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REPORT | MARCH 2026

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# Contents

# List of abbreviations and acronyms

| | |
|---|---|
| **AECF** | African Enterprise Challenge Fund |
| **AfDB** | African Development Bank |
| **AMDA** | Africa Minigrid Developers Association |
| **BMZ** | Federal Ministry for Economic Cooperation and Development |
| **$CO^2$** | Carbon dioxide |
| **CEO** | Chief executive officer |
| **DARES** | Distributed Access through Renewable Energy Scale-up Project |
| **DRE** | Decentralised renewable energy |
| **ESMAP** | Energy Sector Management Assistance Program |
| **ESMP** | Environmental and Social Management Plan |
| **EU** | European Union |
| **FMP** | Federal Ministry of Power |
| **GHG** | Greenhouse gas |
| **GIZ** | German Agency for International Cooperation |
| **GVE** | Green Village Electricity Projects Limited |
| **ICT** | Information and communication technology |
| **Green tech** | Green technology |
| **IK** | Indigenous knowledge |
| **IRENA** | International Renewable Energy Agency |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **KII** | Key informant interview |
| **kW** | Kilowatt |
| **MW** | Megawatt |
| **NAPTIN** | National Power Training Institute |
| **NASENI** | National Agency for Science and Engineering Infrastructure |

| | |
|---|---|
| **NBS** | National Bureau of Statistics |
| **NBTE** | National Board for Technical Education |
| **NCCC** | National Council on Climate Change |
| **NDC** | Nationally Determined Contribution |
| **NEET** | Not engaged in education, employment or training |
| **NEP** | Nigeria Electrification Project |
| **NERC** | Nigerian Electricity Regulatory Commission |
| **NESP** | Nigeria Energy Support Programme |
| **NITDA** | National Information Technology Development Agency |
| **NIYEAP** | Nigerian Youth Employment Action Plan |
| **OEM** | Original equipment manufacturer |
| **PPP** | Public–private partnership |
| **PV** | Photovoltaic |
| **R&D** | Research and development |
| **REA** | Rural Electrification Agency |
| **REAN** | Renewable Energy Association of Nigeria |
| **REMP** | Renewable Energy Master Plan |
| **RESIP** | Rural Electrification Strategy and Implementation Plan |
| **SDG** | Sustainable Development Goal |
| **SEforALL** | Sustainable Energy for All |
| **SHS** | Solar home system |
| **STEM** | Science, technology, engineering and mathematics |
| **TVET** | Technical and vocational education and training |
| **UN** | United Nations |
| **UNCTAD** | United Nations Conference on Trade and Development |
| **US** | United States |
| **USADF** | United States African Development Foundation |
| **VC** | Venture capital |

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# Executive summary

According to the Intergovernmental Panel on Climate Change (IPCC), Africa is one of the continents most vulnerable to climate change and climate variability. African countries are responding to this challenge through climate mitigation and adaptation and the development of new sectors and industries. The resulting emergence of green industries and the deployment of green technologies (green tech) present opportunities to address youth unemployment through the creation of green jobs. For green tech to maximise youth employment creation in Africa, government policies, regulations and strategies, as well as interventions by development partners, enterprise support organisations and financial institutions, need to be attuned to the needs of young people in green industries. Furthermore, there is a need for research examining the linkages of youth, women and the applicability of Indigenous knowledge to innovation in the green tech space.

This report aims to understand the key actors, policy context, barriers and enablers in the nexus between green tech and youth employment. As a case study, it takes the Nigerian solar mini-grid tech startup sector, which is capitalising on Indigenous and traditional knowledge to enhance technological innovation for startups. The solar mini-grid industry was selected for this purpose due to Nigeria's progress and growing potential in renewable energy, particularly in off-grid solutions. In fact, Nigeria is one of the largest markets for solar mini-grids in Africa. By 2024, the country had over 155 mini-grids and at least 42 active developers, up from just 11 mini-grids and five developers in 2015 (Nigeria Electrification Programme, n.d.b; Alliance for Rural Electrification, 2024). A significant increase in the number of mini-grids and developers is projected over the next decade.

This study documents how the dimensions of policy, finance, skills and innovation shape youth employment outcomes in Nigeria's solar mini-grid sector. It first examines the current national strategies and policy frameworks guiding the sector and how they shape opportunities for youth employment. This focus is vital, given Nigeria's urgent need to expand energy access while tackling high youth unemployment. The study then assesses how Nigeria's burgeoning tech startup ecosystem could act as a catalyst for scaling green tech and creating job pathways within the solar energy sector, before investigating the roles that solar tech startups are playing in this space, as well as the factors either promoting or hindering their contribution to innovation and development. To fully understand these outcomes, the study also examines cross-cutting factors – particularly gendered barriers and the role of Indigenous knowledge – that shape which young people are able to access, participate in or benefit from emerging opportunities in the sector.

