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MINI GRIDS IN NIGERIA

A CASE STUDY OF A PROMISING MARKET

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The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance program administered by the World Bank. It provides analytical and advisory services to low- and middle-income countries to increase their know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth. ESMAP is funded by Australia, Austria, Denmark, the European Commission, Finland, France, Germany, Iceland, Italy, Japan, Lithuania, Luxemburg, the Netherlands, Norway, The Rockefeller Foundation, Sweden, Switzerland, and the United Kingdom, as well as the World Bank.

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PREAMBLE

The Global Facility on Mini Grids of the Energy Sector Management Assistance Program (ESMAP) hired Castalia to study the regulation of mini grids in six jurisdictions in Sub-Saharan Africa and Asia (Kenya, Tanzania, and Nigeria; and Bangladesh, Cambodia, and the state of Uttar Pradesh in India). The study's objective is to understand what regulatory settings governments may adopt to scale up electrification through private development of mini grids, drawing on the experience of these six jurisdictions; provide technical assistance to four countries that want to further develop their mini grids framework; and disseminate findings and recommendations globally to inform successful mini grids regulation.

The study focuses on mini grids defined as small, privately-owned and operated systems with generation of up to 10 megawatts (MW) capacity and a network that distributes power to several customers. The study includes small mini grids of less than 1 kilowatt (kW) capacity, also known as 'micro' or 'pico' grids.

The six case studies are intended to be combined in one report. The report is to provide a cross-country comparison of these topics: it examines side by side how each of the countries studied have responded to a specific regulatory question, and presents a decision-tree approach to developing regulatory frameworks for mini grids.

This case study is based on in-depth interviews with a number of key stakeholders in Nigeria, conducted during and after a research trip in August 2017. We supplemented the insights gained from these interviews with extensive background research. Several experts in the Nigeria context and mini grids more broadly reviewed this case study for accuracy and clarity, and we have incorporated their comments while retaining a neutral fact-based position.

Like the other five case studies, this document is structured as follows:

- A brief introduction (Section 1 |),
- A brief description of the context of the country (Section 2 |),
- An overview of the power sector (Section 3 |),
- Main aspects of the policy setting for mini grids (Section 4 |),
- Technologies and business models used in the mini grids sector (Section 5 |),
- The process to authorize mini grid operators (Section 6 |),
- Technical and service standards for mini grids (Section 7 |),
- Tariff setting, financing, and subsidies (Section 8 |),
- Handling the relationship with the main grid (Section 9 |), and
- A summary of lessons learnt from the experience of the country (Section 10 |).

1 | INTRODUCTION

The mini grid sector in Nigeria started to develop only recently. Most operators were established in the past five years. Today, eleven private mini grids operate in Nigeria. These mini grids serve about 9,100 people, with a cumulated capacity of about 236kW[1].

Efforts at developing a legal and institutional framework for mini grids have also just started. In 2017, the Nigerian Electricity Regulatory Commission (NERC) adopted the Regulations for Mini Grids ('the Regulations'). Also in 2017, the Rural Electrification Fund (REF) issued its first call for expression of interest for off-grid projects; the Fund was established to develop on-grid and off-grid electrification in rural areas, including mini grids, through financial support and technical assistance.

The Regulations provide a comprehensive setting for mini grids, the key features of which are:

- **Three thresholds of authorization**
    - Below 100kW of distribution capacity, mini grids may or may not apply for a permit. Obtaining a permit guarantees compensation to the mini grid for the takeover of assets when the grid arrives. Operators must register, but they are not subject to any regulation under this threshold. Registered mini grids also freely choose the location of operation.
    - Above 100kW of distribution capacity, but below 1MW of generation capacity, mini grids must obtain a permit.
    - Above 1MW of generation capacity, mini grids must obtain a license. They are not considered as mini grids under the Regulations but instead are considered Independent Power Producers (IPP), either connected to the main grid or not.
- **The possibility for unsolicited mini grids to charge a cost-recovery tariff[2]**
    - Registered mini grids can set their tariffs freely. To do so, they are allowed, but not required, to use the Multi-Year Tariff Order (MYTO) calculation tool, which the NERC designed especially for mini grids and made publicly available on its website, defining themselves the parameters normally set by NERC; or just sign an agreement with the community to be served.
    - Mini grids that apply for a permit must use the MYTO methodology, and have their tariffs approved by the NERC.
- **The obligation to sign agreements with local stakeholders. These stakeholders are:**
    - The community (for isolated mini grids that apply for a permit), and
    - The community and the local distribution company (DisCo) for interconnected mini grids.
- **Clear rules when the grid arrives. The isolated mini grid may:**
    - Convert into an interconnected mini grid, or
    - Sell its assets at the depreciated price plus 12 months of revenue.

Mini grid operators have preferred to be registered systems with a capacity lower than 100kW. This allows them to stay outside of the scope of the new regulation—they can set their own tariffs and

[1] Based on data collected for private mini grids shown in Appendix A. Information found also suggests 19 other mini grids that are public, with a combined installed capacity of about 67 kW.
[2] This rule might change for mini grids that win competitive solicitations held by REA. See section 8.1.

choose their location—while observing how this is enforced in practice before deciding whether or not to add capacity that would take them above the 100kW threshold.

Table 1.1 presents the key metrics of mini grids in Nigeria, including data on mini grids penetration in Nigeria, tariffs and rates, and quality of service.

Table 1.1: Key Metrics for Mini Grids in Nigeria, 2015

Mini grids Penetration		
Number of mini grids	Number	11
Average growth in number of mini grids from 2005 to 2015	%	17%
Customers served by mini grids	Customers, thousands	~1.8
	People, thousands	~9.1
	% of total population	0.005%
	Of the population with access to electricity, % connected to a mini grid	0.009%
Average growth in connections from 2005 to 2015	Thousand/year	0.1
	%/year	98%
Tariffs and Rates		
Cost of connection[(1)]	US$	783
	% of GDP/Capita	14%
Average subsidy per connection	US$	356
	% of GDP/Capita	6%
Monthly bill for Tier 2[(2)] consumption	US$	2.20
	% of GDP/Capita	0.5%
Average tariff[(3)]	US$/kWh	0.36
Quality of Service		
Availability of electricity	Hours of service/day	Between 16 and 24

Sources: GVE Group (2015, 2017), ECREEE (2016)

Notes: (1) The cost of connection refers to the distribution cost, for the developer, of connecting new customers. Connection cost for Nigeria corresponds to one mini grid developer's connection cost (confidential).
(2) A 'tier 2' access to electricity is access that allows for consumption of 73kWh/year to 250kWh/year. Source: World Bank/ESMAP (2015), "Beyond Connections – Energy Access Redefined"
(3) For several mini grids developers, and all categories of customers.

2 | COUNTRY CONTEXT

Table 2.1 presents the summary statistics on Nigeria's demographics, economy, governance, and electricity sector.

Table 2.1: Nigeria Summary Statistics, 1995, 2005, 2014

		1995	2005	2014
Demographics				
Population	Million	108.4	139.6	177.5
Population growth	Annual average	2.5%	2.6%	2.7%
Rural population	Million	73.2	84.7	93.6
Rural population growth	Annual average	2%	1%	1%
Population density, National	People/sq. km	118.6	152.6	193.7
Economy				
GDP	PPP, 2011 US$ million	28,547.0	112,248.4	569,489.9
GDP per capita	PPP, 2011 US$	2,750.1	4,149.3	5,671.9
Real GDP per capita growth	5-year annual compound rate	-2%	8%	3%
Debt to GDP ratio	%	100%	29%	18%
Governance				
Ease of Doing Business rank	See Note (1)	N/A	N/A	147
Corruption Perceptions Index	See Note (2)	N/A	1.9	2.6
World Bank Governance Indicator	See Note (3)	-1.17	-1.11	-1.07
Electricity Sector				
Electricity connection rate, National	% of population	**37.2**	**47.9**	**57.7**
Urban		*74.8*	*76.6*	*78.4*
Rural		*19.3*	*29.4*	*39.3*
Electrification growth rate	% change in population with a connection, 5-year compound rate	9.1%	5.0%	4.8%
Population with an electricity connection	Million	40,310.2	66,840.4	102,318.7
Urban		*26,173.9*	*41,919.0*	*65,519.2*
Rural		*14,136.3*	*24,921.4*	*36,799.5*

		1995	2005	2014
Electrical power consumption	kWh/person /year	91.4	129.3	144.5
	kWh/person with an electricity connection/year	245.9	270.0	250.6
Customers served by the grid	Thousands	**N/A**	**N/A**	**6,159.8**

Source: World Bank Development Indicators (2016), Transparency International (2016)

Notes: (1) The Ease of Doing Business Index ranks countries from one to 190. The closest a country is to 1, the more conducive its regulatory environment is to the starting and operation of a local firm.
(2) The Corruption Perceptions Index ranks countries on a scale of zero to 10, with zero indicating very high levels of corruption and 10 indicating very low levels of corruption.
(3) The Worldwide Governance Index assign scores to countries from -2.5 to 2.5, with higher values indicating higher quality of governance.
(4) We choose 2014 as the last year due to the non-availability of data for some indicators for 2015.

Demographics

Nigeria is the most populous country in Africa, with a population of almost 186 million people. The population has grown steadily over the last two decades, with annual rates between 2.5 and 2.7%.

The share of people living in rural areas has declined as overall population grew. 51% of the population lives in rural areas, compared to 68% in 1995. The population is increasingly concentrated in Lagos, the country's economic and financial center, which grew from 15 million in 2005 to 21 million in 2015.

Economy

Nigeria remains Africa's largest economy in spite of an economic downturn in the past two years. In 2016, its total gross domestic product (GDP) was US$405 billion, down from 568 billion in 2014, a decrease of 29%. GDP per capita decreased even more in percentage terms to US$2,178 in 2016, 32% less than in 2014 (US$3,222).

The Nigerian economy relies primarily on the hydrocarbons sector. Oil and gas represent 35% of GDP, and 95% of exports. As of July 2017, Nigeria exported 1.84 million barrels per day.[3] Other drivers of the Nigerian economy are agriculture, information and communications, and manufacturing.

