SOLAR PV MINIGRIDS FOR ENHANCING ELECTRICITY ACCESS IN LESOTHO

TECHNOLOGY DESCRIPTION

TECHNICAL DESCRIPTION

Mini-grids are small-scale electricity generation and distribution networks that supply electricity to both small groups of customers in remote isolated communities and larger populations in urban centres. They can vary in size from a few kilowatts to 10 megawatts, with smaller systems sometimes being referred to as "micro-grids". Services offered by a mini-grid can vary from Tier 2[1] to Tier 4[2], catering for a few hundred connections, which may include community facilities, small businesses and households.

Solar PV mini-grids typically consist of a solar PV array for electricity generation, a battery bank for energy storage (in some business models), power conditioning units with charge controllers, inverters, AC/DC distribution boards, necessary cabling, and a local low-tension power distribution network. Mini grids can either be completely isolated from the main grid or connected to it in some way. They can either feed excess energy into the main grid, draw energy from it when needed, or do both. Mini-grids that are connected to the main grid typically have the ability to intentionally isolate themselves from it, a process known as "islanding."

Improving access to modern energy services in rural areas in Lesotho is a top priority. Solar mini-grids offer a reliable, clean, and cost-effective solution for delivering electricity to households, businesses, and essential infrastructure. While there are challenges due to the limited market size and difficult geography, there is an opportunity to develop a sustainable model through local pilots and demonstration projects.

CURRENT TECHNOLOGY READINESS LEVEL OR COMMERCIAL READINESS INDEX

Technology Readiness Level (TRL)[3]: The current Technology Readiness Level (TRL) of solar PV mini-grids technology in Lesotho is estimated to be around TRL 7-8, indicating that the technology has been successfully demonstrated in operational environments and is nearing full-scale deployment. Key components and subsystems have been integrated and tested, and the technology has been validated through successful pilot projects and demonstrations in Lesotho's rural electrification programs.

Commercial Readiness Index (CRI)[4]: The Commercial Readiness Index (CRI) is approximately CRI 4-5, suggesting that the technology is in the "Development" or "Demonstration" phase of commercialization. While there is progress in establishing supply chains, business models, and policy frameworks to support solar PV mini-grid deployment in Lesotho, further refinement and scaling up are needed to achieve widespread commercial adoption and cost-competitiveness with traditional grid extension methods. There is growing interest and investment from the private sector and development partners to scale up deployment. The regulatory framework is also starting to take shape, but more work is needed to fully establish the commercial viability and readiness of this technology in the Lesotho context.

CLIMATE RATIONALE OF THE TECHNOLOGY

Solar PV mini-grid technology is a suitable option for rural electrification in Lesotho due to the country's abundant solar energy resources. Lesotho relies heavily on biomass and imported fossil fuels for energy. Switching to solar PV can significantly reduce the carbon footprint. The technology will help decrease the heavy reliance on biomass and kerosene for cooking, as well as kerosene and candles for lighting, leading to a significant reduction in overall GHG emissions. Many off-grid schools, health centres and households that have the means currently rely on petrol or diesel generators to generate electricity for their equipment and lighting requirements, leading to GHG emissions. The country's high-

[1] Available hours of electricity per day: At least four hours, consumption per person per year: 224 kilowatt-hours (kWh)
[2] Available hours of electricity per day: At least sixteen hours, consumption per person per year: 1,800 kilowatt-hours (kWh)
[3] TRL scale measures technology maturity from basic research to commercial deployment, aiding R&D and funding decisions.
[4] CRI evaluates technology readiness for commercial success, analysing market potential, competition, and economic viability.

altitude and mountainous terrain provide ideal conditions for solar energy generation, making solar PV systems an efficient and environmentally friendly choice for electrification in Lesotho.

Solar energy is a clean technology that reduces GHG emissions by replacing fossil fuels in non-electrified and electrified households, schools and health centres. It allows for longer study hours at night without the use of polluting paraffin lanterns or candles. Additionally, it improves indoor air quality and reduces the risk of fires in schools and homes.

- **Resilience to Climate Impacts**: Solar PV minigrids provide a decentralized energy solution that can enhance resilience to climate-related disruptions. For instance, extreme weather events that damage large-scale power infrastructure are less likely to impact distributed solar systems. As climate change alters weather patterns, relying on local solar resources helps communities adapt to these changes.
- **Alignment with National Policies**: Lesotho prioritizes renewable energy, including solar PV, to achieve universal energy access, reduce reliance on fossil fuels and meet commitments under the Paris Agreement and NDC.
- **Environmental Benefits:** Solar PV mini-grids reduce air pollution and preserve natural resources by replacing diesel generators and reducing reliance on firewood or charcoal.
- **Offsetting Imported Energy**: Lesotho currently relies on imported electricity from neighbouring countries that primarily use fossil fuels. By implementing solar PV technology, Lesotho can decrease its dependence on these sources, subsequently leading to lower overall emissions.

