Clean Technology Hub
energy innovation centre

DRIVING MINI GRIDS DEVELOPMENT FOR RURAL ELECTRICITY ACCESS – THE CLEAN TECH HUB WAY

Faisal Hameed

Background

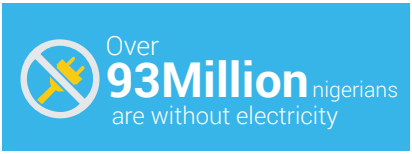
Over 93 million Nigerians or 40% of the population are without access to electricity and several millions of Nigerians connected to the grid experience unstable and irregular power supply on a daily basis with an average of only four hours a day[1].

The hardest hit in terms of energy poverty in Nigeria happens to be rural and deep rural Nigeria, where over 60% of the communities are unelectrified[2].

It is for this reason that the Federal Ministry of Power, Works and Housing unveiled a Power Sector Recovery Program which included the revamping of the power sector through the Rural Electrification Agency (REA)[3].

The Ministry of Power in 2015 also launched its Nigerian Energy Mix that defined a 30% target for renewable energy sources to be achieved by 2030[4]

The Nigerian Electricity Regulatory Commission (NERC) also unveiled the country's first ever Mini Grid



Regulations in 2016 for the development of Mini Grids in Nigeria. There is also the 2008 Captive Power Regulations[5], and the 2012 Embedded Generation Regulations[6] which are all driving rural electrification.

On April 21st 2017, a new board and executive for the Rural Electrification Agency (REA) was appointed by the Nigerian government to drive the country's Rural Electrification Strategy and implementation Program (RESIP). Since the appointment of the board and the executive, the REA has since become the lightning rod for driving distributed renewable energy in Nigeria – particularly Mini Grids.

In December 2017, the REA unveiled its Mini Grid strategy which includes the development of 10,000 Mini Grids by 2023[7]. As a result, there is an uptick in rural off-grid Mini Grid development

[1] 93m Nigerians have no access to electricity. Vanguard
[2] 93m Nigerians have no access to electricity. Vanguard
[3] Power sector recovery program
[4] FG targets 30 per cent in renewable energy mix by 2030. Punch newspaper
[5] Regulation for captive power generation in Nigeria. Nigerian Electricity Regulatory Commission.
[6] NERC (Embedded Generation) Regulations. Nigerian Electricity Regulatory Commission
[7] Off-grid electrification strategy. Rural electrification agency

with many other pipeline projects in development.

The REA's rural electrification strategy is hugely loans supported by the World Bank[8] and the African Development Bank (AfDB)[9] funding to the tune of $350 million and $150 million, respectively.

Furthermore, beyond rural electrification, several peri-urban and urban communities mostly in underserved communities are deploying standalone solar home systems (SHS) to meet their electricity needs.

With several rural communities in Nigeria that remain un-electrified, the advent of Mini Grid electricity into these communities is a novel development in these places. Consequently, several communities as well as micro, small and medium enterprises (MSMEs) run their businesses using Mini Grid electricity as opposed to the electricity from diesel and petrol generators which would otherwise be too expensive.

In general, the availability of electricity in such communities has far-reaching impact in these communities, especially in the areas of education, healthcare and agriculture.

However, Mini Grid electricity remains expensive and above what an average person in the community can afford.

This is because Mini Grid projects are capital-intensive and Mini Grid companies usually want to recoup their investments on time to meet their financial obligations.

Therefore, Mini Grid companies want to charge customers cost-reflective tariffs but such rural customers served by Mini-Grids despite their need for electricity access cannot afford these cost-reflective tariffs. This problem is prevalent in several Mini Grid communities. There is therefore the need to address this problem on affordability and ability to pay and the bridge the gap between consumers and Mini Grid developers.

The Nigerian Electricity Regulation defines Mini-grid as "... an integrated local generation and distribution system with installed capacity below 1MW, capable of serving numerous end users independent of the national grid. It also categorizes Mini-Grids into two types namely 'isolated' Mini Grids or 'interconnected' Mini Grids which are interconnected with the main grid." Isolated Mini-Grids by the NERC definitions are not connected to a distribution network and eligible for

[8] World Bank loan. Rural Electrification Agency
[9] FG secures fresh $200m loan from AfDB. The Cable

deployment in un-served areas; whilst interconnected Mini-Grids are connected to an existing Distribution Licensee's network, and eligible for deployment in underserved areas. GIZ, the German development agency which has conducted an extensive GIS mapping of Nigeria's Mini Grid potential estimates that about 4,000 population clusters that could use mini-grids to power 12.8 million people in Nigeria.

