Interconnected Mini-grids

Where the power supply is unreliable, inconsistent, of poor quality or non-existent, inter-connected mini-grids provide communities with reliable and affordable electricity. These mini-grids providing renewable energy can sustain critical electricity loads and provide a back-up to the main grid or serve as a primary power source with the main grid.

Strengthening Energy Grids With Renewables

About 90% of the grid connections in Nigeria are considered unreliable and only allow for a power supply of about four to eight hours per day. In some areas, there are only two hours of power supply available because power cuts are very frequent and last for long periods of time. Low collection rates, low meter readings and other challenges related to electricity distribution mean that in most cases, distribution companies (DISCOs) are unable to recoup the revenues for the electricity services provided. The revenues collected by the DISCOs cover an estimated 35% of the costs, with about 30% of the energy sold not being invoiced. Because of poor electricity service, customers turn to expensive, polluting alternatives such as gasoline and diesel generators, which cost about $0.40 – $0.60 per kWh of electricity generated. Kerosene alternatives for lighting and other purposes can cost even more at ₦205 ($0.57) per kWh.

The Nigerian government is determined to improve access to electricity and the reliability of electricity supply through regulatory and political leadership. The Rural Electrification Agency (REA) is charged with the electrification of underserved communities as part of the Nigerian electrification project in rural areas. A suitable solution to strengthening weak electricity grids are interconnected mini-grids; electricity-generation systems with an installed capacity of less than 1 MW, which supply numerous end-users of a distributor and can be used in underserved areas.

Market Potential

According to the Rocky Mountain Institute, an estimated 40 million people in rural areas are under-served by the main grid. Based on the current grid coverage, an African Development Bank study shows that 13.6 million people (13% of the non-electrified population) in the country can be best served by mini-grid solutions, another 6.2 million people (6% of the non-electrified population) by Solar Home Systems (SHS), and 86.2 million people (81% of the non-electrified population) by grid expansion, depending on the proximity to the existing grid. Advanced modelling of five Nigeria states (Niger, Sokoto, Plateau, Cross River and Ogun), supported by the Nigerian Energy Support Program in collaboration with the Federal Ministry of Power, show the potential for grid extension to 455 MW, of which 196 MW will be interconnected mini-grids. These interconnected mini-grids, when developed, can cater to 3.3 million people within the five Nigerian states (out of 36 states in total). An estimated 35% of the under-served rural areas could be better served by more than 4,000 commercially viable interconnected mini-grids. The potential revenue from these mini-grids is approximately $1 billion per year, with an estimated $200 million in annual profit for mini-grid developers.

figure 1 Integrating Minigrids in Undergrid Communities

ROCKY MOUNTAIN INSTITUTE

FIGURE 1
INTEGRATING MINIGRIDS IN UNDERGRID COMMUNITIES

RMI-EMRC Under the grid
Legal Framework

The mini-grid regulation of the National Electricity Regulatory Commission provides an explicit framework for the development of mini-grids in Nigeria and has, as a result, contributed significantly to the market development of mini-grids in the country. The regulation permits the construction and operation of mini-grids in the region of a distribution company, using the existing distribution infrastructure to sell electricity to customers in the region. For interconnected mini-grids, the connected community, the mini-grid developer, and the distribution licensee must sign a tripartite agreement, which becomes binding after approval by the commission. The regulation also gives operators the right to set a cost-oriented tariff that allows the financial viability of the mini-grid compared to the current main grid.

A guideline (available from the OSIP platform) provides information for investors conducting due diligence for mini-networks in Nigeria.

Investment Promotion

The Agency for Rural Electrification with support from the NESP, have launched the Mini-grid Acceleration Scheme (MAS) and the Interconnected Mini-grid Acceleration Scheme (IMAS) which are both aimed at developing interconnected mini-grids in Nigeria. Developers for the MAS are selected based on geo-political zones while developers for IMAS were selected based on DISCO regions. The schemes are pursuing a public-private-partnership approach in the development of projects via an open, non-site-specific tendering procedure.

NESP support on IMAS and MAS projects is provided as follows:

1. Technical assistance support to project development for IMAS / MAS projects;
   - A Facilitate collaboration between DISCOs and developers;
   - B Site identification (for some IMAS projects and all MAS projects);
   - C Business planning:
     - i Demand assessment / demand profiling;
     - ii System design;
     - iii Financial modelling;
     - iv Preparation of info memo;
   - D Establishment of contractual relationships (incl. negotiations on Tripartite Agreement with DisCos);
   - E Acquisition of regulatory approvals (developer covers the cost, NESP facilitates the processes);
   - F Acquisition of finance;
   - G Project implementation (construction and commissioning);

2. Equipment procurement (covered by NESP grant);
   - A Grid tender (incl. service line);
   - B Two diesel generators per mini-grid site. The size will be decided based on the refined system design, that will complement the solar generation procured by the mini-grid developers;
   - C Smart meters;

3. Performance monitoring and demand stimulation (upon commissioning);

4. All other equipment, regulatory requirements and installation and labour costs are covered by the developers through equity and debt financing.

Business Models

Although interconnected mini-grids are a fairly new concept, there are already many operational structures that could take on future models. For example, a developer of an interconnected mini-grid could become the owner of the generation technology and operate the DISCO’s network for a fee developed in accordance with the MYTO and agreed to in the tripartite agreement. In addition, the mini-grid developer will designate route the grid power as a back-up, or whenever it is available.

In other cases, interconnected mini-grids can generate additional revenue from renewable energy sources by selling electricity and ancillary services to the main grid. This, in turn, can reduce consumers’ electricity bills while increasing the cost-effectiveness of the mini-grid.

