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FINANCING SUSTAINABLE ENERGY TRANSITION: EVIDENCE FROM THE *SHAPE* RENEWABLE ENERGY PROJECT, NIGERIA

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Abstract

Financing remains a critical barrier to scaling sustainable energy projects across Sub-Saharan Africa. While decentralised renewable energy systems have demonstrated technical feasibility, their sustainability and replicability depend heavily on financing models that balance affordability, cost recovery, and investment returns. This study investigates the financing dynamics of the Shape community renewable energy project in Abuja, Nigeria. Using a qualitative case study approach, data were collected from 24 stakeholder interviews, project reports, and field observations. Findings reveal a financing structure dependent on government grants, with limited community contribution and weak cooperative financial management. Although initial capital costs were covered externally, long-term financial sustainability was undermined by tariff resistance, inadequate revenue collection, and the absence of risk-sharing mechanisms. The case highlights the tension between affordability for low-income households and cost recovery for developers. The article contributes to energy finance scholarship by illustrating how weak institutions, fragmented regulation, and socio-political dynamics characterise financing outcomes in developing-country contexts. Policy recommendations include developing blended finance instruments, designing progressive tariff systems, strengthening community cooperatives, and creating targeted subsidy frameworks.

Keywords: Community renewable energy; Financing; Rural electrification; Mini-grids; Energy transition; Nigeria

1. Introduction

Access to affordable finance is central to the success of decentralised renewable energy systems in developing countries. In Nigeria, despite the abundance of renewable resources, rural electrification using community or mini-grid renewable energy systems has lagged due to limited investment and high upfront costs (Ohiare, 2015; Emodi and Ebele, 2016). Community or mini-grid renewable energy projects require capital-intensive infrastructure, ongoing maintenance, and institutional arrangements for cost recovery. This article examines financing arrangements and challenges in the *Shape* community renewable energy project, one of Nigeria's early rural electrification pilots. It addresses three questions:

1. How was the *Shape* project financed?
2. What challenges emerged in cost recovery and sustainability?

3. What financing lessons can inform the scaling up of mini-grid renewable energy projects in rural Nigeria?

2. Literature and conceptual framing

This section reviews and synthesises evidence on how financing—not technology—primarily determines the performance and scalability of community renewable energy and mini-grids in Sub-Saharan Africa, with emphasis on Nigeria. It (i) distils cross-cutting financing barriers, (ii) examines Nigeria-specific constraints, (iii) evaluates financing models and instruments, and (iv) situates these within Nigeria's policy landscape. The goal is to identify where costs, risks, and institutions undermine viability and to highlight design features—such as Results-Based Finance (RBF), blended finance, Pay-as-you-go (PAYGo), cooperative governance, and Productive Use of Energy (PUE) lending—that can balance affordability with cost recovery, framing the analysis of the *Shape* case.

2.1 Financing barriers in rural electrification

Rural electrification via decentralised, community-scale projects in Sub-Saharan Africa is fundamentally a finance problem rather than a technology problem. Even when systems are technically sound, they struggle to reach commercial close or remain solvent post-commissioning because risks are concentrated across the capital stack, cash flows, and institutions (Blimpo and Cosgrove-Davies, 2019; Eberhard et al., 2017; IEA, 2021). Below are syntheses of these main barriers.

2.1.1 High upfront capital intensity

The high upfront capital cost of decentralised renewable energy infrastructure has long constrained rural electrification in Sub-Saharan Africa. The International Energy Agency (IEA, 2021) estimates that mini-grid deployment requires between US$500–1,500 per connection, depending on system design and location (IEA, 2021; Lombardi et al., 2020). Unlike grid extension projects, which benefit from economies of scale, off-grid mini-grids face diseconomies associated with logistics, dispersed populations, and higher per-unit installation costs (Bhattacharyya, 2012).

2.1.2 Affordability, viability gap and load factor risks

Rural incomes in Sub-Saharan Africa are low and variable; willingness-to-pay often falls below cost-reflective tariffs (Bhattacharyya, 2012; Pueyo, 2019). Where developers set tariffs to cover the cost of operations and replacements, households often reduce consumption or revert to kerosene and generators; where tariffs are suppressed for affordability, operators struggle to recover costs (IEA, 2021). Adequate revenue depends on realised demand and load profiles. Empirical work shows systematic over-estimation of demand at the planning stage; households adopt electricity gradually, cap usage at tight budgets, and shift loads seasonally (Lee et al., 2020; Peters and Sievert, 2016). Under-realised demand raises effective cost, jeopardising cost recovery for investors (Moner-Girona et al., 2018). Transparent results-based finance and viability-gap

subsidies are therefore pivotal to reconcile affordability and solvency (Blimpo and Cosgrove-Davies, 2019; ESMAP, 2022).

