Power to the People: Do with or do for?

Exploring Community Agency in African Mini-grids

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CESET
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About this report

This report has been commissioned by Community Energy Systems and Sustainable Energy Transitions in Ethiopia, Malawi and Mozambique (CESET) which has an aim to facilitate the deployment of Community Energy Systems for a just transition in East Africa while understanding the kind of benefits that they provide to communities and their possible unintended negative impacts. CESET has three objectives:

- Objective 1: To develop a theoretical framework to understand the diversity of CESs in East Africa and their role in delivering energy transitions;
- Objective 2: To deliver a systematic body of empirical evidence on what works and how it works for CESs in East Africa, examining the institutional, technological, financial, and socio-political challenges of implementation; and
- Objective 3: To build research capacity for a long-term, human-centred programme of research on CESs in East Africa.

These objectives are structured in three-cross cutting themes: the diversity of CESs, the need to unpack community in CESs, and situating CESs within the broader political economy of energy in the country and the region.

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Executive Summary

The deployment of mini-grids represents a transformative opportunity for enhancing energy access in Africa. Achieving this potential requires prioritising community engagement, adopting sustainable business practices, and ensuring equitable financing. By fostering inclusive energy solutions that empower local communities, stakeholders can significantly contribute to the realisation of SDG7 and support broader development goals. Transforming rural communities requires providing energy alongside enabling broader socio-economic development and improving the quality of life for millions across Africa.

Access to reliable electricity remains a critical challenge for many communities in Africa, impeding economic growth and social development. Mini-grids offer a decentralised solution to address these challenges by providing affordable and clean energy. However, the effectiveness of mini-grids is contingent upon understanding the unique needs of local communities and promoting active participation in energy governance.

This report examines communities' pivotal role in establishing and maintaining decentralised energy infrastructure, focusing on mini-grids in Sub-Saharan Africa. By exploring approaches to mini-grid deployment across the continent, the report illuminates the multifaceted dynamics shaping energy transitions in rural African contexts.

Central to the analysis is an investigation into the agency of rural communities in the planning, operation, and ownership of mini-grids. By scrutinising the roles assumed by communities, ranging from active participation as stakeholders to passive beneficiaries or customers, the report sheds light on the varying degrees of community empowerment within different mini-grid business models and the implications on sustainability and impact on the community.

The report provides a comparative analysis of community engagement strategies based on diverse case studies encompassing private sector enterprises, social enterprises, and cooperative ventures. It evaluates the extent of investment directed towards community involvement, alongside mechanisms employed to assess the socio-economic impact of mini-grid projects on local populations.

Key findings indicate that while private sector involvement can quickly scale solutions and accelerate deployment, cooperative and social enterprise models better deliver on social equity and community empowerment goals, foster deeper local engagement, and secure long-term viability. Effective community involvement in mini-grid projects is essential for sustainability, and projects that prioritise local governance tend to yield better social outcomes.

There is a significant need for training local technicians and community members in the technical and operational aspects of mini-grid management, and, more broadly, for capacity building around mini-grid business models that balance affordability for consumers and financial viability for operators. There is a lack of comprehensive data on the social impacts of mini-grids, necessitating standardised metrics for assessment.

A comparative analysis of mini-grid initiatives and perceived best practices inform actionable recommendations for policymakers, donors, and practitioners to promote community-led mini-grids. Equitable financing, transparent and clear regulation of community involvement in mini-grids, and promoting local capacity are some salient routes of action.

1. Introduction: providing energy access to rural African communities with mini-grids

Energy plays a fundamental role across multiple sectors, influencing diverse aspects of development. Ensuring a just energy transition[1] in Africa is crucial, and choices made today regarding energy policy, technology, and infrastructure will shape the continent's energy landscape for decades. Against a backdrop of ongoing macroeconomic challenges and geopolitical shifts, sustainable energy systems in Africa must be future-proof, inclusive, sustainable, and equitable [1].

The new energy system envisioned for Africa will embody critical principles and approaches essential for sustainable development. These include ensuring African ownership and agency in energy initiatives and plans, integrating energy system design into broader development objectives and planning, and establishing clear policy priorities such as support for clean cooking and diversification of energy generation and ownership. Additionally, the system must provide scope for delivering energy as a common good, genuinely fostering energy democratisation, and ensuring stakeholder participation, equity, and sufficiency in energy use. By focusing on these principles, Africa can create energy futures that are both sustainable and equitable, allowing all segments of society to benefit from modern energy services [2].

Central to Africa's energy challenge is the colossal task of achieving widespread electrification, with 600 million people currently lacking access to electricity. Achieving universal access to affordable electricity by 2030 necessitates connecting 90 million people annually, three times the current rate. Extending national grids is the most cost-effective and practical solution for nearly 45% of those gaining access by 2030. In rural areas, where over 80% of the electricity-deprived population lives, mini-grids and stand-alone systems, primarily solar-powered, are the most feasible solutions [3]

Mini-grids are defined as systems with central generation providing wired connections to customers not connected to the national grid, offer a low-cost, low-carbon solution to this challenge and are emerging as a promising solution for rural electrification in areas where extending the main grid is cost-prohibitive [4]. The decentralised nature of mini-grids has several inherent advantages over traditional centralised infrastructure, including improved economics, technical performance, environmental sustainability, and regional equity in the context of rural electrification [5]. Rural electricity demand is generally low, and the energy losses incurred through grid transmission and distribution often don't justify the cost of building long and extensive power line infrastructure to remote areas, making decentralised solutions such as mini-grids the most cost-effective solutions to delivering electricity to these areas [6] [7], [8]. Without a decentralised approach to expanding electricity access, many isolated communities far from existing grid infrastructure will likely be left without a connection.

In 2020, 47 million people worldwide were already connected to 19,000 mini-grids, of which at least 2,577 are operational clean-energy mini-grids [9]. However, 180,000 additional mini-grids must be built if the overarching objective of universal access to electricity by 2030 is to be achieved [10]. The International Renewable Energy Agency (IRENA) estimates that mini-grids will be the best solution for over a third of the global population currently living without electricity access [11], and the International Energy Agency estimates that they will

[1] A "just transition" refers to the concept of shifting from a fossil fuel-based economy to a sustainable, renewable energy-based economy in a way that is fair and equitable for all stakeholders, particularly workers and communities that are most affected by the transition [46].

provide 48% of the additional generation needed to achieve universal electricity access by 2030 [12]. In Africa, the number of mini-grid connections almost doubled from 40,700 to more than 78,000 between 2019 and 2021, a 95% increase in the connection rate [13].

The unit costs of mini-grid components, specifically solar photovoltaic (PV) modules batteries, have significantly decreased over time due to technological advancements and economies of scale, leading to a substantial increase in the deployment of mini-grids worldwide [4]. According to the African Mini-grids Developer Association, mini-grids currently offer about a third of the price of grid utility installed in the exact location, and capital costs have fallen in terms of average price per connection from $1,555 to $733, which is radically lower than national utilities in rural areas [14]. These trends have seen the mini-grid market expand, with the sector witnessing the emergence of market leaders as developers such as Husk Power and PowerGen expand into new markets and build out off-grid project pipelines.

Mini-grids can play a critical role in Africa's energy transition. They offer a sustainable and scalable solution to the continent's electrification challenges, bridging the gap for rural and remote areas and contributing significantly to universal energy access. The sustainability of these projects hinges on structuring the electricity infrastructure, including setup, ownership, and financing models. Ensuring the long-term viability and maintenance of mini-grids is crucial, as it addresses the risk of these systems falling into disrepair if not adequately managed.

