BENCHMARKING
AFRICA'S MINIGRIDS REPORT

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CEO's Foreword

It is with great pride that we present the 2024 *Benchmarking Africa's Minigrids (BAM) Report*, a definitive resource capturing the evolution, achievements, and challenges of Africa's minigrid and wider Distributed Renewable Energy (DRE) sector. Now in its third edition, this report builds on the foundational insights of our 2020 and 2022 publications, offering a data-driven analysis that reflects both the resilience and ingenuity of the sector.

The urgency of achieving universal energy access in Africa cannot be overstated. With AMDA members having deployed over 600 minigrids and electrified nearly one million people to date, the sector has demonstrated its capability to bridge the energy gap. Yet, this progress is only the beginning. The imperative to connect 680 million people in Sub-Saharan Africa by 2030 necessitates bold action to scale deployment, unlock financing, and streamline regulatory processes.

The sector is evolving beyond standalone systems toward interconnected solutions, such as meshgrids and metrogrids, which offer pathways to megawatt-scale deployments.

Progress and structural challenges

The 2024 BAM Report highlights key shifts within the sector. Minigrid projects are increasing in size and sophistication, with the proportion of AMDA members' minigrids serving residential connections of over 500 customers rising from 8% in 2022 to 30% in 2024. Capital expenditure (CAPEX) costs have also seen a 20% decline since 2020, demonstrating growing efficiencies. However, despite these advancements, African minigrids continue to face higher CAPEX compared to global benchmarks, underscoring the need for enhanced supply chain efficiencies and financial innovation.

Notably, the sector is evolving beyond standalone systems toward interconnected solutions, such as meshgrids and metrogrids, which offer pathways to megawatt-scale deployments. This evolution reflects a growing maturity and a strategic shift to ensure long-term economic sustainability. To fully realise this potential, the sector must embrace digitalisation, standardised key performance indicators (KPIs), and more streamlined financing mechanisms.

Key findings and strategic imperatives

- **Minigrid market maturity & investment hotspots**: The sector is expanding into regions with enabling regulatory and financial ecosystems, with Nigeria emerging as a leading market due to its conducive policies and large-scale concessional funding. Lessons from Nigeria can guide other markets in structuring their energy access strategies.
- **CAPEX reduction, but regional disparities persist**: A 20% reduction in CAPEX (2020-2024) reflects sectoral efficiencies, yet costs in Africa remain significantly higher than global norms. Addressing supply chain inefficiencies, import duties, and tax policies will be critical in further reducing costs.
- **Concessional capital: critical, yet disbursement remains a bottleneck**: Significant amounts of concessional funding have been pledged to the sector over the last five years. However, slow disbursement is constraining deployment. Streamlining processes, scaling proven financing models, and ensuring that donor programmes align with the realities of developers' needs are paramount. With *Mission 300 (M300)* now positioned to drive DRE

scalability, improving financing mechanisms and strengthening minigrid developers' capital absorption capacity is essential.

- **Diversifying financing models**: New financial structures, including blended finance, extended credit, and escrowed grants, are emerging as critical complements to traditional funding. These innovations will be key in unlocking commercial capital and reducing reliance on donor funding.
- **Regulatory bottlenecks threaten universal access**: The slow pace of regulatory approvals remains a significant impediment to the sector's growth. To meet the World Bank's target of 160,000 minigrids for Africa, we need a paradigm shift in regulatory approaches that accelerates project approvals and facilitates market entry.
- **A driver of jobs and economic growth**: With over 6,200 jobs created in four years by AMDA's members, the minigrid sector is proving to be a catalyst for socio-economic transformation. Expanding this impact will require policies that not only promote minigrid development but also stimulate productive energy use within electrified communities.

A call to action

The BAM 2024 Report is more than a retrospective; it is a strategic blueprint for the future of minigrids in Africa. Its findings make it clear that achieving the continent's electrification goals requires bold, coordinated action from governments, investors, and industry stakeholders. In a nutshell, business as usual cannot continue!

Collaboration is essential to dismantling the financial, regulatory, and operational barriers that hinder growth. To scale the impact of minigrids and other DRE solutions, we must prioritise regulatory reform, facilitate access to capital, and ensure that every investment accelerates sustainable development. The lessons from Nigeria and other pioneering markets provide a roadmap for other African countries seeking to create enabling environments for minigrid success.

The strength of this report lies in the quality of the data contributed by developers across the continent. As we work towards the next edition, we encourage all stakeholders to continue sharing their insights and data to further enrich our collective understanding of the sector. Robust and transparent reporting will be instrumental in driving informed decision-making and fostering greater investment in minigrid solutions.

The BAM 2024 Report is more than a retrospective; it is a strategic blueprint for the future of minigrids in Africa. Its findings make it clear that achieving the continent's electrification goals requires bold, coordinated action from governments, investors, and industry stakeholders.

Acknowledgements

We extend our deepest appreciation to our members, partners and stakeholders, who have contributed their knowledge and data to this report. AMDA remains committed to supporting its members, advocating for enabling policies, facilitating access to capital, and advancing research that drives evidence-based decision-making.

We are also grateful to our external peer reviewers and contributors who have strengthened the BAM Report through their insights and expertise. While this publication represents a significant milestone, it is part of an ongoing process that will continue to evolve with the sector.

I also appreciate the strong efforts of my teammates at AMDA, who rallied to ensure this report was delivered without compromising its integrity. To our partners, Odyssey Energy Solutions, your work ethic, diligence and professionalism have made BAM 2024 not just possible but our best edition yet.

Special thanks to our funders, including the World Bank through its Energy Sector Management Assistance Programme (ESMAP), Good Energies Foundation, the UK Government's Foreign, Commonwealth & Development Office (FCDO), and the Swedish International Development Agency, joint funders of the Energy Access Institutions Facility (managed by CLASP). Their support enables us to drive change at scale.

The BAM Report 2024 reaffirms our shared commitment to transforming Africa's minigrid and DRE sector into a scalable, sustainable, and inclusive solution for energy access. Together, we can ensure that no community is left in the dark.

Olamide Niyi-Afuye,
Chief Executive Officer
Africa Minigrid Developers Association (AMDA)

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Abbreviations and Acronyms

AC	Alternating Current
ACPU	Average Consumption Per User
ADELE	Access to Distributed Electricity and Lighting in Ethiopia
AFSIA	African Solar Industry Association
AFUR	The African Forum for Utility Regulators
AMDA	Africa Minigrid Developers Association
AMP	Africa Minigrids Programme
ARPU	Average Revenue Per User
ASCENT	Accelerating Sustainable and Clean Energy Access Transformation
ASR	Africa Speciality Risk
BAM	Benchmarking Africa's Minigrids
BESS	Battery Energy Storage System
BGFA	Beyond the Grid Fund for Africa
BII	British International Investment
CAPEX	Capital Expenditure
CBA	CrossBoundary Access
CBEA	CrossBoundary Energy Access
CEDI	Unit of Currency of Ghana
CEI Africa	Clean Energy and Energy Inclusion for Africa
CTF	Clean Technology Fund
DARES	Distributed Access through Renewable Energy Scale-up
DART	Demand Aggregation for Renewable Technologies
DC	Direct Current
DECIM	Digital and Energy Connectivity for Inclusion in Madagascar
DFC	Development Finance Corporation
DFIs	Development Finance Institutions
DRC	Democratic Republic of the Congo
DRE	Decentralised Renewable Energy
D-REC	Distributed Renewable Energy Certificate
EAP	Energising Agriculture Project
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EPC	Engineering, Procurement, and Construction
ESG	Environmental, Social, and Governance
ESMAP	Energy Sector Management Assistance Programme
EU	European Union
EV	Electric Vehicles
FCDO	UK Government's Foreign, Commonwealth & Development Office

FEI	Facility for Energy Inclusion
FX	Foreign Exchange
GBP	British Pound Sterling
GCF	Green Climate Fund
GEAPP	Global Energy Alliance for People and Planet
GEDAP	Ghana's Energy Development and Access Project
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMG	Green Minigrids
IAEREP	Increased Access to Electricity and Renewable Energy Production
IDA	International Development Association
IEA	International Energy Agency
IFC	International Finance Corporation
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
KPIs	Key Performance Indicators
kW	Kilowatt
kWh	Kilowatt Hour
kWp	Kilowatt Peak
LCOE	Levelized Cost of Electricity
M300	Mission 300
MW	Megawatt
MWh	Megawatt Hour
NEFCO	Nordic Environment Finance Corporation
NEP	Nigeria Electrification Project
NERC	Nigerian Electricity Regulatory Commission
NGN	Nigerian Naira
NRECA	Natural Rural Electric Cooperative Association
O&M	Operational Maintenance
OeEB	Oesterreichische Entwicklungsbank AG/ The Development Bank of Austria
OPEX	Operating Expenses
PPA	Power Purchase Agreements
P-RECs	Peace Renewable Energy Credits
PUE	Productive Use of Energy
PV	Photovoltaic
RBF	Results-Based Financing
REA	Rural Electrification Agency
REC	Renewable Energy Credits
REPP	Renewable Energy Performance Platform
REREC	Rural Electrification and Renewable Energy Corporation

RIT	Rochester Institute of Technology
RMI	Rocky Mountain Institute
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SEFA	Sustainable Energy Fund for Africa
SEforALL	Sustainable Energy for All
SHS	Solar Home System
SIDA	The Swedish International Development Cooperation Agency
SRMI	Sustainable Renewables Risk Mitigation Initiative
SSA	Sub-Saharan Africa
TCX	The Currency Exchange
TOU	Time-of-Use
UEF	Universal Energy Facility
UK	United Kingdom
UNDP	United Nations Development Programme
UPBEAT	Utility Performance and Behaviour in Africa Today Initiative
UREA	Uganda's Rural Electrification Agency
USAID	United States Agency for International Development
USD	United States Dollar

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1 Executive Summary

Photo Credit: ARC Power-Rwanda

1 Executive Summary

1.1 Key findings

This report builds on data and insights from the past two editions of *Benchmarking Africa's Minigrids (BAM)*[1], with updated reporting covering January 2022 to quarter three (Q3) 2024, based on data collected from 27 minigrid companies. As the only sector-specific analysis offering a year-over-year comparison of consumption and revenue trends across minigrid sites in Africa, this latest BAM report highlights six key trends and opportunities in the sector:

Reflecting a maturing market, minigrids are growing in size and favouring geographies with an enabling financial and regulatory ecosystem and supporting policy. Relative to the previous BAM report, AMDA members are reporting an increasing number of minigrids serving large communities with substantial numbers of commercial and productive users. In 2022, only 8% of minigrids served over 500 residential connections, but by 2024, 30% of reporting AMDA members minigrids did so.[2] Similarly, the period from 2022 to 2024 saw a preponderance of AMDA members increasing the number of sites they built in countries where a market-friendly regulatory environment was matched with large-scale concessional and commercial financing opportunities—particularly Nigeria. This presents a lesson for policymakers and finance providers hoping to attract a similarly vibrant ecosystem of private sector-led development in other markets.

While minigrid costs have decreased globally due to technological advancements, capital expenditure (CAPEX) for deployment in Sub-Saharan Africa remains higher than in other regions. CAPEX for minigrids has declined by approximately 20% between 2020 and 2024, dropping from $8,500 per kWp to a four-year average of $6,824 per kWp. In addition to the global downward trend in solar photovoltaic (PV) component prices in recent years, this reduction in average CAPEX may also be explained by the ongoing popularity of solar-diesel hybrid minigrids (less expensive than solar PV + battery technology), as well as the trend discussed below towards companies building larger sites and capturing economies of scale. Despite this reduction, the cost remains significantly higher than the global CAPEX of $3,000 per kWp, as reported by SEforALL's CAPEX and operating expenses (OPEX) benchmark study.[3] This disparity highlights regional differences in minigrid development costs, driven by factors such as logistics, geographic areas with low population density and low projected demand can result in developers building smaller and more costly (per kWp) systems. Continued focus on efficiencies in the supply chain, improving economies of scale, and the tax treatment of solar PV components are all necessary to bring down CAPEX expenses further.

Concessional capital remains crucial for developing minigrids in Africa; recent large commitments are encouraging, but timely disbursement will be critical. More than $9 billion[4] concessional funding from various sources has been committed to the sector over the past five years. Historically, disbursement of

Continued focus on efficiencies in the supply chain, improving economies of scale, and the tax treatment of solar PV components are all necessary to bring down CAPEX expenses further.

[1] BAM 1st Edition & BAM 2nd Edition

[2] This BAM report only reports on newly added minigrid sites, rather than densification of existing sites. Future reports will seek to gather data on densification trends over time.

[3] Mini-grid CAPEX and OPEX Benchmark Study: A Regional Approach in Burkina Faso, Nigeria and Sierra Leone.

[4] Estimates based on financial commitments from major donors, including the World Bank, African Development Bank, USAID, EU, GIZ, GEAPP, SEforALL, FCDO, CEI Africa, KfW, etc.

donor commitments has lagged behind ambitions, hindering the speed and scale of market growth. In 2024, Power for All reported that only 14%[5] of committed funds had been disbursed—an increase of just 1% from the 2020 BAM report findings. This slow disbursement has caused significant project delays and hindered market growth. Programmes should be designed to match the state of the markets they serve to prevent delays. Successful existing financing programmes with experienced teams that have proven adept at timely administration of funds should be expanded rather than more fragmentation and new starts. Fewer, larger financing windows with harmonised reporting requirements would disburse faster, and help companies access concessional finance and grow.

As the minigrid sector expands, alternative financing mechanisms are gaining traction. New financing mechanisms are emerging to complement traditional commercial finance options and help developers address capital challenges. These include new sources of blended finance, which combine public, private, and philanthropic capital to mitigate investment risks and attract private investors, as well as extended credit terms on equipment that assist with working capital constraints during the construction phase. Lenders are looking at escrowed grant payments from donor programmes as a way to unlock and derisk commercial bank lending for minigrid projects. Renewable Energy Credits also offer an additional financing pathway for minigrid projects in Africa by monetising environmental benefits to attract corporate and institutional investment.

Without significant acceleration in regulatory improvements, the current slow pace of regulatory approvals risks leaving hundreds of millions without electricity access by 2030. The World Bank estimated 160,000 minigrids would be required in Sub-Saharan Africa to achieve universal access.[6] Even achieving the 9,000 planned minigrids cited by the World Bank—equivalent to 1,500 regulatory approvals annually—will require a paradigm shift in regulatory processes. Streamlining and standardising approvals, addressing bureaucratic bottlenecks, and adopting innovative regulatory frameworks are critical to ensure the swift, timely deployment of minigrids.

Minigrids significantly contribute to job creation in Africa, both directly and indirectly. The 27 minigrid developers participating in this study have collectively created 6,234 jobs over the past four years, highlighting the sector's significant contribution to economic growth and development. Of these, 3,602 positions were created in the communities where the minigrids are located, while 2,632 roles were core corporate positions, supporting operational and administrative functions. Regionally, companies in Western and Central Africa led the way, generating 3,980 jobs, while companies in Eastern and Southern Africa contributed 2,254 jobs.

1.2 Recommendations for decision-makers

The minigrid sector in Africa presents a transformative opportunity to bridge the energy access gap in unserved and underserved regions. This report presents a picture of an industry that is maturing and expanding, but in which companies are still pushing in challenging markets to achieve financial sustainability and access funding. A rethinking of financing mechanisms, regulatory frameworks, and collaborative approaches is critical to facilitating the flow of capital, accelerating the deployment of minigrids, ensuring affordability, and fostering inclusive growth.

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[5] From commitments to disbursements: The mini-grid sector remains underfunded.

[6] Solar Mini Grids Could Sustainably Power 380 million People in Africa by 2030 (worldbank.org).

AMDA has identified some key areas of stakeholder action aimed at helping companies strengthen their bottom line and improving the flow of capital into the sector.

Actionable steps for public sector stakeholders

- **Transparently communicate** national grid expansion plans to facilitate improved planning and development of minigrids in alignment with national electrification plans and strategies.
- **Simplify licensing requirements and procedures for minigrids** to accelerate the deployment of minigrids.
- **Streamline and expedite the disbursement process for donor funding** to accelerate the implementation of projects, reducing bureaucratic delays, enhancing transparency, and implementing clear accountability measures to ensure timely fund allocation.

Actionable steps for donors and other concessional finance providers

- **Consolidate Result-Based Financing (RBF) programmes** - support existing RBF programmes with experienced fund managers to help them scale—pool resources to streamline funding and reduce administrative overheads. Similarly, support larger RBF funding envelopes with longer-term commitments as short-term or small-scale RBF funds create uncertainty. Larger, longer-term RBF programmes will attract more developers and encourage investment.
- **Design programmes to facilitate commercial finance** - well-designed subsidy programmes offer significant de-risking for private lenders to participate. Designing programmes so that grant payments can be escrowed or paid into third-party accounts, and otherwise ensuring that milestones are conducive to commercial lenders will unlock capital and accelerate deployment. Programmes should also reward reliability and not just connections. This ensures end-users have the confidence to invest in productive appliances and move up the energy ladder.
- **Integrate economic growth with energy access** - donors should integrate targeted support to local economies and local businesses in communities where they are also supporting energy access to increase productive demand as an anchor for minigrids and assisting households and businesses in raising incomes and affording more advanced energy services over time.
- **Transform technical assistance** from short-term deliverable-driven engagement to long-term cooperation to help companies identify their constraints, build internal expertise in key areas, and identify and retain talent.
- **Align financing programmes with national electrification plans and strategies** - there should be an incentive for developers to abide by stated national policies and planning.

Actionable steps for private capital providers

- **Provide complementary forms of capital** to bridge funding gaps alongside concessional finance by offering tailored instruments, such as bridging financing for RBFs, construction credit financing, long-term debt, and equity financing.

- **Adopt a portfolio approach** to underwrite revenues and mitigate demand risk. Evaluating projects individually in Sub-Saharan Africa can expose investors to significant demand risk,[7] given the variability of energy consumption in rural areas.
- **Simplify environmental, social, and governance (ESG) reporting** by implementing streamlined, scale-appropriate frameworks to reduce compliance costs and focus resources on project execution.
- **Advocate for supportive policies by** collaborating with stakeholders, including AMDA, to push for streamlined permitting, fair tariffs, and accessible subsidies.

