MINI-GRIDS AND OFF-GRID SOLUTIONS: THE FUTURE OF RURAL ELECTRIFICATION IN AFRICA

INTRODUCTION

Darkness cannot drive out darkness; only light can do that.

While Martin Luther King meant this quote in the context of his philosophy of non-violent resistance for millions of Africans living in rural areas, this is more than a figurative rhetoric. It reflects how their inability to access electricity has hampered the continental drive towards economic growth, adequate healthcare and efficient education. This energy inadequacy is primarily tied to the overdependence of African economies on centralised grids and the substantial financial and logistic costs of connecting these grids to rural areas.[1]

This essay explores the possibilities of off-grid and mini-grid electrification for Rural Africa as immediate solutions to these concerns while supporting the continental quest for sustainability.

THE RISE OF MINI-GRIDS AND OFF-GRID SOLUTIONS

The concept of mini-grid electrification hovers around the localisation of electricity distribution in a manner that functions independently or conjunctively with the central grid.[2] The energy sources for mini-grid systems can be solar, hydro, wind or hybrid sources.

The benefits of mini-grids for rural users are wide-ranging. First, they boost the local economy. For example, thousands of businesses and households in Tanzania, including local wielders, millers and fish distributors, have benefited from JUMEME's solar hybrid mini-grid project.[3]

Adopting mini-grids could also help resolve the issue of unreliable electricity bedevilling more than 60 per cent of Sub-Saharan Africa's healthcare facilities,[4] more so in the rural areas. This approach is already underway in Togo, with the West African country successfully electrifying over 300 rural health centres in partnership with the Africa Development Bank, elevating the quality of nighttime and emergency care while improving vaccine storage.[5] By the World Bank's estimation, mini-grid systems, if holistically adopted as soon as possible, could also reduce carbon emissions by 1.2 billion tons before the end of 2030.[6]

While mini-grids may operate together with central grids, off-grid electrification emphasises standalone generation and distribution of electricity. This includes micro-hydro systems, solar

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[1] Pistelli, L. (2020). Addressing Africa's energy dilemma. In *Lecture notes in energy* (pp. 151–174). https://doi.org/10.1007/978-3-030-39066-2_7.

[2] Babayomi, O. O., Olubayo, B., Denwigwe, I. H., Somefun, T. E., Adedoja, O. S., Somefun, C. T., Olukayode, K., & Attah, A. (2023). A review of renewable off-grid mini-grids in Sub-Saharan Africa. *Frontiers in Energy Research, 10*. https://doi.org/10.3389/fenrg.2022.1089025.

[3] *JUMEME's business model for mini-grids reaping multiple benefits in Tanzania*. (2020, 27 May). Sustainable Energy for All. https://www.seforall.org/news/jumemes-business-model-for-mini-grids-reaping-multiple-benefits-in-tanzania.

[4] World Health Organization (2023, 31 August). *Electricity in health-care facilities*. https://www.who.int/news-room/fact-sheets/detail/electricity-in-health-care-facilities.

[5] Thomas, D. (2025, 7 February). *Bringing light and opportunity: How solar electrification is transforming rural Togo. African Business*. https://african.business/2025/02/quick-reads/bringing-light-and-opportunity-how-solar-electrification-is-transforming-rural-togo.

[6] World Bank (2022, 27 September). Solar Mini Grids Could Power Half a Billion People by 2030 – if Action is Taken Now. *World Bank*. https://www.worldbank.org/en/news/press-release/2022/09/27/solar-mini-grids-could-power-half-a-billion-people-by-2030-if-action-is-taken-now.

home systems (SHS) and standalone wind turbines.[7] Off-grid electricity is advantageous to rural areas because of logistic and distance difficulties caused by grid-based connections.

The scalability of off-grid electrification is another of its many benefits. It enables consumers to start up at any level and scale up or down according to personal or household usage changes. Reports also exist of households that have reduced their annual energy expenditure by more than 70 per cent by bringing their grid dependence to the bare minimum.[8]

Off-grid solutions based on renewable energy also assure the best energy security and climate resistance by reducing dependence on climate-vulnerable centralised grids. This energy strategy is already enjoying widespread adoption in sub-Saharan Africa, with notable examples including Nigeria, where today's off-grid capacity is three times its on-grid capacity.[9]

FINANCING RURAL ELECTRIFICATION

While mini-grid and off-grid rural electrification can be key drivers of sustainable development, financing them can be challenging due to uncertainty in rural revenue streams and lack of investment attraction.[10] The following financing options offer valuable solutions to these funding difficulties.