1.1 Challenges and opportunities for African mini-grids

African mini-grids face unique challenges and opportunities as they strive to provide reliable and sustainable energy access to remote and underserved communities. Despite significant progress, several barriers hinder the widespread adoption and effectiveness of mini-grids, including inadequate financing, technical challenges, regulatory hurdles, and socio-economic constraints. However, alongside these challenges, numerous innovations are emerging within the mini-grid sector that promise to overcome these obstacles and accelerate the deployment of decentralised energy solutions across the continent. Barriers, opportunities and innovation trends are summarised in themes below.

Political

Policy frameworks often fail to provide a conducive environment for mini-grid development. Many policies prioritise large-scale energy projects and neglect or downplay the potential of decentralised solutions like mini-grids. Furthermore, regulatory uncertainty and bureaucratic hurdles can delay projects and increase costs, deterring investment and innovation in the sector. Modifications to current policies are required to create a more supportive landscape for mini-grid initiatives, encouraging both public and private sector engagement [15].

For example, obtaining permission to operate mini-grids can be fraught with regulatory challenges. In many countries, electricity generation and supply are heavily regulated activities, and existing legal provisions often do not accommodate decentralised supply models like mini-grids. Challenges include stringent requirements to obtain licenses, ambiguity in the service area coverage for mini-grids, or lack of legal or commercial protection for mini-grid developers if the national grid encroaches on their service territory [16]. This regulatory oversight can stem from outdated laws or intentional exclusions to avoid overburdening the regulatory system. The absence of a straightforward approval process creates business uncertainty, discouraging potential investors due to the ambiguity and potential for alternative legal interpretations.

As an emerging sector, many new entrants lack the technical, financial, and organisational capacities to operate decentralized electrical infrastructure successfully. The supply conditions also pose significant challenges for mini-grid operators, who must meet specific safety, security, and performance standards to ensure reliable and non-discriminatory service to all eligible consumers. The lack of clarity regarding these business engagement conditions can reduce the effectiveness and reliability of mini-grid operations, further complicating the regulatory landscape and business environment [17].

Tariff-related issues present one of the most contentious barriers. Confusion or disagreements over tariff setting can jeopardise the viability of mini-grid businesses. While operators seek cost recovery, high supply costs can limit consumer affordability, reducing the customer base and falling short of predicted electricity consumption revenues. Conversely, imposing price parity with the central grid or uniform tariffs across all mini-grids can create financial viability issues for investors. Most empirical evidence suggests that mini-grids cannot operate at a nationally harmonized tariff without substantial subsidy. Striking a balance between affordability for consumers and financial sustainability for operators is challenging. An overly prescriptive approach can deter investors, while a very lenient approach might lead to market abuses by suppliers. Negotiated solutions, though allowed in some contexts, can be influenced heavily by the supplier's bargaining power, potentially skewing decision-making processes [18].

Economic

One of the primary concerns with the proliferation of mini-grids is ensuring that they are adequately maintained over time. Financial models must generate sufficient revenue to replace components at the end of their lifespan and warranty coverage for timely replacement in case of premature equipment failure. Balancing operational and capital expenditure costs with affordable tariffs remains a critical hurdle [19]. Local communities' involvement in managing and maintaining the mini-grids ensures ongoing reliability and service. Many rural and low-income households struggle to afford the connection fees and ongoing electricity costs, which limits the customer base and financial sustainability of mini-grid projects [20].

Subsidies play a critical role in the deployment and sustainability of mini-grids, especially in rural and underserved areas. However, the current level of subsidies for distributed renewable energy is insufficient to meet the long-term challenges faced by these communities. To date, schemes for distributed renewable energy have often relied on short-term subsidies that fail to provide the sustained support necessary for long-term viability and scalability [21]. These temporary financial aids address immediate needs but do not foster the conditions for enduring infrastructure and economic growth. Without more substantial and ongoing subsidy programs, the potential of mini-grids to provide reliable and sustainable energy access to rural African communities remains limited.

Access to finance is a significant economic barrier to the deployment of mini-grids in Africa, creating financial imbalances that hinder the economic feasibility of these projects. Many mini grid initiatives struggle to secure the necessary capital due to high perceived risks and the limited availability of affordable financing options. The lack of access to finance not only impedes the initial deployment of mini-grids but also stifles innovation and limits the scale-up of successful projects, ultimately slowing progress toward universal electricity access. Despite approvals totalling USD 2.07 billion by March 2020, only 13 percent of these funds had been disbursed, leading to delays in project advancement. The mini-grid market also faces a lack of pure commercial financing due to its limited scale, unclear regulations,

developers' limited project track records, and residential consumers' low power demand and ability to pay [22].

Pay-as-you-go (PAYG) models and other customer-centric approaches are transforming how electricity is delivered and consumed in mini-grid systems. PAYG systems allow consumers to purchase electricity using mobile money platforms in small, affordable increments. This flexibility makes electricity access more affordable and manageable for low-income households, reducing the barrier to entry. Additionally, customer-centric business models focusing on user satisfaction, service reliability, and tailored energy solutions are gaining traction, driving higher adoption rates and customer loyalty.

Supporting Productive Uses of Energy (PUE) on mini-grid leverages electricity to drive economic development and improve livelihoods in rural and underserved communities, transforming the socioeconomic landscape and creating a sustainable pathway for poverty alleviation and community empowerment. By designing mini-grids to meet residential but also commercial and industrial energy demands, operators can achieve higher utilisation rates and better economies of scale. This holistic approach ensures that mini-grids are financially sustainable while fostering local economic development.

New sources of revenue are also being explored, including climate finance and Distributed Renewable Energy Credits (DRECs). Carbon credits are tradable certificates representing the reduction of one metric ton of CO_2 emissions. Distributed Renewable Energy Credits (DRECs) are similar but tied to renewable energy generation from decentralized sources like mini-grids [23]. Both mechanisms provide financial incentives for reducing greenhouse gas emissions and promoting clean energy. Leveraging carbon credits and DRECs can enhance the economic viability of mini-grid projects; by monetizing the environmental benefits of renewable energy, mini-grid operators can access additional revenue streams.

Technical

Advancements in renewable energy technologies and grid management systems are revolutionising the deployment and efficiency of mini-grids in Africa. Cutting-edge technologies such as advanced photovoltaic (PV) panels, high-capacity lithium-ion batteries, and smart inverters are enhancing the performance and reliability of solar mini-grids. Innovations in grid management, including smart metering, automated demand response systems, and Internet of Things (IoT) applications, enable more efficient monitoring, control, and optimization of energy distribution. These technologies collectively contribute to reducing operational costs, increasing grid stability, and improving energy access reliability [24].

Technology innovations that allow the interconnection of mini-grids to each other and the main grid offer greater reliability, flexibility, and efficiency in energy distribution. Such approaches facilitate the sharing of resources and infrastructure, improving reliability and performance while reducing the overall costs of energy provision [25]. Integrating electric cooking, or eCooking, within mini-grid systems also represents a promising trend and innovation utilising efficient cooking devices. The conclusion of recent synthesis reports [26] indicates that eCooking is feasible and cost-effective in various mini-grid contexts. This approach can enable significant cost savings for consumers while increasing profitability for mini-grid operators.