The Government has made significant efforts to improve the economic environment. 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.[4] The country has improved in the following indicators: starting a business, dealing with construction permits, registering property, getting credit, and paying taxes. However, the 2018 report marks no improvement in the 'getting electricity' indicator. Still, Nigeria ranks 145th in the 2018 report, up from 169th in the 2017 report.

Governance

[3] Vanguard (2017), *Nigeria's oil export to rise by 13% in July* (https://www.vanguardngr.com/2017/06/nigerias-oil-export-rise-13-july/) Accessed 10 November 2017

[4] World Bank (2017), Doing Business 2018 (http://www.doingbusiness.org/~/media/WBG/DoingBusiness/Documents/Annual-Reports/English/DB2018-Full-Report.pdf) Accessed 13 November 2017

Nigeria has strengthened its democratic governance after forty years of instability following independence. The country became an independent federal state in 1960, after a century of British presence and colonial rule. The ensuing period of political change saw civilian and military rule alternating until 1999, when the political system became a presidential democracy. Under this system, the President holds executive power, and a bicameral system composed by a House of Representatives and a Senate holds the legislative power. Following the establishment of democracy, the People's Democratic Party continuously ruled the country until 2015. In that year, Muhammadu Buhari from the All Progressives Congress smoothly succeeded Goodluck Jonathan.

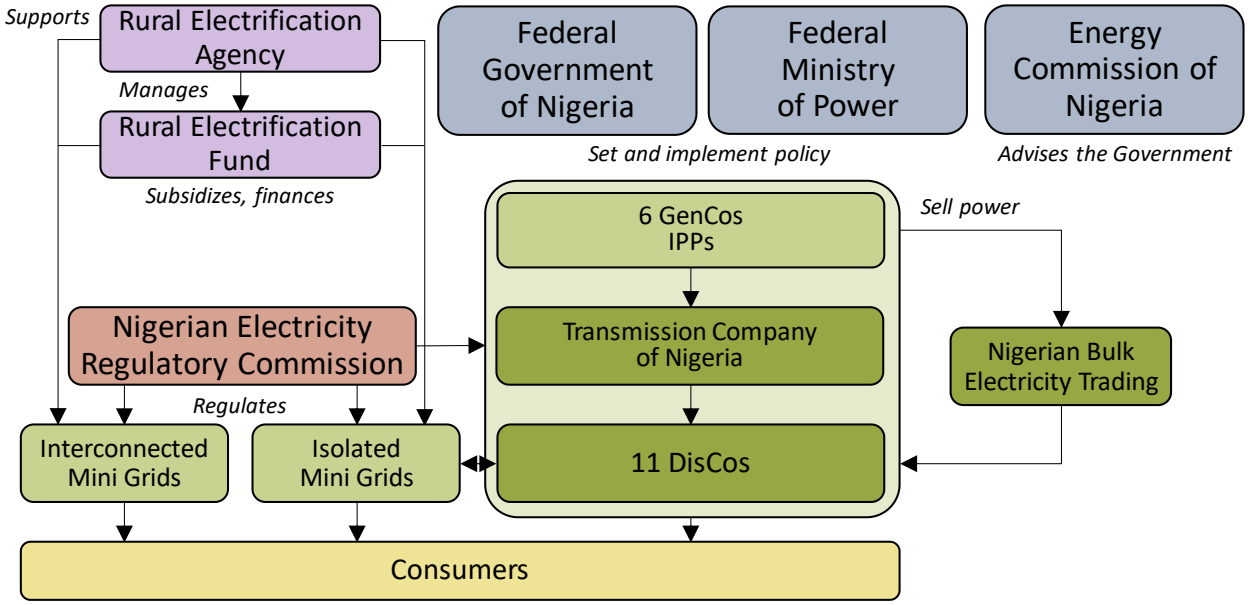
At the same time, civil conflict has intensified during the 2000s. Since 2009, the terrorist group Boko Haram has carried out several attacks in Nigeria. The number of attacks has substantially decreased in the last couple of years, but the group remains active in the north-eastern region of the country. Boko Haram primarily targets rural settlements in the states of Borno (particularly arounds its capital city, Maiduguri), Kano, and Yobe. The Niger Delta Avengers also proclaimed its existence in 2016; they seek to cause disruption in the operations of the oil and gas industry by carrying out relatively small attacks on production facilities in Nigeria's South-South region.

3 | OVERVIEW OF THE POWER SECTOR

The Electric Power Sector Reform Act of 2005 ('the Act'), the overarching law ruling the power sector, allowed for the extensive reform of the power sector in Nigeria. The National Electricity Power Authority (NEPA), the public utility that acted as a monopoly, was the major actor of the power sector until 2005. The Federal Government of Nigeria ('the Government') unbundled NEPA, which became the Power Holding Company of Nigeria (PHCN), in preparation of the Act. Then, the Act further reformed the sector by introducing several key actors. The Act deepened the unbundling of the utility, transforming PHCN into six Generation Companies (GenCos), a transmission company, and eleven DisCos. The Act also established the NERC as the regulatory agency.

Figure 3.1 presents the structure of the power sector in Nigeria.

Figure 3.1: Nigeria Power Sector Structure



3.1 Main actors

The most important actors of the power sector in Nigeria are the NERC, DisCos, the Nigerian Bulk Electricity Trading Plc, the Federal Ministry of Power ('the Ministry of Power'), and GenCos.

The Nigerian Electricity Regulatory Commission (NERC)

Section 31 of the Act established the NERC as an independent regulatory body tasked with driving the reform of the power sector. NERC aims at promoting and ensuring efficient market structures, fair and competitive electricity trading, and an investor-friendly sector. It regulates and monitors the power sector, and ensures private companies' compliance with market rules and operating guidelines. As section 6 | highlights, NERC also regulates the mini grids sector.

NERC sets generation, transmission, and end-user retail tariffs.[5] It does so with the MYTO methodology (see section 4.2). In setting tariffs, the NERC seeks to reconcile cost recovery and affordability for consumers.

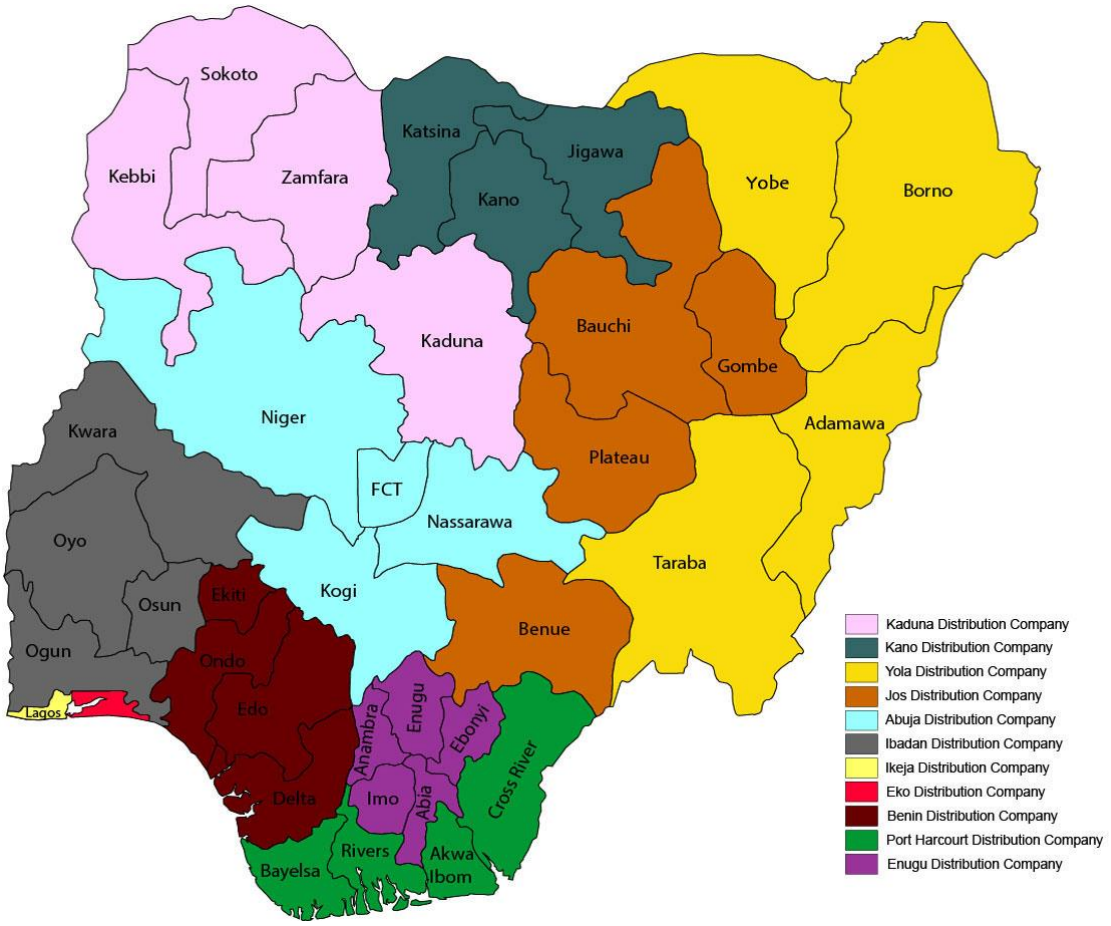
The NERC also licenses and regulates persons engaged in the generation, transmission, system operation, distribution, or trading of electricity. The NERC oversees application approval for licenses to operate independent power plants with capacity above 1MW; and decides the eligibility of IPPs to negotiate power purchase agreements (PPAs) with the Nigerian Bulk Electricity Trading Plc (NBET), the central off-taker.

[5] NERC (2017). Electricity Tariff in Nigerian Electricity Supply Industry (http://www.nercng.org/index.php/home/myto) accessed 30 August 2017

Distribution Companies (DisCos)

There are 11 DisCos, each covering a delimited area. Figure 3.2 indicates each company's coverage area. The privatization of the DISCOs (and GENCOs) was completed in November 2013. The Federal Government of Nigeria retains a 40 percent ownership in the DISCOs.