Actionable steps for the private sector/industry

- **Embrace technology for cost savings** - new digital tools help companies inexpensively streamline their processes for identifying and planning out remote sites, right-size generation and storage, prepare financing plans and proposals for lenders/investors, and monitor their assets remotely.
- **Target revenue-enhancing business models** - securing commercial off-takers, identifying industrial/commercial clusters and markets, and helping finance or support the uptake of energy-intensive equipment for productive use can stimulate demand and improve capacity utilisation at minigrid sites. Diversifying revenue streams to offer additional services such as water pumping/purification, clean cooking, battery rental/charging for e-mobility, or other uses may help boost profitability. However, smaller sites face challenges due to low population density and limited revenue generation, leading companies to focus on larger, high-demand sites that offer greater profitability and economies of scale.
- **Enhanced data collection and benchmarking** - AMDA will continue to assist the industry in promoting uniform Key Performance Indicator (KPI) collection, streamlined data sharing, and providing aggregated operational and financial benchmarking for minigrids. This will help the sector assess performance more effectively and enable financiers to conduct high-quality due diligence. Additionally, AMDA will assist governments, regulators, and local authorities by providing digital tools to monitor minigrid operations and track performance within their jurisdictions.

Disclaimer:

The analysis presented in this report is based on data collected from 27 minigrid companies (24 AMDA members and three non-AMDA members). It reflects trends observed within this subset of the minigrid industry in Sub-Saharan Africa. While these findings provide valuable insights, they are not intended to represent the entire landscape of minigrid companies operating in the region. Readers should interpret the results within the context of this sample.

[7] State of the Global Minigrid Market Report.

2 Introduction

Photo Credit: NOA Uganda.

2 Introduction

Minigrids have the potential to provide a high-quality supply of renewable electricity to unserved and underserved communities across Sub-Saharan Africa, where access to electricity remains relatively low or unreliable. As a scalable and flexible solution for many communities, minigrids present a cost-effective pathway to bridging the continent's energy access gap by 2030. Minigrids provide reliable power where conventional grid extension is often too costly or logistically challenging. In this context, the World Bank has estimated that powering 380 million people in Africa by 2030 will necessitate the construction of over 160,000 minigrids, at a cumulative cost of $91 billion. It is further estimated that the cost of electricity generated by minigrids will drop to as low as $0.20/kWh, positioning it as the most affordable solution for over 60% of the unelectrified population.[8]

However, the pace of development has yet to meet expectations on the continent. The minigrid sector is growing, but as this report and other recent industry reports have shown, it is not at a pace to connect the hundreds of millions of people who need access to electricity. Several factors contribute to the slow pace of minigrid deployment in Africa, including the limited availability of affordable and long-term patient capital and sufficient concessional funding. Additionally, regulatory bottlenecks heighten project risks and complicate the fundraising process, slowing development efforts. Given the nascent stage of the industry, information asymmetry presents a challenge that affects decision-making among project developers, financiers, donors, and governments. The Africa Minigrid Developers Association (AMDA) seeks to bridge this information gap by enhancing transparency and understanding of the sector, identifying the factors that facilitate or hinder progress, and analysing the tools necessary to shift the current status quo.

This is the third edition of the Benchmarking African Minigrids report. It examines developments since the previous edition published in 2022, serving as a critical resource for understanding the evolving landscape of minigrids in Africa. Furthermore, it highlights new opportunities for fostering growth and ensuring long-term sustainability, thereby equipping stakeholders with the knowledge to navigate the complexities of energy access and investment in the region. The findings presented here are the outcomes of a high-quality data collection and detailed analysis process conducted across Sub-Saharan Africa by AMDA in collaboration with Odyssey Energy Solutions. Twenty-seven minigrid companies, comprising 24 AMDA member minigrid companies across 19 African countries, along with three non-member minigrid companies operating in two countries, contributed data, enriching the analysis with broader insights and perspectives. The analysis emphasises key metrics such as capital and operating costs, revenue per user, and service quality, providing a clear picture of the sector's health. The remainder of this report will explore these critical challenges in greater depth, addressing what is required to boost funding flows and accelerate the deployment of minigrids.

2.1 Our organisations

The 2024 Benchmarking Africa's Minigrids (BAM) report was a joint effort by AMDA and Odyssey Energy Solutions. AMDA spearheaded the data collection from members and non-members for Odyssey's analysis.

[8] Solar Minigrids Could Sustainably Power 380 million People in Africa by 2030.

2.2 AMDA

Established in 2018, AMDA is an industry association created by private sector minigrid developers and operators, development partners, and investors interested in improving political and financial environments for minigrid companies in Africa. The organisation specialises in creating favourable policy environments and securing safer investment conditions for the private minigrid sector and its financiers. Traditionally, AMDA's membership base consisted of only minigrid developers and operators. However, that changed in 2024 with the membership expansion to include ecosystem companies in the sector, which provide services and/or products to minigrid developers and operators. As of 2024, AMDA has 52 members in 24 countries across five regions in Africa. AMDA supports its members through four core pillars: sector coordination and member value; access to capital; policy, regulatory and regional coordination and research, data and standards.

AMDA operates at the intersection of policy and regulation, concessional and commercial capital, helping key stakeholders overcome market barriers. By providing data-driven insights and evidence-based recommendations, AMDA supports governments, donors, and investors in making informed decisions that maximise impact and accelerate efforts to achieve universal electrification across Sub-Saharan Africa.

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Since its inception, AMDA has grown significantly. Launched initially by 11 minigrid developers, AMDA now represents 52 member companies. These members are private, decentralised utilities that develop and operate minigrids in 24 countries across Sub-Saharan Africa. AMDA members now account for approximately 70% of developers who have commissioned at least one minigrid site on the continent.

As of 2024, AMDA members have deployed nearly 600 minigrids, providing electricity to nearly one million people in rural and peri-urban areas. These minigrids serve more than 110,000 households, businesses, and public institutions, with a total installed capacity of over 16.5 MW. AMDA continues to be a key player in driving the growth and impact of the minigrid sector, supporting Africa's path toward sustainable and inclusive energy access.

2.3 Odyssey Energy Solutions

Odyssey Energy Solutions is a leading technology company and platform designed to accelerate finance into the distributed energy sector enabling renewable energy companies, financiers, and suppliers to deploy more projects, faster.

Odyssey's platform has backed 53 financing programmes in 42 countries across Africa and beyond, pulling data for over 2.3 million systems. Their advanced tools allow real-time tracking of electricity connections, system performance, and operational reliability while measuring programmatic impact.

To date, Odyssey has facilitated over $ 2.1 billion in capital for solar minigrids and other distributed energy projects, accelerating energy access across underserved regions. For this BAM report, Odyssey's platform served as the primary tool for data collection and monitoring, providing the critical insights that drive the report's findings.

To date, Odyssey has facilitated over $ 2.1 billion in capital for solar minigrids and other distributed energy projects, accelerating energy access across underserved regions.

3 Sector Growth

Photo Credit: Renewvia Energy-Kenya

3 Sector Growth

This section examines the growth of the minigrid sector across Sub-Saharan Africa, highlighting the expansion in connections and the scaling of deployment over the past decade. It also provides valuable insights into the sector's growth in terms of installed capacity and the number of sites.

Solar minigrid deployment in Sub-Saharan Africa has accelerated remarkably in the last decade. A sector-wide analysis from Sustainable Energy for All found that projected minigrid installations in 2024 will be around six times higher than what was achieved in 2018.[9][10] Minigrid developers, including AMDA members, have been pivotal in expanding minigrids in the region by actively engaging with stakeholders, including local communities, unlocking new market segments for minigrids, and refining business models to enhance project viability. AMDA has played a key role in advocating for improved policies and creating favourable financial conditions for its members. Additionally, the sector's success has been bolstered by the adoption of advanced technologies, smart digital power solutions, and capacity-building initiatives at the local level.

Solar minigrid deployment in Sub-Saharan Africa has accelerated remarkably in the last decade. A sector-wide analysis from Sustainable Energy for All found that projected minigrid installations in 2024 will be around six times higher than what was achieved in 2018.

Despite this progress, developers still face considerable challenges that hinder the sector's growth. Although several countries have adopted proactive and market-friendly minigrid policies and regulations to encourage investments and private sector participation, there remain crucial policy and regulatory barriers and implementation challenges in many countries. These challenges include limited access to affordable and long-term financing, difficulties obtaining permits and navigating the complex bureaucratic landscape,[11] high initial capital expenditure, grid integration risks, tariffs, subsidy imbalances, and lack of sufficient local expertise.

In this section, we review key aspects of the minigrid sector, including the number of connections, total installed capacity, number of sites, funding opportunities, challenges, and the role of government subsidies in driving growth. We also highlight the main drivers of growth, where growth is happening, and areas that need improvement. The section concludes with key takeaways for stakeholders on the sector's opportunities and challenges.

3.1 Number of connections

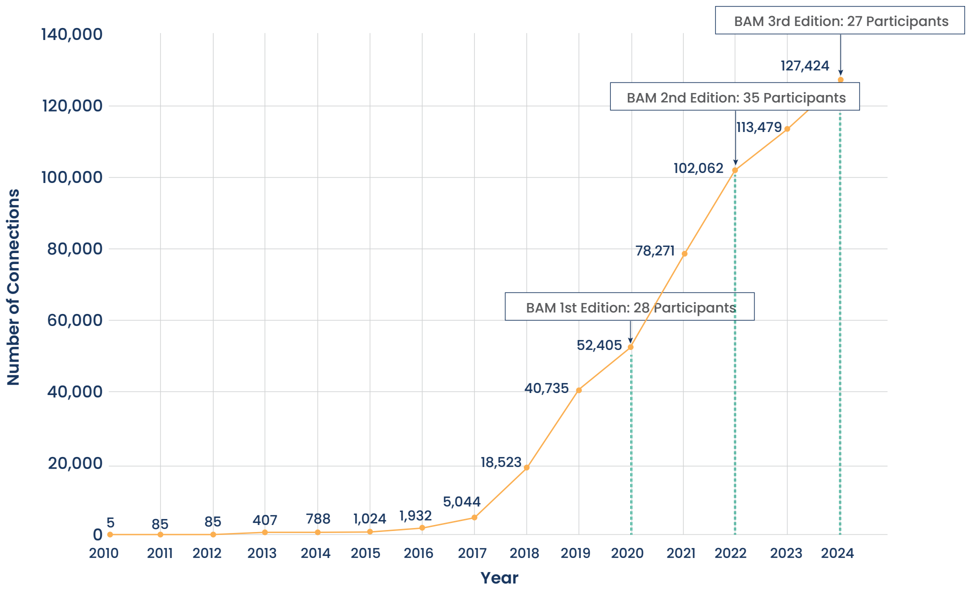
As shown in our previous BAM reports, the first several years of the deployment of minigrids witnessed negligible growth in connections, reflecting limited initial adoption or possibly high barriers to entry, such as regulatory or financial constraints. Starting with fewer than 2,000 connections reported by AMDA members in 2016, 127,000 connections were reported in 2024 (see Figure 1). While the absolute number and growth trajectory of connections in this report is influenced by the number of respondents year-to-year, some conclusions can still be drawn from the characteristics of the connections in the communities served.

[9] State of the Global Minigrids Market Report

[10] This report includes only partial data for 2024; the authors are aware that there was minigrid installation activity by developers who did not elect to respond to the survey and, therefore cannot be captured in its entirety.

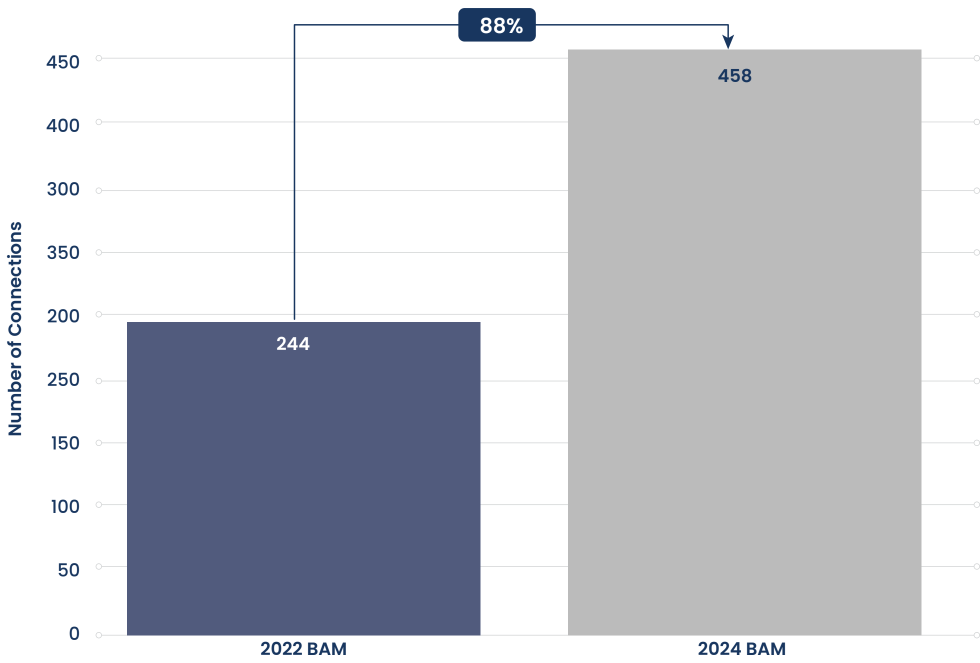
[11] Unlocking Africa's Minigrid Market: USAID Scaling Up Renewable Energy Program (SURE)

Figure 1: Number of connections reported by AMDA members (cumulative)



Newer minigrids are serving larger communities on average, suggesting a trend towards improved economies of scale and momentum towards better economics for minigrid companies. From 2022, when only 8% of minigrids served over 500 residential connections, by 2024, 30% of reporting AMDA members' minigrids did so. In the previous BAM study, the average number of connections per minigrid was 244 per site. In the current study, that figure has almost doubled to 458 per site. However, these figures belie a real regional disparity, with minigrids built in Eastern and Southern Africa much smaller on average, at 209 connections per site, whereas sites in West and Central Africa average 592 connections per site.

Figure 2: Average connections per minigrid site[12]



[12] It is important to note that, the total number of respondents in the 2022 report was 32 compared to 27 in the 2024 report.

3.2 Total installed capacity and number of sites

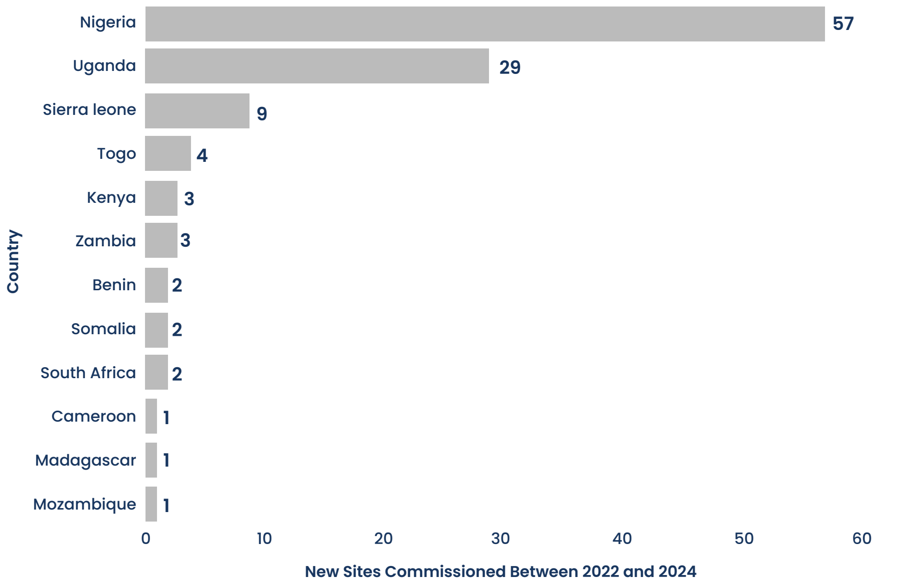
From 2022-2024, responding AMDA members installed 116 new minigrid sites in 15 countries. Almost half of the newly commissioned sites (57) were in Nigeria, with another 29 sites in Uganda. Building on prior BAM reports, these new additions bring the total number of sites for which data has been submitted to AMDA to 545 (see figures below) out of well over 600 sites built by AMDA members.

From 2022-2024, responding AMDA members installed 116 new minigrid sites in 15 countries. Almost half of the newly commissioned sites (57) were in Nigeria, with another 29 sites in Uganda.

Table 1: New sites commissioned 2022-2024

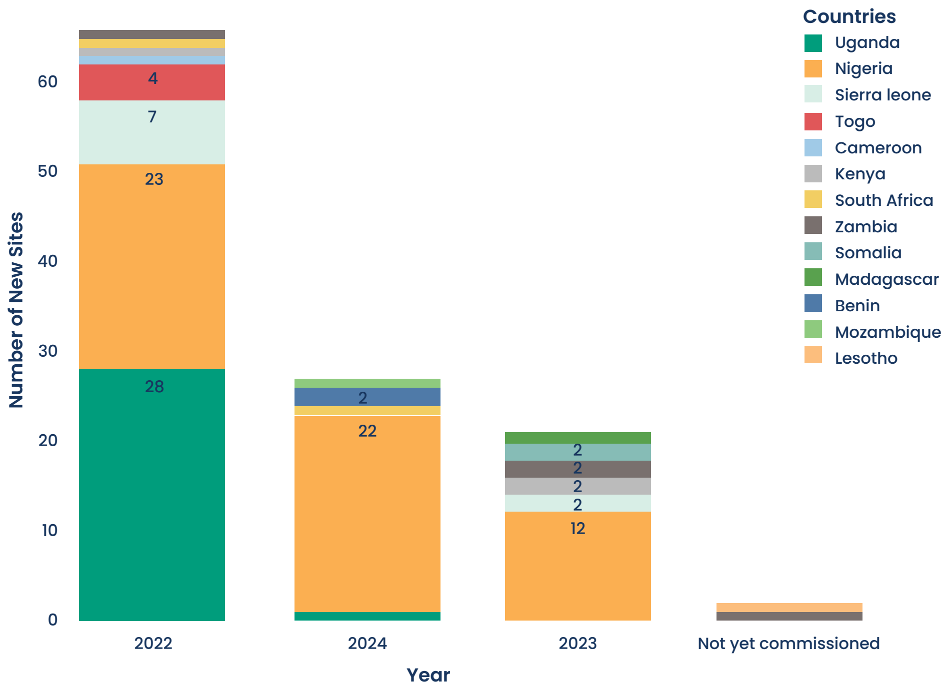
Country	Sites Installed
Nigeria	57
Uganda	29
Sierra Leone	9
Togo	4
Zambia	3
Kenya	3
South Africa	2
Somalia	2
Benin	2
Mozambique	1
Madagascar	1
Cameroon	1

Figure 3: Sites installed by country



Year-on-year, 2022 was the most productive year, with 66 minigrids commissioned by AMDA members. In 2023-2024, the overall numbers reduced somewhat and also shifted significantly to Nigeria, whereby in 2024, almost all newly commissioned sites were built. This is not surprising, considering that the reporting period coincides with the implementation period of the Nigeria Electrification Project's Performance-Based Grant window, a World Bank-funded programme implemented by the Rural Electrification Agency of Nigeria, which provided significant CAPEX grants against completed minigrids and succeeded in commissioning over 170 sites in the course of its operations.