Despite this progress, technical barriers include challenges related to the quality of power supplied and the technical expertise required to maintain and operate mini-grids. Power quality issues, such as voltage fluctuations and interruptions, are significant concerns for

users. These issues can lead to dissatisfaction and reduced trust in mini-grid solutions, further impeding their adoption [27].

Additionally, there is a critical shortage of locally trained technicians with the skills needed for mini-grid technical design, installation, and maintenance. This skills gap limits communities' ability to independently manage and sustain their energy systems, making them reliant on external expertise, which can be costly and logistically challenging [28].

1.2 Communities' role in the just energy transition

While economic and technical concerns have been the primary focus in studies of mini-grid deployment in Africa, the critical interplay between mini-grids and the communities they serve is often overlooked [29]. Understanding these communities' roles, agencies, and dynamics is essential for the sustainable success of mini-grid projects. This section explores literature perspectives on how communities engage with mini-grid systems and the socioeconomic impacts of this interaction. By shifting the focus towards community involvement and empowerment, we can uncover insights that enhance the effectiveness and sustainability of mini-grids, ensuring they truly serve the needs and aspirations of the local populations.

The concept of community agency, as articulated by Amartya Sen in his seminal work *Development as Freedom* [30], emphasises the capacity of individuals and groups to act independently and make their own free choices. In the context of African mini-grids, community agency is a critical factor that determines the success and sustainability of energy projects. Sen's framework underscores that development is not merely about economic growth but about expanding the freedoms and capabilities of individuals to shape their lives and influence their environment.

Electricity access through mini-grids can improve quality of life by increasing the level of health, education, welfare, and technology [31], is a crucial part of socio-economic development [32]; and is responsible for increasing youth literacy rates and improvement in health care through upgraded facilities [33] [34]. It has also been found to enhance employment, especially among women [35], by enabling income-generating activities, and advancing rural productivity [36].

However, the technology deployed without a critical assessment of community needs can lead to system failures, and combining a technical outlook with a sociological one during system design improves sustainability. Understanding social factors and their role in system failures improves prospects of future prevention. Technology adoption cannot be considered successful until there is verifiable evidence that perceived benefits have been delivered to recipient communities. By exploring social habits, cultural attitudes, and the networks of social relationships and behaviours, a more precise explanation of the unsuccessful design and adoption of electrification technologies can be made. This, in turn, translates into a socio-technical solution that is more likely to result in the success of such programmes [37].

A comprehensive review of community participation in mini-grid projects [38] found that while community involvement is universally acknowledged as crucial for system sustainability, it is often conflated with mere customer acquisition, and projects lacking adequate community buy-in tend to fail. For instance, if tariffs are set too high, communities may be unable to afford them, negatively impacting the revenue generated by the mini-grid and compromising its maintenance. Other studies have shown that in some mini-grids, poorer households often pay more per unit of electricity than wealthier households due to tariff structures. Treating electricity as an economic good conflicts with the notion of it

being a social right, and some approaches can lead to increased inequality and a lack of community participation in planning [39].

Without proper engagement with the community before the project begins, the actual demands of customers are often misunderstood, leading to systems that are either undersized or oversized and thus unsuitable for community needs. Undersized systems can lead to frequent power cuts and reduce customer satisfaction, while oversized systems can be underutilised and fail to generate sufficient revenue to cover high capital expenditure costs.

The complex rural community ecosystem is a central but undervalued factor in the sustainability of mini-grids in rural areas of Africa [40]. A key challenge identified is the mismatch between energy affordability and mini-grid tariffs, which threatens both the sustainability and scaling of energy access projects. The strategic inclusion of community-ecosystem parameters in mini-grid planning may prevent this, with the objective of designing projects accordingly to realistic energy affordability levels and adopting an added value approach that includes dynamic financing mechanisms and targeted measures to generate added value through energy consumption.

Local communities are often inadequately resourced to institute and manage their projects [41]. Yet, centralised energy governance is less effective at resolving conflicts than decentralised approaches. Poor communication and a lack of responsiveness to community needs often create dissatisfaction with centralized energy projects. In contrast, decentralised energy initiatives are more likely to achieve sustainability due to higher community participation and engagement levels. Consumer satisfaction is derived from a reliable energy supply that is responsive to community needs rather than from inconsistent electricity that is merely inexpensive [42].

Encouraging communities to play an active role in creating and managing mini-grids will accelerate the just energy transition. A just energy transition prioritises social equity, environmental sustainability, and community empowerment. It emphasises the need for local stakeholders to participate actively in and benefit from energy initiatives, ensuring that the unique challenges marginalised communities face are addressed. Understanding communities' capacities and influence is essential for fostering sustainable and equitable energy solutions that are technically feasible and socially relevant. A just energy transition requires moving away from projects for communities to foreground projects made with communities, if not led by them.

Different ownership and operation models are possible in scaling mini-grid operations across Africa, including government-owned, social enterprise approaches, cooperative ownership, and private sector involvement. Each model presents unique opportunities and challenges to ensure community involvement and system sustainability. The following sections present evidence about the operation of those models from empirical case studies (Section 2), expert interviews (Section 3 and Appendixes 1 and 2), and an analytical discussion (Section 4). The report concludes with specific and actionable recommendations for donors, policymakers, and mini grid developers.

2. Case studies: approaches to mini-grid development

Private sector, social enterprise, and cooperative ownership models are the most common ownership models for African mini-grids. Each model offers a unique approach to developing, financing, operating, and maintaining mini-grid projects, presenting distinct advantages and challenges. The following section analyses each model's perceived sustainability and impact on the community through an in-depth examination of real-world examples.

2.1 Engie Energy Access International

Overview

Engie Energy Access is dedicated to extending electricity access to rural communities by providing clean, reliable, and sustainable energy solutions. The company has witnessed considerable expansion in African markets, serving nine markets with a notable focus on Zambia. Establishing a presence across the country, Engie has set up bases in all ten provinces and established a network of distributors and agents on the ground. In the realm of mini-grids, Engie is currently in a pilot phase with expansion plans.

Engie's business development role encompasses facilitating the establishment of mini-grids, guiding projects through various stages of the project cycle, from pre-feasibility and feasibility studies to development and construction. Engie plays a pivotal role in these processes, ensuring that mini-grids are successfully established and operated.

Engie's primary motivations for deploying mini-grids stem from various levels, including global commitments such as contributions to the Conference of Parties (COP), national-level targets outlined in Nationally Determined Contributions (NDCs) and Sustainable Development Goal 7 (SDG7), and the recently developed national energy strategy. Recognising a significant gap in rural electrification, particularly in Zambia, where only 8% of rural areas have access to electricity, Engie aims to support the Government of Malawi's ambition to drive this figure to 50% by 2030.

While low-carbon motivations are part of Engie's broader objectives, the primary driver for rural communities is the assurance of a secure source of electricity to alleviate poverty and foster economic development. In these communities, the focus is on replacing diesel-powered systems with cleaner alternatives. Concerns about climate change may not resonate equally in all communities, with some still relying on traditional fuel sources like wood and not fully embracing climate change mitigation strategies.

Role of community in project planning, operation and maintenance

Engie recognises the pivotal role of the community in the successful delivery of their energy technologies, placing a strong emphasis on community engagement throughout the project lifecycle. Upon identifying a site for deployment, Engie seeks permission from local Traditional Authority leaders, such as chiefs, in accordance with the local hierarchical structure. These leaders grant authorisation for site access and aid in locating suitable land for the generation site, including negotiations regarding land prices. Engie actively involves the community in these processes, seeking their agreement on land prices and ensuring alignment with local customs and cultural practices. Engie informs the community about the project plans and processes, obtaining their consent before proceeding.