Figure 3.2: DisCos Coverage Areas



Source: NERC (2017)

Rural Electrification Agency (REA)

The REA supports and coordinates electrification initiatives in rural areas through technical and financial assistance. It was established by Section 88 of the Act, and started its activity in 2006.

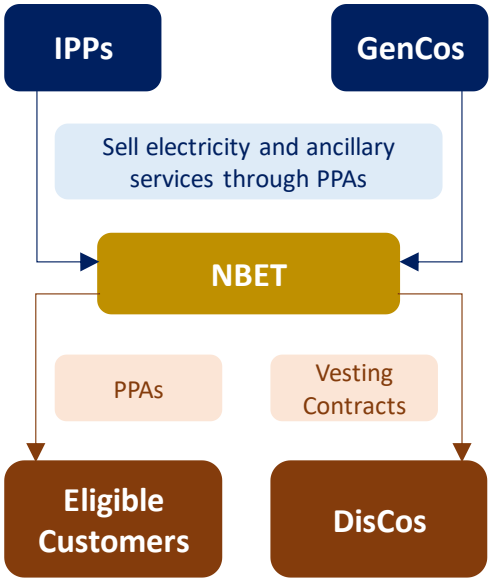
The REF is the financial arm of the REA. Established alongside the REA, it remained dormant until 2017, when the REA adopted its operating guidelines. Funding is competitively allocated through tenders run by the REA. The REF is funded through various sources, most notably the Government, local state governments, fines paid to the NERC, and grants and loans from international organizations. The REA has earmarked 30.2 billion Naira (NGN), or US$84 million, for the REF for 2017. The REA disbursed NGN4.45 billion (US$12.4 million) from the REF as of October 2017, or 15% of its earmarked budget for 2017.

Nigerian Bulk Electricity Trading Plc (NBET)

The NBET was established in 2010 as the country's only bulk trader. Figure 3.3 shows how NBET purchases electricity and ancillary services from the GenCos and IPPs to resell it to DisCos through vesting contracts, and to other eligible customers through PPAs.

Credit enhancement is key to viable PPAs in Nigeria, and the object of recent policy efforts. DisCos used to provide guarantees to support PPAs contracted by the NBET. However, DisCos' own insolvency issues made this structure ineffective. In March 2017, the Government set up a NGN701 billion (US$1.95 billion) payment assurance guarantee facility to back PPAs contracted by the NBET and GenCos. The Central Bank of Nigeria will disburse the assurance guarantee to GenCos and their gas suppliers for liabilities contracted between January 2017 and December 2018.[6]

Figure 3.3: Role of the NBET, the Bulk Trader



Other power sectors actors

The power sector has four other notable actors:

- The Ministry of Power. The Ministry of Power is responsible for formulating, implementing and administrating policies, strategies, and planning in the energy sector.
- The Energy Commission of Nigeria (ECN). The ECN advises the Government on energy strategies and planning, and on creating and disseminating knowledge. It also promotes research in the energy field.
- The Transmission Company of Nigeria (TCN). The TCN is responsible for planning, building, operating, and maintaining the grid, as well as ensuring its reliability and efficiency. The TCN is a public monopoly.

[6] Premium Times (27 March 2017). Analysing the N701 Billion CBN Guarantee To the Power Sector. (https://opinion.premiumtimesng.com/2017/03/27/analysing-the-n701-billion-cbn-guarantee-to-the-power-sector-by-odion-omonfoman/) and This Day (2 March 2017) FG Approves N 701 bn Power Purchase Guarantee for GenCos (https://www.thisdaylive.com/index.php/2017/03/02/fg-approves-n701bn-power-purchase-guarantee-for-gencos/) Accessed 10 November 2017

- GenCos. Six GenCos produce and sell electricity to NBET through PPAs. Their combined installed capacity amounts to 5,048MW, which is about half of the total in Nigeria. Table 3.1 lists the six GenCos', showing their plant type and installed capacity.

Table 3.1: GenCos' Plants – Type and Installed Capacity (MW), 2017

Generation Company	Plant Type	Capacity
Afam Power Plc (I-V)	Thermal (Natural Gas)	776
Egbin Power Plc	Thermal (Natural Gas)	1,020
Kainji/Jebba Hydro Electric Plc	Hydro (Impoundment)	1,338
Sapele Power Plc	Thermal (Natural Gas)	414
Shiroro Hydro Electric Plc	Hydro (Impoundment)	600
Ughelli Power Plc	Thermal (Natural Gas)	900
TOTAL		**5,048**

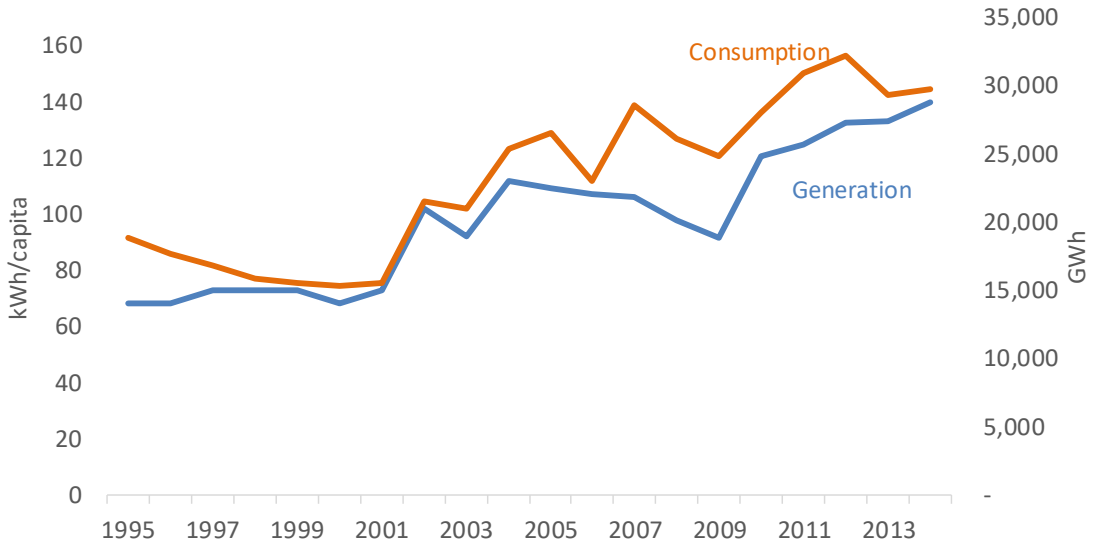
Source: NERC (2017)

3.2 EVOLUTION OF THE SECTOR

Overall consumption and supply of electricity has increased in the past 20 years. Between 1995 and 2015, consumption per capita grew by 3.2% per year on average, from 91kWh per year to 144kWh per year, while electricity generation increased by 4.6% per year on average, from 14TWh per year to 30TWh per year.

Consumption and supply of electricity experienced recent increases and downturns. As Figure 3.4 shows, both consumption and generation started to grow again in 2010, after five years of almost continuous decline. Except for the period 2004-2006, changes in consumption matched changes in generation.

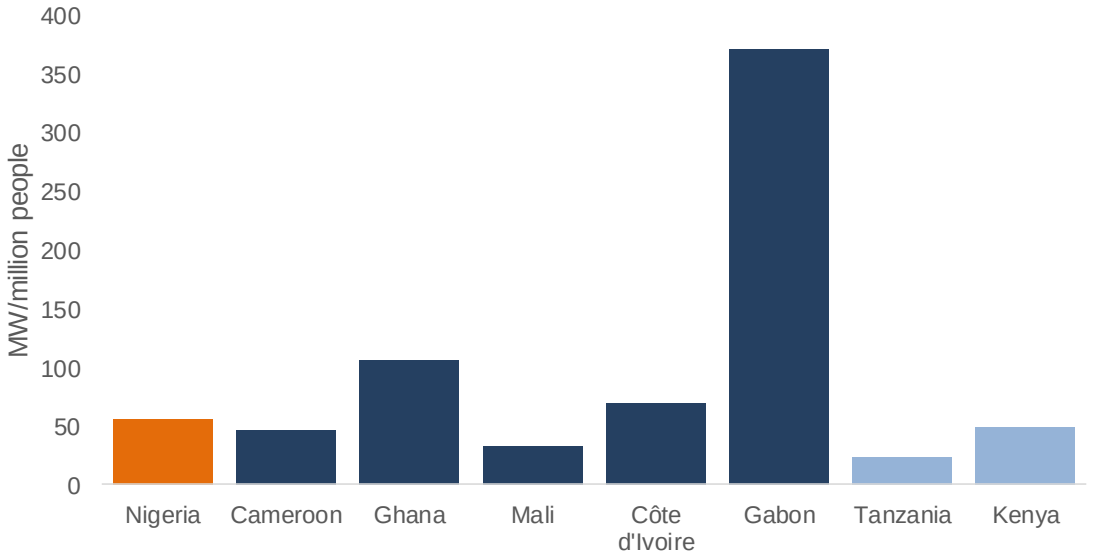
Figure 3.4: Evolution of Power Consumption (kWh/person) and Generation (GWh), 1995-2014



Installed capacity grew slowly in the same period. Installed capacity totaled 10,396MW in 2015, up from 5,800MW in 1995, representing an increase of 80%.

Nigeria's installed capacity per capita is on average levels when compared to neighboring countries and other Sub-Saharan African case study countries examined in this assignment (Tanzania and Kenya). At 53.5MW per million people, Nigeria is similar to Kenya (49.2MW per million people). Figure 3.5 illustrates that Nigeria performs slightly better than Cameroon, Mali, or Tanzania; but its generation capacity per million people is about half of Ghana's, and a seventh of Gabon's.

Figure 3.5: Electricity Generation Capacity (MW per million people),2014



The increase in installed capacity and generation falls short of the increase in the population's demand for power. The sector suffers from poor availability of generation capacity and frequent fuel shortages, which make already insufficient capacity even more unreliable. Typically, only 6GW of the 10.4GW of total installed generation capacity are available,[7] and even full availability would be far from an estimated demand of 31GW in 2015.[8] In 2009, only 30% of the demand of the interconnected population was met.[9]

Power infrastructure is unevenly spread across the country. Most of the power plants and transmission and distribution lines are installed around the economic center, Lagos, and the South region, as shown in Figure 3.6. Transmission lines barely cross some states, such as Taraba and Yobe.