Figure 4: Total new minigrid sites added by country



FEATURE BOX: UGANDA and NIGERIA

Notably, the leading countries for which new sites were added by reporting AMDA members were Nigeria and Uganda. Both tell us a story of concerted public-private effort to bring mini-grids to market at scale.

In UGANDA, the European Union (EU) and GIZ teamed up to plan and tender out 25 minigrid sites to pilot the efficacy of minigrids and the supporting environment. This programme successfully drove the deployment of these operational sites and underpinned a follow-on tender in late 2024 funded by the German Development Bank, KfW, to electrify 153 communities with minigrids.

In NIGERIA, the Nigeria Electrification Project Performance Based Grant programme funded by the World Bank successfully led to the commissioning of over 170 minigrids, catalysing a vibrant ecosystem of minigrid developers, equipment suppliers, and financiers. Building on the Nigeria Electrification Project (NEP) track record, the forthcoming DARES project scales up the ambition to aim for over 1,000 minigrids. It incorporates data-driven electrification planning and analysis to identify communities with the most conducive attributes for minigrids and reward good service provision.

In both cases, clear national-level energy planning based on solid analytic data for least-cost planning across different technologies, paired with supportive regulatory and financing schemes led to a marked upswing in installed minigrid systems.

At the end of 2021, AMDA received data for roughly 429 sites; with the additions in this report, the figure grew to 545. Figure 5 illustrates moderate growth in numerous established markets, with Nigeria representing a significant share of installed sites each year over the last three years. Overall, AMDA members have built well over 600 minigrid sites as of mid-2024.

Figure 5: Number of minigrid sites reported by AMDA members in 2021 versus 2024

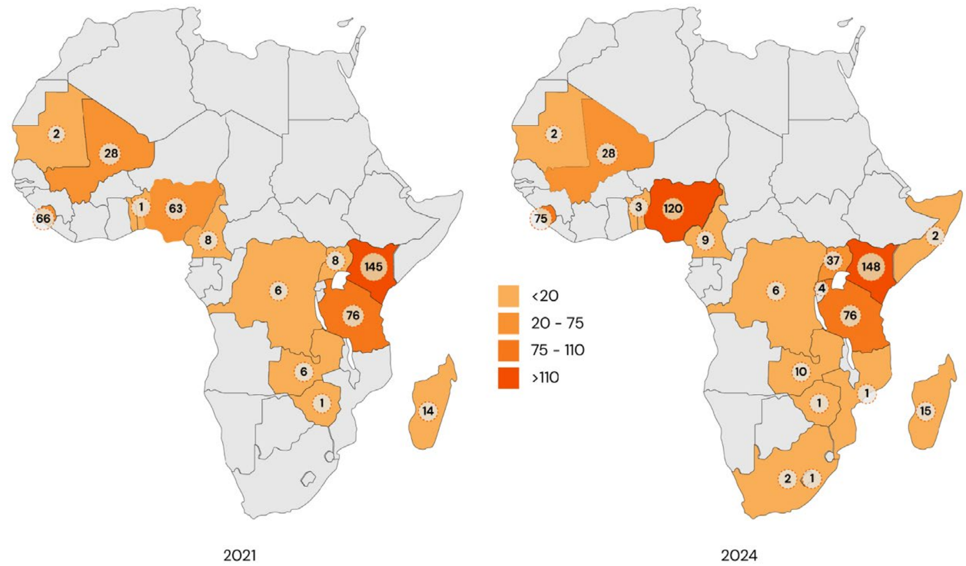


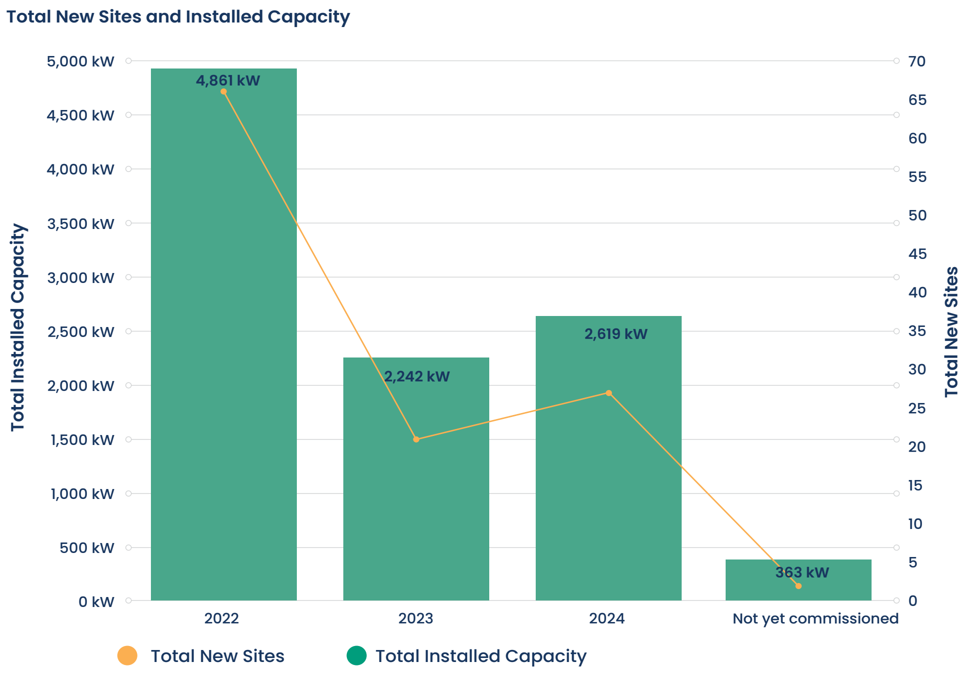
Table 2: Total number of sites for which data was submitted to AMDA

Countries	Total sites	Year of first site	Year of latest site
Benin	3	2019	2024
Cameroon	9	2014	2022
DRC	6	2017	2021
Kenya	148	2013	2023
Lesotho	1	-	-
Madagascar	15	2017	2023
Mali	28	2007	2021
Mauritania	2	2017	2018
Mozambique	1	-	-
Nigeria	120	2013	2024
Rwanda	4	2019	2021
Sierra Leone	75	2019	2023
Somalia	2	2023	2023
South Africa	2	2022	2024
Tanzania	76	2012	2020
Togo	5	2019	2022
Uganda	37	2021	2024
Zambia	10	2009	2023
Zimbabwe	1	2021	2021

In addition to growing in number, newer minigrid installations are—on average—larger systems serving larger communities, reflecting a maturity in the sector and a positive trend towards achieving more sustainable economics. If the trend toward larger mini-grid systems and larger communities continues, fewer small mini-grids are likely to be built. This shift could leave many rural communities without access to electricity, posing a challenge to achieving electrification goals. Historical data shows a consistent rise in average peak load capacity across minigrid sites. For instance, from 2019 to 2020, the peak load increased by over 50% on a per-grid basis, and the average number of connections per site rose from 196 to 319. By the end of 2020, the total installed solar capacity of minigrids reported by AMDA members across the continent reached approximately 7,000 kW, marking a more than 30-fold increase over seven years.[13] The total installed capacity of minigrids continues to grow significantly into 2024, now reaching 16,500 kW of capacity installed by AMDA members.[14] **Over the last 3 years, the average kWp size of installations grew from 73 kWp to 99 kWp.**

Figure 6 showcases a detailed graphical representation of newly constructed minigrids alongside the annual newly installed capacity, as reported by respondents to this study.

Figure 6: New minigrid sites and total installed capacity - study respondents



3.3 Technology choices and supply chain

The dataset from respondents in this study indicates that all newly built minigrid sites relied on solar power, employing two primary technologies:

- **PV-battery storage:** These systems operate solely on solar power, incorporating a battery energy storage system (BESS) that stores electrical energy generated by solar panels. The stored energy provides power when solar generation is unavailable, such as during cloudy periods or at night.
- **Diesel-hybrids:** This technology combines solar power with a battery storage system and a backup diesel generator. Solar panels generate electricity stored in batteries when sunlight is insufficient. The diesel generator is a backup to ensure a continuous power supply during extended cloudy periods or at night.

[13] BAM 2nd Edition.

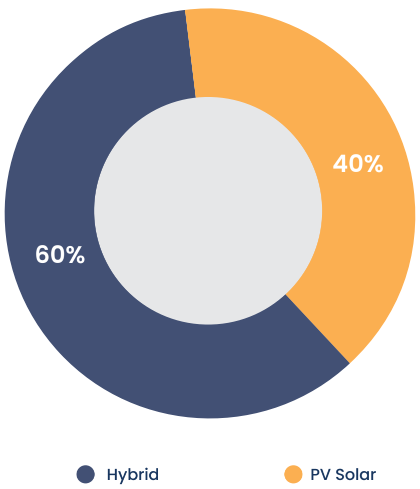
[14] Because the pool of reporting companies differs somewhat from the 2022 BAM report, the aggregate findings may be skewed. These should be taken as showing overall direction and trend rather than absolute figures.

The choice of technology for minigrid projects significantly affects procurement lead times and directly impacts the costs, efficiency, and sustainability of the minigrid systems. The 2024 BAM report reveals that from 2021 to 2024, the PV-diesel hybrid configuration has emerged as a popular choice for new minigrid sites, accounting for 60% of deployed sites. In comparison, solar PV-battery systems make up 40% (see Figure 7).

The minigrid landscape in Africa has seen a steady rise in diesel-solar hybrid systems, reflecting the growing emphasis on improving energy supply reliability and availability within CAPEX cost constraints. Notably, Nigeria accounts for the majority of these installations, with 56 sites, compared to just a few sites in other countries. While PV-diesel hybrid systems have lower CAPEX and a reliable power supply, their dependence on a consistent fuel supply makes them challenging and costly to deploy due to logistics and price volatility. See Section 6 below for a further discussion on the cost implications of technology choices.

The minigrid landscape in Africa has seen a steady rise in diesel-solar hybrid systems, reflecting the growing emphasis on improving energy supply reliability and availability within CAPEX cost constraints.

Figure 7: Total new minigrid sites by technology type (from 2021 to 2024)

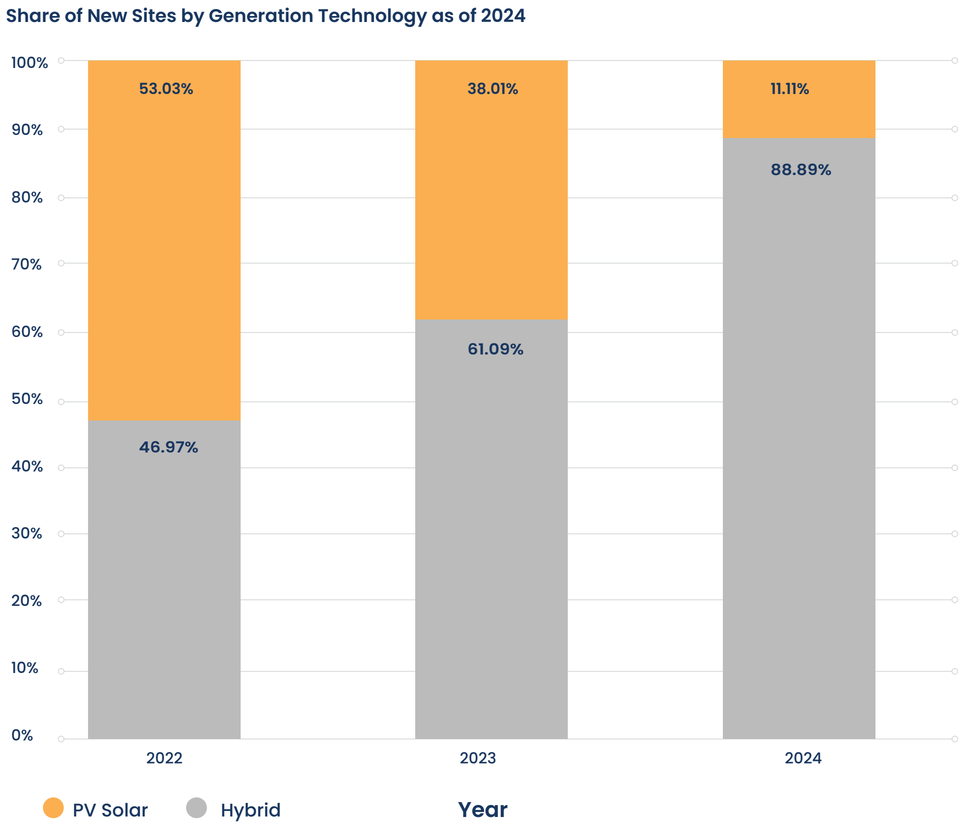


The choice of technology dictates the type of components required and from where they are sourced. Efficient transportation networks are essential for delivering components to remote areas intact and on time. Poor infrastructure can cause delays and increase costs. Encouraging local manufacturing and assembly of key components is essential for reducing costs, creating jobs, and shortening lead times.

However, achieving this requires implementing policies that support local capacity building and skills development. Figure 8 provides an analysis of the evolving technology mix from 2021 to 2024. The analysis shows that hybrid renewable energy systems, combining solar PV with diesel backup, have become the dominant choice, continuing the trend from earlier BAM reports which showed a shift away from PV-Battery systems as the technology of choice to a diesel-hybrid model. This trend not only underscores the role of hybrid technology in enhancing service reliability and addressing the variability of renewable sources amid growing consumption but also reflects the cost advantages of solar PV over diesel. While battery storage costs remain high, they are declining, which helps avoid the need for oversized systems designed solely for extreme reliability that are underutilised most of the time. The hybrid setup, therefore, balances low PV costs with moderate storage sizes, reinforcing the sector's commitment to balancing innovation, sustainability, and customer satisfaction.

Poor infrastructure can cause delays and increase costs. Encouraging local manufacturing and assembly of key components is essential for reducing costs, creating jobs, and shortening lead times.

Figure 8: Technology trends favour hybrid minigrids



3.4 Sector growth projections

AMDA members report ambitious growth plans for the coming five years that point to a step change in scale and speed of deployment. If realised, the sector would see a 10x increase in minigrid deployments over the next five years from AMDA members alone. While still short of the scale and speed required to close the energy access gap, it demonstrates a level of ambition that must be matched by policymakers, finance providers, donors, and other industry actors to smooth the path. The pipeline also suggests where AMDA members see the most conducive markets for investment and success, as shown in the table below.

Table 3: Indicative pipeline of new sites through 2030

Country of Operation	Number of Pipeline Minigrid Sites
Benin	240
Cameroon	468
DRC	121
Ethiopia	4
Liberia	30
Madagascar	53
Mozambique	130
Niger	17
Nigeria	3501
Senegal	81
Sierra Leone	88

Country of Operation	Number of Pipeline Minigrid Sites
Tanzania	180
Togo	173
Uganda	346
Zambia	404
South Africa	90
Kenya	134
Somalia	56
Total	6,116

The total estimated financing estimated by responding AMDA members to fund this pipeline is roughly $2.2 billion, of which roughly 50% is expected to come in the form of concessional or grant finance. These 6,000 sites—assuming an average of 450 connections per site *(per 2024 BAM figures cited above)*—could connect nearly 14 million people to electricity by 2030.

3.5 Key insights

Minigrids are serving larger communities with more connections per site. This trend suggests companies are pursuing greater economies of scale with larger sites that allow them to maximise revenue across a broad mix of residential, commercial, public, and productive users. However, it is important to note that policy measures, such as output-based subsidies, have influenced site sizes. These policies incentivise developers to connect entire communities–extending beyond the few anchor connections that typically carry the majority of the load, as the economics of serving additional, less concentrated connections are often challenging without such support. While not all countries have settlement patterns and demographics that support this model of minigrid deployment, the presence of these policy incentives indicates that some developers are indeed pursuing a path toward broader economic sustainability.

The majority of minigrid deployment has shifted to markets with conducive regulatory environments and a critical mass of concessional and commercial financing. Nigeria's Rural Electrification Agency has been successful in creating a consistent environment of support for minigrids with two successive large-scale funding programmes backed by the World Bank, joined by other Development Finance Institutions (DFIs) such as the African Development Bank, as well as concerted efforts to simplify and streamline regulatory processes and generate commitments from commercial financiers. This "united front" has achieved results, as evidenced in the marked shift from AMDA developers over 2023-2024 to launching the majority of new minigrid deployments in Nigeria. Similarly, Uganda's national-level planning effort and staged tender of minigrid sites have also shown how integrated planning efforts and up-front techno-economic analysis can result in more sustained gains.

PV-diesel hybrid generation systems have taken centre stage as the preferred setup to mitigate outages and improve service quality. PV-diesel hybrid systems offer lower CAPEX ($1,500–$2,500 per kWp) but incur higher OPEX ($0.30–$0.50 per kWh) due to multiple factors, including fuel costs, high load factors, increased maintenance requirements, component wear, etc. The rise of hybrid systems combining solar PV and diesel backup reflects their reliability, achieving over 90% penetration by 2024.

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4 Access to Capital

Photo Credit: Engie Energy Access-Zambia.

4 Access to Capital

This section focuses on the funding landscape for minigrids in Africa. It explores a wide range of available financing options, including blended finance and grant finance that mitigate risks and attract private capital, as well as commercial funding sources and successful fund closures from recent years—highlighting the growing interest of financiers in the sector.

Despite Africa's huge potential in energy resources, the continent has the lowest access to electricity globally and only receives about 12% of the $250 billion in climate investments required annually.[15] A total of $91 billion is required in the minigrid sector alone to enable developers to build more than 160,000 minigrids to power the over 380 million inhabitants in underserved communities by 2030.[16] While solar component prices have reduced globally, overall capital expenditure costs in Sub-Saharan Africa remain higher than in other regions, as does the cost of capital. These financial challenges are further compounded by the difficulty of realising economies of scale, especially in remote or sparsely populated regions. To overcome these hurdles, access to concessional capital, grants, and subsidies plays a crucial role in making projects viable and sustainable.

Access to capital remains one of the largest barriers to scaling minigrid projects. Many projects require significant CAPEX, much of which is invested in United States Dollars (USD), making local currency devaluations particularly risky. In markets like Nigeria, where the local currency (NGN) has depreciated sharply, this creates a heavy financial burden for developers. A comprehensive mix of financing options, including local currency instruments and blended financing, could mitigate this exposure to currency risk. Equity financing is available but often moves slowly, and although concessional capital is becoming more common, debt financing remains difficult to secure due to perceived risks.[17] Additionally, affordability is an issue, as minigrid tariffs are often significantly higher than subsidised grid tariffs, making it challenging for unserved and underserved communities to afford electricity that is not subsidised to the same degree as the national grid, further hampering demand and project sustainability.

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The financial landscape of the minigrid sector in Africa is significantly impacted by foreign exchange fluctuations. Most components of minigrids are imported, and funding in the sector is dominated by foreign currencies. This makes minigrid projects vulnerable to Foreign Exchange (FX) risks, which have, over time, hindered investments and growth of the sector.