2.1.3 Collections, credit risk, and payments infrastructure

Cash-flow reliability is moulded by payment discipline and the availability of digital payments. PAYGo and mobile money have markedly reduced arrears in East Africa (Aklin et al., 2018; Taneja et al., 2018). In markets with lower mobile-money penetration (including parts of Nigeria), projects rely on cash, increasing leakage and enforcement frictions (Lombardi et al., 2020).

2.1.4 Currency and macro-financial risks

The parts for community-scale energy projects are largely imported and therefore linked to foreign currencies, while revenues are in local currency. Currency depreciation and inflation create mismatch risk and squeeze margins (Blimpo and Cosgrove-Davies, 2019). Hedging is often unavailable or too costly for small projects; concessional debt and guarantees are used as imperfect substitutes (Eberhard et al., 2017). Macroeconomic shocks also raise sovereign risk premiums and bank risk weights, pushing up borrowing costs (IEA, 2021).

2.1.5 Regulatory uncertainty, tariff enforcement, and grid encroachment

Developers need clarity on licensing, tariff approval, and service territories. Uncertain or slow tariff processes, overlapping mandates, and weak enforcement deter lenders (Lombardi et al., 2020). The risk that the central grid later encroaches on mini-grid service areas—without compensation—undermines asset life assumptions and debt tenors (Eberhard et al., 2017; ESMAP, 2022). Predictable encroachment compensation and interconnection rules are therefore essential in protecting decentralised renewable energy investments.

2.1.6 Lifecycle, reserves and reliability risk

Community-scale grids fail financially when mid-life capex (notably battery replacement in years 5–8) is unfunded. Many projects lack sinking funds or reserve accounts; when faults occur, repair delays depress revenue and user trust, creating a negative feedback loop (Lombardi et al., 2020). Lenders increasingly require operation and management reserves and performance covenants, but these are not yet standard in small projects (ESMAP, 2022).

2.1.7 Data scarcity and bankability information gaps

Bank credit committees demand operational data (losses, collection rates, and uptime). Sparse, non-standardised data lead to conservative risk pricing (Eberhard et al., 2017). Where advanced metering infrastructure (AMI) and prepaid systems exist, data transparency improves underwriting and enables receivables financing, but adoption varies (IEA, 2021).

2.1.8 High transaction costs and weak local intermediation

Duthie (2024) identifies the high fixed transaction costs associated with mini-grid provisioning in rural areas, especially when cash flows and commercial demand remain weak. Local banks often lack sector expertise and prefer collateral-based lending over cash-flow-based project finance. Legal documentation is bespoke and expensive at a small scale. Without on-lending facilities or standardised project bankable documents, domestic participation remains very low (ESMAP, 2022).

2.1.9 Other barriers

Electrification is politically salient. Local elites may pressure cooperatives to lower tariffs or tolerate non-payment; elections can disrupt collections and subsidy regimes (Sovacool, 2017). The lack of sustained community engagement and perceived unfairness undermines the willingness to pay—even when service quality is good (Bauwens et al., 2016). Similarly, unclear land rights complicate siting and collateralisation of assets. Lenders find it difficult to perfect security interests over distributed assets (poles, meters), raising recovery risk and borrowing costs (Eberhard et al., 2017). Vandalism, theft, and regional insecurity also raise operational and insurance costs. Climate variability (heat stress, extreme weather) affects PV performance and battery life, adding uncertainty to output and replacements (IEA, 2021).

2.2. Financing challenges specific to Nigeria

2.2.1 High upfront cost burdens

Equipment, storage, import duties, and foreign exchange risks have continued to be major cost drivers in the Nigerian clean renewable energy sector. Many developers struggle to source imported hardware due to import duty tariffs and logistics constraints, which increase capital expenditure (capex) and cause delays in implementation (IRENA, 2020; SEforALL, 2022).

2.2.2 Access to affordable capital and domestic finance

Local banks are often reluctant to lend to small and medium-scale renewable projects that lack collateral or proven revenue streams. Financing terms are typically characterised by high interest rates, short repayment periods, and elevated risk perception (AfDB, 2020; OECD, 2020). Moreover, the limited operational track record of community projects in Nigeria amplifies perceived risks, further restricting access to affordable capital (IFC, 2019).

Nigerian rural electrification projects frequently face political pressure to maintain low tariffs or absorb revenue losses, reducing cost recovery and profitability (REA, 2022; ESMAP & World Bank, 2022). Consumer willingness to pay is also inconsistent. Recent discrete choice experiments demonstrate that rural and peri-urban households and SMEs value reliable, high-capacity connections but resist high upfront connection fees and steep tariffs (Lee et al., 2020; ESMAP, 2015).

2.2.4 Regulatory uncertainty and policy consistency

Although mini-grid regulations exist—such as those developed by the Nigerian Electricity Regulatory Commission (NERC, 2017)—implementation challenges persist. Issues include weak enforcement, uncertainty around licensing, delays in obtaining permits, inconsistent subsidy applications, and unpredictable changes in government policy (SEforALL, 2022). Developers are also exposed to the risk of grid encroachment, which creates further uncertainty.

