



**RURAL ELECTRIFICATION AGENCY**

ENERGY ≡ EMPOWERMENT ≡ EFFICIENCY

# THE OFF-GRID OPPORTUNITY IN NIGERIA

Upscaling minigrids for least cost and timely access to electricity  
Action Learning Event

Abuja, 4<sup>th</sup> - 8<sup>th</sup> December

# 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 and solar home systems

- Nigeria has the largest economy in Sub-Saharan Africa (GDP of \$405 billion), has 180 million people, and a flourishing economy (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 (₦ 5 trillion) annually on inefficient generation that is expensive (\$0.40/kWh or ₦140/kWh or more), of poor quality, noisy, and polluting.
- Developing off-grid alternatives to complement the grid creates a \$9.2B/year (₦3.2T/year) market opportunity for minigrids and solar home systems that will save \$4.4B/year (₦1.5T/year) for Nigerian homes and businesses.
- There is a large potential for scaling—installing 10,000 minigrids of 100 kW each can occur by 2023 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, has created the Off-Grid Electrification Strategy which is part of the Power Sector Recovery Programme (PSRP).

# THE 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 entrepreneurialism 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 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 situation 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.

The Nigerian minigrid investment brief is available on the REA website [www.rea.gov.ng](http://www.rea.gov.ng)

## PARTNERSHIPS

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 The World Bank, which 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, Kaduna, Sokoto and River states.
  - The NEP will be implemented under a market-based approach—private firms are expected to develop minigrids, with subsidies from REA. It is expected that about 1,200 mini grids will be developed under the project.

# ENABLING ENVIRONMENT

Government, donor 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 200 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 (₦7 trillion) and annual revenue opportunity exceeding \$3 billion (₦1 trillion).

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

## POWER SECTOR RECOVERY PROGRAMME

### 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.

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.

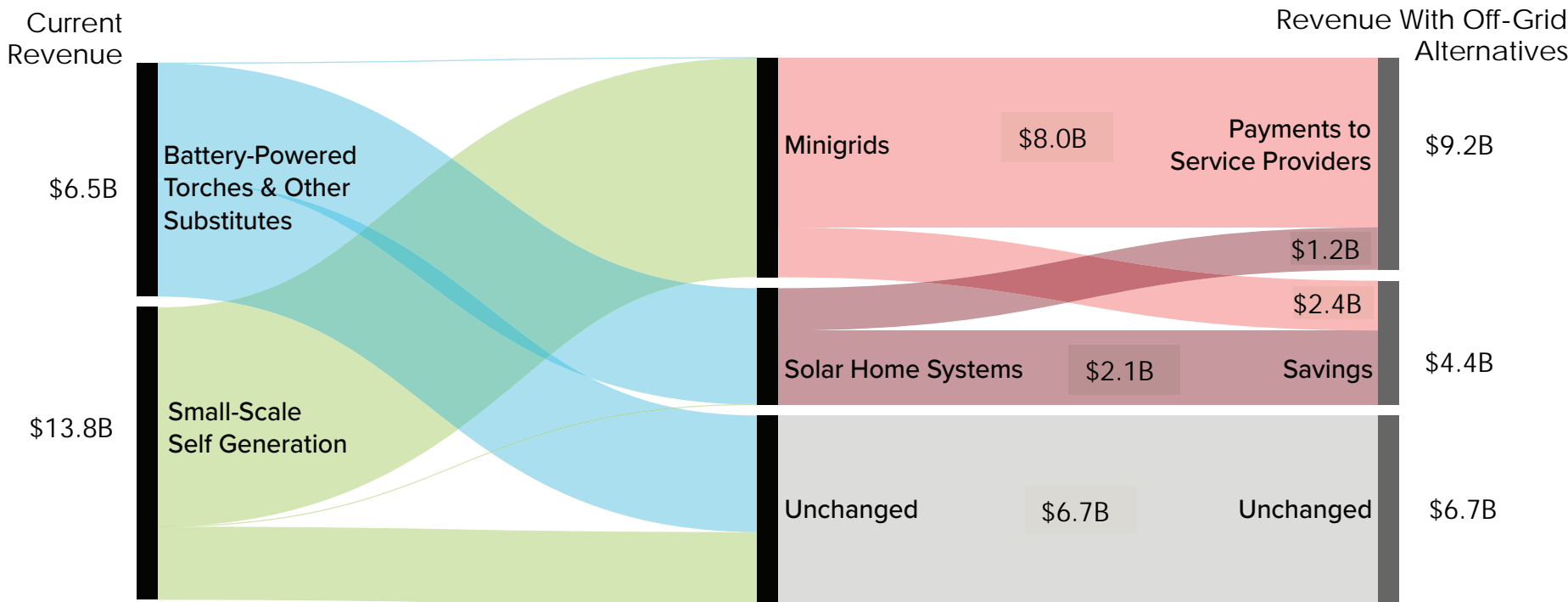
The FGN developed the PSRP in collaboration with the World Bank Group. Holistically, the objectives of the PSRP are to:

- 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.

# THERE IS A \$9.2B/YR (₦3.2T/YR) MARKET OPPORTUNITY TODAY FOR MINIGRIDS AND SOLAR HOME SYSTEMS THAT WILL SAVE NIGERIANS \$4.4B/YR (₦1.5T/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 over current energy costs

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



Source: RMI analysis

\* 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

# TO DO THIS, REA WILL SUPPORT MULTIPLE MARKET SEGMENTS

## REA Programmes

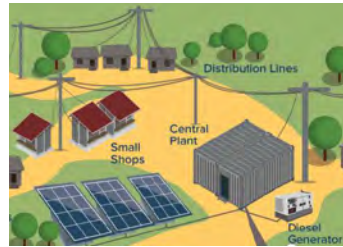
Solar Home Systems



Remote customers with low load or low ability to pay

Who will be served?

