EXECUTIVE SUMMARY: THE OPPORTUNITY

Nigeria is the biggest and most attractive off-grid opportunity in Africa, and one of the best locations in the world for minigrids

- Nigeria has the largest economy in Sub-Saharan Africa (GDP of $405 billion), has 180 million people, and flourishing growth (CAGR of 15% since 2000).
- A significant amount of the economy is powered largely by small-scale generators (10–15 GW) and almost 50% of the population have limited or no access to the grid.
- As a result Nigerians and their businesses spend almost $14 billion annually on inefficient generation that is expensive ($0.40/kWh or ~₦140/kWh or more), poor quality, noisy, and polluting.
- Developing off-grid alternatives to complement the grid creates a $9.2B/year market opportunity for minigrids and solar home systems that will save $4.4B/year for Nigerian homes and businesses.
- There is large potential for scaling—installing 10,000 minigrids of 100 kW each can occur for 10 years and only meet 30% of anticipated demand.
- Getting off-grid solutions to scale and commercial viability in Nigeria will unlock an enormous market opportunity in Sub-Saharan Africa across 350 million people in countries with smaller demand and/or less-robust economies.
- The Rural Electrification Agency (REA), tasked with developing the Nigerian off-grid power market, created the Off-Grid Electrification Strategy as part of the Power Sector Recovery Programme (PSRP).
EXECUTIVE SUMMARY: BUSINESS CASE

Evaluation of specific sites shows a strong minigrid business case for typical locations in Nigeria and indicates there are thousands of high potential sites:

- Unlike many regions in Africa, Nigeria’s economy and strong entrepreneurism mean that millions of commercially-viable businesses are powered with expensive and/or unreliable power.
- Consequently, there are high densities of power use, large latent demand, and a strong willingness to switch to more-effective alternatives.
- Recent efforts by REA have already identified hundreds of high potential sites for investment and demonstrated potential for commercial viability.
  - Deep dive analyses in Ogun and Cross River states show numerous sites that are ready for large-, medium-, and small-scale minigrids, and a significant opportunity to meet more remedial needs with solar home systems.
    - For example, a medium-scale system (e.g., 200 kW) can make commercial returns while covering its cost of capital, creating a return on investment of 3 years—this is a opportunity not currently found elsewhere in Sub-Saharan Africa.
    - Many rural households spend more than $6/month (~₦ 2,100/month) on kerosene or battery powered torches, making a compelling case for solar home systems.

This independent assessment of the Nigerian minigrid market is a result of a partnership between the Rural Electrification Agency (REA), the World Bank (Energy team), and Rocky Mountain Institute (RMI).
Nigeria has strong development partner support and has established the Rural Electrification Fund for off-grid development

- REA established the **Rural Electrification Fund (REF)** to support the Federal Government of Nigeria’s (FGN) Rural Electrification Strategy and Implementation Plan (RESIP), in order to help finance rural electrification expansion in Nigeria.
  - The REF has a **legal mandate** to promote “fast and cost-effective expansion of electricity access in un-electrified rural areas evenly across the different geopolitical zones in Nigeria” through both off-grid and on-grid electrification solutions.
- There is **strong support from World Bank**, who is working with the FGN to develop a five-year Nigeria Electrification Project (NEP), expected to be finalized by The World Bank in April 2018 and implemented by REA.
  - The World Bank’s contribution for NEP is expected to be $350 million, with **$150 million allocated to minigrids**.
  - Minigrids developed under NEP are expected to serve **200,000 households and 50,000 local enterprises**.
  - The project is **nationwide in scope**, with early activities expected in Niger, Plateau, Ogun, Sokoto, and Cross River states.
  - The NEP will be **implemented under a market-based approach**—private firms are expected to develop minigrids, with subsidies from REA, and roughly 1,200 minigrids are expected to be developed under the project.
Government, development partners, and the private sector are actively working together in Nigeria to create enabling conditions for successful minigrid development

- Nigeria is providing an enabling environment for off-grid market growth, including:
  - **Developer protection** through the NERC Minigrid Regulations.
  - An innovative and best practice site-selection process to de-risk projects has already identified over 250 promising sites.
  - The selection process has also screened for baseload demand (e.g., schools), population/energy density and productive use.
  - Partnering with World Bank to line up finance, streamline competitive tendering, and to provide technical assistance.

- The government and development partners are inviting the private sector to work with them to capture this opportunity, while saving Nigerians money and powering economic development to further expand the market.

- With an enabling environment, continued cost reductions, and targeted finance, the Nigerian minigrid market can scale rapidly to over 10,000 sites by 2023, powering 14% of the population with capacity up to 3,000 MW and creating an investment potential of nearly $20 billion and annual revenue opportunity exceeding $3 billion.
CONTENTS

1 THE OFF-GRID OPPORTUNITY IN NIGERIA

2 CASE STUDIES: POTENTIAL MINIGRID SITES

3 ENABLING CONDITIONS FOR MINIGRID DEVELOPMENT

4 BRINGING THE MINIGRID MARKET TO SCALE

5 MOVING FORWARD
NIGERIA IS PRIORITIZING OFF-GRID SOLUTIONS AS PART OF THE COUNTRY'S OVERALL POWER SECTOR RECOVERY PLAN

INTRODUCTION

• The Nigerian Rural Electrification Agency (REA) has developed the Off-Grid Electrification Strategy—its primary objective is to increase electricity access to rural and underserved clusters.