In 2022 alone, the cedi depreciated by nearly 54% against the USD, a significant factor that led the country to default on its sovereign debt in December of that year, and in 2023, the Kenyan shilling depreciated by about 15% against the USD.[18] This introduces uncertainty into project budgets and increases the overall cost of repaying loans in foreign currencies.

[15] GEAPP joins urgent calls at Africa Climate Summit for increased investment and action in Green Growth and Climate Finance Solutions.

[16] Solar Mini Grids Could Sustainably Power 380 million People in Africa by 2030 – if Action is Taken Now.

[17] Mini-grids seeing unprecedented growth in push to achieve universal energy access.

[18] Currency Conundrums: Volatile African Exchange rates and What Can Be Done.

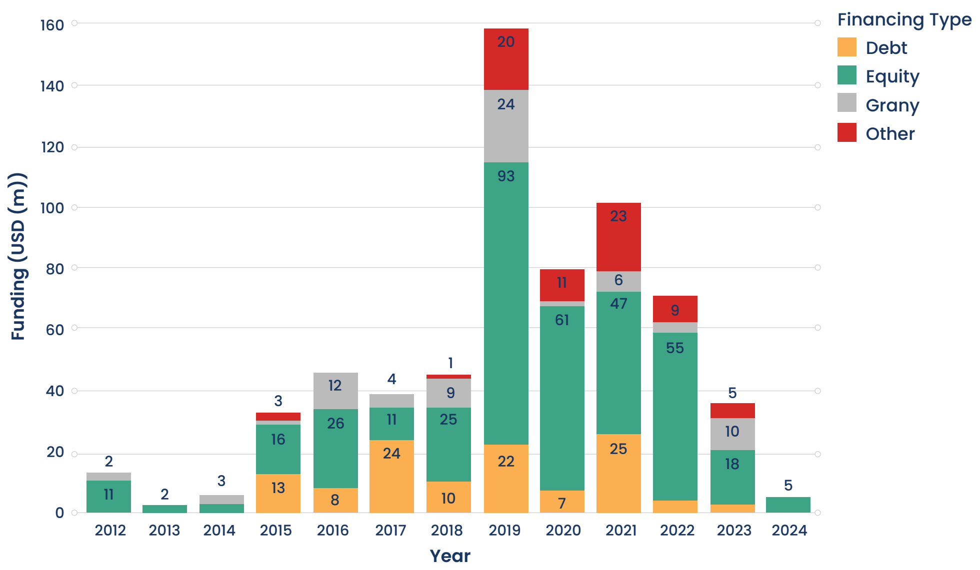
To address FX risks in the sector, financial institutions such as InfraCredit (debt fund company) and Dhamana (debt and guarantee company) offer debt and guarantee investments in renewable energy projects with local currency denominators. This significantly reduces the foreign exchange fluctuations risks. Additionally, The Currency Exchange(TCX) Fund and other hedging funds are offering hedging against currency mismatch risks in the sector. However, most minigrid developers are not opting for hedging services as they are expensive and significantly impact the overall project economics.

Minigrid developers had accessed around $640 million in funding across debt, equity, and grant support at the corporate level (as opposed to project-level grants). Of that total funding amount, roughly 68% was equity financing, 20% was debt, and 12% grant funding to support core operations.

4.1 Historical funding trends

AMDA undertook a comprehensive review of 85 minigrid companies and their sources of funding from 2012 to the present. The findings indicated that over this period, **minigrid developers had accessed around $640 million** in funding across debt, equity, and grant support at the corporate level (as opposed to project-level grants). Of that total funding amount, roughly 68% was equity financing, 20% was debt, and 12% grant funding to support core operations. The funding trends are depicted in Figure 9; note that the figures do not include project-specific grant financing such as that provided by donor-backed Results-Based Financing Programmes. Such sources nevertheless represent a significant source of support to minigrid developers. In Nigeria alone, the World Bank-funded Nigeria Electrification Project, implemented by the Rural Electrification Agency, subsidised minigrid deployments at a range of $350-$600/connection, representing a significant portion of the overall project CAPEX.

Figure 9: Funding by financing type



Based on respondents' data, over this entire period, the most active providers of equity funding based either on number of deals or volume were:

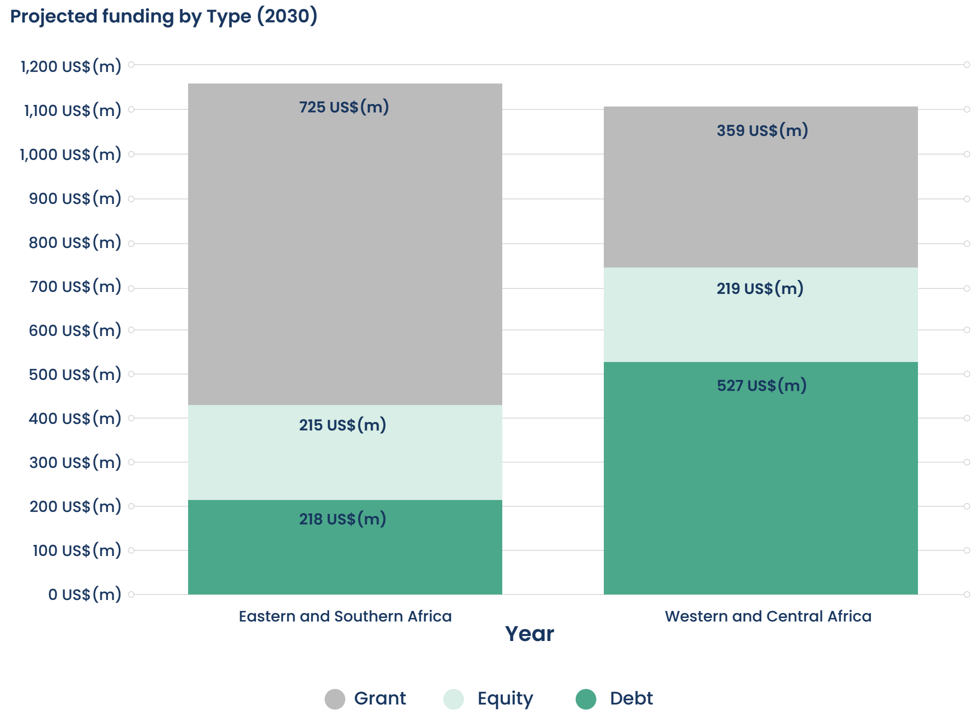
- ElectriFi
- InfraCo Africa
- Gridworks
- All On
- CrossBoundary Access
- Norfund
- Renewable Energy Performance Platform (REPP/Camco)

The most active debt providers over the same period (based on number of transactions or volume) were:

- ElectriFi
- European Investment Bank
- InfraCredit
- InfraCo Africa
- Renewable Energy Performance Platform (REPP/Camco)

Looking ahead, as noted in section 3.4 above, respondents to AMDA's survey reported a pipeline of over 6,000 minigrid sites representing $2.2 billion in investment. The figure below shows a breakdown of the financing needs anticipated by respondents to deliver on this ambition.

Figure 10: Projected funding by finance type (2030)



As shown in Figure 10, significant grant funding (over $700 m) will be required to realise the pipeline of projected minigrid projects anticipated by AMDA respondents.

The recently launched M300 initiative is poised to drive high-level funding commitments by providing structured support to minigrids in Africa. Spearheaded by the World Bank Group in partnership with the AfDB, Rockefeller Foundation, GEAPP, and other stakeholders, M300 aims to connect 300 million people in Sub-Saharan Africa (SSA) to electricity by 2030.

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According to the National Energy Compacts reports[19] based on M300 that offers a detailed view of energy access strategies across 12 African countries: Chad, Côte d'Ivoire, DRC, Liberia, Madagascar, Malawi, Mauritania, Niger, Nigeria, Senegal, Tanzania, and Zambia. The National Energy Compacts are focused on the following pillars:

[19] The National Energy Compacts Reports for different countries can be accessed here: https://www.afdb.org/en/mission-300-africa-energy-summit/compacts.

- Expanding Generation and Transmission
- Promoting Regional Trade
- Scaling Distributed Renewable & Clean Cooking Solutions
- Enabling Private Sector Investment
- Strengthening Power Utilities

Analysis from these compact country reports shows that the private sector investments and DRE technologies are expected to contribute $61.84 billion towards the required **$115.24 billion** funding. The majority of the remaining **$53.40 billion** will come from national governments and development partners.

4.2 Concessional funding

As the minigrid industry is still nascent across Africa, subsidies remain essential to close the economic feasibility and financial viability gap. Concessional funding is crucial in de-risking investments, facilitating access to commercial financing, reducing connection costs through CAPEX subsidies, and lowering costs to consumers with demand-side subsidies (i.e., consumer-facing subsidies). Central to the case for concessional funding is the reality of the affordability gap that persists: the bulk of the current population without electricity access in Sub-Saharan Africa are poor households that cannot afford significant demand at cost-reflective tariffs. Public and concessional finance should aim to close the affordability gap while simultaneously planning for local growth.

There remains a significant disparity in government support between off-grid and on-grid programmes. On-grid programmes receive substantially larger government investments compared to minigrid initiatives, even when studies have shown that larger populations could have been connected by off-grid solutions for the same level of subsidy.[20] The current institutional structure in the power sector incentivises grid extension into areas where minigrids would be more cost-effective and often more reliable. However, due to cross-subsidies on centralised grids that are unavailable to private minigrids, these potential cost savings are frequently not passed on to minigrid customers.[21]

State-owned utilities benefit from not only substantial government subsidies but also significant cross-subsidisation from urban and industrial customers to rural areas. This combined support allows them to offer electricity at prices significantly lower than the levelized cost of electricity (LCOE). While these mechanisms are critical for maintaining affordability and service reliability for grid-connected consumers, the limited availability of similar support for mini-grids creates a financial imbalance. As a result, minigrid developers face higher capital and operational costs, which can make electricity access less affordable for rural and underserved communities.

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The sector has seen a notable increase in concessional funding commitments in recent years, poised to drive further growth and development. For example, the World Bank has announced a series of significant programmes focused on distributed renewable energy, including the $750 million Distributed Access for Renewable Energy Scale-up (DARES) project in Nigeria, as well as the $5 billion

[20] Stretching budgets by not stretching power lines: Faster and cheaper electricity access through careful subsidy allocation in Africa.

[21] Rural electrification subsidy estimation: a spatial model development and case study.

Accelerating Sustainable and Clean Energy Access Transformation (ASCENT) for East and Southern Africa. Table 4 highlights key concessional funding programmes currently supporting minigrid projects across Africa.

Table 4: Concessional funding programmes/commitments for minigrid programmes

Programme/Funder	Description of Programme	Programme Amount	Countries
Accelerating Sustainable and Clean Energy Access Transformation (ASCENT) Programme	World Bank programme to provide sustainable energy to 100 million people across 20 countries in Eastern and Southern Africa, with a $5 billion commitment from IDA focusing on distributed renewable energy and clean cooking technologies.	$5 billion	Eastern and Southern Africa
Distributed Access through Renewable Energy Scale-up (DARES)	$750 million World Bank's IDA credit, expected to mobilise over $1 billion in private capital, including $100 million from GEAPP and $200 million from JICA.	$750 million	Nigeria
Global Energy Alliance for People and Planet (GEAPP)	Committed $1.5 billion to support energy access and transitions in developing markets, aiming to enhance minigrid bankability and attract private investments.	$1.5 billion	Developing markets
Sustainable Energy Fund for Africa (SEFA)	AfDB-administered facility with 40% allocated to Green Minigrids (GMG), offering financial support, including technical assistance, concessional loans, and risk mitigation to catalyse private sector investments.	$500 million	Africa-wide $40 million allocated to Nigeria in 2021 $15 million allocated to Mauritania in 2021 $10 million allocated to Cross Boundary Energy Access $8 million allocated to Ethiopia in 2024
CEI Africa	Three financing windows offering different forms of finance for green minigrid developers and other off-grid services companies.	€78 million	minigrids: Kenya, DRC, Sierra Leone, Benin, Madagascar, Mali
Mwinda Fund	A government RBF initiative backed by donors including the World Bank ($70 million).	$70 million with the aim of reaching $250 million	DRC

Programme/Funder	Description of Programme	Programme Amount	Countries
Africa Minigrids Programme (AMP)	UNDP-led programme, in collaboration with RMI and AfDB, supporting enabling environments for private investors in 21 African countries to enhance minigrid viability.	$50 million	Angola, Benin, Burkina Faso, Burundi, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Ethiopia, Eswatini, Liberia, Madagascar, Malawi, Mali, Mauritania, Niger, Nigeria, Sao Tome e Principe Somalia, Sudan, Zambia
Universal Energy Facility (UEF) Expansion	Pan-African multi-donor RBF Platform hosted by SEforAll that aims to become a $500 million facility	$44 million with the aim of reaching $ 500 million	Benin, Sierra Leone, Madagascar, DRC, Nigeria, Zambia
Increased Access to Electricity and Renewable Energy Production (IAEREP)	EU and Zambian government initiative with €25 million for renewable energy promotion and access expansion.	€25 million	Zambia
Beyond the Grid Fund for Africa	Regional initiative with €30 million for renewable projects in Burkina Faso, Liberia, and Zambia, with additional calls for Mozambique and Uganda. Managed by NEFCO, supported by international donors like Sida and KfW.	€30 million	Burkina Faso, Liberia, Zambia, Mozambique, Uganda
Nigeria Electrification Project (NEP)	Federal Government initiative supported by the World Bank ($350 million), AfDB ($150 million), and Africa Growing Together Fund ($50 million)	$550 million	Nigeria
Access to Distributed Electricity and Lighting in Ethiopia (ADELE)	World Bank-backed project to expand energy access through $500 million in performance-based grants and subsidies.	$500 million	Ethiopia
BRILHO Programme Mozambique	UK FCDO-funded initiative with financial support ranging from GBP 50,000 to GBP 1.5 million to expand off-grid solutions.	GBP 30 million	Mozambique

Programme/Funder	Description of Programme	Programme Amount	Countries
Scaling MiniGrid (SMG) Programme	$400 million initiative to deploy 180 MW solar PV, supported by the International Finance Corporation (IFC), Canada, Italy, Sustainable Renewables Risk Mitigation Initiative (SRMI), Rockefeller Foundation, GCF, and Global Infrastructure Facility.	$400 million	Current focus is the DRC, with plans to expand to other countries. Long term goal is to electrify more than 100 cities in Africa
Digital and Energy Connectivity for Inclusion in Madagascar (DECIM) Programme	The DECIM programme will deploy targeted infrastructure investments and mobilise private capital to address critical gaps in energy and digital connectivity.	$400 million	Madagascar

The magnitude of these commitments is encouraging for the sector and could portend a step-change in speed and scale if administered efficiently and effectively. In particular, it is helpful to see follow-on extensions of landmark programmes—as is the case with the DARES announcement in Nigeria—which allows the sector to avoid "stop-start scenarios" and maintain momentum and the ecosystem of services that help propel the sector. Furthermore, donors contributing to *expand existing programmes and facilities that are already successful,* rather than re-creating the wheel by establishing new and competing, is a welcome trend. The recent funding increase to CEI Africa,[22] the expansion of the Universal Energy Facility (UEF) into Zambia with support from the Rockefeller Foundation and GEAPP,[23] and the interest of Japan International Cooperation Agency (JICA) in contributing to the DARES funding envelope are all examples of this trend.[24]

Launching concessional finance programmes with sufficient scale and/or topping up existing successful facilities helps minigrid developers access concessional finance with greater ease, harmonising the administrative burden on these companies to apply for and report against grant progress, and it rewards fund administrators who have established skills and track record in effectively deploying funds to the sector.

4.3 Commercial funding

To successfully deploy minigrids at scale and ensure their long-term sustainability, minigrid developers need a well-structured mix of funding sources. This mix should include commercial financing to complement public and concessional funding. Commercial financing is crucial as it provides the necessary capital for large-scale deployment and encourages efficiency and innovation by involving private sector expertise. However, the minigrid sector in Africa faces challenges

To successfully deploy minigrids at scale and ensure their long-term sustainability, minigrid developers need a well-structured mix of funding sources. This mix should include commercial financing to complement public and concessional funding.

22 CEI Africa Receives EUR 24 Million from KfW to Boost Clean Energy Access.

23 Universal Energy Facility Launches Financing Mechanism to Expand Energy Access in Zambia.

24 JICA Conducts Fact-Finding Mission to Advance DARES Support.

in attracting commercial capital, despite the growing demand for decentralised energy solutions.

Key stakeholders such as AMDA, UNDP, AfDB, Global Environment Facility (GEF), and philanthropic organisations and impact investors like the Shell Foundation, All-On, GAIA Impact Fund, Schmidt Family Foundation, the Renewable Energy Performance Platform (REPP), DOEN Foundation, and Good Energies have played vital roles in de-risking investments. Developers, including Husk Power Systems, Energicity, GVE, PowerGen, Darway Coast, Nuru Energy, and others, have accessed commercial funding to scale operations and demonstrate the sector's viability. Commercial financiers such as IFC, E3 Capital, and Voltalia have been key players in funding minigrid projects across Africa. Public funding schemes, such as RBF and guarantees, have further helped bridge the financing gap. Consequently, recent years have witnessed a notable increase in participation from strategic financiers such as utilities, oil majors, international banks, and trading houses in the minigrid sector—including Shell, TotalEnergies, EDF, and Sumitomo Corporation. This development reflects growing confidence in the commercial viability of minigrid projects and a gradual shift towards more sustainable business models supported by broader investor interest.

In 2023, the industry witnessed the largest-ever equity raise by a private developer, Husk Power. The company successfully closed a $43 million Series D equity funding round, led by STOA Infra & Energy, with participation from the U.S. International Development Finance Corporation (DFC) and Proparco, alongside existing investors such as Shell Ventures, Swedfund, and FMO. Additionally, the company secured $60 million in debt financing from institutions, including the European Investment Bank (EIB) and the IFC, bringing the total funding to $103 million.[25] In the same year, Nuru announced the successful close of over $40 million in Series B equity funding and anticipated the close of an additional $28 million in project finance. This financing was provided by market-leading equity investors, including the IFC, REPP, Proparco, E3 Capital, Voltalia, the Schmidt Family Foundation, GAIA Impact Fund, GEAPP, and the Joseph Family Foundation. Additionally, IFC's equity investment includes financing from the Finland-IFC Blended Finance for Climate Program.[26]

In 2019, the AfDB launched its debt financing facility, the Facility for Energy Inclusion (FEI), a platform supported by the AfDB, KfW, Norfund, European Union, OeEB, IFC and Clean Technology Fund (CTF) to provide commercial debt to small-scale renewable energy projects with a strong focus on minigrids. The $400 million facility has since supported several minigrid projects across the continent.[27] In June 2023, FEI's most significant debt funding of $30 million was provided to CrossBoundary Energy Access (CBEA)[28] to enhance its energy access portfolios in underserved communities. This financing complemented a 2022 blended financing round of $25 million, which included both equity and concessional capital raised by ARCH Emerging Markets Partners Limited, Bank of America, and Microsoft Climate Innovation Fund.