Minigrids



Communities with load less than 1 MW

Energizing Education



37 universities, 7 teaching hospitals, and the surrounding communities

Energizing Economies



Economic clusters: areas with high commercial activity and high growth impact on the economy

Crosscutting energy database – online visualization of resources for energy development



# THE \$2B/YR (₦700B/YR) SOLAR HOME SYSTEM MARKET IS A COMPELLING VALUE PROPOSITION FOR HOUSEHOLDS

An example village

## Context

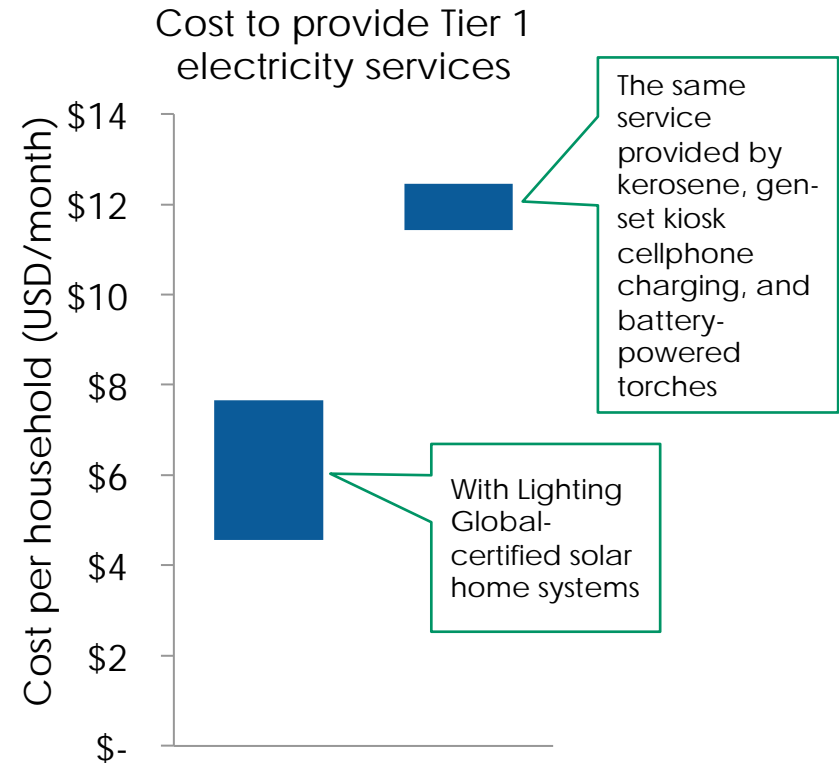
- 30 households
- 10 km away from nearest electrified town
- Low income, low energy consumption

## Proposed Solution: solar home systems

- SE4ALL Tier 1 systems can provide service at \$4.50/mth (₦1,600/mth) per household with an initial payment of \$11 (₦3,900)
- Tier 2 systems targeted at SMEs can provide service at \$13/mth (₦4,600/mth) per business with an initial payment of \$70 (₦25k)

## Customer Savings and Benefits

- Customers save 50% or \$4.50/mth per household compared with equivalent kerosene, battery-powered torch, and cellphone charging
- Even basic service can greatly expand hours of operation and productivity for SMEs



# THE NIGERIAN MINIGRID MARKET IS UNDERPINNED BY THE MOST APPEALING MINIGRID SITES IN AFRICA

|                                    | Small Off-Grid<br>Obot Ekpene,<br>Cross River | Medium Off-Grid<br>Onyen-Okpon,<br>Cross River | Medium Underserved Peri-urban<br>Mokoloki, Ogun | Large Underserved Peri-urban<br>Okun-Owa, Ogun |
|------------------------------------|---|--|---|--|
| Peak Load                          | 16 kW   | 200 kW   | 85 kW   | 1.8 MW   |
| Current Cost, Diesel Generation*   | \$0.75/kWh                                    | \$0.52/kWh                                     | \$0.39/kWh                                      | \$0.25 (industrial)                            |
| Estimated Tariff Today (15% IRR)** | \$0.51/kWh                                    | \$0.40/kWh                                     | \$0.42/kWh                                      | \$0.33/kWh                                     |
| Customer Savings                   | \$0.24/kWh                                    | \$0.12/kWh                                     | \$0.03/kWh                                      | \$0.08/kWh                                     |
| IRR if Tariff Matches Current Cost | 26%   | 22%  | 13%   | 6%   |
| Capital Cost                       | \$130,000                                     | \$1.1 M  | \$600,000                                       | \$9.7 M  |
| Consumption per Day                | 200 kWh                                       | 2,500 kWh                                      | 1,300 kWh                                       | 27,000 kWh                                     |

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

These sites are very good relative to most minigrid sites (typically \$0.60+/kWh or ₦210+/kWh) and provide superior service relative to self-generation

# FOR EXAMPLE, POOR QUALITY ELECTRICITY COSTS AS MUCH AS \$0.52/kWh (₦180/kWh) IN ONYEN-OKPON DESPITE LARGE PRODUCTIVE LOADS

## Context

- 500 households, 7 km from electricity
- 100 kW existing self generation is not reliable, affordable power solutions are available

## Consumer type

300 households (3/5 of total)

## Load

60 kW

Commercial/productive-use

170 kW

## Ability and Willingness to Pay

- Community leaders and residents have high willingness to pay
- Majority of residents currently pay \$0.43/kWh (₦150/kWh) for petrol generation or \$0.52/kWh (₦180/kWh) for diesel
- Un electrified households spend ~\$6/mth (₦2,100/mth) 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

