Sustainable and Socially Resilient Minigrid Franchise Model for an Urban Informal Settlement in Kenya

Serena N. Patel,[a] Isa L. Ferrall,[b] Byrones Khaingad,[c] and Daniel M. Kammen[d]

1 Motivations underlying the research

This article provides a case study of an environmentally sustainable and socially resilient minigrid distribution model to serve communities in an urban informal settlement in Kibera, Nairobi, Kenya. The process of designing resilient and sustainable urban solutions must account for the different needs, requirements, and barriers common to informal settlements, our understanding of which suffers from a severe lack of data. Therefore, we use an interdisciplinary approach, integrating a wide range of methods including: surveys, sensor-based monitoring, energy system simulation, policy analysis, and evaluation of a proposed business model. Conducted in collaboration with the Kibera Town Center (KTC), we collect unique primary electricity production and usage data to analyze informal settlement electricity demands. However, unlike previous literature in informal settlements that focuses on residential energy, this research focuses on critical, centralized community-scale energy that supports schools, water delivery, and livelihoods. Furthermore, under a policy change in Kenyaâ€™s Energy Act 2019, this minigrid now has the opportunity to expand and sell power to the local community under new business models. When scaled, our proposed innovative minigrid franchise business model can support microenterprises and return agency to slum dwellers.

Our research is guided by the following questions:

- What is the existing electricity landscape of the community center, local schools, and local shops?
- What is the optimal amount of solar photovoltaic (PV) capacity to serve KTC and the adjacent Olympic Primary and Secondary schools?
- Which technical minigrid scenarios provide the lowest cost of electricity? Is it at a higher or lower cost than grid extension?
- How can a community minigrid franchise model - made possible through Kenyaâ€™s Energy Act 2019 and approached in collaboration with communities, non-governmental organizations (NGOs), and government stakeholders - showcase environmentally sustainable and socially resilient planning for urban informal settlements?
- How can results from this case study inform other resilient and sustainable infrastructure for informal settlements?

2. Research Performed

2.1 Minigrid Simulation

Using HOMER Pro, we first simulate the minigrid's techno-economic expansion from KTC to also serving the school and shop loads. Our simulation scenarios were designed with local stakeholder input so that the simulation results can inform real and policy-relevant decisions. The scenarios include: a business as usual scenario, adding school loads without increasing the system size, optimal solar expansion, constraining the system to 100% renewable energy, and adding shop loads.

a Renewable and Appropriate Energy Laboratory (RAEL), Energy and Resources Group (ERG), and Energy Engineering College of Engineering, University of California, Berkeley.

b Corresponding author. RAEL and ERG, University of California, Berkeley. Send correspondence to Energy and Resources Group, 345 Giannini Hall, University of California Berkeley, CA 94720-3050 E-mail: isa.ferrall@berkeley.edu.

c Kibera Town Center, Human Needs Project, Nairobi, Kenya.

d RAEL, ERG, and Goldman School of Public Policy, University of California, Berkeley.

2.2 Minigrid Franchise Business Model

Figure 7 in the full article depicts this research's key contribution of a Framework for a Minigrid Franchise Model at KTC, and the benefits to key stakeholders. In this model, the utility and government first grant the NGO with a license to generate and sell electricity under the Energy Act 2019. The NGO acts as a franchiser, relying on its established social capital. Microbusinesses are selected as franchisees that agree to connect and regulate payments for others that opt into the community minigrid. The NGO and other key community loads will be able to sustainably consume high-quality power to support basic community needs, empowerment services, and education. In doing so, they will reduce non-technical losses, increase grid resiliency, and support a growing local economy.

3. Main Conclusions and Policy Implications

This research details the extensive monitoring and evaluation efforts that can inform future resilient and sustainable urban planning for informal settlements. We manifest the benefits of investing in collaborations and ethically gathering electricity data, which can serve as a model for future city planners and basic needs providers.

We find that the community center, local schools, and individual shops surrounding the center respectively consume an average of 324 kWh, 274 kWh, and 2 kWh each daily. Through our minigrid simulation, we find that the levelized cost of energy (LCOE) will decrease by 60% with optimal minigrid expansion, thereby demonstrating expansion's economic feasibility. Net present value calculations indicate that KTC could save over $38,000 USD over the next 25 years by implementing the community minigrid instead of maintaining the status-quo system.

Through stakeholder mapping efforts we identify the franchise model's key drivers of success which include: the community's need for safe wires, better maintenance of the minigrid equipment, shifting a utility liability into a valuable community asset, and increasing opportunities for skilled employment. We also quantify significant potential emissions reductions which can improve both local health and global climate.

Environmentally sustainable and socially resilient planning for urban informal settlements hinges on enabling policies, such as Kenya's Energy Act 2019, combined with applied research and informed business models to leverage opportunities for equitable transitions toward sustainable urban development.