1. **Blended Finance**: This involves the provision of grants and guarantees of concessional loans by government, development finance institutions and donors to mobilise investments from private sector actors in projects with socioeconomic benefits. Blending this public or philanthropic capital with private investment improves the bankability of these projects while reducing risk exposure for the investors. The International Finance Corporation's Scaling Solar Program is a prime example of how blended finance can lower capital costs.[11]
2. **Results-Based Financing**: This mechanism links financial incentives directly to achieving pre-agreed performance milestones, which, in the case of rural electrification, may include the volume of energy distribution or the number of new connections. Under this system, investment utility is more or less assured, while developers are driven towards delivering high-quality, sustainable projects. Thanks to the Global Partnership on Output-Based Aid, this is already being used to subsidise the electrification of targeted rural areas in Tanzania.
3. **Public-Private Partnership**: Under this arrangement, private companies would bring in their technical expertise and capital while national or regional governments would support the development and operation of mini-grid projects through subsidies, favourable policies and, in

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[7] Manohar, R., & Hikihara, T. (2024). Design of a stand-alone hybrid dispersed generation network unified by passivity-based control. *Royal Society Open Science, 11*(7). https://doi.org/10.1098/rsos.230458.

[8] Garcia, A. (2024, 11 September). *In conversation with Oti Ikomi on Proton Energy's vision and the future of Nigeria's energy sector*. Energy & Utilities. https://energy-utilities.com/in-conversation-with-oti-ikomi-on-proton-energy-s-news125348.html.

[9] Pagan, K. (2024, 22 November). We're retired and save over £200 a month on our energy bills – here's how you could save too. . . *The Scottish Sun*. https://www.thescottishsun.co.uk/money/13901199/retired-couple-save-money-energy-bills-off-grid/.

[10] Nyarko, K., Whale, J., & Urmee, T. (2023). Empowering Low-Income Communities with Sustainable Decentralized Renewable Energy-Based Mini-Grids. *Energies, 16*(23), 7741. https://doi.org/10.3390/en16237741.

[11] Stritzke, S. (2018). 'Clean energy for all': the implementation of Scaling Solar in Zambia. *World Journal of Science Technology and Sustainable Development, 15*(3), 214–225. https://doi.org/10.1108/wjstsd-11-2017-0042.

some cases, burden-relaxing finances. India's collaboration with Tata Power[12] and Nigeria's World Bank-backed electrification project[13] has yielded immense deployment results for mini-grid and off-grid solutions in the respective countries.

4. **Pay-As-You-Go (PAYG) Models**: PAYG models recognise the access difficulties of low-income consumers and resolve the same by allowing them to cover their total energy costs in small instalments. Under this system, operators are also assured of steady revenue streams. For consumers, there is the opportunity for reduced upfront costs in exchange for subsequent payments using mobile payment technology.[14]

POLICY AND REGULATORY FRAMEWORKS

The role of government incentives in promoting mini-grid deployment is crucial as it can help create an attractive renewable energy market. One incredibly unique incentive here is the introduction of feed-in tariffs, which ensures that mini-grid developers are paid a fixed price for the energy they feed into the central grid.

Still, on governmental policies, volatility and uncertainty in regulatory trajectories tends to create delays and disruptions in mini-grid deployment. This must be remedied or avoided by developing clear, long-term policy frameworks, thereby mitigating investment risks.

Considering the highly communal nature of African rural areas, community engagement is another crucial factor that can induce the success or failure of renewable energy projects. Involving local communities in this vision through orientation and as owners, operators, and managers of mini-grid projects has produced positive results in countries like Tanzania.[15]

CONCLUSION

A careful examination of the electricity deficiency currently being suffered by Rural Africa reveals an interesting opportunity in disguise. Mini-grid and off-grid solutions offer environmentally sustainable alternatives to the coal and natural gas that presently dominate the centralised systems of generating electricity across Africa. If the policy and financing initiatives discussed above are applied, renewable energy can quickly become the beacon illuminating the future of Africa's rural residents.

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[12] India Times (2023, 14 December). *Tata Power's TPRMG recognized for clean energy initiative in rural India by World Economic Forum*. Indian Times. https://energy.economictimes.indiatimes.com/news/renewable/tata-powers-tprmg-recognized-for-clean-energy-initiative-in-rural-india-by-world-economic-forum/105985995.

[13] Tunji, S., & Tunji, S. (2024, 31 July). *World Bank restructures $350 million loan to Nigeria to allow completion of seven power plants*. Nairametrics. https://nairametrics.com/2024/07/31/world-bank-restructures-350-million-loan-to-nigeria-to-allow-completion-of-seven-power-plants.

[14] Barry, M. S., & Creti, A. (2020). Pay-as-you-go contracts for electricity access: Bridging the "last mile" gap? A case study in Benin. *Energy Economics, 90*. https://doi.org/10.1016/j.eneco.2020.104843.

[15] Ngoti, I. F. (2024). The role of sense of ownership in rural community mini-grid management: qualitative case study from Tanzania. *Energy Sustainability and Society, 14*(1). https://doi.org/10.1186/s13705-024-00496-7.