CRITICAL FACTORS FOR SUCCESSFUL MINI-GRID ELECTRIFICATION: THE GHANA EXPERIENCE

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Presentation Outline:

- Country Brief
- Status of Renewable Energy in Ghana
- Ghana’s Mini-grid Policy Snapshot
- Mini-grid Experience in Ghana
- Lessons Learned
- Critical Factors for Successful Mini-grid Electrification
Country Brief

Demo:
- Total population: 27,499,924
- Urban population: 56.1% of total population (2018)
- Population growth rate: 2.17%
- Urban population growth rate: 3.5%

Politics:
- Democratic governance

Economics:
- GDP of $47.03 billion (2017 est.)
  - Agriculture: 18.3%
  - Industry: 24.5%
  - Services: 57.2%
- Growth rate of 8.4% (2017 est.),
- GDP per capita was USD 4,700
Country Brief - Power Statistics

Power Generation:
- Installed Generation Capacity – 4,440MW

<table>
<thead>
<tr>
<th>Hydro</th>
<th>Renewable</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,580MW</td>
<td>43MW</td>
<td>2,817.5MW</td>
</tr>
<tr>
<td>36%</td>
<td>1%</td>
<td>63%</td>
</tr>
</tbody>
</table>

Generation by IPP: 41%
Generation by Public Utilities: 59%

Power Transmission:
- Open Access Transmission Utility

Power Distribution:
- 2 Major Distribution Utilities (and a small utility for Freezone Enclave)

Electricity Access:
- Electrification - Total Population: 84.32%
- Electrification - Urban Areas: 96%
- Electrification - rural areas: 67% (2017)
### Status of Renewable Energy in Ghana

#### Completed Grid Connected Projects
- 0.715MW Solar PV MoE/JICA for Noguchi
- 2.5MW Solar PV /VRA
- 20MW Solar PV PV/BXC (IPP)
- 20MW Solar PV /Meinergy

#### Annual Installed Capacity (MW)

<table>
<thead>
<tr>
<th>Year</th>
<th>Off-grid</th>
<th>Distributed</th>
<th>Utility</th>
<th>Mini-Grids</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>0</td>
<td>0.495</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>1.350</td>
<td>0.443</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>4.023</td>
<td>0.7</td>
<td>20</td>
<td>0.267</td>
</tr>
<tr>
<td>2016</td>
<td>1.238</td>
<td>2.626</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2017</td>
<td>0.678</td>
<td>4.266</td>
<td>0</td>
<td>0.58</td>
</tr>
<tr>
<td>2018</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>7.289</td>
<td>8.530</td>
<td>42.500</td>
<td>0.325</td>
</tr>
</tbody>
</table>

Total RE installed capacity – 58.6 MW
On-going Renewable Energy Initiatives

**SREP GHANA PROGRAM**

Investment Projects co-financed by SREP

**PROJECT 1**
- Renewable energy mini-grids and stand-alone solar PV systems
- Executed by: MoP and AfDB
- Funded by:
  - SREP: USD 17.5 million
  - AfDB: USD 27 million
  - DPs: USD 12 million
  - GOG: USD 8 million
  - Beneficiaries & private sector: USD 18.5 million

**PROJECT 2**
- Solar PV based net-metering with storage
- Executed by: Energy Commission and AfDB
- Funded by:
  - SREP: USD 12.5 million
  - AfDB: USD 15 million
  - DPs: USD 12 million
  - GOG: USD 8 million
  - Beneficiaries & private sector: USD 45.5 million

**PROJECT 3**
- Utility-scale solar PV/wind power generation
- Executed by: private sponsors and IFC/AfDB
- Funded by:
  - SREP: USD 10 million
  - IFC: USD 10 million
  - AfDB: USD 10 million
  - Beneficiaries: USD 10 million
  - Private sector: USD 45.5 million

**PROJECT 4**
- Technical assistance to scale-up renewable energy
- Executed by: Energy Commission and AfDB
- Funded by:
  - SEFA: USD 1.5 million
  - DPs: USD 2.5 million

**SECO PROJECT**
- Development of 3 mini-grids for island communities in the Ada East District
- Procurement for 3X50KW MG ongoing

**USTDA, NEPAD, SINOHYDRO and Other MG PROJECTS**
- Prepatory activities for about 50 MGs ongoing
MINI/ MICRO-GRID POLICY SNAPSHOT

- MGs mainstreamed into National Electrification Scheme and aligned with policy on rural electrification
- Public sector-led Business Model: ownership
- Management of mini-grid installations:
  - VRA responsible for O&M of MG assets on islands
  - ECG and NEDCo responsible for O&M of MG assets inland within their respective jurisdictions.
- ZERO connection fee charge for RE-based mini-grid customers.
- Tariff: the existing Uniform Tariff Policy (UTP) applies to RE-based mini-grid customers. e.g. lifeline consumption which is equivalent to 50kWh/month
  - PURC includes MGs in the National Electricity Tariff Rate Setting Methodology (weighted average; cross subsidization)
MINI-GRID EXPERIENCE IN GHANA

- GEDAP involved the use of multiple electrification systems, including renewable energy-based off-grid and mini-grid systems, to provide electricity access to remote communities.

