Best Practices in MV & LV Design & Maintenance in Mini-Grids

Powering Progress: Practical Insights for Mini-Grid Development

GGEEA
Growing Government Engagement in Energy Access

Overview

Expanding access to electricity is critical for improving health, education, and livelihoods in rural communities. Yet delivering reliable power in these areas, especially through mini-grids, comes with many challenges, from high costs and difficult terrain to limited data and maintenance capacity. This brief outlines practical guidance for developing and managing Medium-Voltage (MV) and Low-Voltage (LV) networks in rural mini-grids. It covers key areas including how to forecast energy demand, size and design network components, plan village electrification, ensure long-term maintenance, address operational challenges, minimise environmental impact, and prepare for repairs. The aim is to equip practitioners and Rural Electrification Agencies (REAs) with clear, actionable insights to help build resilient, efficient, and sustainable mini-grids that truly serve 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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Understanding energy needs: Forecasting rural demand

Knowing how much electricity a community will need, both now and in the future, is one of the most important steps in planning a successful mini-grid. Good demand forecasting helps avoid under- or over-building the system.

It ensures the right amount of power is available, helps direct investment where it's needed most, and reduces long-term costs. In rural areas, forecasting can be tricky. There's often little reliable data, and electricity use may change with the seasons or as new services (like irrigation or small businesses) grow. One way to improve accuracy is to work closely with the community, using surveys, local knowledge, and simple tools that respect cultural and language differences.

While it's difficult to predict future demand with complete certainty, using a range of estimates (instead of just one number) can help prepare for different outcomes.

Photo: Electrical power lines (A. Metelev (2021) via Unsplash)

This approach becomes even more useful when combined with new technologies that help monitor usage patterns and adjust the system as needs change, especially when using solar and other renewable energy, which can vary from day to day.

By combining local engagement, flexible planning, and practical tools, practitioners can build energy systems that truly meet community needs and grow with them over time.

Building the backbone: Sizing MV & LV networks

Properly sizing MV and LV networks is essential for delivering safe, reliable, and cost-effective electricity. This involves estimating how much power a community will need, choosing the right number and size of transformers, and selecting cables that minimize power loss and voltage drop.

Transformers should match the expected peak load, considering efficiency factors—e.g., a 220 kW load might require two 160 kVA units. Cables must be selected based on their material, length, and capacity to ensure voltage stays within safe limits. Protection devices like circuit breakers and fuses help isolate faults and prevent damage, keeping the rest of the system running smoothly.

Good design also includes clear fault detection and planning, so that only the affected section shuts down during a problem. Overall, careful sizing and protection help reduce outages, lower maintenance costs, and ensure long-term system performance.