• Part of this strategy is to fast track development initiatives toward achieving the overall objective of the FGN Economic and Recovery Growth Plan and the Power Sector Recovery Programme.

POWER SECTOR RECOVERY PROGRAMME

The Power Sector Recovery Programme (PSRP) is a series of policy actions, operational, governance and financial interventions to be implemented by the FGN over the next five years to restore the financial viability of Nigeria’s power sector, improve transparency and service delivery, resolve consumer complaints, reduce losses and energy theft, and **RESET** the Nigerian electricity supply industry for future growth.

The FGN developed the PSRP in collaboration with the World Bank Group. Holistically, the objectives of the PSRP are to:

i) **Restore the sector's financial viability;**

ii) **Improve power supply reliability to meet growing demand;**

iii) **Strengthen the sector's institutional framework and increase transparency;**

iv) **Implement clear policies that promote and encourage investor confidence in the sector; and**

v) **Establish a contract-based electricity market.**
SUSTAINABLE OFF-GRID POWER SOLUTIONS CAN ACCELERATE ECONOMIC GROWTH

Nigeria offers the best off-grid market opportunity in Africa—there is relatively high economic activity, latent demand, and ability to pay in rural areas:

- Nigeria has the largest population and GDP in Africa with significant rural economic activity
- 14 GW served by small petrol and diesel gen-sets
- Nigerians already spend $14B annually on off-grid power from small self generators
- There are 85 million people underserved and/or unconnected to the grid, which is an enormous investment opportunity
- On-grid costs are nearly $3B (₦1.1T) annually

Source: RMI analysis
THERE IS A $9.2B/YR MARKET OPPORTUNITY TODAY FOR MINIGRIDS AND SOLAR HOME SYSTEMS THAT WILL SAVE NIGERIANS $4.4B/YR

- $9.2 billion (₦3.2 trillion) annual market opportunity to supply off-grid and underserved customers with minigrids and solar home systems*
- With 8% economic growth through 2030 there is an additional $670 billion (₦235 trillion) value proposition
- This estimate is based on current expenditures, but customers may pay more for superior service
- This shift would save Nigerians customers $4.4B/yr (₦1.5T/yr) over current energy costs

Today’s off-grid and under-grid annual market size in Nigeria, by off-grid technology*

<table>
<thead>
<tr>
<th>Current Revenue</th>
<th>Revenue With Off-Grid Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>$6.5B</td>
<td>Minigrids $8.0B Payments to Service Providers $1.2B</td>
</tr>
<tr>
<td>$13.8B</td>
<td>Solar Home Systems $2.1B Savings $2.4B</td>
</tr>
<tr>
<td>$13.8B</td>
<td>Unchanged $6.7B Unchanged $6.7B</td>
</tr>
</tbody>
</table>

* Assumes 50% adoption of solar home systems by torches and other substitutes, and 75% adoption of minigrids by small-scale self generation; conservatively does not assume growth in electricity use
**MINIGRIDS ARE A CRITICAL COMPONENT OF REA’S PROGRAMMES TO SUPPORT ECONOMIC DEVELOPMENT AND ENERGY ACCESS**

<table>
<thead>
<tr>
<th>Who will be served?</th>
<th>Stand-Alone Systems</th>
<th>Minigrids</th>
<th>Energizing Education</th>
<th>Energizing Economies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote customers with low load or low ability to pay</td>
<td>Communities with load less than ~1 MW</td>
<td>37 universities, 7 teaching hospitals, and the surrounding communities</td>
<td>Economic clusters: areas with high commercial activity and high growth impact on the economy</td>
<td></td>
</tr>
</tbody>
</table>

| What is REA’s role? | Promote development and roll-out | Promote community, private development | Develop independent power plants to serve | Intervene to provide power under eligible customer policy directive |

| Benefits to community | Provide critical basic services; cheaper than kerosene or other energy alternatives; create jobs | Promotes economic activity; interconnection potential | Provide nearly 100 MW generation across 6 geopolitical zones; improve educational quality | Replace costly, inefficient, polluting diesel with centralized power source; promote MSME growth |

| Benefits to developer | Supportive regulatory environment, coordination around market expansion, education and awareness | 10,000+ potential sites offer high customer density, clustering; access and scaling in Africa’s largest market | Solar hybrid and gas engine plant generation opportunities | High load and customer concentration; clear value proposition to customers |

**Crosscutting energy database** – online visualization of resources for energy development

Source: REA strategy presentation
CONTENTS

1 THE OFF-GRID OPPORTUNITY IN NIGERIA
2 CASE STUDIES: POTENTIAL MINIGRID SITES
3 ENABLING CONDITIONS FOR MINIGRID DEVELOPMENT
4 BRINGING THE MINIGRID MARKET TO SCALE
5 MOVING FORWARD
### The Nigerian Minigrid Market is Underpinned by the Most Appealing Minigrid Sites in Africa