The transmission system in Nigeria is expanding slowly, and remains underdeveloped. Transmission lines measure 15,022km, up from 11,000km in 2005. As a comparison, Côte d'Ivoire, with a similar territory size and 7.5 times less population than Nigeria, has less transmission lines in length (4,700km) but more

[7] NERC (2017), Power Generation in Nigeria (http://www.nercng.org/index.php/home/nesi/403-generation) Accessed 26 October 2017
[8] Energy Commission of Nigeria (2015), Commission Puts 2015 Power Need at 31,240MW (http://www.energy.gov.ng/index.php?option=com_content&view=article&id=121) Accessed 26 October 2017
[9] African Development Bank (2009), Nigeria: The Economic and Power Sector Reform Program Appraisal Report (https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Nigeria_-_The_Economic_and_Power_Sector_Reform_Program__EPSERP__-_Appraisal_Report.pdf) Accessed 26 October 2017

lines on a per capita basis. Cote d'Ivoire has 198km of lines per million people, versus 80km per million people in Nigeria.

Moreover, the transmission system is in a poor state. Transmission lines are regularly overloaded, and transmission losses average 7.4%.[10]

The distribution network is composed of 23,800km of 33kV lines and 19,200km of 11kV lines. This is comparable to the length of distribution lines in Côte d'Ivoire, which has 42,300km of medium and low voltage distribution lines.

Deficiencies in power infrastructure development result from a lack of liquidity, revenue shortfalls, and accumulating deficits in the sector. In 2017, the Government found that about 1,600 electrification projects (almost all concerning grid extension) had been abandoned by contractors over the previous five years.[11] Tariffs are too low for private companies to renew their distribution assets, let alone expand the grid, in financially sustainable conditions. In 2002, NEPA charged NGN4.5 per kWh for a cost of service of NGN10 per kWh.[12] In 2015, DisCos charged on average NGN27 per kWh, for a total cost of NGN35 per kWh;[13] and the Association of Nigerian Electricity Distributors (ANED) reports losses by the DisCos of over NGN10 per kwh.[14] High levels of losses put revenue under further strain. Before 2005, distribution losses were as high as 45%.[15] In 2016, DisCos' average technical and commercial losses amounted to 54%.[16]

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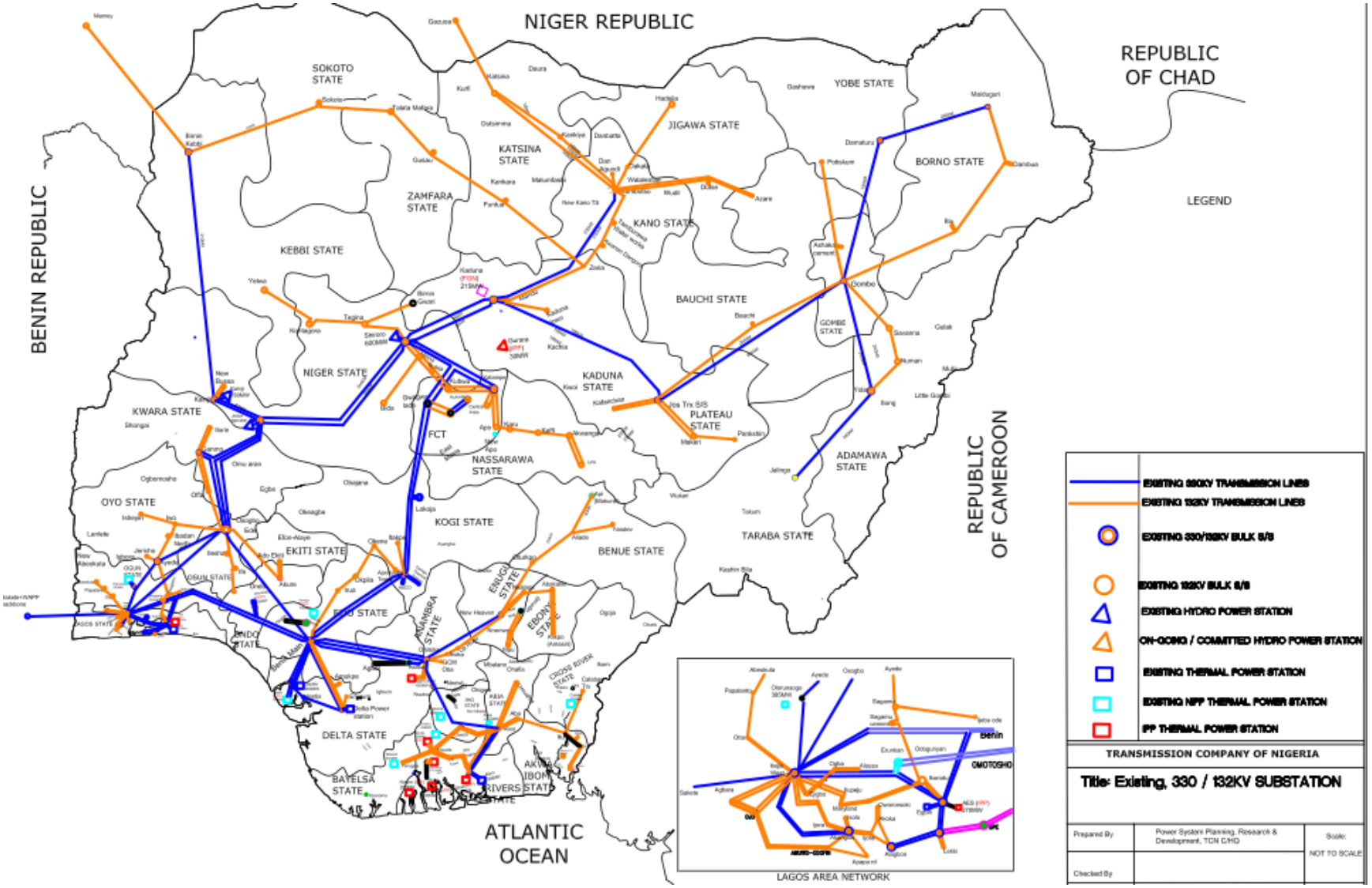
[10] NERC (2017). Transmission http://www.nercng.org/index.php/home/nesi/404-transmission Accessed 30 August 2017
[11] Nigeria Electricity Hub (17 August 2017). 1,600 Rural Electrification Projects Abandoned – REA http://www.nigeriaelectricityhub.com/2017/08/17/1600-rural-electrification-power-projects-abandoned-rea/ Accessed 30 August 2017
[12] Boniface O. Anyaka, Chudi J. Edokobi (2014). The Negative Impact of High Electricity Tariff on Consumers/End-Users in Some Developing Countries. OSR Journal of Electrical and Electronics Engineering http://www.iosrjournals.org/iosr-jeee/Papers/Vol9-issue3/Version-3/F09332734.pdf Accessed 30 August 2017
[13] Estimate based on Association of Nigerian Electricity Distributors (2015), ANED Analytics Reports (http://www.anedng.com/resources/analytics-reports/) Accessed 30 August 2017
[14] Daily Trust (9 December 2016). Electricity suppliers say operating at loss (https://www.dailytrust.com.ng/news/business/electricity-suppliers-say-operating-at-loss/175166.html) Accessed 30 August 2017
[15] Banwo & Ighodalo (2006). Reform and Evolution: The New Nigerian Electric Power Supply Industry (http://www.banwo-ighodalo.com/assets/resources/a6fe7aa55db61f55df68a0085c8a9eb4.pdf) Accessed 30 August 2017
[16] World Bank (2017). *Program-for-Results Information Document (PID), Power Sector Recovery Performance Based Loan* (http://documents.worldbank.org/curated/en/266341497992825758/pdf/Nigeria-Power-Sector-Recovery-P4R-Concept-Stage-PID-8-3-2017.pdf) Accessed 30 August 2017

Figure 3.6: Nigeria's Transmission Network and Generation Plants

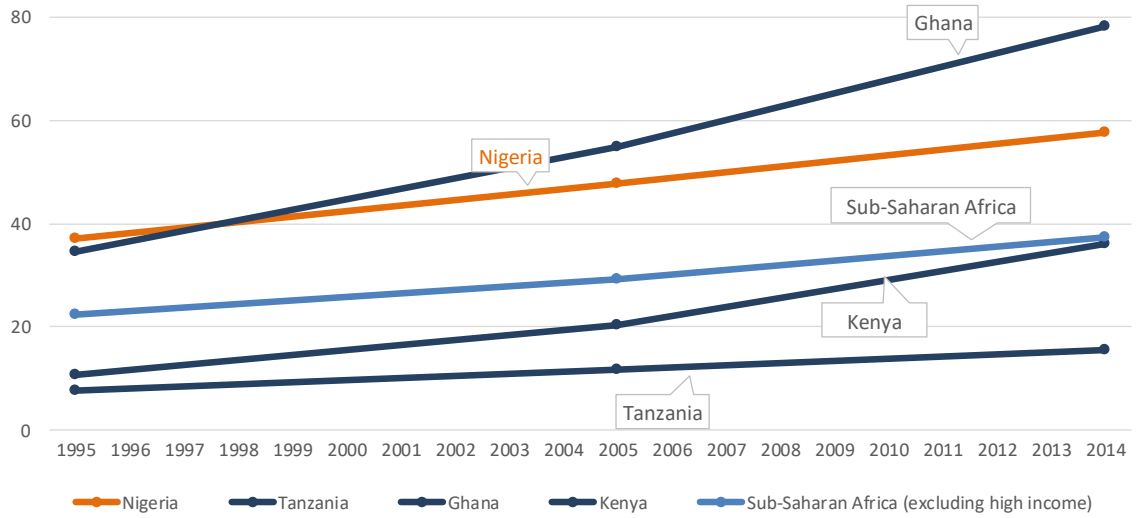


Source: Nigeria Electricity System Operator (2016)

3.3 ACCESS TO ELECTRICITY: MAIN GRID AND MINI GRIDS

Electrification in Nigeria has steadily increased in the past two decades. The share of people connected to the main grid rose from 27% in 1990 to 58% in 2014. In comparison, the overall rate of electrification for Sub-Saharan Africa is 38%.[17] Figure 3.7 shows that connection to electricity service in Nigeria is higher than other Sub-Saharan African case study countries (Kenya and Tanzania) and Ghana (the major neighboring country), as well as Sub-Saharan Africa's average.