## Proposed Solution

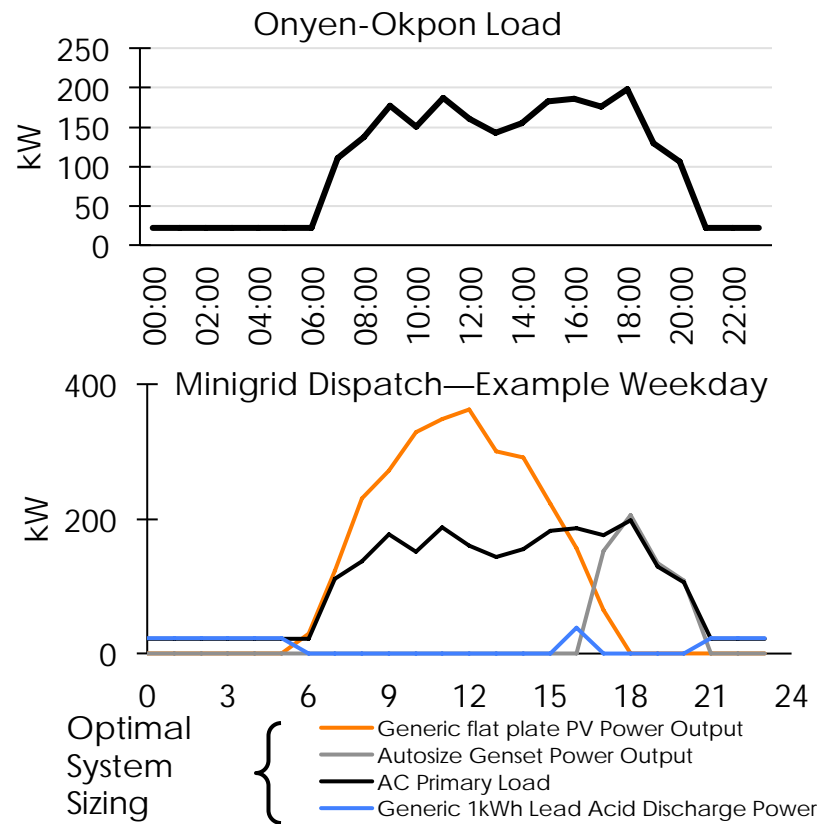
- Levelized cost of electricity is \$0.40/kWh. Minigrid with 470 kW solar, 668 kWh battery, and 220 kW diesel backup can meet overlapping load of residential and commercial loads
- 5 km low-voltage distribution system
- Upfront capital cost of \$1.1 million

## Customer Savings and Benefits

- Customers save up to \$0.12/kWh (₦42/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

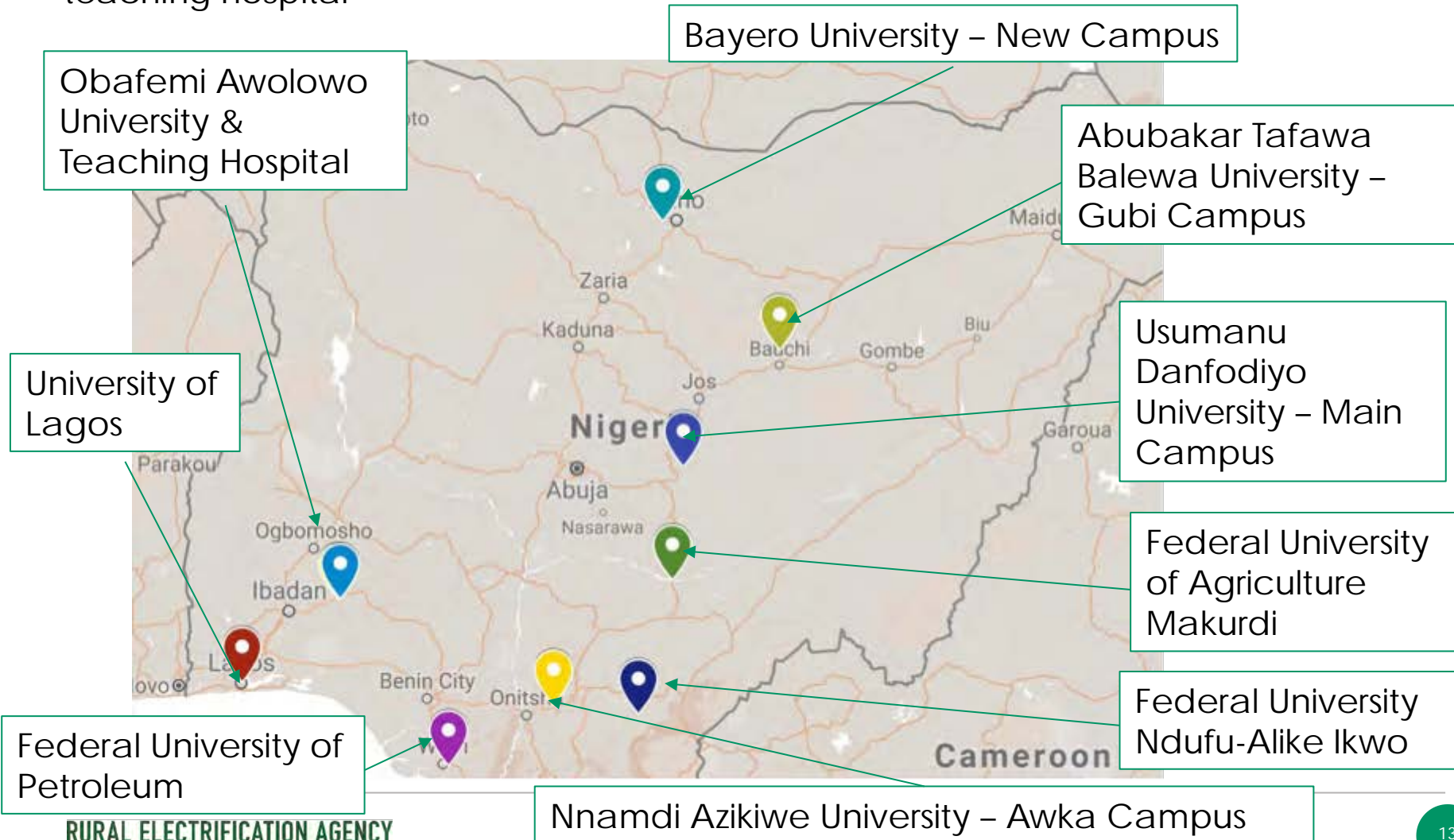
- Predictable \$31,000 monthly revenue that would grow over time