Community sensitisation is considered a crucial step before project approval, especially in rural areas where many residents may have limited exposure to electricity. Engie conducts baseline surveys to assess the community's ability and willingness to pay for the services,

focusing on gender mainstreaming and health and safety considerations. Other sensitisation efforts aim to educate the community about the benefits of electricity, dispel any myths or misconceptions about renewable energy and solar power, and foster understanding and acceptance of the project. Using baseline data, Engie aims to design equipment and household appliances tailored to the community's needs and preferences, considering factors such as energy usage patterns and local institutions and businesses.

Engie prioritises local employment by hiring operators from within the community whenever possible. While challenges may arise in finding qualified individuals, Engie addresses this by engaging practical individuals during the construction and inception stages, providing them with training and mentorship from expert technicians to develop the necessary skills. This approach ensures local employment opportunities and fosters knowledge transfer and capacity building within the community. Additionally, community members may assist with manual labour tasks, such as digging, further enhancing community involvement and ownership of the project.

During operations, the local operator serves as a point of contact for the community, addressing any customer complaints or feedback promptly and efficiently. They also play a crucial role in troubleshooting technical issues and liaising with technicians within the district, ensuring the smooth and reliable operation of the mini-grids.

Engie periodically conducts customer experience surveys to inform improvement in service quality. Any faults or issues reported by customers are communicated to site agents and addressed promptly by technicians who travel to the site to resolve them. To streamline the process and enhance customer convenience, Engie is working towards establishing a call centre where customers can register complaints and seek assistance directly.

Customer contracts are signed to formalise agreements and ensure transparency in service provision. While Engie acknowledges the importance of measuring social impact, specific metrics for assessment are not currently in place. However, occasional surveys and observations are conducted to gauge social impact and community satisfaction.

Financing and ownership

In Engie's mini-grid projects, customers are responsible for covering the tariff and connection fees. Additionally, they can purchase appliances externally or through Engie's supply services. However, Engie manages the financing of the mini-grid infrastructure itself. Engie utilises a combination of grants, debt, and equity to fund the construction and operation of mini-grids across Africa. There is currently no community ownership structure for these mini-grids, and the relationship between the community and the mini-grid provider is typical of a business offering a service to customers.

Engie and other mini-grid developers in Africa face several challenges in financing their projects. Limited access to concessional funding and high loan interest rates pose significant obstacles. The lack of clear regulatory frameworks and inconsistent government support further complicates the financing landscape. Engie must navigate these challenges alongside other developers to ensure the successful implementation and sustainability of mini-grid projects across the continent.

2.2 NRECA International

Overview

The National Rural Electric Cooperatives Association (NRECA) is a longstanding association representing 900 electric cooperatives in the USA since its establishment in 1930. NRECA sets up rural cooperatives to own and operate distribution grids and mini-grids and engages in legislative lobbying to ensure favourable policy outcomes for electric cooperatives. As a non-profit corporation, NRECA International's mission is to improve the quality of life for rural communities in developing economies by providing access to reliable and affordable electricity. In 1962, NRECA signed a cooperative agreement with the U.S. Agency for International Development (USAID), which established a program to share with lower-income countries the lessons from the electrification of the rural United States. Since then, more than 220 million people in 48 countries have benefitted from their work

With approximately 220 million connected consumers internationally, NRECA International operates primarily in Latin America, Sub-Saharan Africa, and Southeast Asia. Notable projects include initiatives in Liberia, where NRECA International assisted in the formation of the Totota Electric Cooperative (TEC). This rural electric cooperative was the second Liberian electricity provider to be licensed, behind LEC, which operates the national grid. NRECA International is implementing electric cooperative development programs in Zambia and Malawi with USAID funding.

The preference for cooperatives over government or private sector involvement stems from historical precedent and practical considerations. Electric cooperatives have played a central role in rural electrification efforts in many countries, including the United States. Other cooperative entities, such as microfinance institutions, women's lending groups, and credit cooperatives, reflect an egalitarian approach to development. Cooperatives, which rely on democratic member participation and ownership, are perceived as more durable than government-led initiatives, which may be subject to changes in political leadership and funding misappropriation. Moreover, although cooperatives are classified as private sector institutions when compared to for-profit companies engaged in electrical infrastructure development, cooperatives offer greater transparency, accountability, and community engagement. The for-profit private sector approach faces a temptation to prioritise profitability over access, which can, in turn, lead to neglecting underserved communities and marginalized demographics within unelectrified populations while failing to ensure affordable tariffs.

Role of community in project planning, operation and maintenance

The success of rural electrification projects facilitated by NRECA International Engagement depends on involving the community as leaders. At the project planning stage, NRECA International collaborates closely with local communities to ensure their active involvement in sustainable ownership of the assets they will operate. This begins with site identification, where considerations extend beyond technical feasibility to include indicators such as population density, willingness and ability to pay, and potential productive energy uses.

Moreover, NRECA International evaluates the community's orientation towards democratic self-governance, assessing existing leadership structures and decision-making mechanisms. This involves examining the presence of cooperative entities, leadership openness, and the inclusivity of decision-making processes within traditional and distributed authority systems.

To formalise community participation, NRECA International facilitates membership drives, allowing individuals to become members of the cooperative venture. Each member holds voting rights, ensuring democratic representation in governance. A steering committee oversees the collection of membership dues and coordinates the establishment of the cooperative entity in compliance with local laws and regulations. At the first General Assembly, all cooperative members will meet to approve the bylaws and elect the co-op's first board of directors, who will incorporate the cooperative, manage finances, and hire the management team.

The community assumes full ownership and responsibility for managing the infrastructure throughout the operation and maintenance phase. NRECA International or other external third parties may provide technical assistance, but the cooperative's legal entity remains distinct. The cooperative owns and manages all infrastructure, empowering members to make decisions regarding tariff adjustments, executive appointments, and operational policies through the democratic process and subsequent General Assemblies.

The cooperative board, elected by the membership, holds authority over critical decisions, including tariff adjustments and personnel management. Only members are eligible to vote to ensure accountability and community representation, and board members are mandated to prioritise the community's best interests. The cooperative and all associated electrical infrastructure and assets are wholly owned by the members who receive electricity from the co-op. No external party or individual may own shares of the cooperative, vote in its elections, or serve on its board of directors. A stipulation is that the cooperative remains non-political and non-partisan in its operations.

In cases where regulatory constraints hinder tariff adjustments, NRECA International advocates for regulatory reforms to empower cooperatives to align tariffs with the cooperative's interests. While NRECA International provides technical support in tariff modelling, the final decision rests with the cooperative board, reinforcing community autonomy and self-governance.

Financing and ownership

Financing electric cooperatives in Africa presents a complex challenge, far removed from the favourable conditions experienced by cooperatives in the United States. While U.S. cooperatives benefitted from public funds at a 2% interest rate over a 35-year term under the Rural Electrification Act in the mid-20th Century, African counterparts in the present context cannot receive debt financing. The lack of commercial finance, limited concessional finance, and higher interest rates often exceed double digits and are typically on 10-year terms. Concessional funds from institutions like the IFC and ADB may offer lower rates for concessional loans to qualified borrowers (typically not to cooperatives). Patient impact investors overlook cooperatives because of the perceived risks and lack of profitability associated with cooperative models.