2.2.5 Working capital and financing of non-capex costs

Community-scale renewable energy projects require financing not only for installation but also for ongoing operations, maintenance, spare parts, and battery replacement. These recurrent costs are difficult to fund without subsidies or established reserve mechanisms (World Bank, 2021; Power for All, 2022). There is very little evidence to suggest Nigeria's experience in establishing reliable sinking funds or reserves in community-scale renewable energy pilots. Some social enterprises have begun raising equity and debt to support these recurrent costs, but such initiatives remain small in scale (GOGLA, 2021).

2.3 Financing mechanisms for community-scale renewable energy projects

2.3.1 Grants and subsidies

Grants and capital subsidies remain the dominant financing model for rural mini-grids (Yadoo and Cruickshank, 2012). They reduce upfront costs for developers but often create dependencies. Once donor support ends, projects struggle to sustain operations, as seen in Nigeria's *Shape* and *Waru* pilots (Ohiare, 2015). Recent evidence suggests that results-based financing (RBF) — where grants are disbursed upon verified delivery — improves accountability and reduces "white elephant" projects (Blimpo and Cosgrove-Davies, 2019).

2.3.2 Pay-as-you-go (PAYGo) models

The PAYGo model, pioneered in East Africa, allows customers to purchase energy services incrementally through mobile money (Taneja et al., 2018). While most prevalent in solar home systems, PAYGo is increasingly integrated into mini-grids to improve collections and reduce non-payment (Aklin et al., 2018). PAYGo enhances affordability but requires a reliable digital infrastructure, which is weaker in rural Nigeria.

2.3.3 Blended finance

Blended finance leverages concessional capital from donors to de-risk projects and attract commercial investors (Eberhard et al., 2017). Instruments include first-loss equity, concessional loans, and guarantees. By mitigating risks, blended finance can reduce the weighted average cost of capital (WACC) and make tariffs more affordable. The World Bank's Scaling Solar initiative in Zambia is a notable example, though mostly applied to grid-scale projects (IFC, 2019). For mini-grids, blended finance remains underdeveloped but is increasingly seen as essential in promoting decentralised energy systems in Sub-Saharan Africa (ESMAP, 2022).

2.3.4 Community cooperatives and ownership models

Community cooperatives mobilise local equity contributions, often through savings groups or microfinance institutions. In Europe, cooperatives have been central to community renewable energy expansion (Bauwens et al., 2016). However, in Sub-Saharan Africa, weak governance structures, low financial literacy, and elite capture often undermine cooperative performance

(Ahlborg & Hammar, 2014). Empirical evidence from Tanzania and Uganda suggests cooperatives can succeed if paired with external technical and financial management support (Kirubi et al., 2009; Sovacool, 2017).

2.3.5 Emerging instruments

Recent innovations include: Carbon finance and green bonds: mini-grids generate verifiable emissions reductions that could be monetised through voluntary carbon markets (Westphal et al., 2022). Productive Use Financing (PUF): credit for appliances like mills or refrigeration can increase demand, improving revenue adequacy (Wearne et al. 2022; GOGLA, 2020). Micro-leasing and revolving funds: local microfinance institutions provide flexible repayment structures (Alstone et al., 2015). Table 1 summarises and compares the different financing models for community renewable energy.

Table 1. Types of financing models for community renewable energy

Financing Model	Advantages	Limitations	Evidence from Africa/Elsewhere
Grants & Subsidies	Reduce upfront costs; enable pilots; politically attractive	Dependency on donors; unsustainable post-commissioning; limited accountability	Nigeria (*Shape*, Waru projects) funded 90% by grants/subsidies (Ohiare, 2015); Tanzania's donor-driven mini-grids often stalled after donor exit (Ahlborg & Hammar, 2014)
Results-Based Financing (RBF)	Improves accountability; links subsidy to performance; reduces "white elephant" projects	High transaction costs; limited to large developers; disbursement delays	Nigeria Electrification Project (NEP) offers $350/connection RBF (World Bank, 2019); successful scale-up in Kenya/Tanzania (Blimpo & Cosgrove-Davies, 2019)
Pay-As-You-Go (PAYGo)	Enhances affordability; improves collections; reduces default	Requires mobile money infrastructure; high transaction costs for mini-grids	East Africa (Kenya, Tanzania) successful with PAYGo-enabled SHS and mini-grids (Taneja et al., 2018); weaker uptake in Nigeria due to low mobile money penetration
Blended Finance	Attracts private capital; lowers risk via concessional instruments; enables scale	Complex structuring; limited domestic bank participation	Zambia's Scaling Solar attracted record-low tariffs (IFC, 2019); early mini-grid blended deals emerging in Uganda (ESMAP, 2022)
Community Cooperatives	Enhances local ownership; mobilises savings; increases legitimacy	Weak governance; elite capture; low financial literacy	European CRE thrives on cooperative models (Bauwens et al., 2016); Tanzania's cooperatives need external technical/financial support (Kirubi et al., 2009)