This strategy document highlights the impending issues affecting both the Mini Grid demand and supply sides. Subjects affecting these stakeholders will be analyzed critically based on the experience and expertise of Clean Technology Hub in the Mini-Grids sector.

Clean Technology Hub (CTH) is a pioneering hybrid hub for the research, development, demonstration and incubation of clean energy technologies in Africa, and their validation for commercial stage development. It is an early 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. CTH is focused on addressing Africa's energy poverty, increasing energy access through clean, renewable energy and sustainability.

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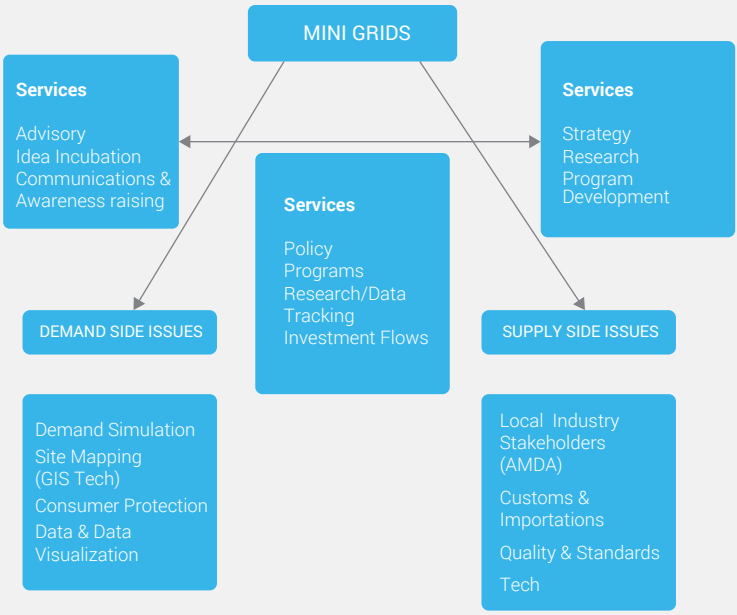
[8] World Bank loan. Rural Electrification Agency
[9] FG secures fresh $200m loan from AfDB. The Cable

Issue Definition in the Mini Grid sector

Mini-grids have major potential for rural electrification in developing countries; however the process of matching supply and demand is more challenging than for a national grid.

As the figure below shows there are a myriad of problems facing the Mini-Grid sector in Nigeria and mostly outside the core engineering of building the actual Mini Grids for deployment.

Figure 1: Clean Technology Hub minigrid mind map



A. Demand Side Issues

There are a number of demand side issues identified in the Nigerian Mini Grid sector – which will be distilled below into two broad categories – Demand side and Supply side.

1. Site mapping (GIS Technology)

According to Nordic Development Fund (NDF)'s Energy and Environmental Partnership (EEP) minigrid report, minigrids often struggle with demand side issues, of determining available community clusters, getting accurate customer data; getting the right payment data and platforms and using these to engage in demand simulation and piloting for Mini Grid issues.

The issue of inaccurate site mapping can lead to the wrong modeling or sizing Mini-Grids and eventually selling electricity far less than the amount of energy produced.[10] Many Mini Grid developers in Nigeria therefore because of lack of data spend significant time and resources, engaging in site scoping and site selection for many times the cost of what it would cost them if they deployed GIS technology.

This is why it is important to support the Mini Grid sector through adequate data such as site mapping necessary for Mini Grid development. Some of the scoping and site mapping for Mini Grids that can be enabled by GIS technology and would include load assessment,
demand projection, land acquisition, and community engagement. GIS technology is not new to the Nigerian power sector, and has for example being a part of the Eko Electricity Distribution Company which employs GIS for asset mapping and customer enumeration[11].

Similarly, Mini Grids site mapping can utilize GIS for accessing specific data in the intended Mini Grid community such as existence or nearness to the closest distribution grid, population, renewable resources and security[12].