<table>
<thead>
<tr>
<th>Case Study #1: Small Off-Grid</th>
<th>Case Study #2: Medium Off-Grid</th>
<th>Case Study #3: Medium Underserved Peri-urban</th>
<th>Case Study #4: Large Underserved Peri-urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obot Ekpene, Cross River</td>
<td>Onyen-Ogpon, Cross River</td>
<td>Mokoloki, Ogun</td>
<td>Okun-Owa, Ogun</td>
</tr>
<tr>
<td>Peak Load</td>
<td>16 kW</td>
<td>200 kW</td>
<td>85 kW</td>
</tr>
<tr>
<td>Current Cost, Diesel Generation*</td>
<td>$0.75/kWh</td>
<td>$0.52/kWh</td>
<td>$0.39/kWh</td>
</tr>
<tr>
<td>Estimated Tariff Today (15% IRR)**</td>
<td>$0.51/kWh</td>
<td>$0.40/kWh</td>
<td>$0.42/kWh</td>
</tr>
<tr>
<td>Customer Savings</td>
<td>$0.24/kWh</td>
<td>$0.12/kWh</td>
<td>-$0.03/kWh</td>
</tr>
<tr>
<td>IRR if Tariff Matches Current Cost</td>
<td>26%</td>
<td>22%</td>
<td>13%</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>$130,000</td>
<td>$1.1 M</td>
<td>$600,000</td>
</tr>
<tr>
<td>Consumption per Day</td>
<td>200 kWh</td>
<td>2,500 kWh</td>
<td>1,300 kWh</td>
</tr>
</tbody>
</table>

** Source: RMI analysis; Fuel price vary by region (₦100-250) and case studies reflect field visit prices

** Assumes 100% debt financed at 10% APR

*** Customer pays more at 15% IRR, but get better power and same price at 6% IRR

### Key Takeaways
- Off-grid sites show opportunities today for significant customer savings while providing developer returns.
- Minigrids can provide reliable electricity to underserved peri-urban sites at or below current costs.
- These economics do not account for additional minigrid benefits, such as increased reliability and reduced environmental pollution.

The pages that follow contain a detailed exploration of each case study.

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RURAL ELECTRIFICATION AGENCY

** These types of sites are fully commercially viable now with a 15% project IRR.

These sites are very good relative to most minigrid sites elsewhere in Africa (typically $0.60+/kWh or ₦210+/kWh) and provide superior service relative to self-generation.
ELECTRICITY COSTS NEARLY $0.75/kWh IN OBOT EKPENE, AND MOST HOUSEHOLDS SPEND $9/MONTH ON ALTERNATIVES

OBOT EKPENE, CROSS RIVER

Context
- 30 households, currently with no electricity access
- 10 km away from nearest grid connection and 3 km away from road access
- 15 kW of existing self generation is used to process agricultural products, including cassava and palm oil
- No reliable, affordable power solutions are available, especially to remote areas
- There are thousands or tens of thousands of such sites in Nigeria

Consumer type | Load
---|---
30 households | 3 kW
Commercial/Productive use | 15 kW

Ability and Willingness to Pay
- Higher-income Obot Ekpene residents currently pay $0.75/kWh for diesel generators
- Most households are unelectrified and spend around $3/month for kerosene as well as $6/month to charge cell phones, torches, and other devices
- Regular income from palm oil and gari sales

Local farmers use diesel generators to run machines that process palm oil, cassava/gari, and other crops
A $130,000 MINIGRID this site generates a 15% project IRR, saves $18,000/year, and provides better service.

### Minigrid Solution

- **Final consumer tariff of $0.51/kWh** Minigrid with 34.5 kW solar, 48 kWh battery, and 18 kW diesel backup
- 5 km distribution system
- Initial capital cost of **$130,000** Optimized operations and maintenance with clustered minigrid sites, smart meters that allow for remote monitoring and control, remote revenue collection

### Customer Savings and Benefits

- Future economic viability should be considered, but **need for electricity access** to drive development in such communities is the greatest in the countryside
- Customers **save $0.24/kWh** compared with self generation, and **save on time and money** usually spent for operations and maintenance
- Many residents have trained and work in town as artisans or businessmen, and would move these operations—and the associated economic gains—home with access to power

Solar home systems may also be considered for many remote customers with low load.

### Project Economics

- **Predictable $3,000 (₦1M) monthly revenue** growing over time

---

Source: RMI analysis
BUSINESSES AND HOMES PAY $0.52/kWh IN OYEN-OKPON DESPITE LARGE PRODUCTIVE LOADS

ONYEN-OKPON, CROSS RIVER

Context
- 500 households, 7 km away from nearest electrified town
- At nearby towns, reliability of grid connections is low, typically just a few, unpredictable hours per day
- Medium–high income community that is a center of commerce; 100 kW existing self generation is used to process agricultural products (cocoa beans, cassava, yams) and power commerce, welding, and other artisans
- There are thousands of such sites in Nigeria

Consumer type | Load
--- | ---
300 households (60% of total) | 60 kW
Commercial/productive use | 170 kW

Ability and Willingness to Pay
- Community leaders and residents stated high willingness to pay and even to contribute to capital costs for a local system
- Most residents currently pay about $0.43/kWh (₦150/kWh) for petrol generation or $0.52/kWh (₦180/kWh) for diesel, or up to $25/month (₦8,900/month)
- Unelectrified households spend ~$6/month (₦2,100/month) for kerosene, plus extra for rechargeable torches, candles, cell charging, etc.