Source: RMI analysis

# THE ENERGIZING EDUCATION PROGRAMME WILL PROVIDE 90+MW OF SUPPLY TO 37 UNIVERSITIES AND 7 TEACHING HOSPITALS

Phase 1 of the programme (29 MW) is funded and consists of 9 universities and 1 teaching hospital





# THE ENERGIZING ECONOMIES PROGRAMME WILL TRANSFORM 4 LARGE MARKETS WITH >50,000 SHOPS PAYING >\$70K/DAY



Distribution lines within the Market



One of the general generators used within the Market

## Status Quo Observations

- 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
- Old overhead distribution lines

# ARIARIA MARKET IS ONE EXAMPLE OF THE MARKETS TARGETED FOR TRANSFORMATION



## Context

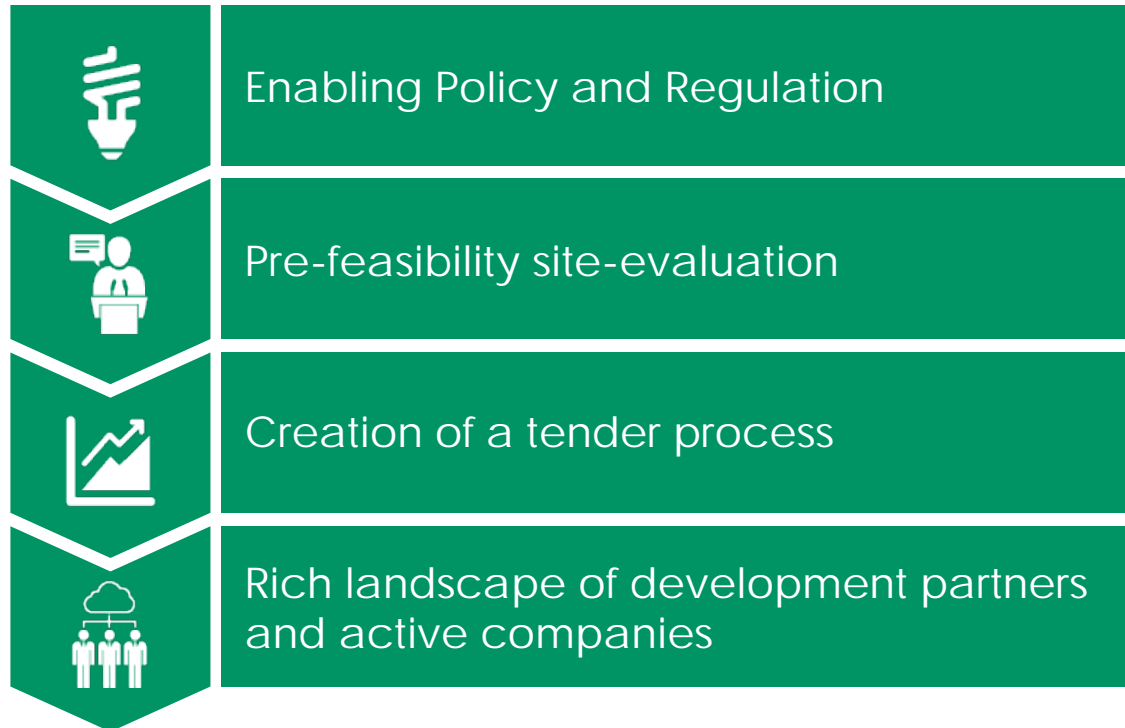
- 37,000 shops, 16,000 of which currently use electricity
- Currently spend \$21,000/day on electricity
- Currently underserved and qualified as eligible customers

## 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

# NIGERIA HAS LAID THE GROUNDWORK TO KICKSTART MINIGRID DEVELOPMENT AND WORK ON OTHER PROGRAMMES IS UNDERWAY





# 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

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### 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

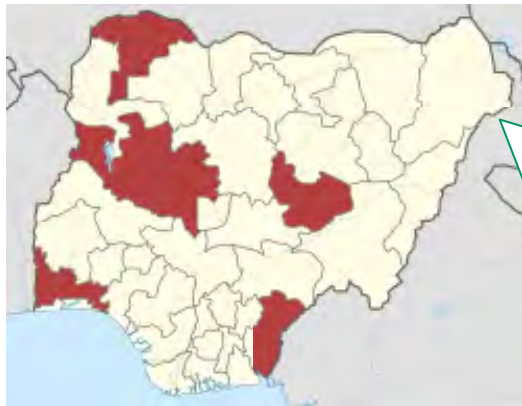
- Clear program for off-grid energy
- Clear priority to support isolated minigrids and their role in powering commercial loads

Source: Nigerian Electricity Regulatory Commission, Regulations for Mini-Grids, 2016.

