Making Mini-Grids Work: Practical Approaches to Economic and Financial Analysis

Powering Progress: Practical Insights for Mini-Grid Development

GGEEA
Growing Government Engagement in Energy Access

Overview

Access to electricity is essential for reducing poverty, improving health and education, and supporting jobs, especially in rural areas. But true access means more than just having power; it must be reliable, affordable, and useful. This brief explores how households, businesses, and public services use electricity differently, and how their needs can be met through solutions like mini-grids, solar home systems, and shared energy services. It highlights the importance of understanding local demand, choosing the right technologies, and planning for both technical and financial sustainability. The brief also explains funding options, like loans, grants, and investments, and how clean energy projects can reduce emissions and support climate goals. Overall, it offers practical guidance for delivering inclusive, sustainable energy to underserved communities.

About GGE-EA

The Growing Government Engagement in Energy Access (GGE-EA) project, funded with UK aid from the UK government via the Transforming Energy Access platform, aims to build government capacity in Sub-Saharan Africa to advance decentralised energy solutions, particularly mini-grids. Led by CLUB-ER and SouthSouthNorth's AMG-CoP under AfCAP, it focuses on strengthening policy frameworks, improving data availability, and fostering public-private collaboration. Ultimately, GGE-EA strives to create an enabling environment for sustainable, affordable rural energy access, supporting Sustainable Development Goal 7.

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Redefining Energy Access: Beyond Just Connections

Access to electricity is essential for improving lives. It helps reduce poverty, support health and education, and fight climate change. Yet, around 760 million people, mostly in sub-Saharan Africa, still don't have electricity, and billions more lack clean cooking options. Electricity access is not just about having power or not, it's about how reliable, affordable, and useful it is. True access means people can use electricity for things like lighting, cooking, running businesses, or powering health clinics. To assess differences in energy access, the World Bank uses the Multi-Tier Framework (MTF), which ranks access from none to full, reliable power. In places with limited power, shared services like charging stations or equipment rentals can make a big difference. Projects like Café Lumière in rural Benin promote meaningful energy use by replacing diesel with electric machines and offering loans to small businesses, highlighting that true energy access empowers people to improve their lives and livelihoods. Real energy access is about more than wires; it's about making energy work for people.

Photo: Post with Solar Panel (Unknown, (2023) via Pexels)

Who Uses Electricity and Why It Matters

Electricity users fall into three groups: farmers and small businesses, households, and community services like schools and clinics. Reliable power helps businesses save costs and grow, while poor rural families need affordable options so no one is left out.

Community services require steady electricity to improve education and healthcare, often needing special funding to ensure stable energy provision. Inclusive energy plans should support vulnerable groups through community involvement. Since extending national grids is costly and slow, small-scale renewable solutions like nano-, micro-, and mini-grids are vital for remote areas. Mini-grids serve many users and work best when tailored locally, while nano-grids quickly provide basic power to small communities. Solar Home Systems offer affordable, easy-to-install power for homes and businesses, with Pay-As-You-Go plans helping low-income users pay in smaller, more manageable amounts.

Energy kiosks and shared service hubs provide charging, refrigeration, and workspaces, boosting local businesses and communities. Solar hub projects in Mali and Tanzania demonstrate the possibilities to create jobs and improve lives. Together, these solutions bring electricity to all and support fair development and stronger communities.