NRECA International receives support from USAID's Cooperative Development Program (CDP), which covers soft costs, vehicles, and staff expenses but does not extend to capital expenditures. While NRECA International prioritises the establishment of cooperatives, securing funding for capital-intensive mini-grid infrastructure remains a challenge, as few funders are willing to invest in cooperative-based models without retaining ownership, influence, and/or governance. Most energy access grants favour for-profit business models by requiring debt and/or equity co-financing or other evidence of blended finance to qualify for grant funding, leaving cooperatives ineligible for funding opportunities.

A fundamental distinction between cooperatives and for-profit private sector entities lies in the absence of a return on investment for cooperatives. Any surplus funds generated beyond operational costs are reinvested into the cooperative's activities or returned to cooperative members as dividends. The cooperative board plays a pivotal role in allocating surplus funds, whether for infrastructure upgrades, grid expansion, tariff adjustments, savings reserve accounts, or dividends paid to members.

2.3 Kuyatsa Sustainable Energy

Overview

Kuyatsa is a newly established energy service social enterprise building on over ten years of experience in Malawi's energy access sector. Originating from the international NGO Self Help Africa (SHA), Kuyatsa represents a shift from donor-led projects towards deploying mini-grids through a social enterprise model, facilitating efficient and sustainable energy access nationwide. With support from the Scottish government-funded EASE program [43] SHA and the University of Strathclyde have spearheaded the installation of two solar mini-grids in Dedza, Malawi, culminating in the development of a comprehensive social enterprise framework. Kuyatsa stands as the tangible outcome of these collaborative efforts.

Legally registered in Malawi as a Company Limited by Guarantee, Kuyatsa benefits from operational and financial backing from its parent organization while maintaining autonomy and agility as an independent entity. This ensures efficient operations and strategic flexibility.

Kuyatsa's mission aligns with the broader vision of achieving universal energy access in Malawi by leveraging scalable solar mini-grid solutions. The core principles of Kuyatsa's mini-grid approach include:

- Sustainable Tariffs: Prioritising affordability and financial sustainability, Kuyatsa adopts a tariff structure that balances customers' ability and willingness to pay while ensuring revenue adequacy for operational expenses and component replacements.
- Data-Driven Operations: Recognising the significance of data in the evolving mini-grid landscape, Kuyatsa emphasises extensive data collection and dissemination, employing remote monitoring, smart meters, and customer journey surveys to track technical, economic, and social impact indicators.
- Community Engagement: Drawing from SHA's extensive community engagement expertise, Kuyatsa strongly emphasizes local capacity building and community involvement, recognising their pivotal role in fostering sustainable business models.
- Productive Use of Energy (PUE): To bolster electricity demand and enhance mini-grid viability, Kuyatsa prioritises the promotion of agricultural Productive Uses of Energy (PUE) as a cornerstone of its community engagement strategies.
- Stakeholder Collaboration: Kuyatsa collaborates closely with government ministries and regulators to ensure compliance with policies, regulations, and standards while advocating for an enabling environment conducive to sustainable energy sector growth.

Role of community in project planning, operation and maintenance

Kuyatsa's approach to developing, installing, and operating solar mini-grids is deeply rooted in community involvement and collaboration with trusted partners. This includes working with local electrical contractors for installation and maintenance, UK universities and consultancies for technical assistance, and engaging national, district, and local governance structures throughout all stages of development.

As a social enterprise, Kuyatsa places community benefit at the forefront of its organisational goals. The company engages with communities at every level, from obtaining necessary approvals to sensitising residents about safe electricity use and building capacity for productive uses of energy and gender mainstreaming. A crucial aspect of Kuyatsa's model is offering tariffs that balance the cost of energy production with the community's ability and willingness to pay. Using smart meters, Kuyatsa implements and adjusts innovative and dynamic tariffs based on extensive community engagement and feedback.

What distinguishes Kuyatsa from other organisations in the mini-grid sector is its emphasis on data collection and analysis to inform technical design and business modelling, specifically tracking social impact through regular customer-journey surveys alongside technical and economic data collected through remote monitoring and smart meters. Understanding microgrid performance through primary data is essential for planning effective maintenance schedules and technical designs for future microgrids. Collecting social impact data helps improve customer service and inform business models that are appropriate and beneficial to the communities. This data-driven approach improves operational efficiency, informs policy interventions, and helps build a knowledge base that can accelerate the microgrid sector nationally and globally.

Financing and ownership

As a social enterprise, Kuyatsa exemplifies organisations that trade for a social purpose, are independent of the state, and are non-profit-distributing. Kuyatsa's defining characteristics include a clear social purpose, engagement in the marketplace through trade, reinvestment of profits, community engagement and participation, and organisational accountability.

Unlike cooperative models, which are directly owned by the community members they serve, Kuyatsa operates as a separate legal entity. However, Kuyatsa strongly emphasises community engagement and participation and dedicates substantial resources to tracking social impact, distinguishing it from purely private sector models. This focus ensures that the benefits of the mini-grid projects are maximised for the communities they serve.

Due to this approach, Kuyatsa is more reliant on donor funding in its early stages, aiming to achieve sufficient scale to become self-sufficient through its revenue streams. One of the key distinctions is that profits generated by Kuyatsa are reinvested into the locally owned Malawian company rather than being repatriated to foreign entities. This approach supports local economic development and aligns with Kuyatsa’s mission of community empowerment and sustainable energy access.

Despite its social enterprise model, Kuyatsa's financial sustainability depends on a mix of grants, debt, and equity financing. The organisation recognises the need for early-stage grant funding to support pilot deployments. This initial funding is crucial to facilitate the transition to other financing mechanisms, such as Results-Based Financing (RBF), debt, and equity, on its pathway to achieving scale and financial sustainability. Kuyatsa’s robust data collection and analysis strategy is designed to prove demand and revenue, reducing risk to potential investors. Through these efforts, Kuyatsa aims to create a scalable and sustainable model for rural electrification in Malawi, contributing significantly to the broader goal of universal energy access.

3. Stakeholder perspectives

This section summarises stakeholder perspectives on community agency within the context of mini-grids in Africa. The insights from expert interviews are categorised into three primary themes: Finance and Ownership Structures, Challenges in Engaging with Local Communities in Mini-grid Projects, and 'Do with' versus 'Do for'. These themes contribute to discussions towards a comprehensive understanding of the various approaches and considerations in implementing community-focused mini-grids, highlighting the successes, challenges, and potential pathways for sustainable and inclusive energy solutions in rural Africa.

3.1 Finance and ownership structures

All stakeholders indicated a shortage of finance and funding opportunities for mini-grids in Africa, which poses a significant barrier to these projects' effective implementation and sustainability. This financial scarcity often limits the ability of communities to engage in ownership and governance of their energy solutions. Stakeholders emphasised that the potential for community-driven mini-grids remains untapped mainly because of inadequate funding. The conversation around finance highlighted the need for innovative funding mechanisms that can bridge the gap between community aspirations and the financial realities they face. By enhancing access to capital, for example, through government initiatives like the Community Development Fund (CDF) in Zambia, communities could harness their resources to develop localised energy projects that reflect their specific needs and priorities. However, the overarching challenge remains: addressing rural communities' financial constraints, often compounded by low-income-generating capabilities. Effective strategies to leverage government funds, such as loans or grants tied to strong business cases and clear impact metrics, are crucial for empowering communities and attracting additional private financing from banks and other institutions.