Figure 3.7: Access to Electricity (% of population), 1995-2014



Source: World Bank, Electricity Access, http://data.worldbank.org/indicator, accessed July 10, 2017

Many more households have access to the main grid than are connected to it, and connected households that actually receive electricity from the grid are even less. According to the Government, 80% of the population have access to the grid. NEPA significantly expanded its transmission and distribution lines from the 1970s to the 1990s, with the support of international aid. The grid might reach a town, but not all its inhabitants might be connected to it, hence the discrepancy between access and actual connection to the grid. Mainly because of poor maintenance, the share of population served by the grid is lower than that connected to it. 43.2 million people receive electricity from the grid, which represents 23% of the population, compared to the connection rate of 58%.

The share of population connected to mini grids is tiny when compared to the population connected to the main grid. In 10 years, the population connected to mini grids grew to an estimated 9,000 in 2015. But (as Table 3.2 shows) the main grid still serves 3,400 times as many people as mini grids. Comparing the evolution of the population with electricity connection to the main grid and to mini grids is not possible based on data made available for this study.

[17] International Energy Agency (2016), *World Energy Outlook 2016*

Table 3.2: Evolution of Population with an Electricity Connection, Grid and Mini grids, 1995, 2005, 2015

		1995	2005	2015
Population		108.4	139.6	182.2
Urban	Million	35.2	55.0	86.6
Rural		73.2	84.6	94.6
Population served by the main grid	Thousand	N/A	N/A	30,799.0
Population served by mini grids	Thousand	N/A	Negligible	9.1

Mini grids offer a moderately more expensive but far more reliable service than the main grid. As Table 3.3 illustrates, mini grid customers pay on average twice the average tariff of the grid. Importantly, relatively low tariffs are the result of subsidies (see section 8.4). Under subsidized tariffs, mini grids typically supply electricity for a time period two to three times longer than the main grid.

Table 3.3: Mini grid and Main Grid Summary Statistics, 2015

		Main Grid	Mini Grids
Customers served	Thousand	7,000.0	1.81
Share of total customers served	%	99.99%	0.01%
Average tariff[1]	US$/kWh	0.08	0.36
Availability of electricity[2]	Hours of service/day	9	▪ 24 hours: 2 ▪ Between 16 and 24 hours: 5

Sources: GVE Group (2015, 2017), confidential source

Note: (1) The average tariff of mini grids gives an estimate. Data on tariffs come from GVE Group and our confidential source, and might differ from other developers' tariffs.

(2) Data on hours of service per day were not made available for this study for all developers.

4 | POLICY SETTINGS FOR MINI GRIDS

The Government has made recent efforts to establish a comprehensive framework for mini grids and increase their penetration in Nigeria. The NERC has issued a comprehensive regulation for mini grids in 2016. The REA has committed to rolling out several hundred mini grids to connect unelectrified customers. The REA intends to let the private sector carry out the development of financially sustainable mini grids. It will provide grants both to solicited and unsolicited mini grids. Finally, the REF has released its operating guidelines which were approved in October 2017, and has launched its first call for expressions of interest.

4.1 FROM UNREGULATED TO REGULATED MINI GRIDS

Early operators developed off-grid generation because the main grid neither extended to isolated areas nor met electricity demand reliably. Less than 15% of the population is connected to the main grid in most Nigerian states. Those who are connected suffer from poor service. Nigeria ranks first both in electrical outages per month and average outage duration in Africa with 33 power outages per month, each averaging 12 hours in 2014. 71% of firms owned or shared a generator[18] to compensate for the grid's deficiency.

Until recently there was no regulation of mini grids. Before the Act, industries built diesel- and furnace oil-fueled embedded generation capacity. These generating units supplied customers and, sometimes, neighboring communities through radial distribution networks. These mini grids were not regulated.[19] Following the Act, mini grids in rural areas still developed slowly and informally because their capacity was not large enough to fall within the scope of the Act, which made licenses mandatory only for systems with generating capacity above 1MW or distribution capacity above 100kW.

With the Regulations, the NERC adopted an overarching regulatory framework specific to mini grids in 2017. The Regulations apply to systems smaller than 1MW. Systems greater than 1MW remain regulated by the Act and the 2012 Regulations for Independent Electricity Distribution Network (IEDN).

4.2 POLICY APPROACH TO NATIONAL TARIFF

Nigeria does not have a national uniform tariff. The only feature that tariff settings of different entities share is the methodology used to calculate them, the MYTO.

The MYTO methodology is based on a building blocks approach with incentives. The Act defines it as a methodology that "allows a licensee that operates efficiently to recover the full costs of its businesses activities, including a reasonable return on the capital invested in the business".[20] For generation tariffs, the methodology uses the asset base and the long run marginal cost of the most economically efficient new entrant, typically a gas-fired plant. For retail tariffs, including those of mini grids (see section 8.1), the methodology takes into account the cost of electricity, regulatory and market administration charges, and distribution costs. The methodology uses the following building blocks:

[18] World Bank (2017), *World Bank Enterprise Survey* (http://www.enterprisesurveys.org/data/exploretopics/infrastructure#sub-saharan-africa) Accessed 10 October 2017

[19] Odubiyi and Davidson (2003), *Distributed Generation in Nigeria's Electricity Industry Deregulation – Assessment and Integration*

[20] Federal Government of Nigeria (2005), *Electricity Sector Report Act* (Article 76)

- A fair return on capital, based on a Weighted Average Cost of Capital (WACC) determined with the Capital Asset Pricing Model[21,]
- A fair rate of depreciation, following the method of depreciated optimized replacement cost, and
- Efficient operating costs.[22] In determining their tariffs, mini grids applying for a license are allowed a maximum of 10% of technical and 10% of non-technical losses.

The NERC carries out reviews of the MYTO. In theory, the NERC should provide a 15-year tariff path, and make major reviews of the MYTO every five years, and minor reviews once or twice a year.[23] However, in practice the NERC has deviated from this schedule. The MYTO established in 2015 runs through 2024; and the NERC has started a major review in preparation of the issuance of a new MYTO.

Tariffs set by the NERC vary substantially between the different DisCos. For 2018, average tariffs range from NGN24 per kWh (US$0.07 per kWh) to NGN43 per kWh (US$0.12 per kWh). At the low end of the spectrum, NERC allows Eko DisCo and Ikeja DisCo to charge respectively NGN24 and NGN25 per kWh on average. On the high end, NERC allows Jos DisCo and Port Harcourt DisCo to charge respectively NGN42 and NGN43 per kWh on average. Such differences are due to variations in the cost of electricity, and in DisCos' distribution costs associated with billing, metering, marketing, and revenue collection, among other factors.[24]

4.3 EXPANSION PLANNING

The high voltage (HV) system is centrally planned. The TCN designs the HV expansion masterplan, and builds and operates the HV lines.

DisCos and mini grids are responsible for expanding the medium voltage (MV) system. DisCos plan grid expansion in their area. The Regulations let registered mini grids choose a site, but restrict the possibilities for location of mini grids that apply for a permit. Developers applying for a permit must install their systems in "unserved" and "underserved" areas:

- Isolated mini grids are eligible for permits in "unserved areas", that is, areas that have not been assigned to another IEDN, or are not already subject to DisCos' five-year expansion plans approved by the NERC. Isolated mini grids may install in unserved areas that are part of a DisCo's expansion plan only if they receive the written consent of the DisCo. Once a site has been identified, the mini grid developer must sign an agreement with the community to be connected**.** This agreement is different from the tripartite agreement that interconnected mini grids must provide.
- Interconnected mini grids are eligible for permits in "underserved areas", defined as areas "within a Distribution Licensee's Network with an existing but poorly supplied or non-functional distribution system".[25] They must sign a tripartite agreement with the DisCo and the

[21] Between 2008 and 2012, the NERC assumed a real pre-tax WACC between 7.9% and 10.8%. NERC (2013) Multi-Year Tariff Order July 2008-June 2013 (https://www.iea.org/media/pams/nigeria/NIFERIA_MYTO1_FIT_20082013.pdf) accessed 10 October 2017. For the period between 2012 and 2018, the NERC assumed a real after-tax WACC of 7%. NERC (2015) Multi-Year Tariff Order 2015 (http://www.nercng.org/index.php/component/remository/MYTO/MYTO-2/2012-MYTO-for-Distribution/?Itemid=591) Accessed 10 October 2017

[22] NERC (2017), Electricity Tariff in Nigerian Electricity Supply Industry (http://www.nercng.org/index.php/home/myto) Accessed 15 August 2017

[23] NERC (2017). *Notice of review of the Multi Year Tariff Order (MYTO) Methodology, 2017*. (http://www.nercng.org/index.php/media-library/public-notices/511-notice-of-review-of-the-multi-year-tariff-order-myto-methodology-2017) Accessed 10 October 2017

[24] NERC (2015). MYTO 2015 (http://www.nercng.org/index.php/library/documents/MYTO-2015/) Accessed 10 October 2017

[25] NERC (2016), *Regulations for Mini Grids*

community to be connected. The NERC provides a model agreement with the community in Annex 11 of the Regulations. Given the broad the definition of "underserved area", DisCos face competition from mini grids in most areas in the country.

Mini grid developers can request information to the NERC about DisCos' expansion plans. DisCos must share their expansion plans with the NERC, but have no obligation to publish them. The Regulations provides for developers applying for a permit for isolated mini grids to request to the NERC whether identified sites are within any DisCo's 5-year expansion plan. For example, GVE's project in Bisanti could obtain the DisCo's expansion plan with the support of the NERC.

A new approach to accelerate mini grids roll out combining top-down and bottom-up approaches is planned. The REA wants to roll out mini grids at scale, using a top-down approach with solicited proposals in a first phase, and a bottom-up approach with unsolicited proposals in a second phase. Initially, the REA intends to issue calls for tenders for mini grids, in packages of 50 sites and more. It issued its first call for capital projects in 2017. Then, it aims to provide investors with data on the most viable sites, let them choose which ones they are interested in investing, and bridge any viability gap through funding from the REF (see section 8.3).