Diesel must be purchased in small quantities to power cocoa processing facilities, but is costly, inefficient, loud, and polluting.
A $1.1M MINIGRID AT THIS SITE GENERATES A 15% PROJECT IRR, SAVES $110,000/YEAR AND PROVIDES BETTER SERVICE

**Minigrid Solution**

- **Final consumer tariff of $0.40/kWh**
- Minigrid with 470 kW solar, 668 kWh battery, and 220 kW diesel backup can meet overlapping load of residential and commercial loads
- 5 km low-voltage distribution system
- Upfront capital cost of $1.1 million Optimized operations and maintenance with clustered minigrid sites, smart meters that allow for remote monitoring and control, remote revenue collection

**Customer Savings and Benefits**

- Customers *save up to $0.12/kWh* compared with diesel self-generation, or $0.03/kWh (₦11/kWh) compared to petrol
- Customers save time and money usually spent on operations and maintenance
- Businesses significantly enhance productivity with 95% system uptime
- Commercial uses can scale up, with **enhanced economic flows** to the community coming from added value through additional cocoa processing

**Project Economics**

- Predictable $31,000 monthly revenue that would grow over time
IN UNDERSERVED PERI-URBAN COMMUNITIES, MINIGRIDS CAN OFFER RELIABLE SERVICE TO SUPPLEMENT THE EXISTING GRID

MOKOLOKI, OGUN

**Context**

- Population 3,000, with access to the centralized grid but receiving extremely unreliable service
- Even with connection, reliability of grid connections is low, typically just a few, unpredictable hours per day
- 80 kW of existing self generation power artisans (welders), cement block factory, agricultural processing, and some households, but economic activity is currently limited by unreliable power
- There are thousands of similar underserved sites in Nigeria

**Consumer type**

<table>
<thead>
<tr>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 Households (50% of total) 50 kW</td>
</tr>
<tr>
<td>Commercial/Productive use 70 kW</td>
</tr>
</tbody>
</table>

**Ability and Willingness to Pay**

- Mokoloki residents currently spend $0.39/kWh for small-scale electricity generation to supplement the grid
- The average household spends $3 per week (₦1,050/week) on energy substitutes, especially battery-powered torches and cell phone charging

**Assumptions:** Half of 600 HH connect to minigrid at an average of 175 W/HH

Source: RMI interviews and analysis, local fuel costs based on interviews at site

Small diesel generators are used to power equipment, such as this cassava grinder, that is vital to the local economy.

Due to the low cost of intermittent grid power from the grid, subsidy or other intervention may be required to make minigrids competitive—until they prove their value through high reliability and consistent service, and developer costs are reduced.
A $600,000 MINIGRID CAN PROVIDE BETTER SERVICE AND MEET CURRENT COSTS WITH A 13% PROJECT IRR

Minigrid Solution

- Tariff can meet current costs with a 13% IRR
- Final consumer tariff is $0.42/kWh with a 15% IRR
- Minigrid with 156 kW solar, 212 kWh battery, and 140 kW diesel component
- 5 km distribution system reaching 300 households, 20 small shops, and a peak 85 kW including 75 kW of productive daytime use
- Initial capital cost of $600,000
- Optimized operations and maintenance with clustered minigrid sites, smart meters that allow for remote monitoring and control, and remote revenue collection

Customer Benefits

- Customers have reliable power and save on time and money usually spent for operations and maintenance
- Main grid is currently operational for about 1% of the time, a minigrid would provide much greater uptime and reliability allowing businesses to plan their work on growth

Project Economics

- Predictable $17,000 monthly revenue growing over time

Source: RMI analysis
MORE-AFFLUENT UNDERSERVED SITES OFFER ATTRACTIVE SCALE AND HIGH PRODUCTIVE USE LOADS

OKUN-OWA, OGUN

Context
- ~5 factories running entirely on diesel generators, 1.5 MW capacity and a relatively flat load shape, operating 24/7
- ~100 large affluent houses with AC and high load
- Beside large factories there is a fair amount of typical economic activity—grain mills, small shops, etc.
- Grid is present, provides a few hours a week or less, sometimes at low power quality. Both community and the large factories are extremely interested in securing reliable and lower-cost power
- There are thousands of similar underserved sites in Nigeria

<table>
<thead>
<tr>
<th>Consumer type</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 Households (100% of total)</td>
<td>45 kW</td>
</tr>
<tr>
<td>Commercial (Shops)</td>
<td>250 kW</td>
</tr>
<tr>
<td>Industrial (Factories)</td>
<td>1500 kW</td>
</tr>
</tbody>
</table>

Ability and Willingness to Pay
- Community leaders and residents stated high willingness to pay and attract additional industry
- Factories pay ~$0.25/kWh for diesel generation
- Small businesses currently pay about $6/week (₦2,100/week) to run diesel gensets plus $10/month (₦3,500/month) for grid power

Assumptions: 225 W/HH average, local fuel costs based on interviews at site
Source: RMI interviews and analysis