Productive Use Financing (PUE)	Increases demand; improves revenue adequacy; creates jobs	Requires credit access; risk of appliance non-payment	GOGLA (2020) finds PUE loans increase mini-grid load factors by 20–40% in Kenya and Uganda
Carbon Finance/Green Bonds	Monetises emission reductions; can generate new revenue streams	Verification costly; carbon prices volatile	Emerging mini-grid projects tapping voluntary carbon markets (Westphal et al., 2022)
Micro-Leasing/ Revolving Funds	Flexible repayment; lowers household barriers	Limited scale; needs strong MFI partnerships	Solar home systems financed via MFIs in East Africa (Alstone et al., 2015); less developed for mini-grids in Nigeria

Source: Author compiled

2.4 Financing community-scale renewable energy projects in Nigeria

Community-scale energy in Nigeria is experiencing growing interest among policy makers, developers, and financiers, but the financing ecosystem remains nascent and highly constrained. Below are key aspects, empirical cases, and emerging instruments shaping how financing decentralised energy systems is playing out in Nigeria.

The Nigeria Rural Electrification Agency (REA) has introduced several instruments, including the Rural Electrification Fund (REF) and the Nigeria Electrification Project (NEP). NEP provides RBF subsidies supported by the World Bank and AfDB. However, the coverage is limited. In 2023, the World Bank's Distributed Access through Renewable Energy Scale-up (DARES) facility was introduced to help developers with upfront costs (World Bank 2023). Private enterprises, such as SOSAI Renewable Energies, leverage blended finance by combining equity, grants, and concessional loans (SEforALL, 2019). In contrast, projects like the Mokoloki mini-grid adopt public-private-community partnerships, utilising profit-sharing models to enhance legitimacy (Zubair, Meng, Chikumbo, & Flesch, 2024). Despite these innovations, challenges such as limited domestic capital, weak cooperative capacity, tariff resistance, and regulatory fragmentation still persist (RMI, 2021; Lombardi et al., 2020).

3. Methodology

This section presents the methodological framework adopted for the study. Rather than seeking to quantify variables, the study is concerned with understanding meanings, patterns, and underlying processes that shape the phenomenon under investigation. The section therefore details the research design, the assumptions guiding the research approach, and the strategies used to collect and analyse the data.

3.1 Research design

This study employs a case study design to investigate the financing dynamics of the *Shape* community renewable energy project. The case study approach is suitable for exploring complex,

context-dependent processes such as financing in rural electrification, where multiple actors—including private donors, government agencies, developers, and communities—interact within an evolving institutional framework (Yin, 2009). In addition to the selection of a case study approach, the study adopted the qualitative research method for this investigation rather than the quantitative method, which is considered suitable for a relatively stable socio-technical system where the parameters are well established. Given that community renewable energy in Nigeria is still at a formative stage, a qualitative design was deemed more suitable than quantitative methods, which are better aligned with stable socio-technical systems.

Besides, this study is both exploratory and explanatory, recognising reality as socially constructed through the experiences and meanings of participants. To capture these perspectives, the researcher engaged closely with respondents to develop a nuanced understanding of their narratives.

3.2 Case selection: *Shape* project

The *Shape* project, located in a peri-urban community near Abuja, was among the earliest donor-supported community-scale renewable energy pilots in Nigeria. It was inaugurated and implemented under the Federal Government's Operation Light-Up Rural Nigeria (OLRN) in 2014 to demonstrate community-scale solar electrification. Prior to the project, the people relied on the use of kerosene, firewood, and small petrol generators for their energy needs. The project deployed both household equipment on rooftops and a solar PV–battery mini-grid targeting households, micro-enterprises, and public services (such as clinics and schools).

3.3 Data collection

Three data sources were used: Semi-structured interviews with 24 key stakeholders that were selected from the Federal Ministry of Power, the Rural Electrification Agency, the Nigerian Electricity Regulating Agency (NERC), donor representatives, community leaders, developers, and citizens; field observations in the *Shape* community, focusing on tariff collection practices, the cooperative, and household electricity use; and, project documentation, including financial agreements and implications, subsidy agreements, as well as monitoring evaluations. The research participants were selected based on a judgmental sampling technique followed by snowballing, where interviewees were requested to name relevant candidates for subsequent interviews. Each interview lasted between 60 to 90 minutes.

3.4 Data analysis

The study employed thematic analysis as the principal method of data analysis. This approach supports both inductive and deductive interpretations of the transcript data (Punch, 2013). Thematic analysis involves a systematic process of coding and categorising data to identify descriptive and explanatory themes. It allows the researcher to explore both manifest themes (explicit or recurring ideas) and latent themes (the underlying meanings and interpretations attached by participants). Thus, even when the analysis highlights recurring surface-level themes, its broader aim is to uncover the deeper meanings that participants associate with those themes.