5 | OVERVIEW OF THE MINI GRID SECTOR

Nigeria has 11 isolated renewable energy-powered mini grids serving about 9,100 people[26] in unserved areas. Their combined installed capacity is about 236kW. All of them operate under the regulation's threshold of 100kW. None operate in underserved areas.

GVE and Nayo Tropical Technology ('Nayo') are the main players in the mini grids market. GVE and Nayo account for more than two thirds of all mini grid capacity, with a total of about 92kW and 99kW respectively. Another significant player is Rubitec Solar with a 85kW solar project in Gbamu Gbamu.

5.1 MINI GRIDS TECHNOLOGIES

Mini grid generation in Nigeria evolved from fossil to renewable sources of energy over the past two decades. From the 1990s until the end of the 2000s, almost all mini grids were diesel-fired. Today, all of Nigeria's 11 mini grids use renewable sources, with solar PV as the dominant technology, in combination with batteries (for example, a 50kW project by GVE in Bisanti).[27] One mini grid uses biogas (Ajima Farms in Rije, 20kW),[28] and two use hybrid solar PV-diesel systems.

5.2 BUSINESS MODELS

No mini grids are regulated. Mini grid entrepreneurs have stayed under the permit threshold of 100kW because they are not yet fully comfortable with the regulation, especially regarding tariff-setting. Mini grid entrepreneurs are less concerned with assets compensation by the DisCo, since they can choose locations that the grid is unlikely to reach before the financial payback period; based on site visits, these

[26] Based on available information shown in Appendix [A]
[27] ECREEE (2016), *op. cit.*
[28] Power Link (27 June 2017), *Firm powers Rije village with 20 kW biogass, prepaid meters* (http://powerlinks.news/article/3b7ba4/firm-powers-rije-village-with-20kw-prepaid-meters) Accessed 10 October 2017

can range between 10 and 15 years. GVE selects sites at least 10km away from the grid to stay clear of interconnection with Abuja DisCo in the long-term.[29]

Operating mini grids provide energy competitively compared to the alternatives of grid and diesel-powered self-generation. In Bisanti, GVE charges a price of NGN208 per kWh (US$0.58 per kWh). The grid provides power at a lower price (between NGN4 and NGN24 per kWh in 2015 for Abuja DisCo). However, supply from the DisCo is very unreliable, with less than three hours of supply per day in the connected village closest to the GVE mini grid in Bisanti. Another mini grid developer intends to charge a price of NGN140 per kWh in another location (US$0.39 per kWh). According to customers interviewed during field visits, diesel self-supply is much more expensive, at around US$50 per month, compared to an average household bill between US$3 and US$6 per month with mini grid.

Most mini grid customers include both households and businesses. Economic activity is one of the key parameters GVE looks at when choosing a site. One mini grid developer plans on having 89 commercial and industrial customers. Nayo's mini grid in Awka provides power exclusively for productive customers, notably timber producers.[30]

Mini grids use a limited array of business models. The main commercial solutions used by operators are:

- A combination of smart prepaid meters together with scratch cards, and a connection fee paid once.[31] In Vincente, customers purchase credit from the local GVE representative. The representative then requests a code from GVE's staff, which the customer inputs in its meter. The meter is credited with the amount of energy purchased.
- The Pay-As-You-Go (PAYG) model using a mobile phone, particularly for solar systems. Arnergy, through its 'solar rental system', allows customers to pay a daily fee of NGN50 (US$0.14) for a 'tier 2' service.[32]
- Cross-subsidies. For example, in Tunga Jika, Nayo charges a higher tariff to business customers (a market and mills for agro-processing), and offers an upfront subsidy for connection and bulbs to residential customers.

6 | AUTHORIZING MINI GRID OPERATORS

The Government made significant efforts to establish formal processes for authorizing mini grids in the past 10 years.

- Before 2005, mini grids operators did not need a license of any kind.
- The Act made licenses mandatory for systems larger than 1MW (generating capacity) and 100kW (distributing capacity). The NERC grants the licenses. However, under the Act, mini grids above the aforementioned thresholds are not considered as mini grids, but as IPPs.

[29] Site visits, August 2017
[30] Site visits, August 2017
[31] ECREEE (2016), op. cit.
[32] Medium (2016), Conversation with Kunle Odebunmi of Anergy (https://medium.com/@GridlessAfrica/conversation-with-kunle-odebunmi-of-arnergy-payg-solar-home-systems-671d06deb3fc) Accessed 30 August 2017

- The Regulations completed the framework for authorizing mini grids. They define mini grids as "any electricity supply system with its own power Generation Capacity, supplying electricity to more than one customer".[33]

Table 6.1 presents the requirements for obtaining a registration, a permit, and a license.

[33] NERC (2016), *Regulation for Mini Grids 2016* (Article 3)

Table 6.1: Requirements for registration, permit, and license

	Registration	Permit	License
Size (Generation capacity)	Less than 100kW	Between 100kW and 1MW	N/A
Location	No restriction	▪ Isolated: restricted to unserved areas, except when local DisCo gives written consent for an underserved area not assigned to another IEDN ▪ Interconnected: restricted to underserved areas	N/A
Exclusivity	▪ Isolated: 12-month exclusivity upon agreement with the community, renewable once ▪ Interconnected: N/A		
Administrative procedure	▪ Isolated: Developer identifies an unserved area; Developer submits online registration application to NERC ▪ Interconnected: Developer identifies a community that is (1) underserved (2) willing to pay higher tariffs than for the main grid; Developer signs a tripartite contract with local DisCo and the community containing usage right, construction and ownership right for additional infrastructure, tariffs for purchase and sales to DisCo and the community; Developer sends online registration application to NERC; Developer submits proposal to DisCo ▪ NERC gives decision within 30 days upon receipt in both situations ▪ Developer that is awarded a grant by the REA must reach and sign a Grant Agreement with the REA within 6 weeks. The Grant Agreement does not affect the registration application	▪ Isolated: Developer identifies an unserved area, and signs an agreement with the community; Developer submits online permit application, confirmation of non-interference with DisCo's 5-year expansion plan or DisCo's written consent, and agreement with the community to NERC ▪ Interconnected: same as registration, except the developer sends online permit application to NERC ▪ NERC gives decision within 30 days upon receipt in both situations ▪ Developer that is awarded a grant by the REA must reach and sign a Grant Agreement with the REA within 6 weeks. The Grant Agreement does not affect the permit application	N/A

	Registration	Permit	License
Relevant information required	▪ Generation: location; source and sizes of generation systems; storage and inverters ▪ Distribution: intended area of distribution; type and sizes of lines; type and number of poles; type and size of transformer ▪ Economic, Financial and Commercial: number of customers by type; expected electricity sales; tariff; share capital contribution; loan capital, and other sources of funding (see Appendix B for registration, and Appendix C for permit)	N/A	
Tariff	▪ Isolated: Developer sets tariff through MYTO calculation tool or agreement with the community ▪ Interconnected: Developer agrees with the DisCo and the community ▪ NERC approves or rejects	▪ Isolated: Developer must use MYTO calculation tool to determine tariff, and attach calculation spreadsheets to its application ▪ Interconnected: 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 retail tariff, and calculation spreadsheets must be attached to the application ▪ NERC approves or rejects	N/A

Sources: FGN (2005), Electric Power Sector Reform Act, NERC (2010), Regulations for the Application of License, FGN (2012), Independent Electricity Distribution Network Regulations, NERC (2016), Regulations for Mini Grids

The Regulations distinguish three types of mini grids, with different procedures according to their size and whether they are isolated or interconnected:

- Isolated systems of less than 100kW of distributed power per site may ask for a permit or simply go through a mini grid registration procedure with the NERC. If they choose to register, the NERC simply gives a non-objection. The advantage of obtaining a permit lies in the possibility to be compensated when the grid arrives**.**
- Isolated mini grids with more than 100kW of distributed power and generation capacity of up to 1MW per site must apply for a permit, and must have an agreement with the Community**.**
- Interconnected mini grids, regardless of their size, must sign a binding Tripartite Contract with the local DisCo and the Community, instead of applying for a permit. The NERC approves the contract. The contract must contain**:**
    - The tariff for electricity generated by the mini grid and fed into the DisCo network (if applicable),
    - The agreement of the Connected Community to purchase electricity from the mini grid, and
    - The usage right for the interconnected mini grid, that is, the right for the mini grid developer to use the DisCo's network infrastructure.
- Interconnected and isolated mini grids with generation capacity above 1MW are not considered mini grids, but IPPs.

Requirements for public disclosure differ according to the type of authorization. Mini grid developers who apply for a registration are not bound to publish a notice of application. In practice, developers try to involve communities to ensure support for the projects. Mini grid developers who apply a permit have to disclose their plans to the community as they must sign an agreement with it.

The NERC is bound to grant or deny a permit or license within 30 days upon receipt of the application. If the NERC objects to a registration or denies a permit, it must state in writing its reasons to the applicant.

Isolated mini grid developers may benefit from a 12-month exclusivity period upon agreement with the Community. This period may be renewed once pending the Commission's approval, as long as the site is outside the five-year extension plan of the local DisCo.

An ambiguity in the Regulations may enable developers to build systems of capacity greater than 100kW and still stay under the 100kW threshold. The ambiguity is that several distribution systems under 100kW linked by a feeder line to a generation facility under 1MW can be considered as separate projects, according to the regulation. None of the currently operating mini grids has used this strategy, but our site visits suggest that some developers are planning on doing so.

Mini grid developers must provide other documents when applying for a registration or permit:

- A certificate of incorporation, memorandum and articles of association, deed of partnership or deed of trust,
- A certificate of occupancy, that is, a land permit, delivered by the State Ministry of Land,
- Building permits, issued by the State Government and approved in three or four months,
- Filled standardized spreadsheets used for tariff calculation, with a template provided by NERC on its website, and
- For mini grids that interconnect, six schedules are contained in the Regulations, which must be signed by the mini grid operator, the DisCo, and the community: map of the interconnected

network, list of deficiencies in the distribution grid, distribution network infrastructure installed by the mini grid operator, map of pilot for power generation assets, diagram of fixed infrastructure for generation assets, and boundary values of the distribution grid.