Large factories demand consistent, reliable power but offer significant economic benefits to the local community
A $9.7M MINIGRID CAN PROVIDE BETTER SERVICE AND MEET CURRENT COSTS WITH A 6% PROJECT IRR

<table>
<thead>
<tr>
<th>Proposed Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Tariff can <strong>meet current costs</strong> with a <strong>6% IRR</strong></td>
</tr>
<tr>
<td>- Consumer <strong>tariff of $0.33/kWh</strong> with <strong>15% IRR</strong></td>
</tr>
<tr>
<td>- Minigrid with 4 MW solar, 3.6 MWh LA battery, and 2 MW diesel backup can meet overlapping load of residential and commercial loads</td>
</tr>
<tr>
<td>- 6 km distribution system</td>
</tr>
<tr>
<td>- Upfront capital cost of <strong>$9.7 million</strong></td>
</tr>
<tr>
<td>- Optimized operations and maintenance with clustered minigrid sites, smart meters that allow for remote monitoring and control, remote revenue collection</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Customer Savings and Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Customers <strong>save time and money</strong> usually spent on <strong>operations and maintenance</strong></td>
</tr>
<tr>
<td>- Businesses significantly enhance productivity with <strong>95% system uptime</strong></td>
</tr>
<tr>
<td>- <strong>Enhanced economic flows</strong> could result from ability to attract new industries to the area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Predictable $270,000 monthly revenue that would grow over time</td>
</tr>
</tbody>
</table>

---

Source: RMI analysis
Serving the greatest immediate need

- The Mokoloki load and site is typical of many of the most significant unserved and underserved loads in Nigeria—commercial demand and ability to pay are high
- This is true of the majority of potential minigrid sites with more than 75 kW of potential peak load
- Minigrids may be the least-cost, most reliable way to provide these sites with service

Providing greater reliability

- Many of these sites have existing distribution network that is not energized, or have grid connections with infrequent power available—reliability provided by the grid is low
- Grid reliability is unlikely to improve significantly in the near future; even if customers switch to cheaper grid power when it is available, this will not hurt the minigrid case

Regulatory clarity

- Minigrids are allowed to operate in underserved communities with the agreement of the DisCo and community.* Communities are allowed to request the presence of minigrids to supplement their access to power [NERC Mini-Grid Regulation S.9(1), (2)]
- Existing, recently approved regulations planning for interconnection, both technically and financially, are crucial for these sites

Economic activity

- Reliable power is seen as the primary need for increased economic activity in peri-urban areas
- Interviews suggest lack of consistent grid power has affected artisans and others, or they have moved to urban centers
- Demand planning and productive use stimulation key as population and economic activity can swell faster in peri-urban areas

De-risking of sites

- REA & development partners exploring the best types of sites and working with NERC to de-risk the process

See appendix for additional information on relevant regulatory policies and procedures

Source: RMI analysis

*Ripartite agreement could include distribution usage right, tariff rate, concession length, PPA if applicable, and integration plan at expiration of contract
THE ENERGIZING ECONOMIES PROGRAMME SIMILARLY TARGETS LARGE MARKETS FOR COST-EFFECTIVE CONVERSION TO MINIGRIDS

One of the general generators used within a market

Distribution lines within a market

Private generators used to augment supply from the general generators

Status Quo Observations

- 4 large markets have >50,000 shops paying >$70K/day (₦24.5M/day) for power
- Higher energy cost compared to renewable and other gas-fired solutions
- Noise pollution from heavy duty diesel generators and small generators
- Potential Health, Safety, and Environment (HSE) infringement resulting from ad hoc installations
- Shoddy overhead distribution lines
ARIARIA MARKET IS ONE EXAMPLE OF THE ATTRACTIVE ECONOMICS AT MARKETS TARGETED FOR TRANSFORMATION

**Context**
- **37,000 shops**, 16,000 of which currently use electricity
- Currently spend **$21,000/day (₦7.4M/day)** on electricity
- Currently underserved and qualified as **eligible customers**

**Proposed Solution**
- **Phase 1**: **5 MW** of natural gas and diesel capacity
- Initial capital cost of **$12M**
- **12,000 shops** electrified with average load of 100–200 W
- **Independent Distribution Network**
- Dense market area minimizes distribution costs, and smart meters allow for remote monitoring and control
- **$0.22/kWh solution** is competitive with alternatives

The **private sector** is responsible for funding, generation, distribution, metering, and collections and the **REA** will manage and facilitate all interactions with the various state and federal level ministries, departments, and agencies

Source: REA Energizing Economies Baseline Survey and Energy Audit Report, 2017; RMI analysis
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5 MOVING FORWARD
NIGERIA HAS LAID THE GROUNDWORK TO MAKE IT THE BEST LOCATION FOR MINIGRID DEVELOPMENT TODAY

- **Enabling policy and regulation** unmatched elsewhere
- **Pre-feasibility site evaluation** to de-risk projects and reduce developer costs
- **Creation of a tender process** to facilitate near-term investment
- **Rich landscape** of development partners and active companies
NIGERIA’S POLICY AND REGULATORY ENVIRONMENT SUPPORTS MINIGRID MARKET GROWTH

Nigerian regulation provides more guidance, preparation, and protection for minigrid development than policies in other markets

**NERC Regulatory Framework for Minigrids**

### Setting Tariffs
- Tariff flexibility currently allowed
- Minigrids under 1 MW allowed to set cost-reflective tariffs

### Grid Exit
- Minigrid interconnection with the grid included in regulatory framework
- Technical preparation for interconnection
- Financial preparation for interconnection

### Licensing & Permitting
- Accelerated licensing and permitting process for minigrids

### Integrated Energy Planning
- Clear program for off-grid energy
- Clear priority to support isolated minigrids and their role in powering commercial loads

REA is conducting unprecedented detailed minigrid pre-feasibility evaluations to reduce development risk and cost.

