

Multi-year stochastic planning of off-grid microgrids subject to significant load growth uncertainty: overcoming single-year methodologies

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Abstract-

The optimal design of off-grid microgrids in developing countries is difficult to achieve, as several political and socio-economic risks can hamper investments of private companies. Estimating the energy demand and its growth is a challenging task, subject to high uncertainty that rarely have been accounted for in multi-year simulations at hourly resolution. Besides, from a long-term perspective, the assets degradation can significantly affect the performance of stand-alone hybrid energy systems. In this paper, we address these challenges and propose a novel stochastic dynamic method to size microgrids, simulating with accuracy the system operation and considering the unavoidable uncertainty in load growth and the components ageing. A predefined scenario tree structure allows capturing the load growth uncertainty and obtaining different capacity expansion strategies for each scenario. An illustrative case study for an isolated power system in Kenya using data collected in 23 Kenyan microgrids is shown. The proposed stochastic formulation results in a considerable reduction of the size of components with respect to traditional single-year approaches. Savings in terms of Net Present Cost (NPC) are beyond 16-20% and the effects of assets degradation are about 6%. Results lead to recommend multi-year optimization tools, as single-year methodologies can hardly achieve the same performances.

Index Terms- Generation Expansion Planning (GEP); Real Option Analysis (ROA); PV-Battery-Diesel-Tank Mini-grid; Multi step investment plan; Rural electrification; Particle Swarm Optimization (PSO)

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