One major challenge is the lack of information and awareness about mini-grid projects among potential investors, which increases risk and decreases appetite for investment. Knowledge exchange and sensitisation efforts are needed to demystify these projects and highlight their benefits and impacts. Primary data is essential to quantify technical and economic performance to prove financial sustainability and gain investment. Impact investors, particularly in developing countries, show interest in these projects due to their potential community benefits highlighting the need to track the social impact mini-grids have to access this investment.

Stakeholders indicated that Result-Based Financing schemes are available, but more businesses and local ownership are needed to scale these efforts effectively. Facilitating local businesses and enabling them to participate in distributed utility models can be beneficial. However, local entities often struggle to access international finance due to various regulatory and logistical barriers. Aggregation of projects could be a viable solution to overcome these challenges. By pooling resources and selecting promising projects, stakeholders can create a standard investment assessment framework that benefits investors and communities.

Stakeholders indicated that for mini-grids to achieve a favourable rate of return, more affluent sites will be targeted with higher-paying customers, making the less well-off sites less attractive for mini-grid deployment. An estimate was provided that less than half are suitable for a profit-focused private sector model, and universal electrification is, therefore, unlikely with this approach. Stakeholders emphasise that rural communities should lead these initiatives. Local people can manage the system at tariff levels appropriate to their

community, offering a uniquely positioned solution that doesn't necessarily need to generate profits for foreign investors. There is potential for a middle ground with social enterprises, where the community could hold a 20% ownership stake to dilute investor control. This model hasn't been sincerely tried yet, as private-sector developers often do not offer community ownership.

Although multiple grant applications and donor schemes are available, local businesses and cooperatives often find it challenging to access these funds. In Africa, securing long-term, low-interest loans remains challenging. Interest rates can be in double digits, sometimes over 25%. Concessional funds from institutions like the International Finance Corporation (IFC) or the African Development Bank (ADB) offer rates of around 9-11%, but these are still high. Patient impact investors may accept lower returns (5-7%) given the risks, but these are exceptions rather than the rule. Cooperatives, for example, could take low-interest loans and own both the infrastructure and the debt, aligning their interests with debt repayment However, the creditworthiness of these cooperatives is often questioned since they are not operating for profit, and a significant shift in financing approaches is needed to support cooperative models and ensure universal access to electricity.

3.2 Challenges in engaging with local communities in mini-grid projects

Stakeholders indicate several significant challenges in engaging with local communities for mini-grid projects. One common issue is the myth that renewable energy cannot power larger appliances. In many communities, there is scepticism about the ability of renewable energy sources to power heavy-duty equipment such as hammer mills effectively. Convincing the community of the reliability and capability of renewable energy systems is a critical step. Additionally, clean cooking solutions must be integrated into mini-grid packages, as communities prefer to cook traditional meals, which they fear may not be supported by renewable energy systems.

Stakeholders indicated that land acquisition is another major challenge. Hierarchical, tribal, or traditional laws complicate land ownership in many rural areas. Mini-grid project developers must navigate these complex land ownership issues, which can involve generational connections and restrictions that prevent land purchase, necessitating leases instead. Negotiating land rental or purchase prices can be particularly difficult and time-consuming, adding another layer of complexity to project development.

A key challenge stakeholders identified is the community's lack of trust towards mini-grid developers. This distrust is partly due to past experiences with failed donor projects, which have left communities sceptical about the promised benefits. Additionally, there is a perception that mini-grid developers are primarily interested in profiting from the community, leading to concerns that the price tariffs for mini-grid electricity are significantly higher than those for grid electricity. These concerns are compounded by the fact that, in many cases, the community does not see the immediate benefits of the mini-grid, leading to further distrust and hesitation to engage.

Data collection frameworks regarding protections for rural communities also pose a challenge. Mini-grid developers need data on revenue and demand to inform their technical and business models. Smart meters can provide real-time data on customer usage, and social impact surveys can gather potentially sensitive information. However, many African countries have no stringent data protection laws, leaving room for potential exploitation of rural customers. While academic projects often adhere to ethical guidelines, private sector developers may not follow the same standards, raising concerns about data privacy and security.

Building trust is crucial for successful community engagement. Some community members are wary that developers will not deliver on their promises or that they are merely interested in extracting money from the community. The extended time required to develop mini-grid projects can also lead to disillusionment and loss of hope among community members.

3.3 Policy affecting mini-grids

The views of stakeholders indicate that policy plays a crucial role in fostering development in rural communities through mini-grid projects. Well-designed policies can accelerate mini-grid deployment, whereas inefficient or unsuitable policies pose significant hurdles. For instance, stakeholders cite a presidential commitment to deploy 1000 mini-grids in Zambia as a driver that has accelerated deployment. Conversely, in Tanzania, a policy prohibiting cost-reflective tariffs undermined mini-grid viability, leading to the collapse of the private sector's involvement.

Stakeholders emphasise that effective regulation is essential to protect communities by establishing minimum standards for mini-grid developers, including installation quality, health and safety measures, and environmental regulations. Such regulations safeguard communities from risks associated with substandard infrastructure and ensure reliable energy supply. However, stakeholders also note that overly stringent regulations can inflate costs for developers and delay mini-grid deployments. For example, in Malawi, some stakeholders highlighted the need for an environmental and social management plan for each new mini-grid site. While crucial for community protection and environmental stewardship, the extensive documentation needed imposes significant financial and administrative burdens on developers.

Given the World Bank's estimate of needing 200,000 mini-grids to achieve SDG7, stakeholders express concern about the time-consuming approval processes that could significantly delay deployment efforts. Stakeholders have experienced project delays due to regulatory complexities, illustrating how policy alignment with deployment goals is critical.

The stakeholders stress the importance of regulations prioritising community interests and ensuring their active participation in mini-grid projects. They advocate for transparent processes where developers demonstrate community engagement in obtaining licenses. Fair tariff structures are also highlighted as crucial to prevent exploitation and ensure affordability for local communities.

Stakeholders advocate for a balanced regulatory framework that serves both community interests and developer needs. They emphasise the need for regulations establishing minimum service levels for communities while facilitating rapid and sustainable mini-grid deployment. This balanced approach protects communities from exploitation while fostering an enabling environment for private sector investment in mini-grid projects.

3.4 Engaging with communities to provide energy access

Stakeholders acknowledge the necessity of external support for communities to initiate and sustain mini-grid projects, as these communities often lack the resources to do so independently. This support can come from government entities, NGOs, or the private sector. However, questions arise about who should represent the community in these projects. Should it be the local government, national government, or specific community leaders? Often, a community or council head can lead by asking villagers to opt in and identifying those who want to be part of the initiative. Defining "community" is crucial in

this context. Does it mean involving everyone in the village or just the interested stakeholders? Clarifying this ensures the right people are engaged and the project benefits the intended recipients.

When the private sector is involved, there is a potential risk of community exploitation. Like any other business, private sector-led mini-grid projects can evolve into monopolies, leading to exploitation over time. Given that many rural communities have low ability and willingness to pay, there is a danger that mini-grids could end up extracting more money from these communities than they provide in benefits.

To avoid such exploitation, stakeholders suggest that projects must be empowering and focus on capacity building and implementing productive uses of energy, helping communities achieve economic development. Social impact surveys are crucial for tracking positive and negative impacts on the community and can help identify whether the mini-grid developer is genuinely contributing to the community's development or merely exploiting it.

A broader issue stakeholders highlight is the role of colonialism in mini-grid projects. All case studies examined have European or North American technical support or financing, raising the question of whether these initiatives are a form of neocolonialism. Are there any African mini-grids that operate completely independently of external support? Is complete independence necessary or even desirable? These questions need careful consideration to ensure that mini-grid projects are genuinely beneficial and empowering for local communities rather than perpetuating historical patterns of exploitation.