**REA site selection process provides clarity, reduces risk, and accelerates process for private minigrid development**

First-cut prioritization with existing data has identified 200+ sites with at least 100 kW demand.

REA teams prioritized sites by:
- Sufficient load/density
- Productive-use, daytime, and flexible loads
- Supportive local and state government
- Community engagement
- Solar resource and availability of gas
- Accessibility

**REA surveys will provide developers with a better idea of site viability**

REA teams are gathering detailed data at these sites and using that data to improve site selection.

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

Detailed surveys completed: REA visited top 200 sites across 5 priority states (Nov. 2017)

Potential sites identified

Sites visited on the ground

Sites prioritized for initial development
REA SURVEYS OF 200 SITES IN 5 STATES PROVIDE QUANTITATIVE EVIDENCE FOR MINIGRID OPPORTUNITY

**Access to distribution infrastructure**

- 57% Underserved, connection
- 31% Underserved, no connection
- 12% Unserved

**Current energy expenditures by household**

Monthly spending, USD

**Distance to nearest grid distribution by off-grid communities**

- 31% Underserved, connection
- 12% Underserved, no connection
- 57% Unserved

**Insights from on-the-ground surveys**

- Some communities indicated both the **ability and willingness to contribute** to the up-front cost of electricity infrastructure.
- There is a huge **opportunity for the development of underserved areas**. The centralized grid has a far greater reach than previously anticipated by GIZ, REA, and others; however, many of these on-grid communities are still underserved and are interested in alternative electricity sources.

**Key Enabling Factors**

- Only 10% of community leaders reported that electricity needs are met in their community.
- 46% of surveyed communities have telecom signal that would support mobile payments for a PAYG scheme.
- Off-grid households spend, on average, over $30/month (₦10.5k/month) on energy alternatives and consistently spend more on energy than their on-grid counterparts.

Source: REA surveys and RMI analysis
REA’s interactive energy database provides developers with a tool and data for site assessments

REA’s unique tool allows developers and investors to quickly identify promising sites for development.

### Features

**On-Grid Infrastructure**
- Transmission
- Power Plants
- Distribution Infrastructure
- Electrified Communities

**Off-Grid Infrastructure**
- Potential Minigrid Communities
  - 10 km or 20 km from the grid
- Potential SHS Communities
  - 10 km or 20 km from the grid

**Community Details**
- Population, Load Profiles

**Resources**
- Mines
- Solar Irradiance
- Roads

**Amenities**
- Schools
- Water Points

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The availability of digital geospatial data on transmission infrastructure allows easy identification of on- and off-grid communities.

- The tool will continue to be refined, and will incorporate load data from REA surveys.
- REA will expand the tool for other applications (e.g., Energizing Economies, Solar Home Systems).

Sources: REA Off Grid Electrification Strategy, 2017
REA website
REA IS WORKING WITH THE WORLD BANK TO SETUP A MINIGRID TENDER PROCESS THAT WILL STREAMLINE DEVELOPMENT

**Phase 1**
- Site selection identified through REA surveys
- Tender process design

**Phase 2**
- Tender for 1st round projects
- 2nd round process and projects

**Phase 3**
- 1st round projects awarded and constructed
- Tender for 2nd round projects

- Standardized requirements to drive scale and reduce equipment cost
- REA and World Bank work to de-risk projects upfront before bidding
- Development partners provide guidance to companies and technical assistance to government to support success

- Mini-grid proposals by active private developers and/or performance-based grants for minigrid sub-projects
- REA and World Bank coordinate access to finance, capital expenditure support, and credit enhancement to developers and investors
- As developers and REA bring minigrid market to scale, minigrids follow cost-reduction roadmap to further accelerate growth
REA IS COORDINATING DEVELOPMENT PARTNERS TO SUPPORT, FUND, AND ACCELERATE THE OFF-GRID MARKET IN NIGERIA

Examples of development partners in the energy space

- **Nigerian Energy Support Programme (NESP)**
  - Regulatory reform, TA, finance, technical training
- **Solar Nigeria (ASI)**
  - TA, finance, government support
- **Rockefeller Foundation**
  - Advocacy, market acceleration
- **Lighting Nigeria**
  - Finance, supply chain, markets
- **Climate Innovation Center**
  - Market acceleration, finance
- **UNDP: Bank of Industry Access to RE project**
  - Finance
- **World Bank Group**
  - DFID
- **Power for All**
  - Advocacy
- **GIZ**
- **Other DPs**
  - USAID: Power Africa
  - EU: Renewable Energy Cooperation Program (RECP)
    - Policy advice, finance, private sector cooperation
  - UNDP: Bank of Industry Access to RE project
  - CBN: SME Facility
  - AFD: Sunref
  - Shell Corporate: All On
  - Multilateral Investment Guarantee Agency (MIGA)
  - Finance
  - Rockefeller Foundation
    - Markets, information
  - Heinrich Boll Foundation
    - Markets, information
  - USAID: Power Africa
  - DFID
  - Other DPs

