilitating the setting of industry standards, promoting the collective interests of the DisCos and carrying out community sensitisation and stakeholder consultation on behalf of the DisCos.

Clean Technology Hub

Contact: Ify Malo (CEO and Co-Founder)
Link: www.cleantechnologyhub.com

Brief description: Clean Tech Hub is a hybrid hub for the development of clean energy technologies in Africa. They are a start-up incubator for inventions and innovations in clean energy, a consultancy for sustainability and energy efficiency solutions for organizations, and a driver of clean energy investment into Africa.

Cold Hubs

Contact: Nnaemeka C. Ikegwuonu (CEO)
Link: www.coldhubs.com

Brief: ColdHubs is a “plug and play” modular, solar-powered walk-in cold room, for 24/7 off-grid storage and preservation of perishable foods. It addresses the problem of post- harvest losses in fruits, vegetables and other perishable food.

Ecobank Nigeria

Contact: Nkiru Ugwo (Team Lead, SMEs, Commercial Banking Group)
Link: https://www.ecobank.com/personal-banking

Brief description: A transnational commercial bank with a base in Nigeria, Ecobank has funded off-grid projects in the past including the Rubitec Solar mini-grid in Ogun state. The restrictions are that Ecobank requires collateral and 3-years in a trade before they can lend to them, which is uncommon in Nigeria except for the likes of GVE. Ecobank is therefore looking to partner with development finance institutions, as with an existing partnership with the African Guarantee Fund.

National Centre for Energy Research and Development (NCERD)

Contact: Okala Nwoke (Researcher)
Link: www.ncerd.com

Brief description: NCERD is based in the University of Nigeria Nsukka, and is one of the centres of energy research established by the Energy Commission of Nigeria (ECN). Its objective is to “carry out research, development, dissemination, commercialization and manpower training in the various areas of renewable and non-renewable energy technologies such as Solar, Biomass, Biofuels, Wind, Hydro, Geothermal, Fossil Fuels, Energy Management and Environment”.

Heinrich Böll Foundation Nigeria

Contact: Christine. K (Director)
Link: Https://ng.boell.org

Brief description: The global Heinrich Böll Foundation is a think tank, network and agency for the green political movement. HBF Nigeria supports activities that aim to identify greener development options, which would include growth models that promote responsible use of natural resources in times of increasing climate stress. Through its various activities such as publications, conferences, social media debates or public events, HBF want to contribute to a debate that links national and international concerns and issues, especially in the areas of resource politics and climate change.

International Centre for Energy, Environment and Development (ICEED)

Link: http://iceednigeria.org/ic/

Brief description: ICEED is a centre focused on linking energy and climate change policy reform to prosperity for the bottom of the pyramid. ICEED managed the research and consultation process for the development of the Renewable Electricity Action Programme as well as the writing of the Policy and Regulatory Guidelines on behalf of the Federal Government of Nigeria. The ICEED Resource Centre Afikpo (IRECA) was established in 2012 with the aim of enhancing the technical quality, standardization, research and training services that support national and regional clean energy technologies in Nigeria and the West Africa Sub Region.

Moriah Blessed Ventures

Contact: Obot Umoh
Link: https://vc4a.com/ventures/moriah-blessed-ventures/

Brief description: A solar-powered cold room service provider for farmers, traders and small businesses, utilising mobile applications to order and manage the storage of goods in the cold room.

Odyssey

Contact: Emily McAteer (CEO)
Link: https://www.odysseyenergysolutions.com/

Brief description: Odyssey is an innovative web-based platform that streamlines the work flow for building and financing mini-grid projects. Odyssey is working with REA and the World Bank to put potential sites identified in Nigeria on the platform, which will provide ease of access to site information for developers while enabling streamlined procurement for REA and the World Bank.

Renewable Energy Association of Nigeria (REAN)

Contact: Segun Adaju (President, CEO of Consistent Energy Limited)
Link: http://www.rean.com.ng/

Brief description: REAN is an independent, non-profit Industry association, whose mission is “to be the umbrella association for all Renewable Energy promoters enabling and encouraging the sustainable development of the Nigerian economy through Renewable Energy”.

Sterling Bank

Contact: Adesola Alli (Head, Renewable Energy)
Link: https://sterlingbankng.com/index.php

Brief description: A commercial bank based in Nigeria, Sterling Bank are actively considering off-grid and renewable projects. They have previously funded import-retailers in the off-grid space. They are currently looking to develop a financing mechanism for mini-grids, possibly blended with concessional financing from development finance institutions to reduce the offered interest rate.

Solar Energy Society of Nigeria (SESN)

Contact: Prof. B.G Danshehu (President)
Link: http://sesn-ng.org/

Brief description: SESN's objectives are to provide a) medium for national and international dissemination of Solar Energy, b) cooperation among scientists, engineers and technologists working in the field of energy, and c) a focal point for publication.

Tonbofa

Contact: Eva Ashimi (CEO)
Link: www.tonbofa.com

Brief description: Tonbofa provide multi-jurisdictional legal advisory and consultancy services to energy and infrastructure projects in developing nations, including the development of energy and natural resources policy, law, revenue generation, markets and dispute resolution resources in Africa.

ANNEX: OBJECTIVES AND SCOPE OF THE MARKET ASSESSMENT

5.1 OBJECTIVES OF THE MARKET ASSESSMENT

The objective of the Green Mini-Grids Africa Market Development Programme is to support the scale-up of investments in commercially viable GMG projects through a broad range of interventions to improve the enabling environment. The project seeks to remove or reduce market barriers at regional scale and strengthen the ecosystem for the emergence of a thriving GMG sector in Sub-Saharan Africa- contributing significantly to the objectives of the SEforALL. The Market Intelligence business line supports activities that foster the ability of project developers, investors and public entities in identifying market opportunities for GMGs, facilitating a coherent national approach and supporting the linkages between central authorities, local/national businesses, investors and communities with demand for power.

5.2 SCOPE OF THE MARKET ASSESSMENT

This report is one of the country reports that are part of the first deliverable for this project. All published deliverables will be available through the African Development Bank and other dissemination channels. As written in the original terms of reference, the project had three main deliverables:

"**D1 – Publication of country-level analysis on mini-grid market opportunities**, initially focussing on at least 15 countries in SSA that are prioritising GMGs, generated using a pre-agreed opportunity assessment methodology. AfDB will provide the country list and will support the consultant to get access to country institutions, notably the SE4All focal points, and national sources of data to apply the methodology. The D1 deliverable will be a suite of reports on the mini-grid sector opportunity for each of the fifteen target countries.

D2 – Detailed small hydropower assessments (including submission of raw data) in two countries. Critical knowledge gaps for small hydropower resources will be assessed across the 15 countries chosen, followed by two national assessments to evaluate and recommend high potential sites for GMG's using small hydropower as an energy source. This will include evaluation of the 5-10 highest potential hydropower sites in these two countries.

D3 – A methodology and database for continuously monitoring the mini-grid sector across Africa. An information and monitoring system which is able to collate the most up-to-date information on the deployment of GMGs across Sub-Saharan Africa will be developed. This will include a database which provides key GMG sector indicators for SSA, and a process to regularly collect and update information against these indicators."

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