The coding and analysis were conducted in two stages. The first stage began with the researcher immersing himself in the data by reading several interview transcripts line by line, without applying any prior theoretical assumptions. This process enabled close engagement with the text and familiarisation with the participants' accounts. During this phase, relevant passages and quotations were highlighted and colour-coded as they became significant. Codes were then assigned to capture different dimensions of the data. This initial coding followed the systematic approach proposed by Gale et al. (2013) and Saldaña (2021). The process was iterative: transcripts were revisited and compared line by line to ensure consistency. Codes were refined over time; some early codes were subsumed under broader categories, while others were relabelled to reflect more precise meanings. The outcome of this phase was an initial set of codes organised into preliminary categories.

In the second stage, all interview transcripts were imported into NVivo software for further analysis. The researcher repeated the same coding procedures, using NVivo to support systematic organisation and refinement of codes. As the analysis progressed, some codes were collapsed into broader categories, while new codes occasionally emerged. By the time the 24th transcript was reviewed, no new codes or categories appeared. This indicated that thematic saturation had been achieved. At this point, the researcher developed a final coding framework, which captured the full range of views and experiences expressed by participants. This framework provided the foundation for the identification of overarching themes and the generation of explanatory insights.

4 Results and Discussion

4.1 Results

This sub-section presents the key findings from the Shape community renewable energy project. The results are organised around the project's financing structure, tariff framework, demand patterns, institutional arrangements, and community responses. Each theme reflects the practical realities observed during fieldwork, interviews, and document analysis.

4.1.1 Financing Structure of the Shape Project

The project received a combination of federal government donations (90%) and community contributions (~10%) in the form of labour in installation and security. This financial structure makes *Shape* a compelling case for examining the tensions between donor dependency, community ownership, and sustainability. While this arrangement enabled commissioning, it reinforced government donor dependency and limited community ownership. Critically, no reserve funds were established for mid-life replacements, exposing the project to future sustainability risks.

4.1.2 Tariff framework and affordability concerns

There were no formal tariffs set at the time of data gathering; a proposal of NGN 150/kWh was observed in documents and interviews. Many households—especially women-led and low-income families—perceived this level as higher than prevailing grid rates at the time, expecting electricity as a social good rather than a paid service. This perception is likely to trigger payment resistance, mirroring affordability–cost-recovery tensions seen elsewhere (Bhattacharyya, 2012; Pueyo, 2019).

4.1.3 Capacity/peak management risk and accelerated asset wear

Initial feasibility studies underestimated near-term peak demand and the speed of appliance uptake, particularly for productive uses. This created capacity and peak-management challenges (e.g., evening peaks), raising the risk of curtailed supply and accelerated battery wear. This is as a result of the fact that once people have basic access, they resort to acquiring more appliances, machinery, etc (World Bank, 2023). Such tendencies without timely resizing or demand-side management increase cash flow volatility and operation and management costs, thereby weakening cost recovery.

4.1.4 Currency and Macroeconomic Exposure

Although government grants covered the bulk of the capital costs, subsequent expansion plans are likely to be stalled due to currency mismatch risks**.** Equipment imports were USD-denominated, but revenues were expected to be in naira. Depreciation of the naira worsened the viability of scaling up, a barrier well-documented across Sub-Saharan Africa (Blimpo & Cosgrove-Davies, 2019).

4.1.5 Regulatory and institutional fragmentation

The *Shape* project operated under overlapping mandates: the Federal Ministry of Power provided grants, while the Nigerian Electricity Regulatory Commission (NERC) was responsible for tariff oversight. The Rural Electrification Agency's responsibilities cover the deployment and funding of rural electricity provision. Community members reported confusion about who held accountability for tariff enforcement. This illustrates institutional fragmentation, consistent with broader Nigerian mini-grid challenges (Emodi & Ebele, 2016).

4.1.6 Community legitimacy and social acceptance

Despite initial enthusiasm, trust in the community project eroded due to unmet expectations of adequate and cheaper electricity. Households perceived tariff enforcement as inequitable and inconsistent. This eroded social legitimacy**,** reducing willingness-to-pay and weakening collective ownership—again reflecting the political economy risks highlighted in comparative studies (Bauwens et al., 2016).

4.2. Discussion

This section discusses the results in relation to the wider literature on financing community renewable energy in Sub-Saharan Africa and Nigeria. It interprets the Shape case through key themes of affordability, cost recovery, institutional capacity, and sustainability, highlighting both parallels with and departures from existing evidence.

4.2.1 Affordability versus cost recovery: the core tension

The *Shape* project vividly illustrates the affordability-cost recovery paradox. The proposed NGN 150/kWh was perceived as higher than prevailing grid rates at the time, creating pushback. Yet lowering tariffs would widen the viability gap. This confirms Bhattacharyya's (2012) "dual unsustainability"—households cannot afford cost-reflective tariffs, while developers cannot survive without them. Similar findings from Tanzania and Rwanda show that without subsidy design or progressive tariffs, projects fail either socially or financially (Pueyo, 2019; Peters & Sievert, 2016).