One stakeholder emphasized the importance of considering the scaling speed when discussing community ownership of mini-grids. They pointed out that while community ownership has merits, it also risks becoming a local natural monopoly, leading to governance challenges. Locally-owned projects may face slow decision-making processes, often hindered by local politics, and lack the capacity to scale effectively. In contrast, private businesses tend to have advantages in operational efficiency. They can offer turnkey solutions and standardised systems that facilitate rapid deployment at scale. The stakeholder suggested that franchising mini-grid models could draw parallels from the mobile phone industry, which has successfully scaled through clear offerings, bundled services, and competitive tariffs. This raises the question of whether similar strategies could be employed in the energy sector to achieve widespread and efficient access to electricity.

Another stakeholder highlighted that, despite numerous government incentives for the renewable energy sector, there remains a critical question regarding whether these incentives reach the appropriate stakeholders. They noted that, when available, subsidies tend to benefit the developers rather than the communities themselves. This raises an important issue: how can we effectively channel these subsidies and incentives directly to the communities that could benefit most from renewable energy projects? Ensuring that financial support is allocated to empower local populations is essential for fostering sustainable energy solutions and enhancing community ownership of energy resources.

Despite these challenges, stakeholders believe involving local communities in planning, owning, and managing mini-grids is essential for achieving sustainable energy access. By fostering strong community engagement, leveraging local knowledge, and securing appropriate financing, it is possible to create a more inclusive and effective energy landscape in Africa.

4. Discussion

This section compares the merits and drawbacks of three distinct business models — private sector, cooperative and social enterprise —focusing on their potential to achieve Sustainable Development Goal 7 (affordable and clean energy for all) and their impact on communities within a just transition framework. The analysis reveals many approaches to community engagement and emphasises the importance of understanding and fostering community agency in developing and operating their energy infrastructure. It is clear that there is no one-size-fits-all solution; a tailored, case-by-case approach is essential to address the unique needs of different communities.

In pursuing SDG7, the private sector can leverage significant financial and technical resources, allowing for the rapid deployment and scaling of mini-grids. The involvement of the private sector in mini-grid development can introduce innovation, expertise, and funding that may be challenging for public sectors or community-owned systems to provide alone. This capacity enables the implementation of advanced technologies, resulting in reliable and efficient energy services. However, enhancing community engagement is paramount for private-sector approaches to be sustainable. This can be accomplished by establishing robust frameworks for gathering community feedback regarding service quality and tariff structures. Additionally, it is vital to provide customers with accessible channels for voicing complaints. Conducting more social impact surveys will help quantify the benefits and challenges of mini-grid initiatives, enabling businesses to adapt their plans to better serve the communities involved. Furthermore, as profit-driven entities, private companies might prioritise profitability over affordability, potentially excluding the most vulnerable communities from benefiting fully from these energy solutions. Such approaches may undermine long-term sustainability and local engagement.

In contrast, the cooperative model emphasises community ownership and management of energy infrastructure, fostering local buy-in and democratic governance. This approach promotes transparency and accountability and offers resilience against shifts in government or policy, thus providing a stable framework for rural electrification. However, such approaches face technical capacity challenges that can hinder their effectiveness. Addressing these challenges requires targeted technical support and capacity-building programs designed to enhance the skills of community members responsible for managing their energy infrastructure. Specific assistance is needed in mini-grid maintenance and financial planning, including tariff setting, to ensure that customers are not burdened with debt. These challenges are particularly acute for single, community-owned mini-grids. Maintaining a technical team for just one mini-grid can be impractical; scalability is vital for long-term sustainability. Models such as build-operate-transfer and development trusts can provide pathways for more effective management. The challenge of cooperatives in securing long-term, low-interest financing can hinder their ability to scale efficiently.

Social enterprises bring a distinctive perspective, prioritising social impact while ensuring that projects align closely with community needs and are highly aligned with just transition principles. By reinvesting profits locally, social enterprises stimulate economic development and build community resilience. However, many social enterprises, particularly in their early stages, depend on donor funding, which may not be sustainable for large-scale deployment. The challenge for these models lies in achieving financial sustainability while maintaining their commitment to social objectives.

In conclusion, the cooperative and social enterprise models are better aligned with the ideals of equity, inclusivity, and community empowerment essential for a just transition. While the private sector may provide a quicker route to achieving SDG7 at scale, the

cooperative and social enterprise frameworks offer more sustainable and equitable pathways that prioritise community involvement and benefits.

5. Recommendations for Policy Makers, Donors, and Mini-grid Practitioners

This section provides a summary of key recommendations for policymakers, donors, and mini-grid practitioners based on the insights and perspectives gathered from stakeholders on various aspects of mini-grid deployment in Africa.

5.1 Policy Makers:

Streamline Regulatory Processes: Policymakers should aim to simplify and expedite regulatory processes surrounding mini-grid deployment while maintaining robust standards for quality, safety, and environmental impact. Streamlining these processes can reduce bureaucratic delays that often hinder project implementation, enabling faster and more efficient rollouts of mini-grids. However, it is essential to balance expediency with the necessity for thorough assessments to ensure that projects meet safety and environmental standards, protecting both communities and ecosystems.

Promote Community Engagement: Policy frameworks should require developers to demonstrate meaningful community engagement throughout project planning, implementation, and operations. By embedding community involvement into the regulatory requirements, policymakers can help ensure that mini-grid projects are responsive to the needs and priorities of local populations. This engagement can enhance project sustainability, foster trust, and empower communities to take an active role in their energy future, ultimately leading to more effective and impactful energy solutions.

Invest in Local Capacity Building: There is a critical gap in locally trained technicians and skills, particularly in mini-grid technical design and business modelling. Universities and technical colleges should offer specialised training courses in these areas. Additionally, training should be extended to rural communities to enable them to maintain and develop their energy sources. International consultants should adopt a partnership approach to technical assistance, focusing on capacity building rather than delivering one-off solutions.

Develop Standards for Monitoring and Tracking Social Impact: Standards for monitoring and tracking the social impact of mini-grids need to be established. Data collection is inconsistent, with many mini-grid developers lacking the resources to gather and analyse sufficient data. Developing comprehensive and standardised metrics for social impact assessment will be crucial to help monitor community impact and inform policies and deployment approaches.

Allow for Cost-Reflective Tariffs with Adequate Subsidies: Cost-reflective tariffs pose a challenge: high tariffs can impoverish communities, while low tariffs can render mini-grids financially unsustainable. Adequate subsidies should be provided to balance this, making mini-grids financially viable while keeping tariffs affordable for communities. It is unfair for the poorest communities to bear the high costs of mini-grid electricity when electrical infrastructure in the global north has historically been subsidised. By providing electricity in rural areas, mini-grids can help reduce migration to cities and the associated strain on urban services. Revenues for subsidies could be raised from a tax on affluent city dwellers to support mini-grid development in rural areas, promoting balanced regional development.

Support Decentralised Governance through District Energy Officers: Decentralising political power is crucial for ensuring community voices are heard in policy-making. Centralised decisions often overlook the needs of underserved rural communities. Initiatives like the District Energy Officers (DEOs) in Malawi [44], [45] provide a model for how decentralisation can better serve local communities. DEOs conduct energy mapping

and act as conduits between local communities, district governments, and national governments, ensuring that local energy needs and resources are adequately represented and addressed.