In 2019, the AfDB launched its debt financing facility, the Facility for Energy Inclusion (FEI), a platform supported by the AfDB, KfW, Norfund, European Union, OeEB, IFC and Clean Technology Fund (CTF) to provide commercial debt to small-scale renewable energy projects with a strong focus on minigrids.

[25] Husk Power Secures $100 Million in Equity and Debt to Supercharge Growth of Community Solar Minigrids in Rural Sub-Saharan Africa and South Asia.

[26] Nuru Closes over $40 million of Equity Funding to Drive Metrogrid Scaling in the Democratic Republic of the Congo.

[27] 5 years on from the launch of Green Mini-Grids Africa – what's been achieved, and what have we learned?

[28] CrossBoundary Energy raises US$50 million from FEI to advance C&I portfolio across Africa.

Blended financing options appeal to developers as this model combines public and private investments to reduce risks and attract commercial capital. For instance, the Beyond the Grid Fund for Africa (BGFA) uses blended finance to support minigrids across Liberia, Mozambique, Uganda, DRC, and Zambia. The fund secured around €48 million from the Swedish International Development Cooperation Agency (Sida) to support energy access projects in these countries.[29] CrossBoundary Energy Access (CBEA) received $10 million in concessional debt from SEFA as part of an overall $35 million blended facility they raised.

While several commercial financing options exist, blended financing is vital in scaling up minigrid projects across Africa. The Climate Finance Blending Facility exemplifies how public and private partnerships can de-risk investments in minigrids. Integrating public concessional funding with private sector financing enhances the commercial attractiveness of minigrid projects. This approach ensures financial sustainability while scaling up access to clean energy in underserved regions. Specifically, the Climate Finance Blending Facility, backed by £10 million from the UK's FCDO, collaborates with InfraCredit's guarantees to mobilise local currency debt for off-grid initiatives in Nigeria, including the deployment of solar minigrids.[30]

The Climate Finance Blending Facility exemplifies how public and private partnerships can de-risk investments in minigrids. Integrating public concessional funding with private sector financing enhances the commercial attractiveness of minigrid projects.

4.4 Other emerging financing types

Emerging financing types play a crucial role in the development of minigrids in Africa. These financing mechanisms address the significant capital requirements needed to construct and operate minigrid projects, including purchasing equipment and materials.

DART programme: The Demand Aggregation for Renewable Technologies (DART) Programme combines demand pooling, aggregated procurement of solar equipment, and access to affordable finance to unlock economies of scale for solar companies, achieve cost savings for end-users, and accelerate the growth of the renewable energy sector. Launched in 2022 in Nigeria with backing from GEAPP, DART quickly expanded from a $10 million programme to $25 million due to the robust demand from DRE companies.[31] In this model, Nigerian impact investment company All-On provides funding while Odyssey Energy Solutions handles aggregated procurement of the equipment being financed. DART has been able to achieve 5-20% savings on CAPEX costs depending on the particular component procured.

Procurement & construction credit for EPCs and developers: Beyond Nigeria, Odyssey Energy Solutions' Construction Credit product offers a flexible working capital solution for Engineering, Procurement, and Construction (EPCs) and minigrid developers, enabling them to place equipment orders immediately and repay the balance either upon delivery or at the point that they receive payment. This off-balance sheet credit facility allows developers to streamline project timelines and match repayments to their own payment milestones, thus stabilising cashflows.

Blended finance: Although not an emerging financing type, blended finance is another finance approach that combines public, private, and philanthropic capital to mitigate investment risks and attract private investors. For example,

[29] Funding rounds by BGFA.

[30] Local Currency Blended Climate Finance for Renewable Energy Access in Nigeria.

[31] COP28: DART Program in Nigeria to hit $25m

CrossBoundary Access developed a model attracting $10 million from the African Development Bank's Sustainable Fund for Africa (SEFA), showcasing effective blended finance for minigrids.[32] Other examples include Convergence's $175 million blended fund for minigrid developers in Sub-Saharan Africa[33] and InfraCredit's Climate Finance Blending Facility, which leverages donor funding to offer a first-loss guarantee and successfully supported the successful close of a ₦1.55 billion (c. $2m) transaction for ACOB Lighting Technology Limited, and CEI Africa's Crowdlending Windows leverage €64.5 million to support the off-grid sector through a blended mix of senior debt, subordinated debt, guarantees, equity, quasi-equity, and technical assistance.

***Renewable energy credits (RECs)*:** RECs are a market instrument representing 1 MWh of renewable energy production and offering an additional revenue stream for minigrids by monetising their renewable energy production. This additional revenue stream can enhance project viability while advancing renewable energy access and climate goals. In some cases, additional attributes can increase the value of the credits. For instance, peace renewable energy credits (P-RECs) support renewable energy projects in conflict zones by certifying electricity from sustainable sources. This innovative financing mechanism is another source of financing for minigrid developers, exclusively in conflict zones. An example is the Democratic Republic of Congo, where Microsoft purchased P-RECs issued by Energy Peace Partners from Nuru's 1.3 MW minigrid.[34] The D-REC Initiative is similarly developing a specific label to account for RECS from distributed energy assets.

***Grant payments as security*:** Structuring grant payments through escrow accounts or similar mechanisms to provide security against commercial financing is another innovation that could address key challenges in funding capital-intensive projects like minigrids and leveraging the proliferation of Results-Based Financing (RBF) programmes announced for the sector. By agreeing to make grant payments to third-party accounts for financiers, this mechanism creates a financial guarantee that mitigates risks for commercial lenders, making them more willing to extend credit to minigrid developers. The funds in escrow act as collateral or a repayment cushion, ensuring that banks have a safety net if the borrower defaults. Although limited in practice, funders could integrate this into the design of minigrid programmes to crowd in commercial lenders.

4.5 Key insights

Investment requirements for the sector

- AMDA members report ambition to deploy over 6,000 minigrids in the next five years, aspiring to $2.3 billion in financing; fulfilling this pipeline will require a step change in financing deployments.
- Concessional funding, grants, and subsidies are essential to bridge the financial viability gap, reduce connection costs, and lower tariffs to ensure affordability for low-income communities. Significant grant financing will be necessary to fulfil the projected pipeline reported by AMDA members.

[32] CrossBoundary Access' blended finance model attracts $10 million for n=mini-grids from AfDB's Sustainable Energy Fund for Africa (SEFA).

[33] Design of a Blended Finance Project for investing in agricultural technology and mini-grid companies in Sub-Saharan Africa.

[34] First-ever Peace REC (P-REC) transaction drives renewable energy development in Africa.

- Pooling resources into existing Pan-African vehicles that have proven effective at deploying such funding should be a priority and a rallying point for donors and DFIs.
- Creation of a *first-loss equity facility* that will bridge the construction risk that traditional equity is more and more reluctant to take in this asset class. This would enable the construction of minigrid projects and see them through the first 3-5 years of operation before refinancing paves the way for more traditional equity.
- Long-term patient capital that fits with this asset class, e.g. Pension Funds, dedicated infrastructure PE funds, etc.

Emerging financing options

- Emerging financing options include working capital, construction, and procurement credit, which are crucial for addressing capital needs. These are effective credit options for efficient project execution and financial management with a short turnaround time.

5 Costs

Photo Credit: PowerHut Renewables-Tanzania.

5 Costs

This section provides an overview of the CAPEX and OPEX of minigrids in Africa. It highlights a global trend of declining CAPEX while emphasising regional differences in cost structures and efficiencies. OPEX has also decreased due to scale and technological advances. Additionally, the section explores the cost of different generation technologies, such as solar PV and hybrid systems, emphasising how mesh-grid technology offers a cost-effective solution to complement minigrids in low-density communities.

The capacity of minigrids to deliver affordable and reliable electricity to rural communities in Africa depends heavily on their CAPEX and operational costs (OPEX). These costs are influenced by the technology used, the scale of the project, global market prices for components, and the amount of subsidy provided.

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5.1 CAPEX trends

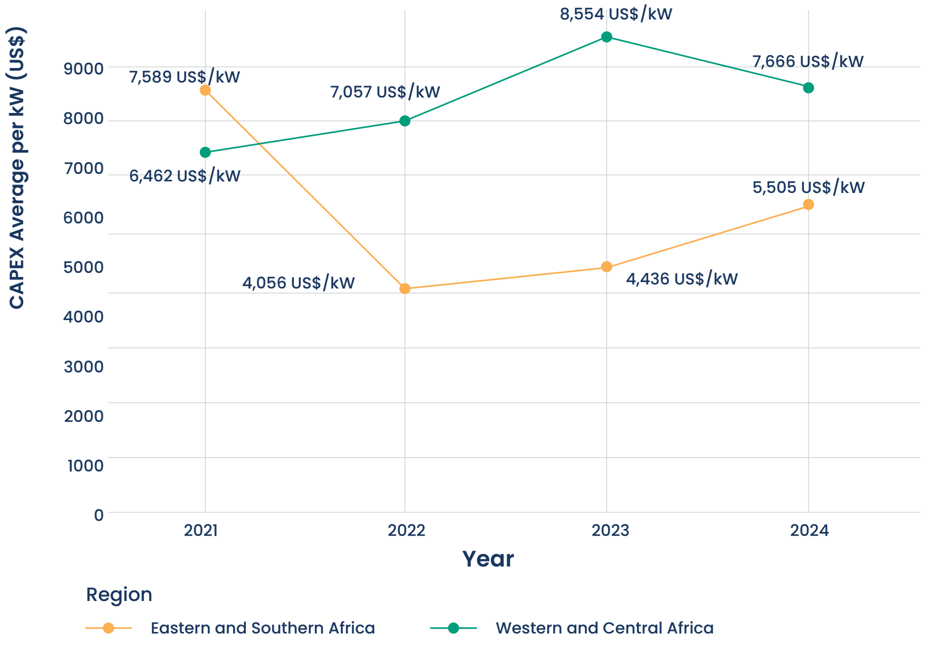
CAPEX encompasses all expenses related to the installation of a minigrid, including costs incurred from conception through all pre-site development activities until the installation of metres at consumers' premises. Several factors can contribute to a reduction in CAPEX for minigrid developers, including but not limited to improved technology, economies of scale, developers' experience and expertise, supportive government policies, local manufacturing and assembly of components, efficient supply chain systems, and access to affordable financing options. Thus, this analysis looks at the following sub-categories for CAPEX:

- **Generation assets:** this includes the cost and installation of PV panels, batteries, diesel generators, and other essential generation assets;
- **Distribution assets:** this includes costs of wiring, insulation, and safety equipment related to distributing electricity to the end-users;
- **Supply chain:** includes costs related to the transportation of components, logistics, and storage at all stages of the development process;
- **Metering and termination:** this includes costs of metres, internal electrical wiring, basic power kits, and other costs associated with connecting the system to a customer;
- **Site development:** includes costs of acquiring the site, preparation, regulatory approvals, licenses, and all associated costs; and
- **Taxes and duties:** includes all taxes paid for importing components, including value-added taxes.

CAPEX has evolved over the past four years. Our 2022 BAM report revealed a modest increase in CAPEX in 2020 compared to 2019, with the average total reaching just over $8,500 per kWp, including distribution costs. This reflected a 2.5% increase from the previous year. However, SEforALL's 2024 State of the Minigrid report indicates that CAPEX per kWp for minigrids remained relatively stable from 2021 to 2024, averaging around $3,000 globally and dropping to $2,200 per kWp in 2024. In contrast, while CAPEX costs reported by AMDA members moderated somewhat from the 2020 levels, the cost levels remain significantly higher than global benchmarks.

As shown in Figure 11, CAPEX has followed an upward trend from 2022 to 2024 despite technological advancements and operational efficiencies. This increase is likely driven by several factors, including currency fluctuations, a higher ratio of battery energy storage system (BESS) capacity to kWp, supply chain bottlenecks, and rising shipping costs. However, the four-year rolling average now stands at $6,807 per kWp, reflecting a modest decline compared to the 2022 BAM report, which reported an average of $7,330 per kWp. This suggests that while structural challenges continue to exert upward pressure on costs, long-term cost reductions are still materialising, albeit at a slower pace.

Figure 11: New minigrid CAPEX trends from 2021 to 2024



A detailed analysis revealed notable regional disparities across Africa. In Eastern and Southern Africa, the four-year average CAPEX stands at approximately $5,775 per kWp. In contrast, Western and Central Africa face significantly higher costs, with an average of $7,209 per kWp. These differences are influenced by factors such as logistical challenges, varying infrastructure development levels, and regional market conditions.[35]

Although the CAPEX per kWp is lower in Eastern and Southern Africa, the CAPEX per connection is 46% higher. This is largely attributed to larger-scale systems serving larger communities in Western and Central Africa versus more dispersed underserved communities that require a higher cost per connection to bring electricity to Eastern and Southern Africa. CAPEX trends vary by region due to unique challenges. In West and Central Africa, peri-urban mini-grids benefit from existing infrastructure and higher population density, lowering per-connection costs. Eastern and Southern Africa, however, face higher CAPEX per connection due to remote, dispersed communities and logistical hurdles. Targeted solutions—better logistics, streamlined regulations, and infrastructure improvements—are key to reducing costs and ensuring mini-grid viability. Figures 12 and 13 provide a detailed visual representation of this data.

[35] It is important to note that Nigeria's extensive mini-grid development significantly skews the West African average upwards. Nigeria's concessional funding environment and market scale have enabled mini-grid deployments with higher CAPEX but larger economies of scale, which may not reflect the broader West and Central African market.

Figure 12: Average CAPEX per kWp and per connection per region

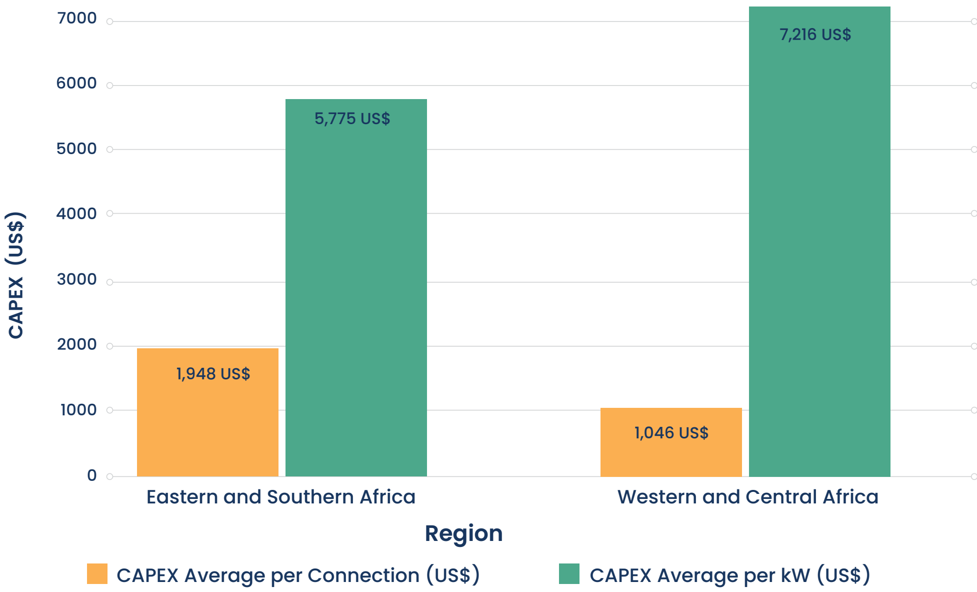
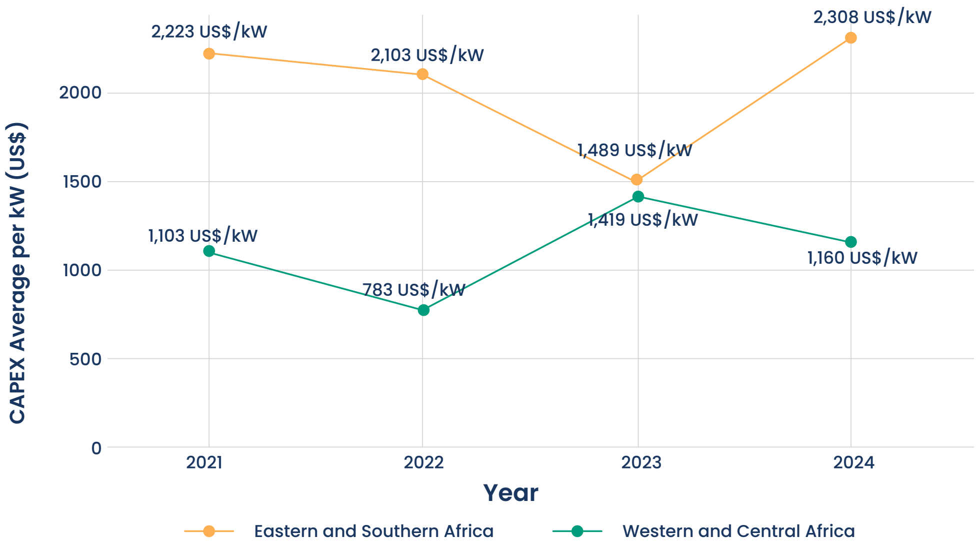


Figure 13: Average CAPEX per kWp 2021-2024 per region



5.2 OPEX trends

OPEX are the costs minigrid operators incur through the normal day-to-day operation of their sites, such as salaries and wages, repairs and maintenance, and office supplies. While some costs are fixed, others are variable depending on the utilisation of the site, such as fuel for backup generators.