2. Data and Data Visualization

Non-technical losses are a common problem for most utilities in Nigeria who are only able to capture 25 percent of their expected revenue . Most of these losses are as a result of customers bypassing their meters and

25%

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[10]Opportunities and challenges in the minigrid sector in Nigeria. Energy and Environment Partnership (EEP) Trust Fund. Nordic Development Fund (NDF).
[11]Exclusive interview with Engr. Oladele Amoda. ESI Africa
[12]Green minigrids in Africa. Green mini-grid help desk. Se4all.
[13]ICT & SDGs—How Information and Communication Technology Can Achieve the Sustainable Development Goals. Ericsson and the Earth Institute at Columbia University

one way to address this problem is to use both historical data and inspection data from customers to build a machine learning model for predicting non-technical losses[14].

Although Mini Grids are doing better than the utilities in terms of managing non-technical losses, there is still a lack of measured load data from the Mini Grids in Nigeria and other developing countries[15].

However, the only way the operation of Mini Grids and its socio-economic impacts can be measured is through data collection. Mini Grids generate a lot of data daily, for example, hourly total power generation from the solar PV systems, total daily power generation, and daily battery charging profile. The data from the customer side includes the hourly energy consumption per household, daily energy consumption per household and total daily energy consumption for the community. All of these data are important for monitoring the operations of the Mini Grid system and consequently planning, to reduce cost and increase battery life.

Nigerian Mini Grids at the moment do not have robust IT systems incorporated to harvest data, and where they do, mobile network is usually unavailable in the Mini Grid communities which are usually in remote areas. With an improved IT infrastructure, detailed energy consumption and socioeconomic data can be obtained from Mini Grid communities. Complementing these with satellite photography and mobile telecommunication data, predictions can be made about future energy demand in Mini Grid communities.

In addition, smart metering and pay-as-you-go (PAYG) has been embedded in the platform of a number of Mini Grids, but the data obtained has not been utilized well.

For example, Nithio and Ammp are two data analytics companies with recently incursions into the Nigerian market. Ammp; already established in Tanzania, provides a software platform which integrates various technologies for operating Mini Grids such as, smart metering, customer communications, payments, system monitoring, ticket management and consumer finance[16].

Nithio on the other hand uses Artificial Intelligence (AI) -driven analytics to interface between investors and Mini Grid operators in order to channel capital to the right Mini Grid operators[17].

[14] Energy analytics for development: Big data for energy access, energy efficiency, and renewable energy. Energy sector management assistance program (ESMAP).
[15] Assessment of load profiles in minigrid: A case in Tanzania. IEEE
[16] https://www.ammp.io/
[17] https://www.nithio.com/
[18] Electrification of Sub-Saharan Africa through PV/hybrid minigrids. Renewable and sustainable energy reviews. ScienceDirect

Although REA, GIZ, Frayme and NoMAP have over the past 18months developed a lot of data, there is still data quality gap between current business model and successfully implemented Mini Grid projects and all of these data analytics companies need reliable data to operate optimally[18].

In general, data analytics and internet-of-things can drive efficiency and profits for renewable energy companies. Two renewable energy companies – Arnergy and Swifta – acknowledged this recently in the renewable energy town-hall organized by Techcabal[19]. In order to modernize the Mini Grids, smart meters and other sensors will be needed and this is expensive. Other challenges include, lack of human capacity and poor connectivity.[20]

There is the need for local data and data analytics support for the Mini Grid sector in partnership with Engineering schools and academic institutions. Providing research grants to such institutions to collect and curate data, study the data and apply energy analytics to determine trends as well as represent it in visual format will certainly be a skill that will connect both the Electrical Engineering and ICT Engineering ecosystem. These data analytics will be supported by market assessment, and will be juxtaposed with data on off-takers such as MSMEs' to come up with concrete socio-economic projections. These data would be quite valuable to both the government and the developers and even financiers looking to make investments into the Mini-Grid sector.