5.2. Donors

Increase Financing for SDG7: To achieve SDG7, significantly more financing for more mini-grids is needed. Current financial flows are insufficient and often misallocated, with funds primarily directed towards large corporations and big-ticket projects. Much of this money is spent on international consultants for technical assistance, with little directly benefiting the communities. Donors should ensure that financing mechanisms are inclusive, accessible, and tailored to support smaller, community-focused projects.

Facilitate Access to Concessional Financing: To promote the widespread deployment of mini-grids, it is essential to encourage concessional financing options that provide lower interest rates and more extended repayment periods explicitly tailored for these projects. By reducing the financial burden on developers, concessional financing can make investing in infrastructure that serves rural communities more feasible. Governments and international financial institutions should collaborate to establish dedicated funds or grants aimed at supporting mini-grid initiatives, ensuring that the financing structures are accessible and attractive to both local and international investors. This financial support can stimulate private investment and foster innovative business models prioritising community engagement and sustainability.

Support Capacity Building: Investing in technical assistance and capacity-building programs for local developers and communities is vital for enhancing the sustainability and management of mini-grid projects. Donor-supported training initiatives should equip local stakeholders with the necessary technical design, operational management, and financial planning skills. By fostering local expertise, these programs can ensure that communities can install and operate mini-grids effectively and maintain and scale these systems over time. Furthermore, capacity building should include training on best practices for community engagement and participation, ensuring that energy solutions are aligned with the needs and priorities of local populations. By empowering communities through education and training, mini-grid projects' long-term success and resilience can be significantly improved.

5.3 Mini-grid Practitioners:

Enhance Community Engagement and Governance: Mini-grid developers must engage communities through capacity-building initiatives on safe electricity use, gender sensitivity, and training on productive uses of energy (PUE). Appliance financing can help reduce the upfront cost of appliances, and promoting electricity use for business activities can drive local economic development. Where possible, mini-grid practitioners should actively involve local communities in the governance structures of projects. Establishing community participation mechanisms in decision-making can empower residents, enabling them to influence the direction of the energy initiatives that directly impact their lives. This collaborative approach strengthens project viability and promotes long-term commitment to the maintenance and success of mini-grid systems.

Embrace Technology and Innovation: Practitioners should leverage advancements in smart metering, data analytics, and renewable energy technologies to optimise mini-grid operations and enhance customer service. Implementing smart metering can provide real-time data on energy usage, facilitating better demand management and improving billing accuracy. Additionally, data analytics can offer insights into user behaviour and preferences,

enabling practitioners to tailor services and improve customer satisfaction. By embracing innovative technologies, mini-grid systems can operate more efficiently, reduce costs, and offer enhanced services that meet the evolving needs of local communities.

Implement Social Impact Assessments: Conducting thorough social impact assessments is essential for monitoring and maximising positive outcomes for local communities while mitigating potential risks associated with mini-grid projects. These assessments should evaluate mini-grid installations' social, economic, and environmental implications, helping practitioners identify beneficial impacts and areas of concern. By integrating social impact assessments into the project lifecycle, practitioners can ensure that projects are designed and implemented to enhance community welfare, address potential adverse effects, and foster a collaborative relationship with local stakeholders. This proactive approach contributes to the sustainability of mini-grids and builds trust and rapport within the communities they serve.

Ensure Equity of Social Impact: Given the high tariff costs of mini-grid electricity, it is likely that only relatively affluent community members will afford connection costs and ongoing tariffs, leading to increased wealth disparities. Cross-subsidization can mitigate this issue. When selecting mini-grid sites, care should be taken to avoid only choosing the "low-hanging fruits"—communities with better access and economic activity—thus ensuring more equitable development.

Promote Gender-Sensitive Approaches: Electricity access significantly impacts women and girls. Mini-grid electricity can positively transform lives by supporting electric cooking, which has gender and climate benefits. For maximum impact, electric cooking should be integrated into the core design of mini-grid projects rather than as an afterthought.

Emphasising collaborative approaches that empower communities fosters ownership, enhances accountability, and maximises the potential for successful and lasting energy initiatives. By prioritising community agency, we can create energy systems that serve the common good, driving inclusive development and resilience across Africa. By implementing these recommendations, policymakers can create a more inclusive, effective, and sustainable framework for expanding energy access through mini-grids, ultimately supporting the achievement of SDG7 and broader development goals.

5.4 Research Agendas

Further research is essential to address the challenges and opportunities surrounding African mini-grids. Such inquiries can illuminate these energy systems' intricate political dynamics, social impacts, and community perceptions. Key areas for exploration include:

Community Benefits and Equity: It is crucial to investigate whether communities genuinely benefit from mini-grids and, if so, in which ways and contexts. This involves identifying who within the community reaps the rewards and assessing whether these benefits are distributed equitably. Understanding how mini-grids have been deployed to impact rural communities positively can provide valuable insights into best practices for replication.

Longitudinal Studies: Conducting longitudinal studies can shed light on the long-term effects of electricity access on various community indicators, such as economic development, education, health, and social cohesion. These studies will provide a deeper understanding of the sustained impacts of mini-grids over time.

Sustainable Business and Delivery Models: Research is needed to develop business and delivery models that ensure the sustainable operation of decentralised electricity infrastructure and effective strategies for embedding communities within the delivery

model. This includes identifying affordable cost structures for the poorest communities and investigating the necessary subsidy and support mechanisms for achieving this sustainability.

Gender, Equality, and Social Inclusion: It is essential to explore how mini-grid projects can be designed to maximise benefits related to gender, equality, and social inclusion within rural communities. Additionally, research should focus on how policies can support these objectives, ensuring that all community members have equitable access to the benefits of electricity.

Data Sharing on Performance: Shared primary data regarding the technical and economic performance of mini-grids, aligned with social impact tracking, is needed. This data can enhance transparency and allow stakeholders to evaluate the effectiveness of various projects and initiatives.

Economic and Social Impact Studies: Broader research initiatives should assess the overall economic development implications of mini-grids on communities, including monitoring financial flows in and out of local economies. Understanding these dynamics will provide insights into how mini-grids can contribute to sustainable economic growth and community resilience.

In summary, a comprehensive research agenda addressing these critical areas will provide the insights needed to optimize the deployment and operation of mini-grids in Africa, ensuring they effectively achieve energy access, social equity, and sustainable development.

6. Outlook

This study has explored the intricate dynamics surrounding community agency in deploying mini-grids across Africa. Recognising that there is no one-size-fits-all solution, the report underscores the importance of context-specific approaches tailored to local communities' unique needs and aspirations.

While significant progress has been made in expanding energy access through mini-grids, it is essential to remain vigilant about the potential risks inherent in a purely profit-driven framework. As mini-grids increase, there is a concern that they may inadvertently propagate a narrow focus on economic outcomes, overshadowing the vital social dimensions that underpin sustainable development.

This policy brief encourages an open dialogue about the implications of mini-grid deployment, prompting critical questions about our trajectory. Are we pursuing the Sustainable Development Goal 7 (SDG7) of affordable and clean energy for all at any cost, or are we committed to achieving this goal in an equitable, sustainable, and just manner?

In conclusion, the discussion surrounding community agency in mini-grids is not merely academic; it is essential for shaping a just energy transition that prioritises social cohesion and local empowerment. By fostering conversations around these themes, we can work towards energy solutions that provide access and enhance the well-being and resilience of communities across Africa.

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