Combatting Energy Poverty with Solar Microgrids in Malawi: Disseminating an Evidence Base to Accelerate Deployment

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Rationale

Energy poverty constrains economic growth and livelihoods, a significant challenge for Malawi where 82% of the population live without access to electricity. Solar PV microgrids offer a cost competitive low-carbon solution to addressing Sustainable Development Goal 7 by enhancing socio-economic wellbeing and offering entrepreneurship opportunities. As a new technology in Malawi, there is a recognised lack of proven business models, field experience and data on microgrid performance and impact, stymying wide-scale deployment. With access to primary data from a microgrid pilot project, an opportunity was identified to understand microgrid technical, economic and social impact performance to inform the sector.

Key research aims

1. Analyse social impact, economic and technical performance of an existing solar microgrid in Malawi, drawing out key evidence of solar microgrid performance and impact on rural communities living in energy poverty.
2. Produce recommendations for practitioners and targeted donor and government support to accelerate microgrid deployment while ensuring sustainable operation.

Summary of research activity

Primary field data available through an active solar microgrid project. Data sources comprise field surveys, remote monitoring and smart meter data, described below:

- Social impact surveys for 60 customers, categorised into themes of energy access; health, education and communication, employment and finance, female empowerment and tariff and service.
- Smart meters logging demand, revenue, and communication uptime
- Remote monitoring of battery, inverter and solar PV performance
- Expert interviews with project field staff to understand experiences of microgrid deployment and operation.

Methodologies used

- Quantitative – analysis of smart meters, remote monitoring and survey data
- Qualitative – informal interviews with project field staff
- Literature review – policy documents, project reports

Findings

Lack of access to energy, or insufficient, unreliable energy supplies act as a constraint to economic growth and improvement of livelihoods, a significant problem for Malawi where just 18% of the population have access to electricity (11.4% on-grid, 6.6% off-grid) (1). With cost decreases in solar PV components and Malawi's abundant solar resource, the establishment of solar PV microgrids is being explored, especially in regions unlikely to get a main grid connection imminently (2). Whilst solar microgrids are estimated to be the lowest cost energy access route for 37% of the population (3),effective and sustainable business models are needed for implementation at scale. These need to be financially feasible while at the same time meeting the social development objectives of the rural communities they serve.

Through the Rural Energy Access through Social Enterprise and Decentralisation (EASE) project, a solar microgrid has been installed in the rural village of Mthembanji in Dedza district, generating and distributing power for domestic and productive customers. The motivation for the project is to pilot and demonstrate a social enterprise ownership model for solar microgrids in Malawi, with the aim of using this project as a platform to deploy further microgrids at other identified sites across Malawi. Since its installation, the microgrid at Mthembanji has been collecting valuable data on technical, economic and social impact performance through smart meters, remote monitoring and enumerator surveys. The data allows for monitoring and evaluation to understand microgrid performance, ultimately informing business strategies for the scaling of microgrid operations in Malawi.

The microgrid installed in Dedza offers reliable electricity to over 350 people through solar PV generation with storage, a low voltage distribution network, and smart meters. Performance monitoring of the microgrid through robust data collection has several benefits for multiple stakeholders in the microgrid sector including system operators, donors, investors and policy makers. Microgrid technical designs and business models can be improved through the capturing and analysis of data through smart meters, remote monitoring, and social impact surveys to inform positive interventions in the microgrid ecosystem.

As the first project of this scale implemented in Malawi, the deployment of the microgrid faced significant challenges including supply chain and regulatory hurdles, inflation and foreign capital constraints, Covid-19 and lack of local capacity, all contributing to long deployment timelines. Skilled local technicians and field staff with international remote support allowed for rapid installation once components arrived.

Solar PV with lithium-ion batteries offer low maintenance generation, with effective remote monitoring assisting in troubleshooting. The systems have generally performed efficiently and

effectively, providing reliable energy to communities and demonstrating resilient energy delivery in areas vulnerable to climate shocks. Challenges were experienced with the smart meters, with technical faults and problems with mobile signal dropouts causing blackouts and necessitating frequent callouts for maintenance engineers.

Capital and operational costs have been found to be high compared to African benchmarks, reflecting the nascent market of microgrids in Malawi. Revenue from electricity sales covers site based operational costs of maintenance contract, data and site agents, but does not cover wider organisational costs such as transport, replacement of main system components and staff salaries. This is being addressed through stimulating demand by increasing the number of connections and targeting recruitment to daytime business customers, while looking to reduce OPEX costs through more efficient operation and maintenance strategies. Cost reflective tariffs have been calculated and tariff bundles developed to match customer ability and willingness to pay, with ongoing tariff negotiations through sustained community engagement.