# REA IS CONDUCTING UNPRECEDENTED DETAILED MINIGRID PRE-FEASIBILITY EVALUATIONS TO REDUCE DEVELOPMENT RISK

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 100kW demand



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

REA teams prioritized sites by:

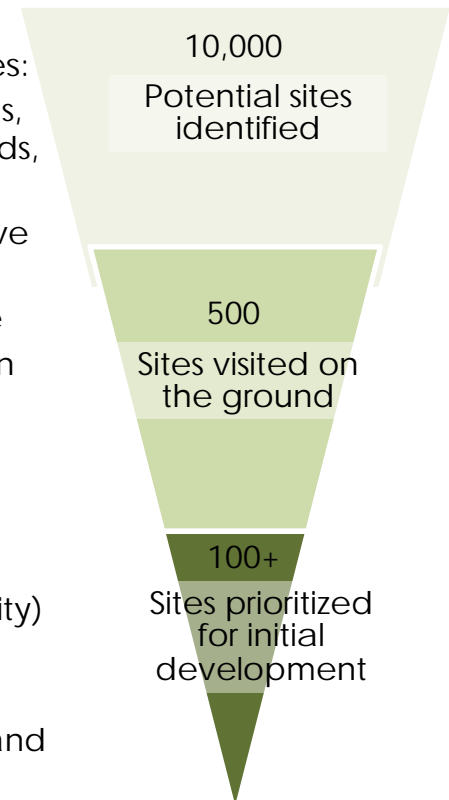
- Sufficient load/density
- Productive-use, daytime, and flexible loads
- Supportive local and state government
- Community engagement
- Solar resource and availability of gas
- Accessibility

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

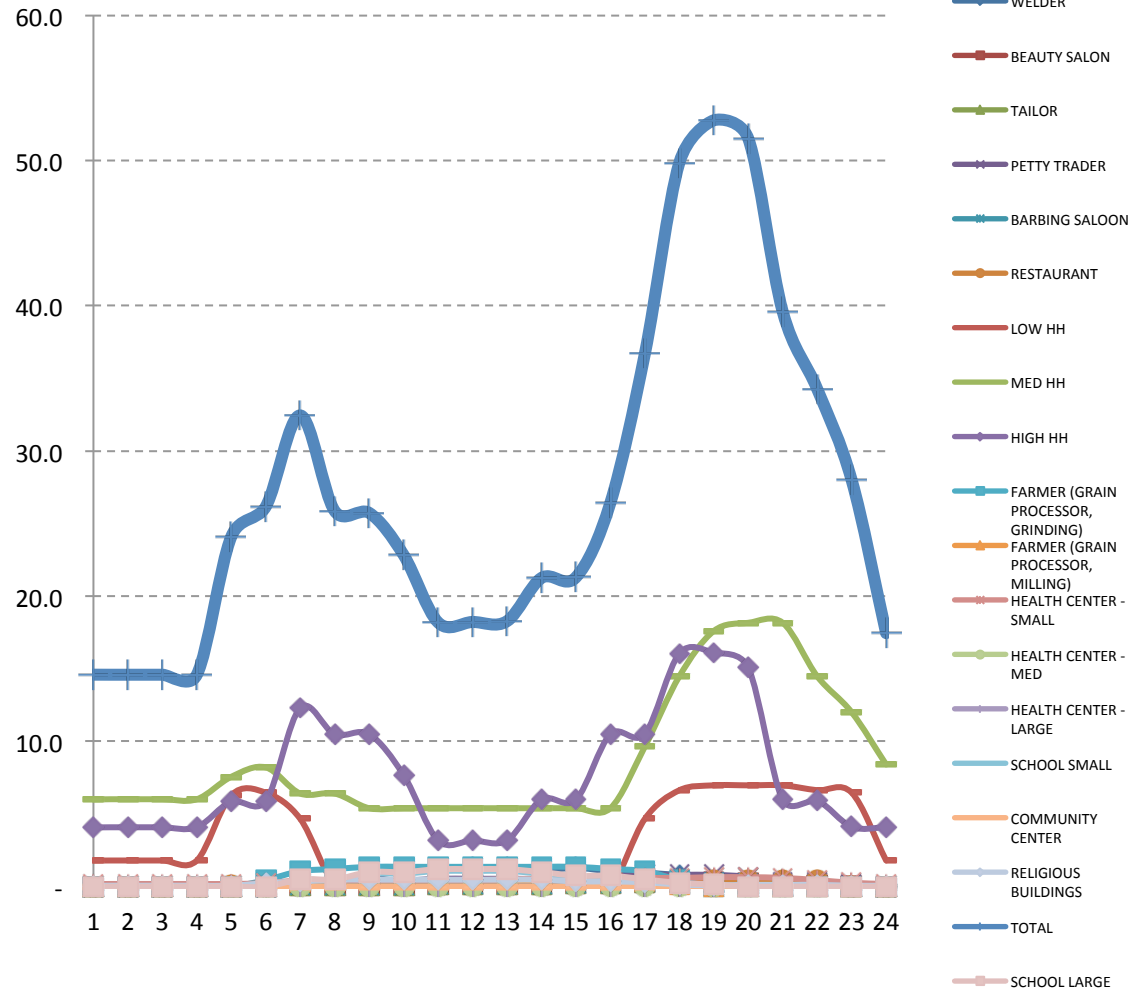


# REA SURVEYS OF 200 SITES IN 5 STATES PROVIDE QUANTITATIVE EVIDENCE FOR MINIGRID OPPORTUNITY - SAMPLE SITE: GIERE, SOKOTO