Source: RMI development partner interviews
CONTENTS

1 THE OFF-GRID OPPORTUNITY IN NIGERIA
2 CASE STUDIES: POTENTIAL MINIGRID SITES
3 ENABLING CONDITIONS FOR MINIGRID DEVELOPMENT
4 BRINGING THE MINIGRID MARKET TO SCALE
5 MOVING FORWARD
With an enabling environment, continued cost reductions, and targeted finance, the Nigerian minigrid market can scale rapidly to over 10,000 sites by 2023, powering 14% of the population with capacity up to 3,000 MW.

Enabling environment

Donor investments, grants, and private investment

Driving cost reductions

Momentum of Nigerian market drives expansion in other African markets

RURAL ELECTRIFICATION AGENCY
MINIGRIDS ARE COMMERCIALLy VIABLE TODAY IN NIGERIA—ADDRESSING KEY CHALLENGES WILL UNLOCK MAXIMUM SCALE

To realize the potential of Nigeria’s minigrid market, developers and investors can work with the Nigerian government to make rapid progress on these challenges.

**DEVELOP BEST SITES**
Prioritize sites that provide high capacity utilization and strong initial demand as well as ability to pay

**INNOVATE MODELS**
Develop viable, replicable, and scalable business models that combine expert local market knowledge with global supply chains

**FURTHER COST REDUCTIONS**
Reduce both hard and soft costs to unlock additional sites for development
COST-REDUCTION OPPORTUNITIES WILL EXPAND THE REACH OF MINIGRIDS BEYOND VERY GOOD SITES

Hardware cost reductions will be driven by REA’s large-scale competitive tender, standardized systems and solar/battery cost trajectories.

Cost reductions will be driven by demand stimulation program, and remote monitoring/control via smart meters, supported by the minigrid program design.

Soft cost reductions will be driven by clustering, standardization, and remote monitoring/control facilitated by software and smart metering.

Cost reductions could increase Nigeria’s minigrid market from $8 billion to $13 billion in annual revenue.

Source: Cost reduction is based on current global hardware cost trajectory and cost-savings documented and modeled by RMI that depend on remote monitoring and payment, automated software, clustering, and other measures.
CONTENTS

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DEVELOPMENT PARTNERS CAN ACCELERATE NIGERIA’S OFF-GRID MARKET BY WORKING TOGETHER WITH REA

**REA will enable the private sector while preserving competition**

- Work with regulator to provide private sector with **enabling regulation that is clear and predictable**
- **Community engagement** to create interest and find willing local
- **Data collection** to help identify attractive sites and **de-risk projects**
- Develop **tender process** for both solicited and unsolicited projects
- Support **land acquisition, permitting, regulation, and partnering** for innovative new projects

**Development partners can support and accelerate the nascent off-grid market**

- Immediate and flexible **funding for enabling REA activities** like data collection and community engagement
- **Concessional financing** including FOREX hedging
- Grant funding for **pilot projects**
- **Technical assistance** and **capacity building** for regulators and government
SUCCESSFUL DEVELOPERS AND INVESTORS WILL TAKE ACTION TO REALIZE THE MINIGRID OPPORTUNITY IN NIGERIA

<table>
<thead>
<tr>
<th>Investors</th>
<th>International &amp; Domestic Developers</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Next stage market development leveraging REA pre-feasibility work</td>
<td>- Develop standard, replicable minigrid systems and business models</td>
</tr>
<tr>
<td>- Pathways to concessional financing</td>
<td>- Pursue high-potential sites for initial development to refine economics, load growth approaches, and customer acquisition strategies</td>
</tr>
<tr>
<td>- Pursue pathways to address FOREX challenges</td>
<td>- Develop projects together with REA, then own and operate</td>
</tr>
<tr>
<td>- Support collaboration by convening developer working groups (e.g., to unlock hardware cost reductions)</td>
<td>- Create robust supply chains</td>
</tr>
<tr>
<td></td>
<td>- Iterate rapidly for second generation models to get to scale by 2020</td>
</tr>
<tr>
<td></td>
<td>- Build relationships between Nigerian and international companies</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Power Companies &amp; Financial Service Providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Explore synergies with minigrid companies to further expand market</td>
</tr>
<tr>
<td>- Engage with minigrid developers early</td>
</tr>
</tbody>
</table>
The Minigrid Regulation is specifically designed to accelerate electrification in areas without any existing distribution grid (unserved areas) and areas with an existing but poorly electrified or non-functional distribution grid, especially but not limited to rural areas. The regulation shall promote the engagement of the private sector, communities, non-governmental organizations, and other stakeholders in achieving nationwide electrification, and it seeks to minimize major risks associated with minigrid investments such as:

1. Sudden tariff changes: as tariffs would have been agreed in advance by the relevant parties; and

2. Stranded minigrid operator investments due to the connection of the main grid to minigrid in circumstances where the main grid has been extended to cover the minigrid area. In such cases, a fair compensation mechanism would be applied for minigrid operators that choose to exit.

