Geospatial Planning for Grid & Off-Grid Electrification

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Geospatial Platforms for Master Planning

• By its nature electrification planning focuses on service delivery on a spatially oriented basis.
• Geographic information systems (GIS) allow multiple data sets to be employed to evaluate costs and benefits of multiple electrification options.
• Integrate affordability data, population data, grid infrastructure data, natural resource data, and financial data in a single, geographically-referenced digital platform
• Integration of satellite imagery to digitize location of unserved consumers allows for a much more refined analysis of costs, opportunities and returns
Principal Activities: REA Mastering Planning Process

1. Creation of a high resolution GIS to be used as a least-cost electrification planning platform
2. Data gathering and validation for development of a series of master plans
3. Projections of demand based on consumption data and WTP surveys
4. Optimization of grid and off-grid systems, including an analysis of a plan of phased investments to scale-up electricity access
5. Evaluation of business sustainability needs including training, capacity building, business systems and other needs
REA Master Planning Project

• Develop master plans for 13 service territories
• Evaluate and recommend improvements in expansion planning organization, methodologies and execution.
• Prepare business plans for service territories which will integrate
  • Annual investment requirements for grid and off expansion
  • Growth of the utility on internal investments requirements and operating costs
  • Overall organizational structure including capacity building needs
  • Financial model to evaluate tariffs required to result in long-term sustainability for each service provider
Steps in Planning Process

• Update GIS for each service territory
• Implement willingness to pay surveys
• Evaluate service options including:
  • Densification of grid service
  • Grid expansion
  • Mini-grids
• For each option, evaluate connection potential, costs and financial returns
• Perform an organizational assessment to determine how the utility will need to grow to meet service requirements
• Evaluate financial long-term sustainability
• Perform risk assessment
Grid Expansion Analysis

• Expansion of grid coverage is a function of the geographic population distribution – we need to build grid infrastructure to where people live

• The process consists of the following steps:
  • Update geodatabase for UEDCL & UMEME MV system data
  • Create base map
  • Digitize housing structures using satellite imagery
  • Define & evaluate projects by extending MV lines and placing transformers to serve housing clusters
  • Evaluate project capital costs, operating costs and potential revenues
  • Prioritize projects based upon cost/consumer and net revenue analysis
Household Clustering Methodology
Project Identification

• Identify all unserved household, which can be considered for either grid or off-grid.
Generating buffers
Create Line Route
Intensification Analysis: Adding Consumers to Existing Transformers

- UEDCL currently serves ~4,619 consumers connected to 156 transformers – approximately 30 consumers per transformer
- All 156 transformers were evaluated to determine how many additional consumers could be connected:
  - Over 38,700 additional consumers within 1000 meters of the transformers
  - The existing penetration rate is only 12% of the potential!
- With an average transformer size of 50 kVA, up to 150 consumers could be connected to the transformers
- Taking advantage of the new REA connection policy, up to 50% of this total would likely qualify for a connection resulting in ~17,600 new connections – w/o introduction of additional transformer capacity
- Total estimated cost: $3.1 million
System Reliability Investments

• As load is added by grid expansion and/or grid intensification, the load-carrying capacity of distribution transformers, feeders and substations can be challenged

• It is necessary to evaluate increases in load and the impact on upstream circuit elements

• The GIS team prepared a distribution system model for the NRECA engineering team to perform load flow analyses on all circuit elements subjecting substations, feeders, and transformers to higher loads and evaluating mitigation measures
Load Flow Analysis: Base case analysis_2018

Lira – Gulu feeder total length 715kM
Load Flow Analysis: 2020 Increased Load, No Interventions

Lira – Gulu feeder total length 898 km
Load Flow Analysis: 2020 Increased Load, with Interventions

Two capacitor banks
One Voltage Regulator
Load Flow Analysis: 2020-27

Load 13MW
Loss 4.8%
Mini-Grid Identification & Evaluation

- Grid electrification will not reach all villages and housing clusters
- Mini-grids can be used in some areas to provide high quality service
- We assume mini-grids will use solar-battery charging systems, lithium ion batteries and low voltage distribution systems