Total Households: 376

| Household Penetration rate:   |       | 75%          |
|-------------------------------|-------|--------------|
|                               | Count | Avg. kWh/day |
| <b>Household distribution</b> |       |              |
| Small HH - Hut                | 225   | 0.3          |
| Med HH - Bungalow             | 113   | 1.9          |
| High HH - Modern House        | 38    | 4.8          |
| <b>Public</b>                 |       |              |
| Health Center - Small         | 1     | 10           |
| Health Center - Med           | 0     | 60           |
| Health Center - Large         | 0     | 150          |
| School small                  | 3     | 3            |
| School large                  | 0     | 10           |
| Community center              | 0     | 3            |
| Religious buildings           | 2     | 3            |
| <b>Commercial</b>             |       |              |
| Beauty salon                  | 1     | 3            |
| Tailor                        | 1     | 3            |
| Petty trader                  | 3     | 3            |
| Barbing saloon                | 1     | 3            |
| <b>Productive</b>             |       |              |
| Welder                        | 1     | 12           |
| Restaurant                    | 1     | 6            |
| Farmer (grinding)             | 3     | 7            |
| Farmer (milling)              | 1     | 7            |

Peak Load: 53 kW



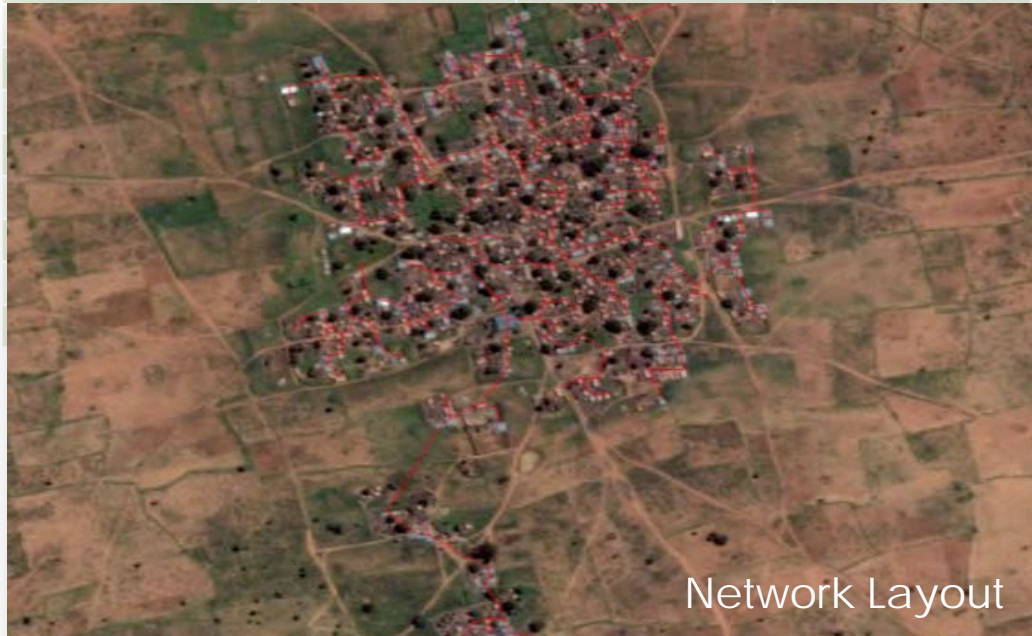
# REA SURVEYS OF 200 SITES IN 5 STATES PROVIDE QUANTITATIVE EVIDENCE FOR MINIGRID OPPORTUNITY-SAMPLE SITE: GIERE, SOKOTO

| Capital cost:           |                      |                  |                       |                  |                       |                  |
|-------------------------|----------------------|------------------|-----------------------|------------------|-----------------------|------------------|
|                         | No diesel constraint |                  | Diesel limited to 50% |                  | Diesel limited to 20% |                  |
|                         | Size                 | Capital (USD \$) | Size                  | Capital (USD \$) | Size                  | Capital (USD \$) |
| Solar PV + installation | 82.25 kW             | 57,575           | 145 kW                | 101,500          | 225 kW                | 157,500          |
| Battery + installation  | -                    | -                | 832 kWh               | 180,900          | 1420 kWh              | 308,700          |
| Diesel Generator        | 60 kW                | 21,877           | 60 kW                 | 21,877           | 5 kW                  | 5,760            |
| Inverter                | 62 kW                | 13,132           | 62 kW                 | 13,132           | 60 kW                 | 12,558           |
| MPPT Charge controller  | -                    | -                |                       | 15,338           |                       | 23,800           |
| Network + distribution  | 6.15 km              | 77,415           | 6.15 km               | 77,415           | 6.15 km               | 77,415           |

| Network Design: |             |                  |
|-----------------|-------------|------------------|
| Name            | Length (km) | Capital (USD \$) |
| Weasel          | 5.19        | 62,290           |
| Ferret          | 0.30        | 3,854            |
| Rabbit          | 0.40        | 5,655            |
| Dog             | 0.17        | 3,465            |
| Dingo           | 0.06        | 1,371            |
| Panther         | 0.03        | 780              |