Types of minigrids covered in the regulation

1. Isolated minigrids up to 100 kW of distributed power (registration required)

2. Isolated minigrids larger than 100 kW of distributed power and up to 1 MW of generation capacity (permit required)

3. Interconnected minigrids larger than 100 kW of distributed power and up to 1 MW of generation capacity, the connected community the mini grid developer and the distribution licensee have to sign a Tripartite Contract which becomes binding for a parties upon approval by the Commission. (permit required)

4. All minigrids larger than 1 MW must apply for a full license.

Source: REA Off Grid Electrification Strategy, 2017
How to register an isolated minigrid project
(distributed power below 100 kW)

Step 1
Identification Of The Eligibility Of Underserved Area

Step 2
Contact With The Community To Sign Off On Exclusivity Agreement

Step 3
System Design

Step 4
Sign Commercial Agreement With Community

Step 5
Acquire land and Necessary Building Approvals

Step 6
Construct, Test and Commission Mini Grid

Step 7
Registration with NERC

ISOLATED MINIGRIDS < 100 kW
ACCOMPANYING DOCUMENTATION FOR REGISTRATION REQUIRED BY NERC

1. Certified copy of Certificate of Incorporation, Memorandum and Articles of Association, Deed of Partnership or Deed of Trust, as applicable

Source: REA Off Grid Electrification Strategy, 2017
How to get a permit for an isolated minigrid
with capacity up to 1 MW and distribution above 100 kW
(optional for systems with distributed power <100 kW)

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Identification Of The Eligibility Of Underserved Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2</td>
<td>Contact With The Community To Sign Off On Exclusivity Agreement</td>
</tr>
<tr>
<td>Step 3</td>
<td>System Design</td>
</tr>
<tr>
<td>Step 4</td>
<td>Sign Commercial Agreement With Community</td>
</tr>
<tr>
<td>Step 5</td>
<td>Acquire land and Necessary Building Approvals</td>
</tr>
<tr>
<td>Step 6</td>
<td>Apply To NERC For Operating Permit For Intended Area</td>
</tr>
<tr>
<td>Step 7</td>
<td>Construct, Test and Commission Mini Grid</td>
</tr>
</tbody>
</table>

### ISOLATED MINIGRIDS (100 kW – 1 MW)
**ACCOMPANYING DOCUMENTATION FOR PERMIT APPLICATION REQUIRED BY NERC**

| I.  | Contract between the community representative and minigrid operator, where applicable |
| II. | Power station layout drawings |
| III. | Map with position of power station and distribution network marked using indicators to distinguish single phase and three phase as well as medium voltage networks |
| IV. | Certified copy of Certificate of Incorporation, Memorandum and Articles of Association, Deed of Partnership or Deed of Trust, as applicable |
| V.  | Certified copy of Certificate of Occupancy or lease agreement for project site |
| VI. | Certified copy of building permit |
| VII. | Filled standardized spreadsheets for tariff calculation |

Source: REA Off Grid Electrification Strategy, 2017
How to get a permit for an interconnected minigrid with capacity up to 1 MW and distribution above 100 kW

**Step 1**
Identification Of The Eligibility Of Underserved Area

**Step 2**
Contact The Disco And Community For Operating Agreement

**Step 3**
Contract with the DisCo and Community for Exclusivity Period

**Step 4**
Tripartite Contract and Registration

**Step 5**
System Design

**Step 6**
Sign Commercial Agreements with community and DisCo

**Step 7**
Acquire land and Necessary Building Approvals

**Step 8**
Apply to NERC for an Operating Permit for Intended Area

**Step 9**
Construct, Test and Commission Mini Grid

**INTERCONNECTED MINIGRID (100 kW to 1 MW)**
**ACCOMPANYING DOCUMENTATION FOR PERMIT APPLICATION REQUIRED BY NERC**

- Certified copy of Certificate of Incorporation, Memorandum and Articles of Association, Deed of Partnership or Deed of Trust, as applicable
- Certified copy of Certificate of Occupancy or lease agreement for project site
- Certified copies of building permit
- Filled standardized spreadsheets for tariff calculation
- Map of the interconnected network
- List of deficiencies in the distribution grid
- Distribution network infrastructure installed by the minigrid operator
- Map of plot for power generation assets
- Diagram of fixed infrastructure for generation assets
- Boundary values of the distribution grid

Source: REA Off-Grid Electrification Strategy, 2017
This independent assessment of the Nigeria minigrid market is a result of a partnership between Rural Electrification Agency (REA), The World Bank (Energy Team), and Rocky Mountain Institute (RMI).
For further information please contact:

Damilola Ogunbiyi  
Managing Director & CEO  
RURAL ELECTRIFICATION AGENCY  
damilola.ogunbiyi@rea.gov.ng

Lolade Abiola  
Head of Renewables  
RURAL ELECTRIFICATION AGENCY  
lolade.abiola@rea.gov.ng

www.rea.gov.ng