For the IMAS & MAS schemes, selected developers will receive in-kind grants in the form of procured equipment of up to €310 per connection. Below is the grant model for both schemes.

<table>
<thead>
<tr>
<th>Grant Amount</th>
<th>€4,216,000</th>
<th>€3,689,000</th>
<th>€7,905,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of Total</td>
<td>53.33 %</td>
<td>46.67 %</td>
<td>1</td>
</tr>
<tr>
<td>Number of Lots</td>
<td>4</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Number of Actual Connections Per Lot</td>
<td>3,400</td>
<td>1,700</td>
<td>represents at least 85% *</td>
</tr>
<tr>
<td>Total Number of Connections</td>
<td>13,600</td>
<td>11,900</td>
<td>25,500</td>
</tr>
<tr>
<td>Grant Amount Per Lot</td>
<td>€1,054,000</td>
<td>€527,000</td>
<td></td>
</tr>
<tr>
<td>Grant Amount Per Connection</td>
<td>€310</td>
<td>€310</td>
<td></td>
</tr>
</tbody>
</table>

* of total planned connections proposed
**Tariff Model For Mini-Grids**

The unique role played by mini-grids often poses particular problems in finding a tariff structure that can maximise electrification while encouraging investment. Grid-level tariffs are almost without exception cheaper than cost-reflective mini-grid tariffs. While these cheaper tariffs would remove all cost barriers for potential customers, they can also discourage investment in the mini-grid sector.

A compromise between these two extremes is necessary to promote mini-grids for faster and more reliable electrification. Examples include cross-subsidies based on customer classes or the setting of different tariff levels according to the size and capacity of mini-grids.

It is important to consider mini-grids as a hybrid component of the network, which is not necessarily a complement to the network or an unnecessary bridging. Subsidies, cross-subsidies, or other forms of support for mini-grids need to keep this long-term vision in mind. Tariff rates vary from one location to another and a single tariff is usually applied to all customers, usually developed in consultation with the host community. However, different tariffs may be developed for residential and business customers.

**Key Performance Indicators**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Range of Site Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Energy Use</td>
<td>Welding, Barbier, Retail / Provision Stores, Grinding</td>
</tr>
<tr>
<td>Household Energy Use</td>
<td>Electric Bulbs, Electric Fans, Television Sets, Radio Sets, Cell Phones, Refrigerators</td>
</tr>
<tr>
<td>Local Cost of Petrol</td>
<td>US$0.41 – US$0.86 per litre</td>
</tr>
<tr>
<td>Local Cost of Diesel</td>
<td>US$0.46 – US$0.86 per litre</td>
</tr>
<tr>
<td>Tariff</td>
<td>US$0.34 – US$0.86/kWh</td>
</tr>
<tr>
<td>System Size</td>
<td>16 kW – 100 kW</td>
</tr>
<tr>
<td>Capital Expenditure</td>
<td>US$90,000 – US$300,000</td>
</tr>
<tr>
<td>Annual Operating Expense</td>
<td>US$900 – US$6,900</td>
</tr>
<tr>
<td>Capacity Utilisation</td>
<td>2% – 100%</td>
</tr>
<tr>
<td>Collections</td>
<td>98% – 100%</td>
</tr>
<tr>
<td>Energy Export</td>
<td>16 kWh / day – 300 kWh / day</td>
</tr>
</tbody>
</table>

RMI Nigeria Minigrid Investment Report

**Risks**

Despite an increase in beneficial conditions for mini grids in Nigeria, there are some concerns that investors may have.

**Regulatory And Policy Framework Improvement Plan** — The Nigerian Mini-grid Regulation is more supportive of market development than in most developing countries, where such policy is either less advanced or non-existent. Recently, there has been an increase in supportive policies, plans, and regulations in a bid to create a clear policy environment.

**Improved Reliability from Grid** — Interconnected mini-grids serve as a new strategy for distribution companies, which pose a threat to developers who are worried about the DISCO stealing their customers after investing largely in the project. The tripartite agreement signed in agreement with the community and distribution company mitigates this risk.

**Technical Barriers** — Technical issues involved in setting up and maintaining mini-grids such as obtaining the expertise for initial deployment, maintenance, and standards of components.

**Economic Viability** — The economic viability of mini-grid projects can be improved through grants or subsidies from donor organisations. This allows a developer to expand its customer base, with great potential for accelerating business development. If customers are unwilling or unable to pay for electricity as expected, this could lead to an economic downturn and the developer could find it difficult to repay the investment and operating costs. Developers can mitigate this risk by selecting communities where customers have sufficient purchasing power and an economic incentive to purchase electricity from the mini-grid.

**Data Availability** — The REA’s main support to the private sector is to reduce development costs by providing pre-development information, including the identification of site locations and facilitating cooperation with local and state governments. As part of this work, the REA maintains a GIS portal with 8,000 potential mini-grid communities, which also takes socio-economic factors into account. This portal allows for market estimates based on selected criteria including economic activity and distance from the national grid.

**Success Stories**

The **Solar hybrid project** in Mokoloki community is Nigeria’s first rural commercial under the grid mini-grid, online since February 2020. Through an innovative partnership between Ibadan Electricity Distribution Company (IBEDC) Nayo Tropical Technology (Nayo Tech), and the Mokoloki community — with advisory support from the Rocky Mountain Institute — this project demonstrates a path to collaboration. Early evidence suggests the project improves electricity service, supports community development, and reduces utility losses:

- Created cost-savings for the utility, which previously registered aggregate technical and commercial losses of up to 70 percent in Mokoloki;
- Opened a new revenue stream and mini-grid market segment for the developer;
- Avoided about 15,000 kg of CO₂ emissions in its first three months of operation; and
- Reduced customer electricity costs by ₦20/kWh (US$0.06/kWh)