AMBITION OF THE TECHNOLOGY

SCALE FOR IMPLEMENTATION AND TIME-LINE

The goal of this technology aligns with Lesotho's plan to increase rural electricity access to 75% by 2038. The plan includes installing 160 MW of solar PV capacity and connecting households to off-grid energy solutions and mini-grids. This initiative aims to generate 6,500 GWh of electrical energy and achieve a significant reduction in GHG emissions over 25-year period. The Ministries of Energy and Environment will oversee the project over a six-year period. The TAP will be reviewed and updated by 2030 to meet current needs. The implementation will be nationwide, with a focus on vulnerable communities.

Preparation (6-12 months):

- Feasibility Studies: Conduct technical, economic, and social feasibility studies to identify suitable locations.
- Stakeholder Engagement: Involve local communities, government agencies, NGOs and international partners.
- Funding and Resources: Secure funding from donors, government and private sector.
- Capacity Building: Train local technicians, engineers and project managers.

Pilot Phase (6-12 months):

- **Site Selection**: Identify and select pilot sites based on feasibility studies.
- **Infrastructure Development**: Install Solar PV systems and necessary infrastructure.
- **Community Training**: Educate the community on the use and maintenance of the systems.
- **Monitoring and Evaluation**: Track performance, gather feedback, and make necessary adjustments.

Expansion Phase (1-2 years):

- **Scaling Up**: Expand infrastructure development to additional communities.
- **Supply Chain Development**: Establish reliable supply chains for equipment and maintenance.
- **Community Outreach**: Conduct awareness and training sessions in new communities.
- **Monitoring and Evaluation**: Continuously assess performance and impact, refining operations as needed.

Full-scale Implementation (3-5 years):

- **Nationwide Rollout**: Ensure widespread installation and operation of Solar PV mini-grids.
- **Subsidy and Financing Programs**: Develop programs to make Solar PV systems affordable for all households.
- **Sustained Support**: Provide ongoing technical support, maintenance, and education.
- **Policy and Regulation**: Implement supportive policies, incentives, and standards for renewable energy projects.

AMBITION FOR TECHNOLOGY READINESS LEVEL OR COMMERCIAL READINESS INDEX

Ambition for Technology Readiness Level (TRL): The goal is to achieve a TRL of 9, representing a technology that has been proven through successful deployment in operational environments. This will involve continued integration and optimization of all system components, including solar PV panels, batteries, inverters, and balance-of-system elements. Additionally, extensive field testing and demonstration of solar PV mini-grid systems will be conducted in diverse rural and remote locations across Lesotho. Rigorous performance monitoring and evaluation will be carried out to validate the reliability, efficiency, and long-term durability of the technology under Lesotho's unique environmental conditions. Capacity building and knowledge transfer initiatives will also be implemented to ensure widespread technical expertise and maintenance capabilities within the country.

Ambition for Commercial Readiness Index (CRI): The ambition for the Commercial Readiness Index of solar PV mini-grid technology in Lesotho will be to achieve a CRI of 5-6, which represents the "Demonstration" or "Early Commercial" phase of commercialization. This includes developing robust and scalable business models for the deployment and operation of solar PV mini-grids, including innovative financing mechanisms and tariff structures. It also involves establishing a well-functioning supply chain and local manufacturing capabilities to support the widespread rollout of solar PV mini-grid systems. Additionally, implementing supportive policy and regulatory frameworks that provide incentives, streamlined processes, and clear guidelines for the integration of solar PV mini-grids into Lesotho's rural electrification efforts is crucial. Fostering partnerships and collaborations between the public and private sectors, as well as with international development agencies, to attract investments and drive the commercialization of the technology is essential. Promoting consumer awareness, community engagement, and capacity building to ensure the long-term sustainability and ownership of solar PV mini-grid projects is also a key aspect.