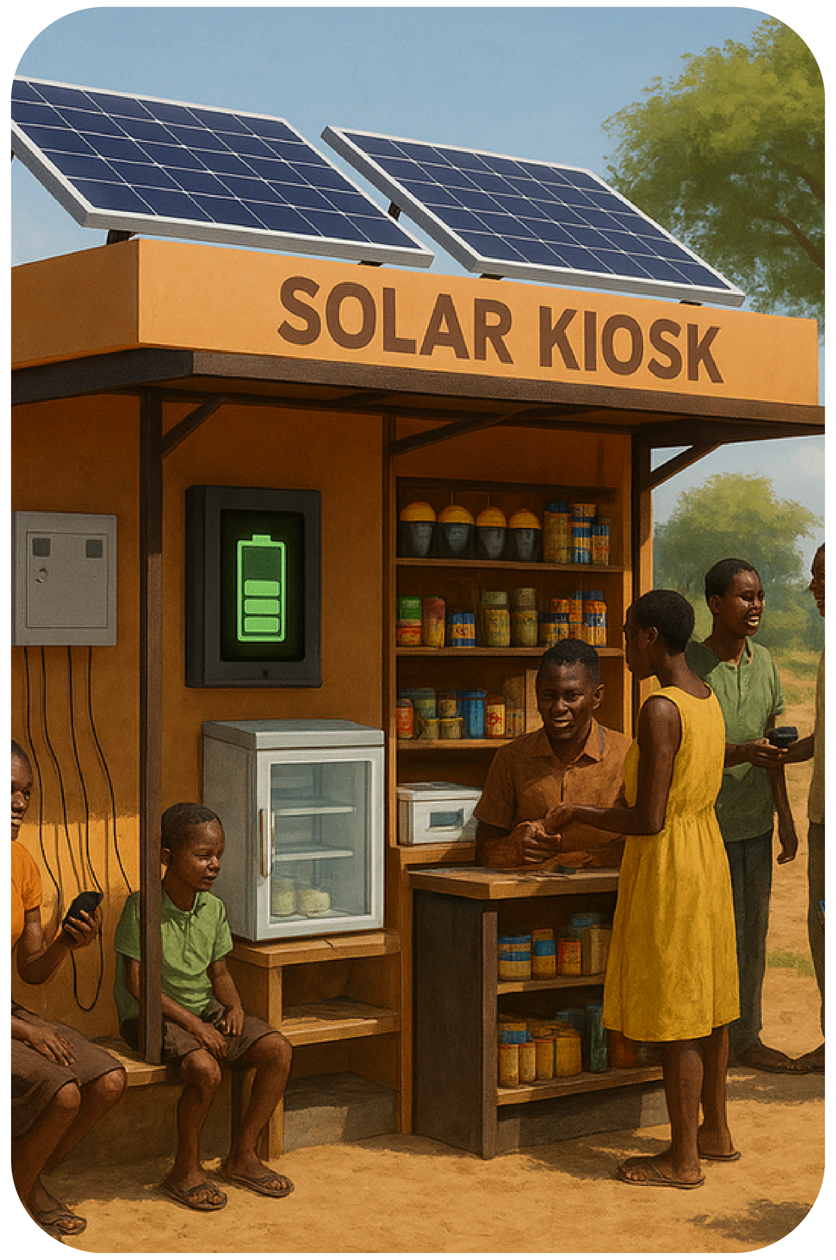

Photo: Solar-powered Kiosk offering energy, connectivity and essential services

Assessing Real Demand for Energy Services

To design effective electrification projects, it's important to collect clear, relevant data from users through well-planned surveys. With local support and proper training for surveyors, these surveys collect data on current energy use, costs, and future needs. Understanding when and how electricity is used is important for designing systems with sufficient capacity and reliability, especially for critical services like health clinics. Accurately estimating what people can afford is important for the sustainability of potential energy projects. This thorough data collection is carried out using indirect methods rather than direct income questions, and it supports the planning of inclusive, efficient, and financially viable energy solutions.

Selecting the Right Electrification Solution

After understanding user needs, the next step is to assess local energy sources like solar, small hydro, biomass, wind, and diesel, each with pros and cons depending on local conditions. Larger urban areas are typically connected to national grids, villages often rely on small grids, while scattered homes rely on solar kits or hybrid systems. Local skills for installation and maintenance are vital, supported by training centers like **Senegal's Casasol.** Falling costs of solar and lithium-ion batteries make them increasingly important solutions, especially with tax support. Designing small, sustainable grids that meet local needs requires careful design and planning of technical elements like energy source (solar, wind, etc.), the form of generated electricity (AC or DC), and the necessary storage capacity, among other factors.

Key Economic and Financial Variables to Consider

A decentralised electricity project has three main stages: feasibility studies, engineering and construction, and operation. Early stages need large upfront investments with no income, while operations generate revenue to cover running costs and repay investments.

Profitability requires income to exceed these costs, often under regulated tariffs. Managing working capital (short-term cash flow) is essential. **Free Cash Flow** (FCF) shows actual yearly cash after all expenses; positive FCF means the project is financially healthy. Understanding these financial aspects is crucial for sustainable projects.

How to Measure the Profitability of a Project

To determine whether a project will be profitable over time, we look at key indicators. One is called **Net Present Value** (NPV), which compares a project's current cost with its potential future earnings. If this figure is positive, it indicates that the project could be profitable. Another is **Internal Rate of Return** (IRR), which shows the potential percentage return that the project may generate and is helpful for comparing different project. Lastly, **Levelised Cost of Energy** (LCOE) indicates how much it will cost on average to make one unit of electricity during the project's life. None of these indicators should be looked at in isolation; they should be used together to help in deciding whether an energy project is a viable investment.