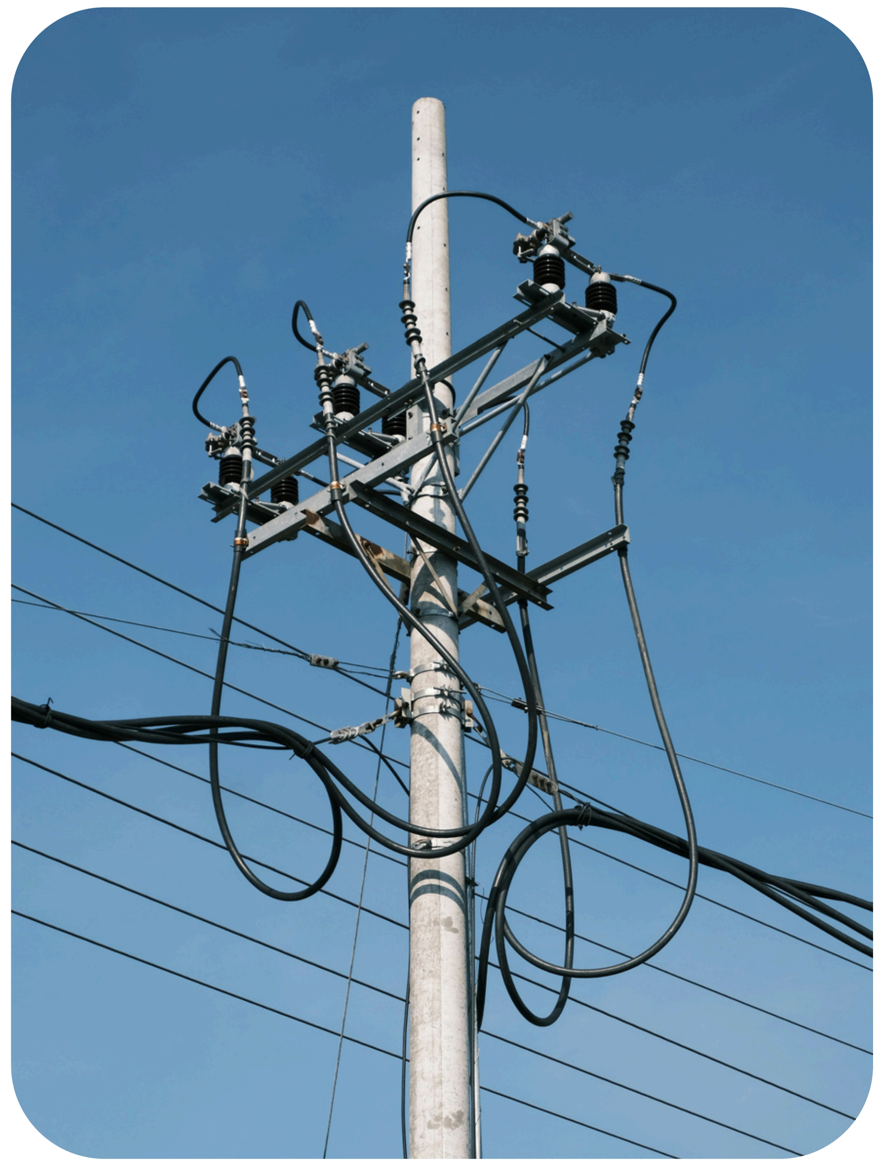

Photo: Electric Pole (A.Ammar (2024) via Unsplash)

Designing for the terrain: Mechanical planning of power lines

The mechanical design of overhead lines is key to building safe, reliable, and affordable rural electricity systems. This includes placing poles or towers, managing conductor tension, and ensuring the structures can handle weather and terrain conditions.

Tools like JOVE software help streamline this process. It allows engineers to model real-world conditions using GPS or satellite maps, and automatically plan pole placement, check line tension, and estimate materials. For rural networks, JOVE simplifies tasks like balancing loads, checking voltage drops, and adjusting designs for local environments.

By combining smart tools with field knowledge, practitioners can design systems that are both technically sound and suited to the unique needs of rural communities.

Protecting the environment: Sustainable maintenance practices

Maintaining MV and LV networks helps in protecting the environment. Poor maintenance can lead to waste, pollution, and harm to local ecosystems. Using eco-friendly materials, managing waste properly, and choosing energy-efficient tools can reduce these impacts.

Training plays a big role. When maintenance teams are well-trained in sustainable practices, systems last longer, perform better, and meet safety and environmental standards. Regular evaluation of training, looking at engagement, skills, and results, helps ensure these efforts have lasting impact. By combining smart maintenance with sustainability, rural electrification can support both community development and environmental protection.

Photo: Electrical line workers performing maintenance on power lines (A.John (n.d) via Unsplash)

Keeping the system running: Effective maintenance and repairs

Maintaining medium and low-voltage (MV & LV) networks is essential to provide reliable, safe, and affordable electricity in rural areas. This involves regular inspections, timely repairs, and careful planning to prevent breakdowns and extend the life of equipment.

Maintenance includes different approaches: routine checks, fixing issues when they occur, and using data to predict problems before they happen. Teams may work centrally or locally, but they all focus on keeping equipment like conductors, insulators, poles, and switches in good shape.

Rural networks face challenges such as aging infrastructure, limited spare parts, skilled worker shortages, and tough weather conditions. Overcoming these requires investment, local training, good planning, and strong safety measures like tools, protective gear, and coordination with local authorities. Before any repairs, careful route surveys and safety permits are needed.

Construction and maintenance work must balance technical standards with community cooperation to ensure a resilient, efficient power system. Quick responses to faults, along with backup plans like load shedding, help reduce outages and protect both people and equipment.

By combining steady maintenance, clear planning, and strong safety practices, practitioners can ensure long-lasting, reliable electricity for rural communities.

Key Reccommendations

- Use **probabilistic demand forecasting** combined with community engagement to improve planning accuracy and support renewable energy integration.
- **Size transformers and cables based on actual demand and power factor,** ensuring voltage drops stay within standard limits for optimal cost and performance.
- Utilise **mechanical design tools like JOVE** to ensure structurally sound and cost-effective overhead line construction adapted to diverse terrains and climates.
- Adopt a **hybrid maintenance strategy** (preventive, predictive, corrective) to reduce downtime, extend equipment life, and enhance network reliability.
- Overcome rural electrification challenges through **investment in infrastructure, local workforce training, and sustainable funding mechanisms.**
- Implement **sustainable maintenance practices** by promoting eco-friendly materials, responsible waste management, and environmental training for personnel.
- Ensure **regular inspections and strict safety protocols**, especially around seasonal events like monsoons, to maintain reliability and reduce faults.

Photo: Electric Transmission Tower (S.Rehman (2021) via Unsplash)

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