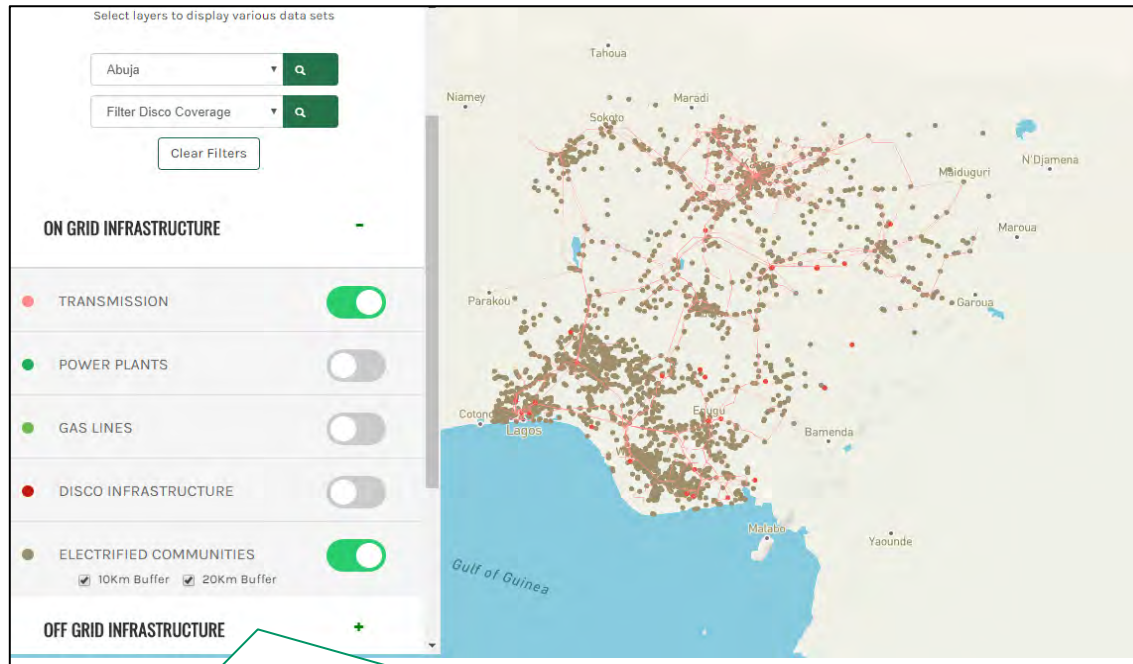
Generation System: USD 170,000 (min)  
 Distribution System: USD 77,415

Estimate Capex: \$247,415



# 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



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)

## Features

### On Grid Infrastructure

- Transmission
- Power Plants
- Distribution Infrastructure
- Electrified Communities