3. Consumer Protection

In order to sustain the growth of the Mini Grid energy sector in driving rural electricity access, it is crucial that a comprehensive and circular approach that takes into consideration the social impact of Mini Grids on the consumers is undertaken. This is in addition to the business benefits that are utilized in these communities that can help with building out more demand and better service offerings. Therefore, there needs to be an efficient relationship management established between the mini-grid developers and consumers. The Nigerian Electricity Regulatory Commission's (NERC) 2016 Mini-Grid Regulations explicitly emphasizes for fair prices, transparent bills, impartial dispute settlement mechanisms, as well as confidential information protection between mini-grid developers and rural consumers[21] .

In a Mini Grid community, the main

[19] The future of Africa's energy. Techcabal
[20] Energy analytics for development: Big data for energy access, energy efficiency, and renewable energy. Energy sector management assistance program (ESMAP).
[21] 2016 NERC Regulation for Mini-Grid. Nigeria Electricity Regulatory Commission
[22] 2016 NERC Regulation for Mini-Grid. Nigeria Electricity Regulatory Commission

relationship that exists is that which exists between the developer and the consumers. The developers are highly profit-driven and this is because Mini Grid projects are capital intensive thereby requiring huge loans to execute.

Furthermore, Mini Grid companies are also permitted by law to charge cost-reflective tariffs and may charge amounts that are unrealistic and difficult for the customers to meet[22]. It is also crucial that Mini Grid electricity generation does not deteriorate the community's environment in any way.

It is important that the regulator working with donors and other implementing partners and including the Mini- Grid developers engages in consumer rights awareness programs this is to ensure the long term harmonious sustainability of the Mini Grids and the communities in which they are built.

By working closely with the Association of Mini Grid Developers – an industry association for Mini Grid developers on consumer awareness, it is possible to get both the developers and the consumers on the same side and ensure the protection of Mini Grid investments as well as the smooth operation of the Mini Grids in these communities.[23] One way to do this is by drafting customer engagement strategies suited to each local communities in a way that takes into account the needs and concerns of both developers and the diversity of those consumers, so that both parties are able to communicate regularly and clearly.

4. Demand Simulation

Most Nigerian Mini Grid development often generate much more power than is needed and are only able to sell a portion of it. This is the case of many Mini-Grids currently in operation in Nigeria as they are underutilized, with such Mini Grids providing surplus power but with no customers to sell it to. The reason for this is that the Mini-Grid communities consume only a fraction of the power generated –mostly for residential usage and for very little or no productive activity. For Mini Grid companies to optimize the electricity produced, through productive usage – particularly for more commercial or industrial uses. According to the Alliance for Rural Electrification (ARE), productive use is agricultural production or processing, or for commercial and industrial activities involving electricity services is a direct input to the production of goods or production of services.[24]

This is why there is a huge push to have Mini Grid developers engage in demand simulation by partnering with productive use of electricity.

For instance it is not uncommon to have Mini Grid in communities where

the capacity of the Mini Gird far outpaces the uptake of the power generated by the Mini Grid. In one community, there were about a hundred subscribed customers to a Mini Grid system that can take two hundred. The people of that community are predominantly farmers who farm in the day and thus, most of the electricity consumed is restricted to their homes and mainly used at night.

This is quite similar to the urban areas, but the difference however, is that in the day, most of the power is used in industries and commercial areas. Hence, electricity is mostly used in the day productively. This same methodology needs to be replicated in the rural areas. In order to do this, there must be demand simulation to increase the people's use of electricity either by introducing them to more efficient methods of farming that are electricity based or by siting small manufacturing or processing factories in the rural areas.

Therefore, demand simulation is crucial to increasing rural electrification in Nigeria and Mini Grids need support for in demand simulation work. If demand is still low, Mini Grids will not be profitable, and this will consequently lead to the lack of investments in the sector which will not in any way aid the rural electrification drive of the government..

Figure 2: Demand stimulation through community engagement in a Mini Grid community

[23] https://rmi.org/wp-content/uploads/2018/08/RMI_Nigeria_Minigrid_Investment_Report_2018.pdf
[24] Productive use of renewable energy in Africa. Africa-EU energy partnership.

