Co-Optimization of Costs and Losses in Microgrids Design for Off-grid Villages

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Abstract
This project explores optimizing a microgrid design for Sabon Kafi, an off-grid community in Niger. The design of microgrids especially for off-grid villages can be challenging considering the various design variables that need to be considered: from making decisions on the right generation mix to choosing distribution assets and sizes. This research proposes a co-optimization methodology for cost and voltage drop for off-grid designs.

Introduction
Microgrids have continued to show great promises in electrifying off-grid communities, supporting the centralized grid and accelerating the penetration of renewable energy [1]. These benefits are hinged on the distributed nature, controllability, flexibility and lower transmission losses in microgrids. However, the design of microgrid for off-grid villages without existing power infrastructures can be very challenging due to the myriad number of variables that need to be determined. This project starts with economic optimization based on to determine the most cost-efficient generation assets. These assets are then used to run power flow analysis on a distribution network overlay with GIS information of the target community. This is followed with distribution analysis to ensure IEC standards are met.

Methods
Xendee microgrid decision platform, economic optimization considering generator, solar and battery storage (Lithium Ion vs Lead Acid) was conducted.

Step 1: Determine and ensure the supporting voltage drops and villages considering target Ion

Step 2: Run power flow on the village network with generation assets from step 1.

Step 3: Develop heatmaps and check for IEC standards.

Step 4: Explore conductor sizing to limit voltage drops.

Step 5: Increase generation assets

Step 6: Employing Balancing system devices: voltage regulators, capacitor banks.

Results
Economic optimization was run with load data supplied by lab partners and local cost of the inputs to the microgrid. Lithium Ion and Lead acid were compared but storage technologies were not viable for this position.

<table>
<thead>
<tr>
<th>Optimization Parameter</th>
<th>Results</th>
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</thead>
<tbody>
<tr>
<td>Diesel Gen (kW)</td>
<td>80</td>
</tr>
<tr>
<td>Solar PV (kWdc)</td>
<td>28</td>
</tr>
<tr>
<td>Storage Size (kWh)</td>
<td>0</td>
</tr>
<tr>
<td>LCOE &amp; GCOE (S/kWh)</td>
<td>0.2897</td>
</tr>
<tr>
<td>PV Size (m²)</td>
<td>187</td>
</tr>
</tbody>
</table>

Table 1: Economic Optimization Results

Discussion
After economic optimization, Xendee always reported zero for storage size. However using costs that are 50% less than the actual cost of this technology resulted in not only higher storage sizes but also increased solar PV needed for the system. This will have provided better power flow for the system. This shows that the high cost for storage technologies is hindering maximum utilization of renewables.

Conclusions
A method for co-optimizing costs and voltage drops of microgrids design is proposed. The economic optimization results showed that a decrease in storage technology prices could significantly improve renewable energy penetration in off-grid systems. This research affirms microgrid as a potential solution to electrifying off-grid communities.

References

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