EXPECTED IMPACTS OF THE TECHNOLOGY

1. **Displacement of Fossil Fuels**: Solar PV minigrids will decrease reliance on fossil fuels for electricity generation. This shift directly reduces CO_2 emissions and other pollutants, leading to improved air quality and reduced health risks associated with pollution. By replacing fossil fuels and biomass with solar energy, Lesotho can significantly reduce its carbon footprint
2. **Environmental Benefits and Climate Change Mitigation**: By replacing kerosene lamps and diesel generators, solar PV mini-grids reduce the emission of harmful pollutants such as sulphur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter. This leads to better air quality and health benefits for the local population.
3. **Decrease in Deforestation**: Transitioning to solar energy in Lesotho will reduce the reliance on biomass, which helps alleviate deforestation and land degradation issues. This also contributes to the conservation of natural resources and protects local ecosystems.
4. **Increased Energy Access and Electrification**: Solar PV mini-grids in Lesotho can provide reliable and affordable electricity to rural areas, improving quality of life and supporting development.
5. **Economic Development and Livelihood Opportunities:** Opportunities in the solar PV industry include importing, distributing, and retailing systems and accessories, as well as component sourcing, assembly, installation, marketing, sales, and after-sales services. Solar charging stations offer new eco-friendly business prospects, while solar lighting extends operating hours for merchants. Access to electricity can spur the growth of small and medium enterprises, agro-processing, manufacturing, and tourism, leading to economic development and improved living standards in rural areas.

POLICY ACTIONS FOR TECHNOLOGY IMPLEMENTATION

EXISTING POLICIES IN RELATION TO THE TECHNOLOGY

- **Framework for Private Sector Investment in Electricity Generation, Distribution and Supply**: A Guide for IPPs and PPPs for On-Grid and Off-Grid Development, Ministry of Natural Resources, Department of Energy, 2023
- **The 2021 Mini-Grid Power Generation, Distribution, and Supply Regulations** aim to support the development and operation of mini-grid systems for universal electricity access. They provide guidelines for licensing, tariff setting, and grid integration
- **National Energy Policy (2015)** aims to boost private sector involvement in renewable energy mini-grids to improve electricity access, particularly in rural areas with low electrification rates. Solar mini-grids are prioritized for remote

locations, setting the strategic direction for Lesotho's energy sector with a focus on renewable energy sources like solar PV.

- **Off-Grid Electrification Master Plan (2018)** focus on expanding electricity access through off-grid and decentralized renewable energy solutions like solar PV mini-grids
- **National Climate Change Policy (2017)** emphasizes the importance of solar PV in mitigating and adapting to climate change.
- **Revised NDC 2024** includes commitments to increase the share of renewable energy, particularly solar PV, in the electricity generation mix.

PROPOSED POLICIES TO ENHANCE TECHNOLOGY IMPLEMENTATION

- Provision of financial incentives such as tax exemptions and subsidies to offset the high upfront costs, which is a major deterrent to the deployment and diffusion of the technology.
- Institutional development in the solar sector to ensure strong institutional frameworks and proper coordination among stakeholders
- Skills development to build the capacity of the solar sector workforce
- Standards and quality of off-grid solar systems
- Establishment of national fund for renewable energy initiatives
- Enabling environment for private sector investment in solar PV mini-grids through public-private partnerships.
- Promoting gender-inclusive practices to ensure equal access for women in the solar PV sector, including training, employment, and decision-making roles.
- Net Metering to enable mini-grid operators to sell surplus electricity to the national grid, boosting the financial sustainability of solar projects.

COSTS RELATED TO THE IMPLEMENTATION OF POLICIES

The estimated capital cost per kilowatt (kW) for solar PV mini-grid systems in Lesotho is typically in the range of $2,000 to $3,000 per kW. Therefore, the estimated capital expenditure for the construction of 10 solar PV mini-grid systems, each with a 100 kW capacity, is anticipated to range from: $2,000,000 to $3,000,000.

The average capital cost per kW for solar PV mini-grid systems in Lesotho can vary based on factors like project location and procurement expenses. Actual costs may differ after a detailed feasibility analysis and procurement tailored to the project. Factors like economies of scale, local resources, and government incentives can also impact costs. Financing these systems in Lesotho requires a mix of government support, development finance, private investment, and innovative financing. Leveraging these sources can reduce financial risks and make the transition to renewable energy more feasible. Sources of funding include government grants, development finance institutions, private sector investment, debt financing, public-private partnerships, and climate financing mechanisms

USEFUL INFORMATION

CONTACT DETAILS

Mr. Maqhanolle Tsekoa
LMS and TNA Coordinator
Climate Change Unit, Lesotho Meteorological Services
Ministry of Environment and Forestry
Maseru, LESOTHO
Tel: + (266) 2231 7250
Email: relebohile@gmail.com
URL Address: www.lesmet org.ls

LINKS TO TNA REPORTS

https://tech-action.unepccc.org/country/lesotho/