B. Supply Side Issues

1. Local Industry Stakeholders

There are industry stakeholders who drive the development of Mini Grids as well as promote the operations of Mini Grid developers. An example is the Africa Mini Grid Developers Association (AMDA), responsible for formulating high level principles and propagating them to donors, investors and policymakers[25]. AMDA also serves as a window for donors to meet Mini Grid developers and to catalyze funding and financing for the Mini-Grid sector in Nigeria. These associations are able to as a block – using their common voice, negotiate with government and investors towards meeting their strategic objectives.

2. Customs and Importations (Taxes and Tarriffs)

Most of the major components needed for developing Mini Grids such as, solar panels, inverters and batteries, are imported. Therefore, standardized importation guidelines are critical to Mini Grid development - which unfortunately has also been a bottleneck for the sector. In April 2018, the Nigerian Customs unilaterally implemented a policy which hiked the importation tariffs for solar panels to between 5 and 10%. [26] [27]

This has impacted most of the stakeholders in the Mini Grid sector especially those with project pipelines already in development or deployment stage. For instance, the tax and other charges placed on other solar system components can account for over 10% and cumulatively contribute to higher tariffs being charged when selling Mini Grid electricity to communities.

Therefore, there is an apparent disconnect in Nigeria which in trying to solve its electrification crisis through decentralized and distributed electricity models – particularly through the deployment of solar Mini Grids is at the same time taxing these same components. This speaks to a lack of overarching policy coordination. Other African countries such as Kenya, Tanzania, Rwanda, Burundi, Uganda and Ghana were able to drive and increase rural electrification and grow their solar industry by eliminating importation tariffs on solar system components.[28]

Many local and international organizations have carried out studies on the Nigerian importation process to identify their lapses. In particular, the Renewable Energy Association of Nigeria (REAN) along with several other partners wrote a policy position paper on the solar importation process. This policy paper was endorsed by most of the stakeholders in the sector and has been presented to the federal government of Nigeria to act on accordingly. If the importation charges can be slashed completely, it

[25] https://africamda.org/index.php/about/governance/

will have a reverberating effect on the cost of Mini Grid electricity. This means that customers will buy more electricity and utilize them for productive use activities.

3. Quality and Standards

NERC has been instrumental in the drafting of regulations that guide Mini Grids in Nigeria in terms of development and operations. According to the World Bank Task Team Lead for the Nigerian Electrification Project (NEP) at the NEP Technical Workshop, Jon Exel, "the drafted laws are touted to be some of the most advanced in the world for Mini Grids." [29]

However, despite the sophistication of these laws, Mini Grids are still not where they are expected to be. It is therefore either the case that these laws are not sophisticated or practical enough. Furthermore, it is important to note that the Mini Grid sector is still nascent in Nigeria and needs to build stronger consumer confidence. In other words, for the industry to grow, consumers need to trust both the products deployed and the quality of the service delivery, and this can be achieved only through compliance with high technical standards.

This is why the need for a National certification program that every solar system installer must obtain remains imperative to maintaining service standards and that implementation and enforcements of existing quality standards are carried out without compromise.

4. Technology

The increased investment in Mini Grids for communities, households and businesses necessitates the need for technology solutions that will improve service delivery, energy management and energy efficiency for electricity consumers. It is therefore important to begin to engage technology solution providers and creators to explore how to use technology for Mini Grid electricity applications and to enable them explore business potentials in the sector.

It is for this reason that the tech eco-system needs to play an increased role in the renewable energy Mini Grid sector so that it replicates the same excellence, and efficiency it impacted in the transportation, banking (FinTech) and the Telecommunications sectors. With better connection and integration of the Renewable Energy and Technology ecosystems it will be possible to transform and accelerate the renewable energy sector as well.

Through customized technology solutions, new innovative solutions can be identified and deployed for the Mini Grid sector.[30]

[26] 8 months after import tariff hike. Techpoint Africa
[27] Segun Adaju decries the Nigeria Customs imposition of 5 to 10% import duty. Consistent Energy
[28] Solar import duty and tariffs. To exempt or not? Heinrich Boll Stiftung
[29] Nigeria electrification project. Rural electrification agency

CTH Mini Grid Services

As a hybrid hub focused on research and development, CTH is well positioned to provide a whole range of services from government relations, policy and strategic advisory, to research, to data collection and support the Mini Grid sector in data visualization and analytics summary table.

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[30] The future of Africa's energy. Techcabal

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