### Off Grid Infrastructure

- Potential Mini Grid 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

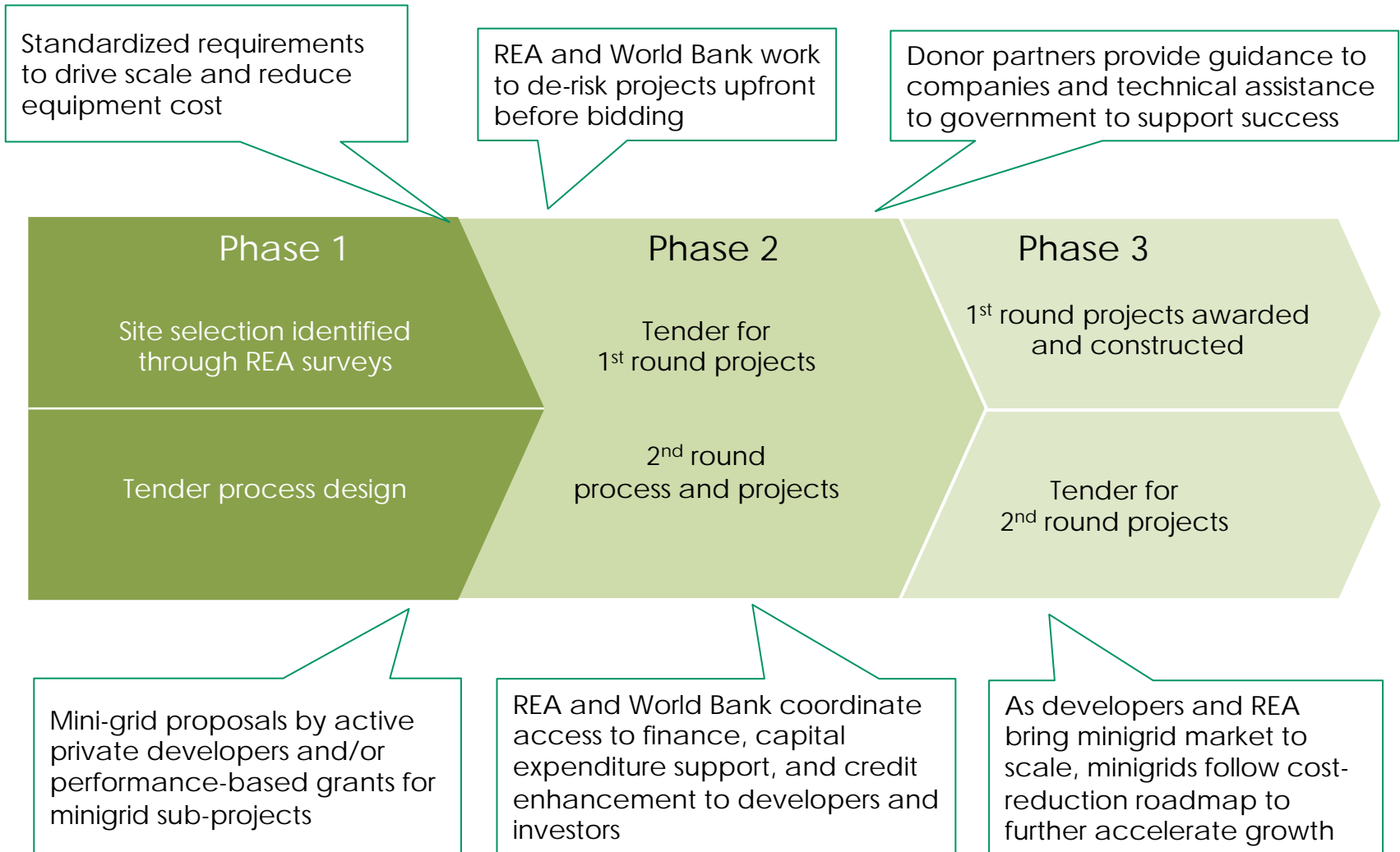
### Resources

- Mines
- Solar Irradiance
- Roads

### Amenities

- Schools
- Water Points

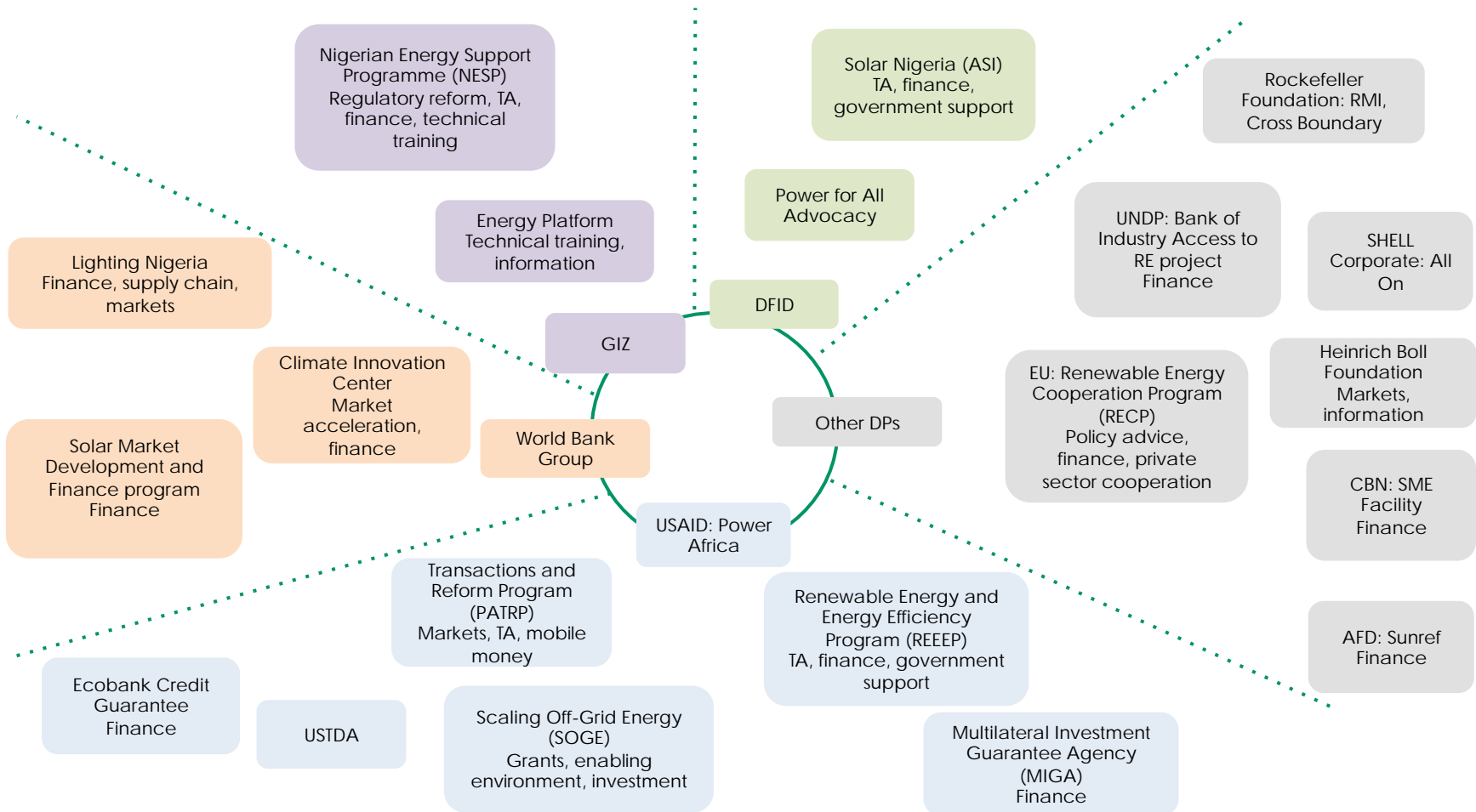
# REA IS WORKING WITH THE WORLD BANK TO SETUP A MINIGRID TENDER PROCESS THAT WILL STREAMLINE DEVELOPMENT





# REA IS COORDINATING DEVELOPMENT PARTNERS TO SUPPORT, FUND, AND ACCELERATE THE OFF-GRID MARKET IN NIGERIA

## Example development partners in energy space



Source: RMI donor partner interviews

# NEXT STEPS

## International & Domestic Developers

- Develop standard, replicable minigrid systems and business models
- Pursue high-potential sites for initial development to refine economics, load growth approaches, and customer acquisition strategies
- Develop projects together with REA, then own and operate
- Create robust supply chains
- Iterate rapidly for second generation models to get to scale by 2020
- Build relationships between Nigerian and international companies

## Investors

- Next stage market development leveraging REA pre-feasibility work
- Pathways to concessional financing
- Pursue pathways to address FOREX challenges
- Support collaboration by convening developer working groups (e.g., to unlock hardware cost reductions)

## Power Companies & Financial Service Providers

- Explore synergies with minigrid companies to further expand market
- Engage with minigrid developers early

## Donor 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



# COLLABORATIONS



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**THE WORLD BANK**



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)



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## THANK YOU FOR LISTENING

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