The Regulations generally require mini grid developers to comply with all applicable environmental legislation. Mini grid developers must perform an analysis of the environmental effects of the project. If the analysis reveals that the project would affect the environment, the developer must undertake an environmental impact assessment, but the NERC does not require a sign off by any environmental agency to approve the application.

Some mini grids have voluntarily sought to obtain other clearances to gain more political guarantees and security. In Tunga Jika, Nayo obtained a State Memorandum of Understanding (MOU) with the State Ministry of Works and Infrastructure to use the distribution network, which is the State's property under the 'split asset model' (see section 8.2). It also obtained a Community Agreement (signed with the community head) that includes the tariff as well as additional services provided by the mini grid, such as street lighting. Together with the certificate of occupancy and the building permits, these documents were integrated into a single 'canopy agreement'.

7 | TECHNICAL AND SERVICE STANDARDS

Compliance with standards varies according to the type of authorization. Registered mini grids must apply minimum technical requirements and ensure quality of service, in accordance with their agreements with the beneficiary communities. They are recommended, but not required to follow the Technical Guidelines for registered mini grids (annexed in the Regulations) and the Distribution Code. In Bisanti, GVE agreed to follow the DisCo's standards.

Mini grids that hold a permit, whether isolated or connected, are bound to follow the Grid Code, the Distribution Code, and the Health and Safety Standards. They must:

- Maintain operational voltage between:
  - 94% and 106% of the nominal voltage value of lines between 230V and 415V, and 33kV,
  - 95% and 105% of the nominal voltage value of lines between 415V and 33kV,
- Maintain frequency between 48.5 and 51.75Hz,
- Notify users of outages at least 72 hours in advance, and
- Report significant incidents to the NERC within 24 hours, defined as malfunctioning of equipment, or injury to a person or an animal due to electrical causes.

Table 7.1 compares the technical standards for permitted and licenses mini grids, and registered mini grids.

Table 7.1: Technical Standards for Licensed, Permitted, and Registered Mini grids

	License and Permit	Registration
Voltage	Between 94% and 106% of the nominal voltage value of lines between 230V and 415V, and 33kV	Between +/- 10% of its nominal value at the consumer's site

	Between 95% and 105% of the nominal voltage value of lines between 415V and 33kV	
Frequency	Between 48.5-51.75Hz	Between +/- 20% of its nominal value
Treatment of outages	Must notify users at least 72 hours in advance	None
Treatment of incidents	Must report to the NERC within 24 hours	None

Sources: NERC (2005) Grid and Distribution Codes, NERC (2016) Regulations for Mini Grids

8 | TARIFFS, FINANCING, AND SUBSIDIES

The NERC regulates the tariffs of mini grids to different extents depending on the type of authorization involved. Different subsidy mechanisms are available to help mini grids extend electrification and comply with quality standards.

8.1 SETTING RETAIL TARIFFS

The process for setting retail tariffs evolved alongside the regulation. Before 2005, mini grid operators charged a tariff agreed with the local stakeholders. On the basis of the Act and the Regulations, the NERC would set mini grids' tariffs for projects with a permit, according to the MYTO methodology.

The Regulations allows unsolicited mini grids to set a cost-reflective tariff with efficiency incentives, following processes that differ according to the type of mini grid. Interconnected mini grids must agree with the DisCo and the community on the retail tariff, and with the DisCo on a user charge for the DisCo's distribution grid and, if applicable, on the tariff for the electricity fed into the DisCo's network by the mini grid. Only the retail tariff must be determined using the MYTO. The agreed tariffs and charges still must be approved by the NERC. The Regulations do not consider cases where the interconnected mini grid would not use the DisCo's facilities. Isolated mini grids that apply for a permit calculate their own tariff, following the MYTO methodology provided by the NERC. The tariff must be approved by the NERC. These rules might change for solicited mini grids that submit proposals, and might be subject to tariff constraints set by the REA.

The NERC designed a MYTO tariff calculation tool for mini grids, which it made available to the public on its website. The model is based on the original MYTO methodology that NERC uses to set DisCos' tariffs. The main difference is that the model for mini grids does not include transmission costs. Mini grids that apply for a permit must attach the filled calculation spreadsheets to their application.

Processes also differ according to the kind of authorization. The NERC must approve tariffs for mini grids with a permit, while registered isolated mini grids are free to set their tariffs. They can, but are not bound to, use the MYTO methodology, or determine their tariff through an agreement with the community served—customers from that community must represent at least 60% of the electricity output of the community. In the latter case, the Commission has the right to adjust the tariff when the operator's rate of return on capital invested exceeds a usual non-recourse commercial debt interest rate in local currency, that is, 6%. This means that the NERC may impose ex-post tariff regulation on

registered mini grids, although registered mini grids entrepreneurs do not seem concerned by the NERC intervening in practice.

Developers of all mini grids are allowed to adjust their tariffs when the actual costs incurred or the actual revenue earned deviate from the ones stated in the tariff definition phase with the Commission. To do so, the mini grid developer may adjust input parameters for tariff calculation to actual values, using the MYTO methodology. The new tariff defined must be approved by the NERC.

In practice, most mini grids set their tariffs on their own to stay under the 100kW threshold. Some registered mini grids have negotiated the tariff with the community to increase the support and customer base, and signed an agreement with the community. However, the agreement is not clear on tariff adjustment rules. Others, like GVE, set their tariff entirely independently, without using the MYTO or negotiating with the community.

As Table 8.1 highlights, tariffs in NGN per kWh have remained constant. This is because GVE was the only player in the market in 2013 and 2014; a second player, Arnergy, commissioned its first mini grid in 2015, but no data on its tariff were made available for this study. Fluctuations in the NGN/US$ exchange rate explain the fluctuations in the US$ tariffs.

Table 8.1: Evolution of Tariffs, Isolated and Connected Mini grids, 2011-2015

		2011	2012	2013	2014	2015
Isolated mini grids	NGN/kWh	N/A	N/A	120	120	120
	US$/kWh	N/A	N/A	0.75	0.66	0.60
Connected mini grids	NGN/kWh	N/A				
	US$/kWh					

Source: GVE Group (2015, 2017); confidential source

8.2 TYPE OF SUBSIDIES AVAILABLE

Few types of subsidies are available. As shown in Table 8.2, these are concessional loans, capital grants, and technical assistance.

Table 8.2: Overview of Subsidies Available

Project stage	Explicit Subsidies	Implicit Subsidies
Design	None	Technical Assistance
Finance	Concessional Loans	None
Construction	Capital Grants	None
Operation	None	None

Sources: GIZ (2015), Bank of Industry (2017), REA (2017)

All mini grid projects in Nigeria have benefited from some form of subsidy. So far, subsidies from which mini grids have benefitted have been mostly capital grants to develop pilot projects from donor agencies, such as the United Nations Industrial Development Organization (UNIDO) or the German Technical Cooperation (GIZ). For example, GIZ supports mini grids through the 'split asset model'. The split asset model de-risks the project from the point of view of the entrepreneur. The grant is used to

build the distribution grid, the ownership of which is transferred to the State. The State then leases the distribution grid to the entrepreneur, and may require a return on the capital leased (no information on the size of the lease payment was made available for this study). The entrepreneur finances and owns the generation facility. This model protects the entrepreneur, because in case of expropriation generation assets are easily removable. All of GVE's mini grids use this model. Nayo also used it for its project in Tunga Jika, but had to reverse it due to the depreciation of the Naira (from NGN200 to NGN500 per US$), so the grant funded the generation assets instead of the distribution assets.

Capital grants have allowed tariffs to reduce by up to 25%. For example, one mini grid charges NGN140 per kWh (US$0.39 per kWh) instead of a cost-reflective tariff between NGN210 and NGN220 per kWh (US$0.58 and US$0.61 per kWh).[34]

8.3 ELIGIBILITY TO GET SUBSIDIES AND SOURCES OF MONEY FOR SUBSIDIES

As illustrated in Table 8.3, sources of subsidies are GIZ, the Bank of Industry (BoI), and the REF. For currently operational mini grids, the main providers were GIZ and BoI.

Table 8.3: Eligibility and Sources of Funds, by Subsidy

Subsidy	Conditions	Eligibility	Sources of Funds
Technical assistance	In the future, REA will provide GIS data, and set up a database of potential viable sites. The REA will also support developers in acquiring permits and approvals	All mini grids	REA
Concessional loans	7% interest (against the 14% national benchmark)	Micro, small and medium enterprises	Bank of Industry
Capital grants	REF: ▪ 75% of the total capital costs of the project, with a minimum of US$10,000 and a maximum of US$300,000 ▪ Grants per connection, according to the SE4ALL Multi-tier framework: Tier 2: US$25 Tier 3: US$300 Tier 4: US$500 Tier 5: US$600 Split-asset model (GIZ): ▪ Assets financed with grants are leased to the State;	REF selects projects that: ▪ Target rural areas, and promote their socio-economic development; ▪ Are technically viable ▪ Demonstrate the constant availability of the energy resource, with renewable energy representing at least 30% of the system's supply, and the ability to provide reliably supply (less than 10 unscheduled blackouts per year) ▪ Are not financially viable for capital expenditure without	REF GIZ

[34] Estimate based on data provided by the developer.

	▪ The State leases it back to the developer ▪ Some States require a return on the leased capital	support, but are sustainable and will not require subsidies for operation expenditure; ▪ Will be operational within a year of the signature of the grant agreement	

Sources: BoI (2017), REF Operational Guidelines (2017), Field notes

The REF intends to become the main source of subsidies. To do so, it has recently adopted operational guidelines. The REF provides funding to bridge viability gaps of private mini grid developers.