In recent years, minigrid OPEX costs have moderated significantly, primarily due to enhanced cost efficiency. In 2019, ESMAP reported that across 18 minigrid systems (seven in Asia and 11 in Africa), the OPEX per connection ranged from $8 to $263 annually, with an average of $80. Most of these costs (76%) were attributed to staff expenses, while fuel costs made up 4.3%, equating to around $8.30 per customer annually. Other operational and maintenance (O&M) costs, including transportation and community engagement, represented 20% of the total expenses.[36]

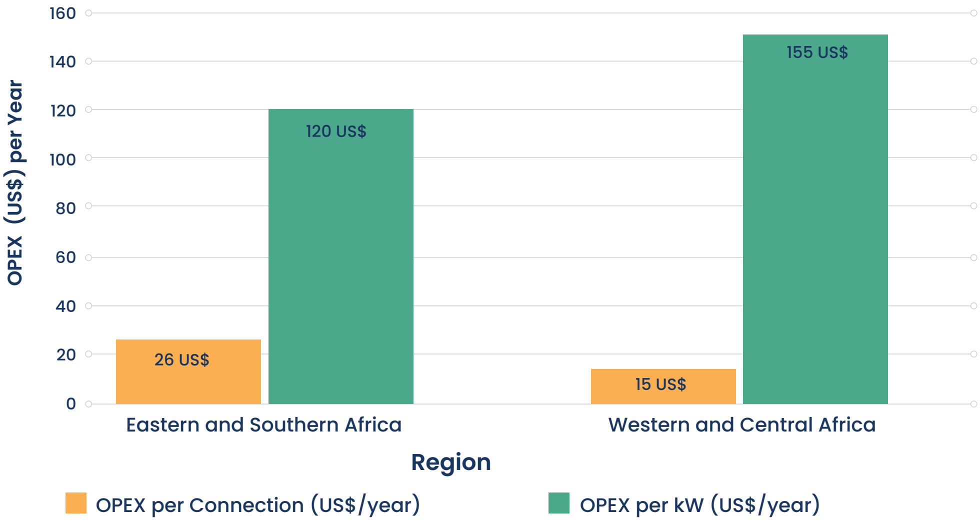
In recent years, minigrid OPEX costs have moderated significantly, primarily due to enhanced cost efficiency. In 2019, ESMAP reported that across 18 minigrid systems, the OPEX per connection ranged from $8 to $263 annually, with an average of $80.

[36] Mini Grids for half a Billion People: market Outlook and Handbook for Decision Makers.

Our 2022 BAM report revealed a notable reduction in annual OPEX per connection, dropping to $12-$48 per connection in 2021—a 30% to 60% decrease compared to 2019 figures of $30-$72 per connection. This reduction was largely due to economies of scale and operational improvements as minigrid projects matured. This trend suggests that as minigrids expand, they become more sustainable, reducing costs and improving their long-term viability.

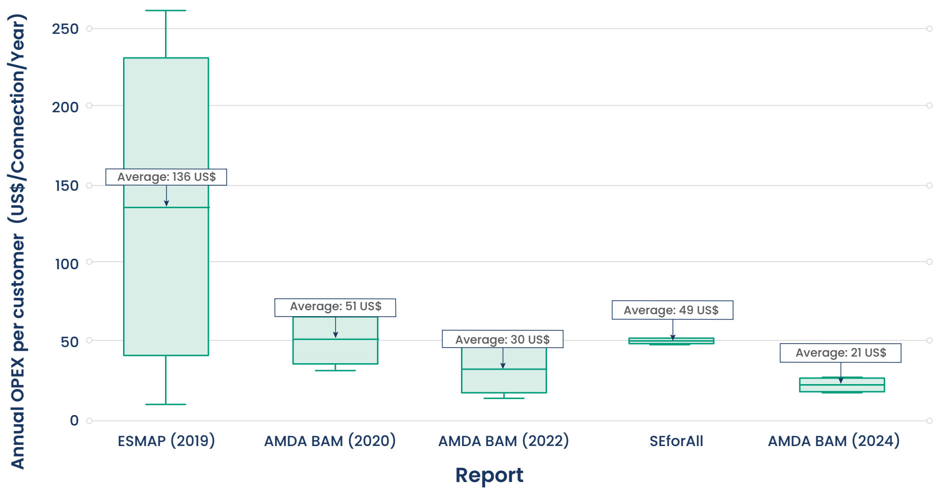
As depicted in Figure 14, the 2024 BAM report shows that OPEX costs remain low, ranging from an average of $16 per connection per year in Western and Central Africa to an average of $26 per connection per year in Eastern and Southern Africa. This reflects improved efficiency and cost management in the minigrid sector as technology evolves and digital solutions are mainstreamed into the operations of minigrid sites.

Figure 14: OPEX across regions



As captured in Figure 15, the evolution of annual OPEX per customer in the minigrid sector demonstrates a consistent trend toward cost optimisation. Starting with a global range of $8 to $263 in 2019, subsequent reports from AMDA and SEforALL highlight gradual cost reductions, narrowing OPEX to $30-$72 in 2020 and $12-$48 in 2022.

Figure 15: Evolution of OPEX from 2019 to 2024



Costs associated with diesel-hybrid and PV-battery generation differ significantly due to the nature of the technologies involved. Globally, diesel-hybrid systems typically have lower initial CAPEX ($1,500 to $2,500 per kW[37]) but higher OPEX costs ($0.30 to $0.50 per kWh[38]) than PV-battery systems due to fuel expenses and maintenance. The costs of diesel-hybrid may also include environmental impacts due to the greenhouse gas emissions. PV-battery systems have higher initial CAPEX ranging from $3,000 to $4,500 per kW.[39] However, they are cost-competitive against diesel hybrids in the long term due to lower OPEX ($0.10 to $0.20 per kWh) offsetting higher CAPEX.

As shown in Table 5, OPEX for minigrid systems differs by configuration. Diesel hybrid systems have consistently higher OPEX due to ongoing fuel costs and frequent maintenance from mechanical wear and tear. In contrast, solar PV-battery systems incur minimal operating costs post-installation.

Table 5: OPEX comparison per technology type

Aspects	PV + BESS Only	PV + BESS + Diesel hybrid
OPEX per KW	137 $/kW	155 $/kW

5.3 Cost reduction through mesh-grids

Mesh-grids are decentralised networks of interconnected solar home systems (SHS) that share power through a 50V Direct Current (DC) line, improving energy efficiency and reliability. In Okra's Hub-and-Spoke model, each household has its own solar PV and battery system, with surplus energy automatically distributed across a modular low-voltage DC network. Despite the DC distribution, households receive Alternating Current (AC) power output, enabling productive use and maximising asset utilisation compared to standalone SHS.

Complementary to minigrids, mesh-grids can be more cost-effective models in certain contexts, particularly for last-mile and low-density communities that still want to benefit from the productive use of energy. Where mini-grids are clearly becoming the winner for large, densely populated peri-urban communities, mesh-grids are rapidly doing the same in more sparsely populated isolated communities.

Implementing mesh-grids technology has demonstrated significant cost reductions in both CAPEX and OPEX for rural electrification projects in terms of their low initial investment requirement, scalability, and operational efficiency. For instance, Okra Solar's Hub & Spoke mesh-grids model has led to over 30% reduction in per-connection costs.[40] This reduction is primarily due to the modularity of mesh-grids, which allow for shared use of large systems by multiple homes, thereby minimising the need for individual installed assets.

Implementing mesh-grids technology has demonstrated significant cost reductions in both CAPEX and OPEX for rural electrification projects in terms of their low initial investment requirement, scalability, and operational efficiency.

[37] Benchmarking Study of Solar PV Mini Grids Investment Costs.

[38] Optimal integration of Photovoltaic in Micro-grids that are dominated by diesel power-plants: recommendations for utilities and consulting engineers.

[39] Benchmarking Study of Solar PV Mini Grids Investment Costs.

[40] One Year later: How Alina Eneji saved 40% pre connection using a Hub & Spoke mesh-grid: A Case Study.

Mesh-grids have been deployed in rural areas with low population densities in Tanzania, Nigeria, Kenya, Haiti, and Bangladesh. These projects have shown that mesh-grids can provide reliable electricity at a lower cost per connection than traditional minigrids.[41]

When evaluating cost-effectiveness, mesh-grids offer competitive utility per dollar because they are designed to meet the specific needs of last-mile communities.

Mesh-grids and minigrids are both technologies tailored to different contexts. Minigrids are suitable for communities where energy demand is steady and predictable. Conversely, mesh-grids are more suitable for smaller, remote, or sparsely populated areas due to their safe, low-voltage distribution modular and adaptable design. As such, minigrids and mesh-grids can play complementary roles in addressing energy access gaps, particularly in remote or underserved regions.

5.4 Key insights

- **CAPEX trends:**
  - While global CAPEX for minigrids has decreased significantly, data from our BAM report show CAPEX remain well above global benchmarks (a three-year running average of $6,807 per kWp compared to the global average of $2,200 per kWp).
  - Regional disparities remain. Eastern and Southern Africa report lower CAPEX per kWp ($5,775), whereas Western and Central Africa face higher costs ($7,209), largely due to logistical challenges and market conditions.
- **OPEX trends:**
  - OPEX per customer has steadily declined, with averages ranging from $16 to $26 annually in 2024, down from $80 in 2019. This reflects operational efficiencies and scaling benefits.

[41] Benchmarking and comparing effectiveness of mini-grid encroachment regulations of 24 African countries: A guide for governments and energy regulators to develop effective encroachment regulations.

6 Consumption and Demand Trends

Photo Credit: Hydrobox-Kenya.

6 Consumption and Demand Trends

This section reports the findings gathered from AMDA members on electricity consumption at their sites from 2021 to 2024, highlighting a growing demand driven by both residential and commercial users. It highlights an increasing trend in average consumption, with regional differences observed across Africa, especially in areas with established minigrid networks. Additionally, it underscores the impact of the productive use of electricity, such as agriculture and manufacturing, on electricity demand.

6.1 Consumption per user

In 2024, the average monthly consumption per user was 16.6 kWh/month, a significant increase from 2022 BAM figures, which showed an average of 6.2 kWh/month for newly built sites and 10 kWh/month for sites over two years old. Residential consumption averaged just under 7 kWh/month, whereas commercial consumption stood at just over 26 kWh/month.

Western and Central Africa show higher average consumption per user, possibly driven by the heavy representation of Nigeria-based minigrids, which are more likely to be peri-urban/represent denser commercial clusters relative to other geographies. Table 6 indicates that the average energy consumption per user in Western and Central Africa is higher and stands at approximately 24 kWh per month. Average consumption per user in Eastern and Southern Africa averages 10 kWh per month, highlighting the presence of newer minigrid sites with limited use of productive appliances, where demand has not yet fully developed.

Western and Central Africa show higher average consumption per user, possibly driven by the heavy representation of Nigeria-based minigrids, which are more likely to be peri-urban/represent denser commercial clusters relative to other geographies.

Table 6: Minigrid monthly electricity consumption per user by region

Aspects	Eastern and Southern Africa	Western and Central Africa
Monthly ACPU	10 kWh/month	24 kWh/month

6.2 Consumption patterns

To understand the consumption patterns, users were divided into two main categories: residential and commercial. Consumption varies significantly across these two user groups, and each group contributes differently to the overall electricity demand.

- *Residential users:* These users form the largest segment of minigrid electricity consumers. Their consumption is primarily driven by basic needs such as lighting, phone charging, and small household appliances (e.g., fans, TVs, and radio sets), which are essential for improving quality of life. Residential users account for 86% in Eastern and Southern Africa and 91% in Western and Central Africa. As shown in Table 7 below, the average consumption per user across regions ranges from 6-8 kWh per month. The price of electricity across user segments ranges from $0.24 to $0.40 per kWh, depending on the region and the specific minigrid operator.

- ***Commercial users***: Commercial users include small businesses and entrepreneurs who primarily use electricity to refrigerate perishable goods, milling grains, welding, beauty salons, small-scale manufacturing, and other productive activities. These activities increase electricity consumption and drive economic growth by enabling businesses to operate efficiently and profitably. According to respondents for this study, commercial users account for about 9 - 14% of electricity consumption from minigrids, and the average consumption per user ranges from 13-40 kWh per month. The disparity in commercial consumption by region is notable and presents a fruitful topic for further research.

Table 7: Average monthly electricity consumption by region and customer category

Customer Category	Eastern and Southern Africa	Western and Central Africa
Residential (ACPU)	6 kWh	8.1 kWh
Commercial (ACPU)	13.1 kWh	39.8 kWh

6.3 Average revenue

Our analysis based on AMDA member responses indicates a decline in the average revenue per user (ARPU) since 2020, which was approximately $5 per customer per month and now stands at $3.16 per customer per month. It should be noted that the findings reported higher consumption levels relative to the previous BAM report, which nevertheless does not result in higher revenue per user figures—suggesting perhaps a change in how companies calculate reporting revenue over the different reporting periods or the impact of currency devaluations over time.

Table 8 provides the current trends in ARPU across the various regions. The current ARPU averages $2.5 for residential consumers and $5.2 for commercial consumers in Eastern and Southern Africa, while in Western and Central Africa, it is $2.0 for residential consumers and $10 for commercial consumers. These variations reflect differences in electricity pricing, consumption patterns, and regional economic activities.

Table 8: ARPU for residential and commercial users

Region	Eastern and Southern Africa	Western and Central Africa
Household (ARPU)	$2.5	$2.0
Business (ARPU)	$5.2	$10.0

Revenue for minigrid companies is driven by electricity sales, connection fees, and potentially other diversified services that the company may provide to the community. Tariffs define the price at which electricity is sold, constituting the bulk of ongoing revenue for the average minigrid company.

As reported by AMDA members, tariffs do not differ significantly, if at all, between residential and commercial users. In Eastern and Southern Africa, the average tariff is $0.40/kWh for residential consumers and $0.38 for commercial. In Western and Central Africa, the average tariff is $0.25/kWh for both residential and commercial users.

6.4 Growing the load

Growing the load of minigrids is essential for ensuring their financial viability and maximising their impact on local communities. Based on insights from various reports and case studies, developers have adopted several strategies to stimulate demand and increase electricity consumption on minigrids.

- ***Offering appliance financing:*** CrossBoundary's Minigrid Innovation Lab has made a strong case for the productive use of energy, particularly through its pioneering Appliance Financing prototype. Data collected from 25 sites and over 12,000 connections over the last four years reveals that sites offering appliance financing experience a 48% higher Average Consumption Per User (ACPU). Notably, the top 20% of appliance financing users consume 16 times more energy than their peers by leveraging appliances that meet essential community needs, such as grain mills and other productive-use equipment. These appliances drive local economic activity and significantly increase electricity demand, making the minigrid model more financially sustainable. This approach demonstrates the critical role that productive use appliances play in stimulating demand, boosting energy consumption, and ultimately improving the profitability of minigrids. By targeting key local needs, the CrossBoundary Innovation Lab has shown that appliance financing can unlock the full potential of renewable energy in underserved communities, contributing to a sustainable energy ecosystem while promoting economic development.[42]
- ***PUE loan programmes:*** Various lenders provide loans for productive uses of electricity (PUE), supporting a broader ecosystem of appliances and entrepreneurship, especially for women and youth in communities served by mini-grids. These loan programmes are often facilitated by mini-grid operators in partnership with local banks, credit unions, or microfinance institutions. Notably, rural electric cooperative development programs have incorporated PUE lending as a key component of integrated rural economic development and industrialisation strategies, offering comprehensive support services to mini-grid users.
- ***Partnerships with local businesses:*** Forming partnerships with local businesses can also help to integrate minigrid electricity into various economic activities. Collaborating with agricultural cooperatives, small manufacturers, and service providers can create a steady demand for electricity.

Sector-specific demand stimulation practices have also yielded results, such as in the agriculture and services sectors:

- ***Agriculture sector:*** The introduction of solar-powered irrigation systems in Nigeria has increased the agricultural yields of rural farmers by about 20%.[43] Cold storage facilities are dramatically extending the shelf life of perishable agricultural produce. For example, the Energising Agriculture Project (EAP) in Nigeria, launched in 2022 (a collaboration between REA, RMI, and GEAPP), is working with cold storage providers and minigrid-connected communities to introduce cold storage systems in the forms of electric refrigeration and freezers to reduce post-harvest losses and increase fishers' income by 30%

[42] Appliances Financing 3.0 Innovation Insight: Cheap, reliable power is the catalyst for driving consumption.

[43] ISS report on African Futures.

per catch.[44] EAP has also piloted the use of electric motorcycles for agricultural extension services in Niger State and Kaduna State in Nigeria. EVs charged via solar minigrids have cut fuel costs by up to 75% compared to petrol bikes.[45]

- ***Services sector:*** In DRC, Nuru launched a 1.3 MW minigrid and provides power to small businesses, including barber shops, internet cafes, and retail stores, which has led to increased business hours and diversified services for these enterprises. Data centres and telecommunication towers are also attractive to clients in need of reliable power in locations outside of major city centres. There are also asset-financing companies, such as EnerGrow in Uganda, whose business model supports the activities of minigrid operators.

6.5 Driving industrial growth through minigrids

Minigrids have the potential not only to support small businesses and households but also to catalyse industrial growth and transformative economic development. To increase electricity demand and enhance capacity utilisation at minigrid sites, it is essential to address demand-side factors and explore opportunities beyond traditional productive uses. Productive applications, such as powering small industries and agricultural processing equipment, have proven highly effective in driving electricity consumption. For example, a grain mill operator on a minigrid site uses approximately 300 kWh of electricity per month, equivalent to 100 typical residential customers who consume an average of just 3 kWh/month.

Industrial appliances, such as grain mills with power ratings ranging from 1 to 10 kW, consume substantially more electricity than commercial fridges (50–100 watts) or household TVs (30–50 watts). These high-energy-consuming appliances often operate during daytime hours when solar electricity is abundant and more affordable, especially under time-of-use (TOU) pricing structures. Implementing TOU tariffs allows minigrids to leverage peak solar production during the day to support industrial loads, increasing grid profitability[46] and improving overall system efficiency.

Minigrids can also be pivotal in advancing rural industrialization by supporting small manufacturing units, cold storage facilities, agro-processing plants, and, recently, a rapidly growing e-mobility growth. Minigrids are well-positioned to drive the e-mobility revolution in Africa, offering a sustainable solution to rural transportation challenges while increasing electricity demand. Green electricity generated from minigrids can power electric vehicles (EVs), such as motorcycles, tricycles, and small vehicles commonly used in rural areas, providing an eco-friendly and affordable mobility option.

Minigrids can also be pivotal in advancing rural industrialization by supporting small manufacturing units, cold storage facilities, agro-processing plants, and, recently, a rapidly growing e-mobility growth.

[44] Energizing Agriculture Through Productive Uses of Energy: The REA-RMI Nigeria Energizing Agriculture programme (EAP) is revolutionizing the way rural communities use electricity in agriculture.

[45] As Petrol Prices Climb, Nigerian Agriculture Extension Officers Cut Fuel Costs With Electric Motorbikes.

[46] Study Design: Appliances Financing 3.0 Energy-Efficient productive use 2020.

For instance, Energicity Corp, through its subsidiary Power Leone, launched a rural e-mobility programme in Sierra Leone in May 2024. This initiative, which utilises solar minigrid-generated electricity to charge electric bikes, addresses significant mobility challenges in rural areas. Energicity aims to scale this programme across its minigrids in West Africa, targeting over 1,000 customers. This approach increases electricity consumption and creates opportunities for local entrepreneurs to operate e-mobility charging stations, enhancing the economic viability of minigrids while promoting sustainable economic development.[47]

6.6 Key insights

Electricity consumption from minigrids has steadily increased since 2020. Western and Central Africa show higher levels of monthly consumption per user. Revenue per user levels have decreased from previous BAM periods. However, this trend may be mitigated somewhat by the corresponding trend of larger communities being served by minigrids.