Social impact data collected through surveys shows that energy access directly correlates with participants' expectations in relation to happiness, opportunities, and economic development. Households are much more satisfied with their home lighting and can entertain, work and study in their homes at night. Energy supply infrastructure, availability, convenience, and environmental and health impacts from microgrid energy have improved. Participants in the survey are generally satisfied with the quality of the service and the project; they consider it a good development, transforming community life and bringing an urban feel. However, some customers find tariffs expensive and the service unreliable, and not conducive to pursuing their business venture ideas.

Key findings suggest that solar microgrids can play a role in reducing energy poverty in Malawi through the provision of reliable electricity in remote areas. However, challenges exist in scaling their potential to significantly contribute to SDG7, primarily centred on the currently unsustainable business models resulting from high costs and low demand, reflective of a nascent microgrid sector.

1. World Bank. Access to electricity (% of population) | Data [Internet]. 2018 [cited 2021 May 18]. Available from: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?end=2018&start=1990&type=shaded&view=map
2. Eales A, Unyolo B. Renewable Energy Mini-grids in Malawi: Status, Barriers and Opportunities. University of Strathclyde, editor. Scottish Government; 2018.
3. Eales A, Alsop A, Frame D, Strachan S, Galloway S. Assessing the market for solar photovoltaic (PV) microgrids in Malawi. Hapres J Sustain Res [Internet]. 2020 Jan 7 [cited 2022 Jan 4];2(1):e200008. Available from: https://pureportal.strath.ac.uk/en/publications/assessing-the-market-for-solar-photovoltaic-pv-microgrids-in-mala

Recommendations

Recommendations are outlined below for practitioners and decision makers in policy, along with suggested research agendas to accelerate access to energy through rapid deployment and scaling of solar microgrids. All stakeholders from the public, private and third sectors, as well as customers and communities need to understand the opportunities presented by solar microgrids, and there is a need for improved capacity to deploy, operate and maintain microgrid technologies as well as for proven business models to ensure long term sustainability.

Recommendations for policy makers are to:

- Implement smart subsidies to reduce tariffs and improve microgrid financials;
- Designate space for microgrids in rural electrification planning;
- Extend VAT waiver on solar equipment to all microgrid components including distribution grid and house wiring materials;
- Ensure sufficient foreign currency is available for purchasing microgrid components from abroad; and
- Invest in research and capacity building.

For microgrid developers recommendations are to:

- Invest in data monitoring and analysis – and share data where feasible;
- Seek collaboration and partnerships with multiple development players;
- Improve financial sustainability through innovative business modelling; and
- Set aside resources for community engagement and measuring social impact.

Research agendas to progress the microgrid sector are proposed in:

- Techno-economic business modelling: More research is required to develop and trial microgrid business models, linked with innovative financing mechanisms. Designing the most effective tariffs for different customer segments and quantifying smart subsidies needed for microgrids to be financially sustainable while offering the social impact desired by governments is a valuable and necessary research agenda to accelerate microgrid deployment.

- Microgrid performance monitoring through data acquisition and analysis: Efficient technical design and sustainable business models are improved with access to, and analysis of, primary data from existing microgrids. Monitoring Key Performance Indicators in technical, economic and social impact domains, and sharing this data, will aid in building the knowledgebase and accelerating the growth of the nascent microgrid sector.
- Understanding demand: There exists a significant gap in understanding demand of newly connected customers in Malawi. Measurement of load profiles, quantification of load growth over time and provision of insight on demand patterns and seasonal trends are essential for designing cost-effective and technically efficient microgrids. Measuring and sharing demand levels disaggregated by customer segments is especially important for informing business models and tariff setting.
- Spatial planning: Combining Geographical Information System (GIS) data such as population density, solar resource, and distance to maintenance centres with estimated demand and load profiles can inform the spatial planning of microgrids, locating and sizing systems, and the optimisation of maintenance logistics across multiple sites.
- Asset management: Assuming the microgrid market grows and future microgrid operators will own and manage multiple microgrid sites, valuable research is needed to inform asset management strategies to sustainably manage a fleet of microgrids. Such research will predict timings for replacement components, optimise maintenance regimes, and maximise cost savings and technical efficiency through remote monitoring.

About the Funder

The Fuel Poverty Research Network (FPRN) was established in 2016 by researchers who were all concerned with different aspects of the interaction between people, homes and energy. The charity supports researchers and facilitates dialogue between researchers, policy and practice. FPRN's grant programme, Engaging in Energy Poverty in Early Career (EPEC), supports early career researchers (ECRs), postgraduate students (PGRs), and early career practitioners (ECPs) based in any country to contribute to efforts to tackle fuel and energy poverty through original research and publication.