The guidelines establish how the REF selects projects eligible for subsidies.[35] First, the REF defines the technologies that qualify for subsidies. In a first phase and in selected communities, it issues a notice about upcoming call for expressions of interest, and organizes a stakeholders' workshop. The aim of the workshop is to ease the bidding process by explaining and discussing the market potential of the areas covered by the call, the regulatory framework, the structure of the selection process, and the expectations from the bidders regarding financial aspects. Then, it issues a call for expressions of interest, followed by a call for proposals. In a second phase, it will let investors select the communities they want to serve. The REF intends to conduct prefeasibility studies itself, based on locations where it believes that clusters of communities could benefit from mini grids. Finally, the REF intends to check very precisely the assumptions and calculations of the application to make sure that they are not providing grants to projects that would have been otherwise financially viable.[36]

8.4 Level of subsidies

Subsidies usually represent a significant amount of project cost. Subsidies from the REF represent up to 75% of the total capital costs of the project. In Bisanti, the grant for the distribution grid represented 25% to 40% of total project cost; GVE also benefited from a concessional loan from the BoI. For other projects, grants represented more than half of capital expenditure (CAPEX).

8.5 Regulatory treatment of subsidies

Subsidies are lightly regulated. Mini grids can take depreciation on the equipment paid for by grants. There is no policy on returns made on CAPEX that is financed through grants.

9 | HANDLING THE RELATIONSHIP WITH THE GRID

The relationship with the grid is still a prospective issue, since no mini grid has dealt with the grid's expansion yet. Developers have installed mini grids in locations they estimate being far enough from the grid not to be concerned with its arrival before 10 to 15 years. However, the Regulations have addressed the issue.

[35] REA (2017), *Approved Operational Guidelines for the REF* (http://rea.gov.ng/inc/uploads/2017/11/Approved-Operational-Guidelines-for-the-REF-2017-v3.pdf) Accessed November 21, 2017

[36] Meetings at the REA, August 2017

9.1 WHAT HAPPENS WHEN THE GRID ARRIVES

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

Isolated mini grids operating with a permit have two options. The first option is to convert into an interconnected mini grid and become a Small Power Producer and/or a Small Power Distributor. The second option is to sell their assets to the DisCo in return for compensation. If the extension of the grid happens within five years of the commissioning of the mini grid operator, the compensation corresponds to the remaining depreciated value of assets, including construction and development costs. If the extension of the grid happens after the five years of the commissioning of the mini grid operator, the compensation corresponds to the remaining depreciated value of assets, excluding construction and development costs.

The DisCo must also pay the mini grid an additional compensation, whether the grid arrives before or after the 5-year threshold. This additional compensation equals the revenue generated during the 12 months before the date of interconnection or buyout. This aims at providing an incentive for mini grids developers to increase the load while preventing predatory behavior from DisCos. Such behaviors would consist of cases where DisCos let mini grids prove the economic viability of a location before expanding their network and taking the mini grids over for a low price.

NERC has the final say when parties cannot agree on the amount of compensation. As noted however, NERC has not played such role yet. There has never been any conflict so far, since no DisCo has extended its distribution system to an area already occupied by mini grids.

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

9.2 WHOLESALE TARIFF SETTING

The process for wholesale tariff setting is different from the one for retail tariff setting. Tariffs that interconnected mini grids pay the DisCo are determined upon agreement between them, instead of the MYTO. If they cannot reach an agreement, the interconnected mini grid and the DisCo must follow the guidelines provided in Annex 8 of the Regulations. These guidelines establish the average profit generated by the DisCo within the last 12 months and any operation and maintenance costs that are not transferred to the mini grid as the basis for the calculation of the wholesale tariff. Power sales from the mini grids to the DisCos are also set by an agreement between them, but the Regulations do not provide any further rule.

9.3 OBLIGATION OF UTILITY TO PURCHASE OUTPUT

There is no obligation for DisCos and NBET to purchase mini grid output yet. The Regulations do not address this question. This is because the formal development of mini grids is recent, and only isolated mini grids are operational or scheduled. This question may be settled in the future when developers will build interconnected mini grids, or when the grid will extend to isolated mini grids.

9.4 Power Purchase Agreements

No mini grid has signed a PPA with the main grid. This too is due to the recent formal development of mini grids, and the fact that only isolated mini grids are operational or scheduled. PPAs may be signed in the future when developers will feel comfortable installing close to the grid, or when the grid will extend to isolated mini grids.

10 | LESSONS LEARNT

The recent experience in regulation and the very small size of the mini grids market make for few lessons learnt supported by evidence. Overall, mini grids are succeeding at providing better quality supply than the public service, at a relatively contained and affordable price that is made possible by subsidies. The efforts at creating a comprehensive and clear framework are encouraging, but probably too recent to reassure investors.

The mini grid sector in Nigeria is growing after two decades of informal and slow development. Companies are showing increasing interest, based on more or less extensive background. For example, GVE was established in 2008 with a six-year plan to deploy 524 mini grids reaching one million customers. Nayo was in the solar business for 21 years before building its first mini grid in 2014; it plans to build four more grids in the Nigerian state of Niger.

Mini grids have greatly improved their economic and environmental sustainability. During the monopoly of NEPA, mini grids were fueled with expensive diesel. Today, all of them use renewable sources, and are competitive compared to diesel self-generation.

The regulatory and institutional framework for mini grids also greatly improved in the past two decades. Mini grid developers are now subject to regulations that are specifically designed for them, after developing informally up until the 2000s. Moreover, agencies aimed at supporting them have been reinvigorated financially and with increased institutional capacity recently.

As of today, mini grids developers do not yet feel comfortable working within the regulatory framework because of the lack of experience and track record of the regulatory system. We learned of no project above 100kW being prepared. Developers are mainly concerned with DisCos and their expansion to areas where isolated mini grids operate. To address this issue, they settle far away from the grid, and invest only in movable assets. Some developers are also concerned with possible political interference, and how it might deter investors who see it as a risk. They seek to protect themselves from potential expropriation from the Government in several ways by avoiding tariff regulation, or by obtaining the State government's endorsement.

Available subsidies have had a greater impact on the sector's development so far. All mini grid projects have benefitted from some form of subsidy. These subsidies have enabled them to access sources of financing and to lower their tariffs, making mini grids affordable to customers in rural areas. One mini grid (confidential source) stated it was able to lower its tariff by a third with subsidies, and consequently increased its customer base to a third of the village's population.

Appendix A: Information on Private Mini Grids

Location (State, Town)	Year	Type	kW	People served	Owner/Funding Source	URL
Privately owned, operational August 2017						
Rivers, Egbeke	2013	Solar PV	6	480	GVE	https://fr.slideshare.net/e4sv/ghana-may16-green-village-electricity-project
Rivers, Egbeke	2015	Solar PV	9	720	GVE	https://fr.slideshare.net/e4sv/ghana-may16-green-village-electricity-project
Rivers, Egbeke	2015	Solar PV	9	720	GVE	https://fr.slideshare.net/e4sv/ghana-may16-green-village-electricity-project
Gombe, Kolwa	2015	Solar PV	34	1,600	GVE	https://www.thenef.org/wp-content/uploads/2017/07/Austin_BOI_Presentation-for-Nigerian-Energy-ForumNEFdraft-revised-6.pdf
Niger, Bisanti	2016	Solar PV	34	1,600	GVE	http://www.ecreee.org/sites/default/files/editor/other/p40_ppt_gve_project_ltd.pdf
Kaduna, Dodan Karji	2017	Solar PV	16	443	ACOB Lighting Technolo	https://www.facebook.com/acoblightingtechltd/videos/vb.1767414803487230/1972595922969116/?type=2&theater
Delta, Oghriagbene	2017	Solar PV	16	N/A	ACOB Lighting Technolo	http://acoblighting.com/2017/07/19/16kw-solar-mini-grid-electrification-of-oghriagbene-in-bomadi-lga-of-delta-state-nigeria/
Rivers, Ihuama	2017	Solar PV	16	636	ACOB Lighting Technolo	https://www.thenef.org/wp-content/uploads/2017/07/ACOB-Presentation-Renewable-Technologies-for-Rapid-Rural-Electrification-modified.pdf
Osun, Idi-Ata/Onibaml	2015	Solar PV	24	1,180	Arnergy	http://orientalnewsng.com/2015/10/bol-commissions-24-kw-micro-grid-solar-in-communities-in-osun/
Edo, Obayantor 1	2016	Solar PV	38	1,180	Arnergy	http://arnergy.com/minigrid
FCT, Rije	2017	Biogas	20	500	Waste-2-Watt / Ajima Far	http://e4sv.org/wp-content/uploads/2016/08/WR20-Smart-Villages-in-West-Africa_Accra-regional-workshop-report_webfinal.pdf https://www.bridgesforenterprise.com/single-post/2017/02/20/28-startups-16-countries-one-mission http://powerlinks.news/article/3b7ba4/firm-powers-rije-village-with-20kw-prepaid-meters
12			**246**	**10,239**		
Privately owned, not operational August 2017						
Niger, Tunga Jika		Solar PV	100	280 households, 50 businesses	Nayo	Field notes
Sokoto, Kurdula		Solar PV Hybrid	90	N/A	GoSolar	https://cleanenergysolutions.org/sites/default/files/documents/2016-11-15-transcript.pdf https://www.esi-africa.com/news/nigerian-state-enhance-rural-electrification-solar/ http://energyplatformnigeria.com/images/4-GoSolarAfrica_solar_minigrids_in_Sokoto.pdf
Ogun, Gbamu Gbamu		Solar PV Hybrid	85	292 households, 142 businesses	Rubitec Solar	http://energyplatformnigeria.com/images/2-Rubitec_solar_minigrid_in_Ogun.pdf

Notes: People served are estimated based on an assumption of about 200 households per typical village served (Bank of Industry, project funder), except for the Kaduna, Dodan Karji system where ACOB Lighting mentions 75 households; and the Rivers, Ihuama and FCT, Rije systems where the number of population is shown (although not all may be connected). The estimate also assumes 5.9 people per household on average.
Source for population and average household: Nigeria National Bureau of Statistics (2015), General Household Survey-Panel Wave 3 (Post Planting) 2015-2016, Third round (http://www.nigerianstat.gov.ng/nada/index.php/catalog/51/study-description) Accessed 30 August 2017

Appendix B: Application Form for Mini Grid Registration

[To be provided as part of final report/link on ESMAP website].

Appendix C: Application Form for Permit

[To be provided as part of final report/link on ESMAP website].