Productive use of electricity (PUE) has been crucial in growing the load and stimulating demand. Successful case studies have demonstrated the impact of these on small businesses across the continent.

Minigrids, when integrated with productive use models, can **transform rural economies** by creating robust demand for electricity and driving sustainable development.

[47] Energicity Launches Rural E-Mobility Program in Sierra Leone.

7 Policy and Regulation

Photo Credit: Engie Energy Access-Benin.

7 Policy and Regulation

This section delves into Policy and Regulation, focusing on the licensing and regulatory frameworks shaping the minigrid sector in Sub-Saharan Africa. It examines licensing and regulatory timelines, analysing how policy frameworks impact the speed of minigrid deployment and their operational sustainability.

The regulatory landscape significantly impacts investments in minigrids in Africa. A favourable regulatory environment is crucial for attracting private investments and ensuring the success of minigrid projects. Effective regulatory frameworks ensure clear guidelines and reduce uncertainties, which is essential for investor confidence.[48] Unfortunately, many African countries lack dedicated laws and regulations for minigrids, creating a challenging environment for investors.[49] As such, the minigrid sector in Africa struggles to scale up due to regulatory hurdles despite the growth potential. These challenges include lengthy approval processes for licensing or permitting and tariffs, high costs of compliance, and lack of standardised procedures, which can impede the expansion of minigrid projects.[50]

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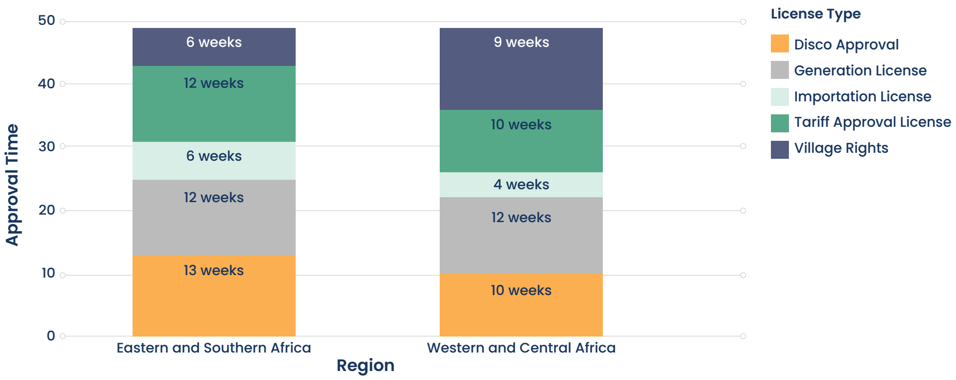
7.1 Licensing and regulatory timelines

Despite extensive efforts to enhance regulatory frameworks on the continent, significant gaps persist, as highlighted by the current study. Although certain regions have achieved notable improvements, challenges remain in others where regulatory reforms still need to be improved. Figure 16 illustrates the differences in regulatory approval timelines between Eastern and Southern Africa and Western and Central Africa. Western and Central Africa faces notably extended regulatory approval timelines, notably tariff approval. The tariff approval process in Western and Central Africa typically takes 17 weeks, compared to 13 weeks in Eastern and Southern Africa. The environmental impact assessment (EIA) approval processes take four weeks in Western and Central Africa, while it requires six weeks in Eastern and Southern Africa. This disparity highlights regional differences in regulatory efficiency, with Eastern and Southern Africa providing an overall quicker pathway to approval.

Figure 16: Evolution of average regulatory compliance timelines



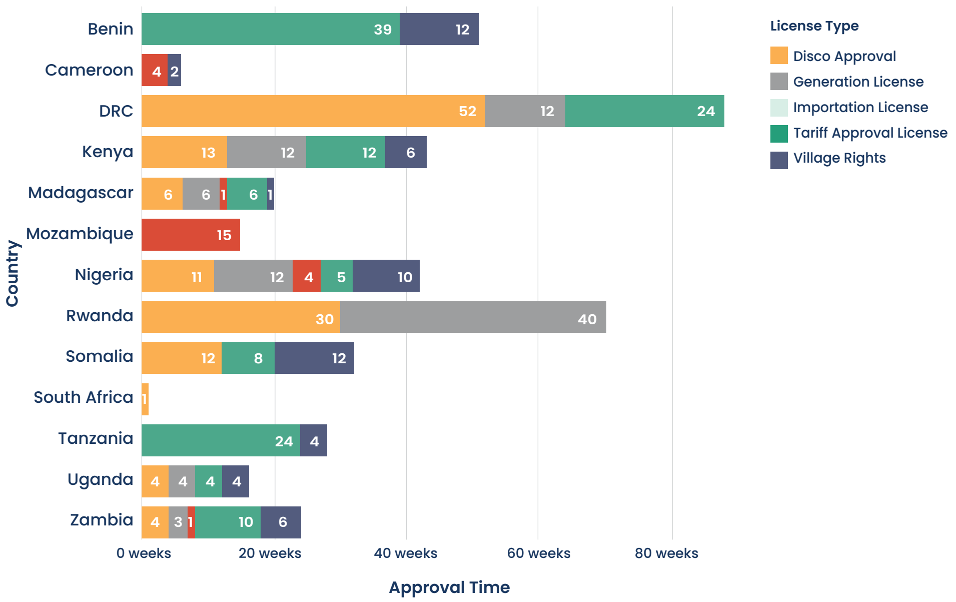
[48] Unlocking Africa's Mini-Grid Market: USAID Scaling Up Renewable Energy Program (SURE).

[49] Legal and compliance information for developers and policymakers of green mini0grids in sSub-Saharan Africa.

[50] Minigrids sector growing energy in Africa access despite regulatory hurdles.

Figure 17 illustrates significant variability in regulatory approval timelines across countries in five categories, with three being particularly key. Disco Approval exhibits the broadest range, with timelines spanning four to 52 weeks, highlighting disparities in regulatory efficiency among jurisdictions. Generation License approvals show significant variability, taking three to 40 weeks to complete, depending on the country. Tariff Approval, while relatively faster, still demonstrates wide variation, requiring four to 39 weeks for completion. The World Bank's projection of 9,000 additional minigrids in Sub-Saharan Africa by 2030 implies a need for 1,500 regulatory approvals annually. While Figure 17 provides valuable insights into regulatory timelines, further analysis is needed to understand how these processes correlate with the actual number of minigrid systems built and the success of different policies in spurring investment.

Figure 17: Licensing and approval processing times per country as of 2024



Simplifying approval steps through digital systems and unified "one-stop-shop" regulatory frameworks could accelerate progress. Without these measures, the target risks becoming unattainable, delaying electrification for underserved communities, and undermining universal access to electricity by 2030.

One successful example worth emulating is the One-Stop-Shop Model implemented under the Nigeria Electrification Project (NEP). This model has streamlined the development process of minigrids by consolidating regulatory approvals and support services into a unified platform, reducing bureaucratic hurdles for developers. Similarly, the African Forum for Utility Regulators (AFUR) has undertaken initiatives to advance minigrid regulatory frameworks in Africa since 2021 by developing the African Model Minigrid Regulations in collaboration with GET.transform and AMDA. This initiative creates a practical toolbox, combining regulatory experience with the latest best practices to address challenges like harmonizing standards and improving regulatory efficiency. The tools are adaptable across diverse jurisdictions, promoting convergence and scalability of minigrid regulations across the continent.[51]

[51] Model Mini-Grid Regulations – A Technical Guide.

7.2 Key insights

Over the past five years, the minigrids regulatory landscape has evolved significantly. These changes have been driven by the need to balance investor confidence with consumer protection while also addressing financial and operational hurdles. Key insights into this regulatory environment highlight the sector's potential to deliver sustainable energy solutions but also reveal persistent challenges in navigating policy and regulatory frameworks, tariff structures, and licensing procedures across different countries. Comparatively, Eastern and Southern Africa offer a more supportive and streamlined policy landscape for permitting and regulatory approvals than Western and Central Africa. For instance, in countries like Zambia, there has been a major regulatory shift impacting minigrids as the government has completely deregulated DRE projects of up to 5 MW as of September 2024.

While some countries like Nigeria have made significant strides in integrating minigrids into their broader energy plans, other countries, such as Tanzania, have experienced disruptions from regulatory shifts. These changes impact the financial stability and predictability of minigrid projects, potentially deterring investment and complicating project execution. Licensing procedures are becoming more accommodating to various scales of projects across the continent, signalling progress. While efforts are underway, more consistent and aligned policies are still essential to further ease the regulatory landscape.

Sierra Leone offers a positive case where recent adjustments to tariff regulations improved clarity. The tariff determination methodology for minigrids in Sierra Leone, designed to be cost-reflective and financially sustainable, has encountered practical challenges since its implementation.[52] While the tariff model theoretically ensures that operational costs are covered, it has revealed certain gaps when applied in real-world scenarios. A key challenge in Sierra Leone's mini-grid sector has been the delay in adjusting tariffs for inflation and currency exchange rates despite regulatory provisions, which have undermined economic viability over the past two years. Another key issue that has emerged over the four years of implementation of the minigrid regulations (2020-2023) is related to the major maintenance reserve account meant for asset replacement and maintenance. Originally, the tariff was structured to include provisions for future infrastructure maintenance and public asset replacement, but in practice, generating enough capital through tariff revenue alone has proven difficult. This has led to a recent agreement that the government should fund the necessary capital for this reserve account, potentially supported by donor contributions.[53]

Licensing procedures are becoming more accommodating to various scales of projects across the continent, signalling progress. While efforts are underway, more consistent and aligned policies are still essential to further ease the regulatory landscape.

[52] Sierra Leone Case Study: A Cost Reflective Mini-Grid Tariff Framework.

[53] Ibid.

8 Service Quality

Photo Credit: Ceesolar Energy Ltd Nigeria.

8 Service Quality

This section highlights the high quality and reliability of Africa's minigrid sector, which often surpasses national grids. The section underscores the importance of advanced technologies like smart metres and remote monitoring for swift issue detection and resolution. It also emphasises the role of PV-battery systems in ensuring continuous power, even during low sunlight, noting that although they have higher upfront costs, they are more cost-effective due to lower long-term operating costs.

The quality of service in the minigrid sector in Africa is generally high and often surpasses that of the traditional national grids. While affordability and sustainability are key considerations, reliability is critical. Data from operational minigrids indicates that they offer higher levels of service reliability compared to the often inconsistent reliability observed in national electric utilities, making minigrids a more dependable[54] option. Indeed, customers of minigrids often report higher satisfaction due to a more consistent and reliable electricity supply.[55]

The quality of service in the minigrid sector in Africa is generally high and often surpasses that of the traditional national grids. While affordability and sustainability are key considerations, reliability is critical.

8.1 Service uptime

Data from AMDA members affirms that most minigrid systems have consistently recorded high service uptime, significantly surpassing national grids. These high reliability levels are attributable to the use of modern technologies such as smart metres and remote monitoring systems that allow operators to identify and respond to operational issues promptly.

The 2024 BAM results indicate a service uptime of 88%. These values are self-reported figures from respondents, and there may be variations in how these were calculated/reported to AMDA between the last study and now. Regional uptime levels remain robust, with Eastern and Southern Africa maintaining an average of 89% and Western and Central Africa achieving 86.3% (refer to Table 9).

Grid-connected firms, on the other hand, experience far poorer service, as evidenced by responses to the World Bank Enterprise Surveys,[56] and a recent Afrobarometer report.[57] Those findings indicate that Sub-Saharan African countries, *on average,* experience eight multi-hour power outages per day, with respondents in eight countries reporting over 10 per day. An average of 50% of firms across SSA have or share a diesel generator. The Afrobarometer survey finds that "fewer than half (43%) of Africans enjoy a supply of electricity that works "most" or "all" of the time".

Table 9: System uptime across countries and regions

Aspects	Eastern and Southern Africa	Western and Central Africa
System Uptime	89%	86.3%

[54] BAM 2nd Edition.

[55] Mini-grid business information for developers and policymakers of green mini-grids in Sub-Saharan Africa.

[56] World Bank Enterprise Surveys.

[57] Still lacking reliable electricity from the grid, many Africans turns to other sources.

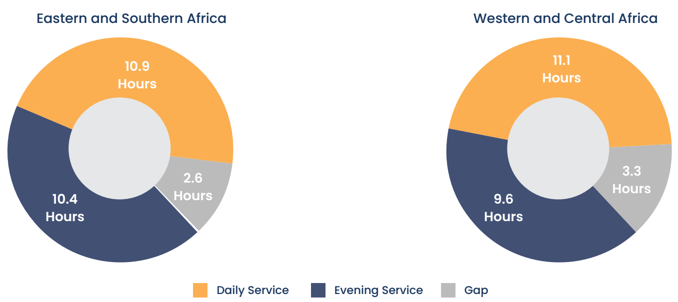
8.2 Outages and service quality

Common reliability metrics for minigrids, similar to those used for electric utilities, include the System Average Interruption Duration Index (SAIDI), which measures the total duration of outages over a year, and the System Average Interruption Frequency Index (SAIFI), which tracks the frequency of outages. The Utility Performance and Behavior in Africa Today (UPBEAT) initiative monitors and evaluates the performance of African electric utilities, revealing significant variability across the continent.

According to UPBEAT data, average outage durations per customer range from 0.35 to 140.6 hours annually, while the average number of interruptions per customer ranges from 1.72 to 3,326[58] interruptions per year. This highlights the disparity in electricity distribution reliability across Africa. In comparison, minigrids exhibit more consistent daily service durations. Figure 18 illustrates the average daily service duration of minigrids in the regions covered by this study. Eastern and Southern Africa record the highest daily service duration at 21.3 hours (10.4 hours in the evening and 10.9 hours during the day). Western and Central Africa follow closely with an average of 20.7 hours of daily service (9.6 hours in the evening and 11.1 hours during the day).

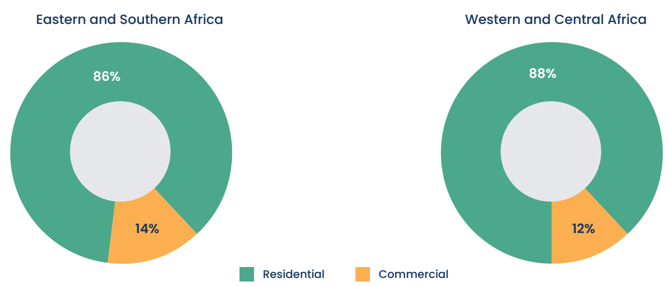
These findings demonstrate that minigrids can deliver reliable electricity service comparable to, and in some cases exceeding, the performance of centralised utility grids in Africa, particularly in underserved areas.

Figure 18: Average service duration across regions



In terms of customer demographics served by minigrids, there is a similar pattern across regions, where roughly 87% of customers served are residential, with the remainder as commercial customers.

Figure 19: Customer category demographics of Minigrids by region



[58] Utility Performance and Behaviour in Africa Today (UPBEAT).

8.3 Key insights

- While Western and Central Africa have more minigrid connections than Eastern and Southern Africa, the proportions of residential and commercial users served remain consistent across regions. Compared to the main grids, the 2024 BAM report highlights that minigrids continue to deliver higher reliability and quality in power supply, showcasing their effectiveness as a solution for underserved areas.
- Considering the high service quality of minigrids, policymakers—especially in nascent markets—should establish more supportive policies to integrate minigrids into long-term electrification strategies, facilitating their widespread deployment to meet the 2030 universal energy access goal.
- For donors, facilitating programmatic mechanisms to attract private-sector investment is essential. This would accelerate minigrid deployment and support the adoption of innovative business models to further enhance service quality.
- For minigrid developers, prioritising service quality and using bottom-up approaches to design demand stimulation programmes can significantly enhance the financial viability of minigrids and support their long-term success.
- Minigrids can deliver reliable electricity service comparable to, and in some cases exceeding, the performance of centralised utility grids in Africa, particularly in underserved areas.

9 Employment

Photo Credit: PowerGen-Nigeria.

9 Employment

This section examines the impact of minigrids on job creation in Africa, highlighting employment trends and opportunities in recent years. West Africa has outpaced East Africa in job creation despite the uneven regional representation of minigrid companies.

The minigrid industry plays a significant role in job creation, especially in regions lacking centralised power. Employment opportunities arise throughout the project lifecycle, from planning and construction to long-term operations and maintenance. Key areas include project development, where engineers and unskilled labour are needed, and operational roles such as technicians, local sales, and customer support are required. AMDA members continue to prioritise employing local staff to build strong community relationships and improve local capacity. Additionally, the productive use of energy stimulates entrepreneurship, creating jobs in small businesses like agro-processing. The sector contributes to developing the skills necessary for energy transition by providing training programmes on technologies and technical maintenance.

AMDA members continue to prioritise employing local staff to build strong community relationships and improve local capacity. Additionally, the productive use of energy stimulates entrepreneurship, creating jobs in small businesses like agro-processing.

9.1 Sector job creation

Beyond economic development, rural electrification through minigrids provides a wide range of job opportunities across the entire value chain for local labour markets. The analysis of employment within the sector is categorised by the types of jobs created:

- Central staff jobs: Permanent jobs created in the core operations of the site, management, customer service and payment collection;
- Site-specific jobs: Employment created for community members in the construction and installation stages and basic O&M; and
- Indirect community jobs: Access to electricity provided by minigrid projects enables community members to start new businesses and create permanent jobs. Rural enterprises can flourish with reliable energy, leading to economic growth and improved livelihoods. These indirect jobs often include small shops, service-based businesses, and agricultural processing facilities that become feasible with consistent power, thus fostering long-term community development and financial independence.

The Decentralised Renewable Energy (DRE) sector, including minigrids, has become a significant source of employment creation globally. Power for All's Powering Jobs Census 2022 established that the DRE sector supports approximately 374,000 jobs across Africa, reflecting its critical role in providing clean energy access and creating livelihood opportunities.[59] As our 2022 BAM report underscored, minigrid projects significantly boosted employment in Africa, creating around 900 jobs in 2020, with the vast majority (approximately 800) concentrated in Eastern and Southern Africa. The 2024 BAM results highlight much higher job creation statistics, with 6,234 jobs generated by participating minigrid developers. These include 3,602 roles based in the minigrid communities and 2,632 central jobs, reflecting the sector's broad economic reach. Table 10 shows regionally, Western and Central

[59] Power for All Distributed renewable Energy Job Report Sees Strong Post-Pandemic Growth.

Africa contributed the majority with 3,980 jobs. In comparison, Eastern and Southern Africa accounted for 2,254 jobs, demonstrating the evolving and dynamic role of minigrids in fostering sustainable employment across the continent.

Table 10: Direct and indirect job creation by region

Aspects	Eastern and Southern Africa	Western and Central Africa
Village jobs	1,499	2,103
Central Staff	755	1,877

9.2 Key insights

Accelerating job growth with policy support: Governments play a vital role in expanding job creation through minigrids by establishing favourable regulatory frameworks that attract investment and foster an enabling environment. Streamlined licensing and clear tariff structures will stimulate private sector participation and boost job creation in the rural areas where minigrids are deployed.