The *Shape* project therefore underscores the need for tiered tariff frameworks, where basic lifeline consumption is subsidised, while higher tiers for businesses reflect cost-recovery. This model has proven workable in East African PAYGo systems (Aklin et al., 2018) and could reconcile the affordability dilemma in rural Nigeria.

4.2.2 Weak cooperative institutions and revenue discipline

Community cooperatives were intended to enforce tariff payments and manage finances. In practice, the *Shape*'s cooperative lacked financial literacy, transparent reporting, and enforcement capacity. This aligns with Bauwens et al. (2016), who note that governance quality—not mere participation—determines cooperative success**.**

The Nigerian case contrasts with stronger cooperative traditions in Europe, where financial discipline is embedded (Bauwens et al., 2016), and with Kenya's PAYGo solar providers, where digital platforms minimise leakage (Taneja et al., 2018). Without capacity building and digitalisation**,** the *Shape*'s cooperative set-up and governance weaknesses remained a bottleneck to sustainability.

4.2.3 Demand realisation, productive use, and load factors

The *Shape* project's planners did not have a reliable estimate of household consumption. Planning documents and interviews revealed an underestimation of evening peaks and PUE uptake, alongside over-optimistic assumptions about medium-term average growth. In practice, short-term peaks exceeded capacity even as longer-run demand growth remained income-constrained. Incorporating PUE finance and viable tariff structures could smooth load profiles, improve revenues, and strengthen community buy-in (Lee et al., 2020).

4.2.4 Institutional fragmentation and policy uncertainty

The *Shape* project's financing was further undermined by institutional overlaps between the Rural Electrification Agency (REA) and the Nigerian Electricity Regulatory Commission (NERC). Tariff enforcement and subsidy disbursement fell into grey zones, weakening investor confidence. This resonates with Lombardi et al. (2020), who argue that regulatory uncertainty and grid encroachment risk are among the greatest deterrents to private mini-grid investment.

Comparatively, Tanzania's clearer regulatory framework for mini-grids (with standardised purchase agreements and interconnection rules) has attracted more private developers (Eberhard et al., 2017). Nigeria's lack of harmonisation means donor dependence persists, leaving communities like the *Shape* project vulnerable once grants expire.

4.2.5 Lifecycle financing gaps: batteries and beyond

Battery degradation risks were heightened by the absence of ring-fenced sinking funds or lifecycle reserves. Establishing an escrow account funded via monthly tariff earmarks for storage replacement would mitigate this chronic weakness seen across most Sub-Saharan African nations.

4.2.6 Currency and macro-financial risks

The *Shape* project faced expansion delays due to Naira depreciation, which inflated import costs for solar and storage equipment. This barrier echoes findings from Blimpo and Cosgrove-Davies (2019) that currency mismatch is one of the hardest risks to mitigate in developing economies. Unlike large independent power projects (IPPs), mini-grids lack access to currency hedging markets.

Government grants partially shielded the *Shape* project, but scaling similar projects will require currency risk facilities**,** concessional debt, or partial risk guarantees—otherwise, projects remain confined to macroeconomic instability.

4.2.7 Social legitimacy

Tariff resistance undermined the *Shape* project's social legitimacy. Households questioned why they would pay more than grid-connected customers. These dynamics confirm Sovacool's (2017) view that mini-grids are as much about politics and legitimacy as they are about kilowatt-hours.

Comparative evidence shows that where communities are engaged early, trust and compliance improve (Li et al., 2013; Kaphengst et al., 2014). The *Shape*'s limited participatory planning weakened perceptions of fairness, fuelling resistance. Stronger participatory processes could align financial rules with community expectations.

The Nigerian case thus exemplifies how financing barriers intersect across technical, financial, and socio-political domains, producing fragile projects that survive on donor support but lack pathways to scale.

5. Conclusion and Recommendations

The *Shape* project highlights the central role of financing in community-scale renewable energy sustainability. While donor and government subsidies enabled deployment, long-term viability was compromised by tariff resistance, weak cooperative capacity, and regulatory uncertainty. For mini-grid renewable energy to scale in rural Nigeria, financing models must integrate blended finance, progressive tariffs, and stronger community institutions and ring-fenced lifecycle reserves. Practically, a standard mini-grid financing term sheet (with RBF triggers, encroachment compensation rules, and ring-fenced reserve accounts) could materially lower the weighted average cost of capital and improve bankability for Nigeria's next wave of community projects.