Turning Ideas into Action with a Solid Business Plan

Creating a business plan for a small, local electricity project starts with clear assumptions based on research and real data. For example, a typical mini-grid might produce a set amount of electricity each year and last about 30 years. The project would earn money by selling electricity, but costs include buying equipment, running the system, and paying taxes. Often, these projects aren't profitable on their own and need financial support like subsidies. There are risks too, such as limits on energy pricing, lower demand because people can't afford it, or payment problems, some of which can be mitigated with prepaid systems like Pay-As-You-Go. Equipment like batteries also needs regular replacement. Knowing and managing these costs and risks well is important in ensuring the project is successful over time. Support from financing and subsidies usually plays a key role in success.

Funding Strategies for Decentralised Electrification

Decentralised electrification projects usually rely on three main funding sources: **debt, equity, and subsidies. Debt** is borrowing money from banks or lenders that must be repaid with interest. **Equity** comes from investors who provide capital in exchange for ownership shares and a portion of profits. **Subsidies** are grants from governments or organisations that don't need to be paid back and help reduce financial risks, especially early on. Projects often combine these funding types to balance costs and risks. Funders carefully evaluate risks such as changing regulations, tariff limits, and competition from other energy providers. Because of this, project developers must show strong risk management procedures and a solid business plan to secure financing. Understanding these funding options and risks is essential for successfully developing decentralised energy projects.

Photo: Solar modules on green field in photovoltaic station
(K. Lacy, (2020) via Pexels)

Green Finance as a Driver for Sustainable Energy

Green finance supports clean energy projects in Africa by mobilising funding from international climate institutions, development partners, private investors, and national governments. This funding includes tools like green bonds (which raise funds for eco-friendly projects), concessional loans (with low interest rates), and carbon credits (which generate income by reducing emissions). Projects are usually financed through a mix of grants, loans, and equity, depending on their size, risk, and stage of development. To qualify, projects must show they are environmentally friendly, financially viable, and socially inclusive. In regions like sub-Saharan Africa, where energy access and climate challenges are linked, green finance helps scale up renewable technologies and strengthen local economies.

Accessing major funds like the Green Climate Fund requires careful planning and meeting specific guidelines, making it essential for developers to understand and follow them.

Measuring and Managing Carbon Footprints

To support climate goals, rural electrification projects must measure and reduce their carbon footprint throughout the project's lifetime. This includes tracking greenhouse gas emissions throughout the project's life, from construction to operation and decommissioning, using global standards like the GHG Protocol. Tools like OpenLCA help calculate emissions, which should be reported clearly. Projects can cut emissions by using renewable energy, improving efficiency, and planning for recycling. These actions strengthen climate impact and improve access to green funding.

Key Recommendations

- **Design with Users in Mind:** Base projects on actual user needs and include vulnerable groups in planning.
- **Match Solutions to Context:** Choose technologies suited to local geography, resources, and energy demand.
- **Ensure Financial Sustainability:** Create business models that balance affordability and long-term viability.
- **Use Mixed Financing:** Blend debt, equity, and grants to minimise financial risks and attract investors.
- **Access Green Finance:** Align projects with environmental goals to unlock green bonds, loans, and carbon credits.
- **Build Local Skills:** Train local workers and involve communities to ensure sustainable operations.
- **Measure Emissions:** Use standard tools to assess and reduce greenhouse gas emissions.
- **Make Access Inclusive:** Offer flexible payment options and promote electricity use for income generation.
- **Plan for Durability:** Select long-lasting technologies and plan for maintenance and recycling.
- **Support with Policy:** Work with governments to improve regulations and reduce taxes on clean energy technologies.
- **Track and Improve:** Monitor project performance and adapt based on data and community feedback.

Building a Strong Business Model for Energy Access

Creating a strong business model and plan is key to successful decentralised electricity projects. The business model shows how the project will serve customers and make money, while the business plan turns that idea into a detailed roadmap with costs, timelines, and strategies.

It includes market research, legal and financial planning, and technical design. A clear, realistic business plan helps attract investors and guide decision-making. It must reflect both the challenges and opportunities of rural electrification, offering affordable, sustainable solutions that improve lives and support clean energy goals.

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