- In 2015, through ICB, an EPCM contract was awarded to a consortium made up of TecnoTramaAbiental (TTA) of Spain (the Lead), GTS of Ghana and Arthur Energy Advisors (AEA) of Ghana to design and construct five (5) pilot mini-grids on islands in Ghana.

- The concept to include the management component was to allow the winning bidder to develop a sustainable management model and test it over a two-year period post technical commissioning of the mini-grids.

- Lessons from the pilot, including the management component, were meant to form the basis for policy consideration for scaling up mini-grid electrification in Ghana.
KEY FEATURES OF PILOT MINI-GRIDS:

- Deliver 99.9% systems reliability (reliable 24/7 electricity service and street lighting)
- Three phase 415V AC-distribution backbone
- Grid-ready Inverters
- Smart energy dispensers with Energy Daily Allowance (EDA), Prepaid metering system, and Time-of-use features
- An environmentally friendly power house
MINI-GRID EXPERIENCE IN GHANA

KEY FEATURES OF PILOT MICRO-GRIDS:
Studer XTH 8000-48 Inverter features:

- Highly programmable
- Inverter / charger functions
- Switches between inverter and transfer system when AC power source connected. Smart boost function allows support of AC source to maintain supply integrity
- Auxillary contacts for intelligent start of generators
- Onsite/ Remote monitoring & control is through RCC 02/03 device or LAN, GSM or SMS interfaces
- Synchronized Vario Track MPPT Controllers for optimal battery management
- Anti-islanding and fault ride-through features
KEY FEATURES OF PILOT MICRO-GRIDS:

Smart Circutor Energy Dispenser (BII) features:

- Energy/demand management
- Programmable EDA and pre-payment
- Real time information (through LCD display) allows customer to intelligently engage in energy/demand control
- Demand response (through LED) indicators signals free/limited energy periods
- Auxillary relay for non-essential loads
- Communication- optical port and RS 485 (modbus protocol) for M & C
- Wireless RFID card system for managing customer contracts
Mini-grid plant & Dist. Network for Kudorkope

552 residential and non-residential connections
LED street/path lighting facility (30 per Community)
LESSONS LEARNED

- The adoption of the most appropriate Business Model depends on the country’s electrification context. In the case of Ghana the Public sector–led Business Model was largely dictated by UTP (with cross subsidization) and the NES.

- The policy decision to mainstream the mini-grids into the NES led to about 94.5% service connections, harmonized the operational processes and eliminated tariff disparities between mini-grid customers and those on the national grid.

- The use of technology significantly improved operational efficiency and reduced operations and management cost as a result of limited human interface (e.g. RFID Card, Intelligent Dispenser, ABC).

- Over 90% revenue collection achieved because of technology which is far above the national average of 75% by the country’s two main utilities (ECG and NEDCo). However, the amount collected as service charges over the two-year period was insufficient to cover the O&M costs. Therefore, without public sector support, it would be difficult to run the mini-grids effectively. Where PUE activities increased, they helped anchor the investments through improved revenues.

- The tariff structure and time use of energy deployed allowed customers to manage their Daily Energy Allowance and also easily upgrade their consumption levels.
CRITICAL FACTORS FOR SUCCESSFUL MINI-GRID ELECTRIFICATION

- Market size – the ability to serve a sufficiently sizeable number of the population at the least capital and recurring cost of the project.

- Policy choice – based on understanding of the local context within which the project must be delivered. There is no one-size-fits-all solution to delivering mini-grid electrification. It important that the interest of beneficiaries override those of external forces. In other words, donors and development partners must be flexible and willing to provide tailored support.

- Integration of concepts – gender, productive uses etc. must be integrally developed and promoted consciously in order to improve the commercial viability of mini-grid electrification.
CRITICAL FACTORS FOR SUCCESSFUL MINI-GRID ELECTRIFICATION

- **Choice of Technology** – the remote nature of mini-grids require well-engineered solutions and technologies that limit human interface whiles balancing cost and service.

- **Human and institutional capacity** – building human and institutional capacities is crucial for the efficient and sustainable management and operation of mini-grids.

- **Financing arrangement** – mini/micro-grids targeted at remote poor communities require a high fraction of concessional funding to improve financial viability. State involvement in financing and delivering of mini-grid electrification service is therefore necessary to reach the poor in remote communities.
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