Regional disparities in job creation: Although Western and Central Africa lead in the overall number of jobs created by minigrid projects, only 53% of these roles are village-based, reflecting a smaller focus on local community employment compared to other regions. In Eastern and Southern Africa, 67% of the jobs created by minigrid projects are village-based.

To sustain momentum in the energy transition, donor-funded skills training programs are critical for building a skilled workforce to support minigrid deployment. These programmes should prioritise technical and operational skills, empowering local workers to construct and maintain minigrids effectively. By strengthening expertise nationally and locally, these initiatives create jobs and ensure the long-term sustainability of minigrid operations. Increasing funding for technical assistance is essential to achieving these goals.

10 Conclusions

Photo Credit: NOA-Uganda.

10 Conclusions

The 2024 BAM report illustrates the vital role of minigrids in reducing Africa's energy access gap. While progress has been commendable, with over 600 minigrids constructed by AMDA members and electrifying more than 700,000 people, the sector's pace needs to accelerate to meet the 2030 goal of universal access to electricity. The challenges of high capital expenditure, fragmented policies, and limited concessional funding require coordinated stakeholder action, as well as consideration of the regulatory, business, and financial models of the present approach.

Key recommendations emphasise the need for innovative financing models, streamlined regulatory processes, and demand stimulation through productive uses of electricity. Strengthening collaboration between governments, private developers, and funders can unlock the potential of minigrids as a cornerstone of Africa's sustainable energy future.

By addressing these challenges head-on, the minigrid sector can scale its impact, delivering reliable, affordable electricity to underserved communities while fostering socio-economic development across the continent. This report calls for decisive, collective action to transform vision into reality. The following section details concrete actions that various stakeholders can undertake to catalyse the deployment of minigrids across Africa.

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10.1 Call to action

The 2024 BAM report significantly contributes to the body of industry knowledge for stakeholders by presenting the state of play and highlighting the evolution of costs, deployment of capital and minigrids, and consumption trends, among other important metrics. AMDA, through its convening platform, aims to leverage its position to foster industry-wide collaboration and accelerate minigrid sector growth across Africa. However, to drive meaningful change, AMDA emphasises the importance of collective action with key stakeholders. Through its partnership approach, AMDA looks forward to working collaboratively with stakeholders to ensure the scalability and success of minigrid solutions in Africa. This unified effort requires coordinated actions by key stakeholders, as outlined below.

Actionable steps for the public sector stakeholders

1. **Transparency in grid expansion plans**: Relevant public institutions need to ensure transparency in the grid expansion plans to protect investments in minigrids. For instance, the Distribution Companies (DISCOs) in Nigeria are required by the minigrid regulations to publish their grid expansion plans. The regulations mandate that DISCOs provide transparency by making their expansion plans publicly available. This requirement is crucial for coordinating minigrid development, ensuring that minigrid projects are not established in areas where the main grid is expected to expand soon. As per the country's 2023 Minigrid Regulations, if a minigrid developer identifies an area within the DISCO's expansion plan, the developer must seek the Disco's written consent before proceeding.[60] This step helps avoid conflicts between

[60] NERC Mini Grid 2023 Regulations.

grid expansion and minigrid development and ensures that all parties know where the grid will likely expand next. However, the actual implementation and regular publication of these plans by DISCOs in Nigeria must be more consistent. Sometimes, the plans are not updated or made easily accessible, leading to challenges in planning and development for minigrid developers. In such instances, governments can increase transparency through strict enforcement of regulations alongside active engagement between DISCOs, minigrid developers, and the entire ecosystem. This collaborative approach can help align objectives and reduce conflicts during grid expansions.

2. **Simplified licensing requirements and procedures for minigrids:** Streamlining licensing requirements and procedures is essential to accelerating the deployment of minigrids across Africa. By simplifying the application process, public sector stakeholders can significantly reduce the time and costs associated with regulatory approvals, making it easier for developers to bring their projects to fruition. Public institutions can create a more efficient and transparent licensing system by consolidating regulatory requirements and eliminating unnecessary bureaucratic hurdles. Implementing online platforms for application submissions, tracking, and approval can speed up the process, reduce paperwork, and minimise errors. The One-Stop-Shop Model under Nigeria's Electrification Project (NEP) has streamlined minigrid development by consolidating regulatory approvals and support services, reducing bureaucratic barriers. Similarly, the African Forum for Utility Regulators (AFUR), in collaboration with GET.transform and AMDA, launched the African Model Minigrid Regulations to enhance regulatory frameworks. This initiative provides adaptable tools that integrate best practices, harmonise standards, and improve regulatory efficiency, fostering scalable and convergent minigrid regulations across Africa.

3. **Adopt digital tools for transparency and efficiency:** Governments need to mainstream digital tools to improve electrification planning and deployment. Through digitalisation, they can integrate advanced planning, aggregation, geospatial data, and tendering processes. With these tools, governments can identify optimal sites for minigrid deployment by analysing geospatial data highlighting areas with high energy demand and limited access. Aggregating these data points allows for the creation of a pipeline of scalable minigrid projects. Additionally, digital platforms enable a more transparent and efficient bidding process by providing clear, accessible information on procurement requirements and timelines. This helps attract more bidders and fosters competition while improving confidence among private sector companies to participate.

Public institutions can create a more efficient and transparent licensing system by consolidating regulatory requirements and eliminating unnecessary bureaucratic hurdles. Implementing online platforms for application submissions, tracking, and approval can speed up the process, reduce paperwork, and minimise errors.

Actionable steps for donors and other concessional finance providers:

4. **Consolidate Result-Based Financing (RBF) programmes:** Results-based financing (RBF) mechanisms have shown promise in supporting the growth of minigrid infrastructure. However, the current fragmentation of programmes in Africa often results in inefficiency, with significant portions of funds directed towards administrative and delivery costs. Companies spend excessive amounts of time in cumbersome processes to apply for and report against the different funding mechanisms. A more integrated, nationally centralised approach could pool resources to streamline funding and reduce administrative overheads. Leveraging successful Pan-African funds with experienced managers, such as the Universal Energy Facility (UEF) or the Clean Energy & Inclusion for Africa (CEI) fund, could serve as a model to

harmonise donor investments into a single pot. This could optimise resource allocation, reduce operational redundancies, and ensure that the full benefit of RBF reaches the targeted projects.

5. **Design programmes to facilitate commercial finance:** Engaging investors early in the design of grant financing programmes is critical for those grants and subsidies to unlock the additional funding companies need to deploy. Grant funds provide a significant source of de-risking for commercial finance—clear payment milestones and methodology and flexibility to give investors some form of surety over the grant payments make it easier for funding to flow to participating companies.

Engaging investors early in the design of grant financing programmes is critical for those grants and subsidies to unlock the additional funding companies need to deploy.

Actionable steps for private capital providers

6. **Provide complementary forms of capital** to bridge funding gaps alongside concessional finance by offering tailored instruments, such as bridging financing for RBFs, construction credit financing, long-term debt, and equity financing. Short-term bridge loans can cover interim funding gaps. Dedicated construction credit further supports the capital-intensive phase of building minigrids, with private lenders,[61] often in partnership with institutions like the IFC,[62] providing loans for constructing solar or hybrid minigrids in rural Nigeria, Kenya, South Africa, and Tanzania, enabling rapid construction and subsequent long-term refinancing. Additionally, a mix of long-term debt and equity investments helps align a project's cash flow with its financing needs; for instance, CrossBoundary Energy has structured combined equity and debt solutions for medium-scale solar installations, leveraging stable power purchase agreements (PPAs) to mitigate risks and attract additional long-term capital.

7. **Adopt a portfolio approach** to underwrite revenues and mitigate demand risk. Evaluating projects individually in Sub-Saharan Africa can expose investors to significant demand risk, given the variability of energy consumption in rural areas. A portfolio approach offers significant benefits. For example, combining projects in rural Nigeria with those in Kenya helps investors offset underperformance in one region with more substantial results in another. In addition, risk-adjusted models can smooth cash flow variability, enabling diversified mini-grid portfolios to reliably meet debt service obligations—even when some sites underperform.[63]

8. **Simplify environmental, social, and governance (ESG) reporting** by implementing streamlined, scale-appropriate frameworks to reduce compliance costs and focus resources on project execution. ESG reporting for African mini-grid projects should target key performance indicators that directly reflect project outcomes, such as service uptime, access improvement, and community impact. This focus minimises administrative costs and simplifies compliance for smaller developers. Additionally, automating data collection and reporting with digital platforms helps tailor ESG efforts to local conditions. The 2023 SEforALL Monitoring Review Report emphasises using scale-appropriate metrics relevant to local energy access and reliability to ease the reporting burden on project teams.

[61] Odyssey Construction Credit, IFC, among others, are examples of lenders in the construction credit market.

[62] Energy Sector Management Assistance Program Annual Report, 2024.

[63] Ibid.

9. **Advocate for supportive policies by** collaborating with stakeholders, including AMDA, to push for streamlined permitting, fair tariffs, and accessible subsidies. By partnering with associations such as AMDA and AFUR, investors can advocate for streamlined permitting processes and fair tariff structures, which are likely to enhance project sustainability and potentially reduce investment risks. According to the 2022 AMDA BAM report, coordinated efforts in several African countries have led to regulatory reforms that shorten approval times and improve revenue certainty for mini-grid projects, a trend that appears to continue today.

Actional steps for the private sector/industry

10. **Embrace technology for cost savings:** New digital tools not only help governments in their planning. They can also assist companies in optimising their processes for identifying and planning out remote sites, right-sizing generation and storage, preparing financing plans and proposals for lenders/investors, monitoring their assets remotely, reducing overheads and operating costs, and improving margins.

11. **Target revenue-enhancing business models:** Prioritising demand stimulation is essential for the economic sustainability of minigrids. In collaboration with microfinance companies and appliance distributors, minigrid companies should embrace innovative financing solutions and encourage local businesses to adopt energy-dependent services (e.g., agriculture processing, refrigeration, telecommunications, small-scale manufacturing, e-mobility). This approach not only increases electricity consumption through the adoption of beneficial uses but also contributes to community development. While diversified revenue streams—such as offering water pumping/purification services or battery rental/charging for e-mobility—can boost profitability, the primary goal remains to enhance the beneficial use of electricity, with increased revenue serving as a natural consequence of improved service provision.

12. **Embrace diverse business models to enable community participation, acceptance, and ownership.** Recent initiatives show that community acceptance of mini-grids improves when local residents and energy users have greater roles in decision-making or ownership. For instance, RMI's Sharing the Power Initiative[64] in Nigeria awarded grants to four mini-grid developers to boost community participation in governance. Additionally, Nigerian stakeholders recently published a Policy Brief on Community-Driven Minigrids,[65] offering guidelines applicable to projects in other countries. NRECA International has established rural electric cooperatives[66] in Liberia, Uganda, and Zambia, where newly electrified communities own and operate their mini-grid assets. Hybrid ownership models and community empowerment will be critical for meeting energy access targets and ensuring mini-grid viability in remote areas not currently served by developers.

13. **Enhanced data collection and benchmarking:** AMDA will continue to assist the industry in promoting uniform KPI collection, streamlined data sharing, and providing aggregated operational and financial benchmarking for minigrids. This will help the sector assess performance more effectively

AMDA will continue to assist the industry in promoting uniform KPI collection, streamlined data sharing, and providing aggregated operational and financial benchmarking for minigrids. This will help the sector assess performance more effectively and enable financiers to conduct high-quality due diligence.

[64] Sharing the Power: Community-Led Minigrids.

[65] Community-Driven Mini-grids: A Promising Approach to Electrifying Nigeria's Rural Population.

[66] Opening Up to Clo-ops: In Zambia, Member-Owned Utilities Are Catching On.

and enable financiers to conduct high-quality due diligence. Additionally, AMDA will assist governments, regulators, and local authorities by providing digital tools to monitor mini-grid operations and track performance within their jurisdictions.

14. **Monitor and track progress of M300:** At AMDA, we are fully committed to supporting this ambitious effort with transparency and accountability. To ensure meaningful progress, we will work with our members and partners to systematically track the following key performance indicators:

    - Volume: We will monitor the amounts committed versus those actually disbursed, ensuring that pledges translate into real investments.
    - Speed: With only six years remaining to achieve these targets, we will track the pace of capital deployment to ensure timely action.
    - Efficiency: We will identify and promote best-practice processes that enhance the efficient allocation of capital. Additionally, we will facilitate intra-governmental dialogue to address bottlenecks and improve coordination.
    - Impact: Delivering sustainable electricity to 300 million Africans by 2030 requires connecting an average of 50 million people per year. We will rigorously track progress to ensure this goal remains on course.

Annex: Methodology

Photo Credit: Engie Energy Access-Zambia.

Annex: Methodology

This year's report builds upon the strong foundation established by previous editions of the BAM report while introducing new elements to offer a more in-depth and comprehensive analysis of the minigrid sector. The 2024 edition features responses from 27 developers, including three non-AMDA members.

AMDA developed user-friendly templates for data collection and leveraged Odyssey's technology to automatically collect available metrics, reducing the need for manual input. For cases where manual data entry was required, we held one-on-one sessions with companies to assist them in completing the templates and ensuring data accuracy. A new approach introduced in this year's report was the direct data collection from minigrid systems through the Odyssey platform, ensuring enhanced data accuracy and granularity for analysis.

The report also includes insights from three donor organisations, four government agencies, and four non-government non-donor entities, providing a comprehensive view of the sector's progress and challenges.

AMDA developed user-friendly templates for data collection and leveraged Odyssey's technology to automatically collect available metrics, reducing the need for manual input.

Data collection

Data was collected from 27 minigrid developers (24 AMDA members and three non-AMDA members) across 116 minigrids in 15 countries commissioned from 2022 to 2024. This edition of the BAM report includes four new countries—Lesotho, Mozambique, Somalia, and South Africa—that were not covered in the previous reports. To protect the anonymity of the developers, as was done in earlier reports, the countries were grouped into regional clusters:

- **West and Central Africa:** Benin, Cameroon, Mali, Mauritania, Nigeria, Sierra Leone, Togo.
- **East and Southern Africa:** Democratic Republic of the Congo, Kenya, Lesotho, Madagascar, Mozambique, Rwanda, Somalia, South Africa, Tanzania, Uganda, Zambia, Zimbabwe.

This regional clustering approach allows for easier analysis while maintaining confidentiality.

Scope of data collection:

This report gathered data from existing and newly participating minigrid developers across Sub-Saharan Africa and interviewed key stakeholders in the minigrid sector.[67] The data collection process captured detailed information on the following:

- Operational performance
- Capital and operational expenses
- Average revenue per user (ARPU)
- Service quality and reliability
- Socio-economic impact indicators, including job creation
- Policy and regulatory regimes
- Donor programmes and available financing for the minigrid sector

[67] Government agencies, donors, academia, and the private sector.

Data sources:

Developers primarily self-reported the data through standardised templates and complemented through direct data pulled from minigrid systems monitored[68] on the Odyssey platform, with permission from the data owners. The collection process also integrated third-party data sources to validate reported figures where possible and interviews with key stakeholders. Sources included:

- Developer-provided data on capital expenditures (CAPEX), operational expenditures (OPEX), and site performance.
- National and international datasets from the World Bank, GOGLA, AfDB, USAID, and other relevant institutions for data triangulation.
- Interviews and data collection templates (mainly as a complement to interviews) with donors, government agencies, and other private sector participants in the minigrid market.

Data verification and validation

Verification process:

The report underwent a rigorous multi-step verification process to maintain data accuracy and integrity. This involved reviewing each data submission for completeness and consistency. Identified discrepancies and missing data were flagged, and developers were followed up to complete the data. The team cross-referenced data with independent sources, such as national electricity regulators and international funding reports, to validate key metrics like connection rates, tariffs, and installed capacities.

Data cleaning:

Once the raw data were collected, a cleaning process was conducted to remove erroneous entries, normalise formats, and ensure consistent data points across the sample. Where developers provided incomplete responses, additional outreach was undertaken to fill gaps.

Key performance indicators (KPIs)

The report categorised the reporting KPIs into financial, operational, and impact metrics to evaluate the sector's overall performance and growth potential.

Operational performance:

- Average uptime of systems, measured as hours of reliable service per day
- Utility cost per kWh delivered (end-user tariff)

Financial performance:

- Average cost per connection and per kilowatt peak (kWp)
- Average Revenue Per User (ARPU), categorised by region
- Operational and maintenance cost trends

Socio-economic output KPI:

- Number of direct and indirect jobs created
- Percentage of households vs. businesses using electricity for productive purposes

[68] These were limited to minigrids that permitted their systems' data to be pulled and analysed as part of this year's report.

Analytical approach

The report adopted a multi-phased approach in analysing and presenting the data, mainly using trend and comparative analyses. The analysis primarily focused on site growth and connection metrics. This includes sharing new sites by generation type and comparing various minigrid types added during the reporting period. Key operational inputs such as plant size, jobs created, and people impacted were also analysed, along with funding allocation. Additionally, the analysis covered policy and regulatory aspects, comparing approval processing times and key consumption and revenue metrics like ACPU and ARPU.

Trend analysis:

The report analysed the trends between the last reporting period to date to assess growth in connection rates, revenue, and operating costs, using roughly the same pool of developers. This allowed the report to capture how developers improved efficiency and scaled operations over time.

Comparative analysis:

This report's key feature is its ability to compare performance across regions, developers, and project sizes. Developers from West and Central Africa were compared with those from Eastern and Southern Africa, identifying geographical trends in cost, service quality, and customer growth. The report also stratified performance data by developer experience, with more established companies compared against newer entrants, to reveal differences in costs and revenue generation.

Limitations

While the report presents the most up-to-date and comprehensive analysis of private sector minigrids in Sub-Saharan Africa (SSA), some limitations need to be acknowledged:

While this edition included self-reports from three non-AMDA members, the overall data collection rate from non-AMDA members remains low. This results in a limited sample size and a narrower perspective in the final analysis of AMDA members.

Some developers could not provide detailed historical data due to client contract restrictions or data availability, limiting the scope of year-on-year comparisons to only the two reporting periods of the BAM report. Thus, the developers ultimately could not provide some data gaps. Due to a lack of comprehensive data from government agencies responsible for off-grid or rural electrification, this report primarily focuses on private-sector developers.

Data reliability was prioritised through a comprehensive validation process. This included iterative follow-ups with participants to validate outliers, followed by data normalisation and filtering to avoid distortion from anomalous data. Reported figures were cross-referenced with concurrent studies and system monitoring data for validation. The inclusion of data from stakeholder interviews and extensive desktop research facilitated a comprehensive analysis of the sector by addressing data gaps.

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