References

African Development Bank (AfDB). (2021). *Africa Mini-Grid Market Acceleration Programme (AMAP).* Available at https://www.afdb.org/sites/default/files/documents/projects-and-operations/multinational_-_africa_mini_grid_acceleration_program_amap_-_par_-_sefa_002.pdf

Ahlborg, H., & Hammar, L. (2014). Drivers and barriers to rural electrification in Tanzania and Mozambique—Grid-extension, off-grid, and renewable energy sources. *Renewable Energy, 61*, 117–124. https://doi.org/10.1016/j.renene.2012.09.057

Aklin, M., Harish, S. P., & Urpelainen, J. (2018). Pay-as-you-go solar energy: Financial inclusion, energy poverty, and economic development. *World Development, 112*, 381–392. https://doi.org/10.1016/j.worlddev.2018.08.016

Alstone, P., Gershenson, D., & Kammen, D. M. (2015). Decentralized energy systems for clean electricity access. *Nature Climate Change, 5*(4), 305–314. https://doi.org/10.1038/nclimate2512

Bauwens, T., Gotchev, B., & Holstenkamp, L. (2016). What drives the development of community energy in Europe? *Energy Research & Social Science, 13*, 136–147. https://doi.org/10.1016/j.erss.2015.12.016

Bhattacharyya, S. (2012). Energy access programmes and sustainable development: A critical review. *Energy for Sustainable Development, 16*(3), 260–271. https://doi.org/10.1016/j.esd.2012.05.002

Blimpo, M., & Cosgrove-Davies, M. (2019). *Electricity access in Sub-Saharan Africa: Uptake, reliability, and complementary factors for economic impact.* World Bank. Available at https://openknowledge.worldbank.org/server/api/core/bitstreams/a6cfde8d-0224-5546-8062-5c2e69b741cb/content

Duthie, M., Ankel-Peters, J., Mphasa, C., & Bhat, R. (2024). The elusive quest for sustainable mini-grid electrification: New evidence from Indonesia. *Energy for Sustainable Development*, 80, 101454. https://doi.org/10.1016/j.esd.2024.101454

Emodi, N. V., & Ebele, N. E. (2016). Policies enhancing renewable energy development and implications for Nigeria. *Research in Science & Engineering, 4*(1), 7–14. Available at https://pubs.sciepub.com/rse/4/1/2/

ESMAP (Energy Sector Management Assistance Program). (2015). *Beyond connections: Energy access redefined.* World Bank. Available at https://openknowledge.worldbank.org/server/api/core/bitstreams/248a7205-e926-5946-9025-605b8035ad95/content

ESMAP (Energy Sector Management Assistance Program). (2023). *Annual report.* World Bank. Available at https://www.esmap.org/sites/default/files/esmap-files/World%20Bank%20ESMAP%20AR%202023_DIGITAL.pdf

ESMAP (Energy Sector Management Assistance Program) & World Bank. (2022). *Mini grids for half a billion people: Market outlook and handbook for decision makers.* World Bank. Available at https://www.esmap.org/sites/default/files/esmap-files/Mini%20Grids%20for%20Half%20a%20Billion%20People%20-%20OKR%20Download%20Version_compressed_MKA.pdf

Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology, 13*, 117. https://doi.org/10.1186/1471-2288-13-117

GOGLA. (2020). *Powering lives and livelihoods: Scaling Productive Uses of Renewable Energy (PURE).* Available at https://gogla.org/wp-content/uploads/2024/11/Gogla_PURE-Handbook_for_Governments_Development_Partners.pdf

GOGLA. (2021). *Off-grid solar market report: Semi-annual sales and impact data H1 2021.* Available at https://gogla.org/wp-content/uploads/2024/12/gogla_sales-and-impact-reporth1-2021_07.pdf

Grimm, M., Munyehirwe, A., Peters, J., & Sievert, M. (2020). A first step up the energy ladder? Low-cost solar kits and household welfare in rural Rwanda. *World Bank Economic Review, 34*(2), 1–22. https://doi.org/10.1093/wber/lhz019

International Energy Agency (IEA). (2021). *World Energy Outlook 2021.* IEA.

International Finance Corporation (IFC). (2019). *Off-grid solar market trends report 2019.* IFC & World Bank.

International Renewable Energy Agency (IRENA). (2020). *Renewable energy market analysis: Africa and its regions.* IRENA.

Kaphengst, T., Velten, E., & Cabrera, A. (2014). Community renewable energy in Germany: Barriers and drivers. *Energy Policy, 61*, 431–442. https://doi.org/10.1016/j.enpol.2013.07.017

Kirubi, C., Jacobson, A., Kammen, D. M., & Mills, A. (2009). Community-based electric micro-grids can contribute to rural development: Evidence from Kenya. *World Development, 37*(7), 1208–1221. https://doi.org/10.1016/j.worlddev.2008.11.005

Lee, K., Miguel, E., & Wolfram, C. (2020). Experimental evidence on the demand for and costs of rural electrification. *Journal of Political Economy, 128*(4), 1523–1565. https://doi.org/10.1086/705417

Li, T., Jara, R., & Whittington, D. (2013). The social acceptance of large-scale renewable energy projects: Evidence from Chile. *Energy Policy, 61*, 1253–1265. https://doi.org/10.1016/j.enpol.2013.06.104

Lombardi, F., Lai, C., Riva, F., Colombo, E., & Balderrama, S. (2020). Mini-grids in Sub-Saharan Africa: A critical review. *Energy Policy, 146*, 111831. https://doi.org/10.1016/j.enpol.2020.111831

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Sage.

Moner-Girona, M., Bódis, K., Morrissey, J., Kougias, I., & Huld, T. (2018). Electrification of Sub-Saharan Africa through PV/hybrid mini-grids: Reducing costs and improving reliability with decentralised generation. *Renewable and Sustainable Energy Reviews, 93*, 600–615. https://doi.org/10.1016/j.rser.2018.05.012

Nigerian Electricity Regulatory Commission (NERC). (2017). *Mini-Grid Regulation 2016.* Available at https://nerc.gov.ng

Organisation for Economic Co-operation and Development (OECD). (2020). *Financing clean energy in Africa.* OECD Publishing.

Ohiare, S. (2015). Expanding electricity access to all in Nigeria: A spatial planning and cost analysis. *Energy, Sustainability and Society, 5*, 14. https://doi.org/10.1186/s13705-015-0037-9

Peters, J., & Sievert, M. (2016). Impacts of rural electrification on household welfare: Evidence from Africa. *Journal of Development Economics, 118*, 181–199. https://doi.org/10.1016/j.jdeveco.2015.10.001

Power for All. (2019). *Utilities 2.0: Integrated Energy for Optimal Impact.* Available at https://www.powerforall.org/application/files/9715/5774/4056/Power-for-All-Utilities-2-0-190514.pdf

Punch, K. F. (2013). *Introduction to social research: Quantitative and qualitative approaches* (3rd ed.). Sage.

Pueyo, A. (2019). What constrains renewable energy investment in Sub-Saharan Africa? *Energy Policy, 126*, 369–382. https://doi.org/10.1016/j.enpol.2018.11.039

Rural Electrification Agency (REA). (2022). *Nigeria electrification project: Progress/impact report.* Available at https://www.scribd.com/document/838196508/rea-impact-report-2022-17

Rocky Mountain Institute (RMI). (2021). *Nigeria mini-grid investment report.* RMI.

Saldaña, J. (2021). *The coding manual for qualitative researchers* (3rd ed.). Sage.

Sovacool, B. K. (2017). The political economy of energy poverty: A review of key challenges. *Energy for Sustainable Development, 36*, 77–83. https://doi.org/10.1016/j.esd.2016.09.004

Sustainable Energy for All (SEforALL). (2022). *Nigeria's energy transition and investment plan.* Available at https://www.seforall.org/system/files/2025-05/Nigeria-ETIP-u.pdf

Taneja, J., Wolfram, C., & Lee, K. (2018). Electrifying rural Africa. *Annual Review of Economics, 10*, 507–536. https://doi.org/10.1146/annurev-economics-080217-053255

Wearne, A., van der Linden, J., & Bloomfield, Z. (2022). *Energy for rural industrialisation: Productive use of energy 2.0.* Available at https://www.get-transform.eu/wp-content/uploads/2022/08/Productive-Use-of-Energy-2-0_GET.transform2022.pdf

Westphal, M. I., et al. (2022). Unlocking carbon markets for mini-grids: Evidence and pathways. *Energy Policy, 168*, 113120. https://doi.org/10.1016/j.enpol.2022.113120

World Bank. (2018). *Nigeria electrification project: Project appraisal document.* Available at https://documents1.worldbank.org/curated/en/367411530329645409/pdf/Nigeria-Electrification-PAD2524-06052018.pdf

World Bank. (2021). *Nigeria energy sector diagnostic.* World Bank.

World Bank. (2023a). *Distributed Access through Renewable Energy Scale-up (DARES) project appraisal document.* Available at https://documents1.worldbank.org/curated/en/099112923130036443/pdf/BOSIB055491e4e0bc0b3ec051772c00f67f.pdf

World Bank. (2023b). *Accelerating the productive use of electricity: Enabling energy access to power rural economic growth.* Available at https://documents1.worldbank.org/curated/en/099092023192023389/pdf/P175152-d3f58f6f-307c-4996-9e14-b8baef6de8dd.pdf

Yadoo, A., & Cruickshank, H. (2010). The value of cooperatives in rural electrification. *Energy Policy, 38*(6), 2941–2947. https://doi.org/10.1016/j.enpol.2010.01.031

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Sage.

Zubair, R., Meng, Z., Chikumbo, M., & Flesch, S. (2024). Sharing the power: Nigerian community takes charge of their energy development. Available at https://rmi.org/sharing-the-power-nigerian-community-takes-charge-of-their-energy-development/