The report delves into the role of women in technology transfer and job creation within the mini-grid sector, identifying the barriers that limit their participation and potential. It also focuses on the need to enhance the uptake of locally developed technologies and Indigenous knowledge systems. This is especially pertinent since Nigeria's National Youth Policy (2019–2023) mentions that one of the strategies for expanding youth employment would be building their entrepreneurial capacity and skills in Indigenous technologies to produce solar panels and renewable energies. Lastly, the study examines how tech startups and, more broadly, youth can be more effectively engaged in innovation and technology transfer, and the structural or systemic constraints that impede their impact. Altogether, these areas of inquiry are essential to designing inclusive, locally grounded, future-oriented interventions that can accelerate both energy access and employment for youth in Nigeria.

This report employed multiple research methods, beginning with a comprehensive review of the literature and policy documents. Data from 35 solar mini-grid companies made up the dataset that was used for the quantitative analysis. This sample was based on publicly available information and represented 37% of members of the Renewable Energy Association of Nigeria. The companies were selected based on their experience of deploying at least one mini-grid in Nigeria and the availability of public information about them – such as year of founding and the gender and age of the leadership. The Nigerian solar mini-grid industry was then mapped to establish the key stakeholders in the space. A policy-convening workshop, bringing together government officials and representatives of private institutions in the sector, provided a platform to validate the desk research findings and identify youth needs in policy, finance and skills. Secondly, through semi-structured interviews conducted with 22 key informants (including those from mini-grid companies, policymakers, researchers and experts), primary data was collected and a qualitative data analysis was thematically conducted.

# Key findings

The desk research and key informant interviews (KIIs) revealed the following:

## Labour dynamics and job opportunities in the solar mini-grid sector

- More than 90 million Nigerians lack access to electricity (Federal Ministry of Power, 2024). This provides an opportunity for solar mini-grids to fill the gap, which, in turn, promises significant potential for addressing Nigeria's youth unemployment crisis by creating jobs. Investing in solar mini-grids is a viable economic strategy that can stimulate rural economies, improve livelihoods and reduce reliance on fossil fuels (Saleh, 2024).
- We estimate that, by deploying over 10,000 mini-grids, the sector could create 212,688 direct full-time informal and productive use jobs across the off-grid and under-grid market segments.[1] Scaling deployment could be a cornerstone of Nigeria's green growth strategy, making the case for stronger government and private sector support, incentives and workforce development programmes aligned with mini-grid growth.
- In the Nigerian mini-grid space, we estimate that 34% of full-time employees are female, which is an improvement over the corresponding percentage of 21% in energy utilities in African countries (Baldinger et al., 2020). We further estimate that women also make up 53% of management staff in the sector.[2] The solar mini-grid sector could therefore become a model for inclusive green tech industries.
- By our estimates, youth make up 82% of full-time staff in mini-grid companies. The sector is already youth-driven, positioning it as a natural avenue for youth empowerment and innovation. This also implies a need for targeted investments in skills development, mentorship and entrepreneurship to equip this workforce with the tools to grow and lead the sector.
- We estimate that youth make up 59% of management staff but only 19% of chief executive officers (CEOs) in the sector. This signals an opportunity to further cultivate young leadership and entrepreneurship through targeted support, such as leadership pipelines, incubation programmes and youth-inclusive financing models.
- The sector supports a range of employment opportunities across the value chain, including roles in manufacturing, installation, maintenance, project development and community engagement. It therefore caters to diverse skill levels and backgrounds – from

highly technical roles to community-facing positions. This makes it suitable for both rural and urban employment initiatives and emphasises the need for diverse, scalable training programmes to meet workforce demand across the entire value chain.

## Needs and priorities for youth in the solar mini-grid sector

- Since the launch of Nigeria's first mini-grid in 2010, the sector has grown significantly, with about 200 mini-grids now in operation (Nigeria SE4All, 2022; Nigerian Electricity Regulatory Commission (NERC), 2025). Many of the companies driving this growth are relatively young, with a substantial portion being youth-led and supported by a dynamic, youthful workforce. These companies need support to develop green skills, access financial resources, achieve sustainability through the growth phase and foster innovation.
- The needs and priorities of youth in the sector include skills development, upskilling, access to finance (to start up and grow a mini-grid company), technical assistance (including meaningful incubation and innovation hubs, female- and youth-focused skills and entrepreneurship programmes) and enabling policies.

### Skills

Both desk research and KIIs identified a skills gap in the solar mini-grid sector, which actors – including training institutions, mini-grid companies' in-house training programmes, technical assistance programmes and research companies – are attempting to address. The following findings were made:

- Semi-skilled local technicians have limited career mobility as they lack both soft professional skills and the extensive hard skills that design engineers and project managers possess. Further formal education is often the only pathway to advancement, without which the sector risks entrenching a two-tier workforce and failing to deliver on its potential to build local capacity. There is therefore a need for more accessible, non-academic professional development models that enable local talent to grow into supervisory and leadership roles.
- While the demand for solar mini-grid deployment is growing, a shortage of job-ready talent is creating bottlenecks in scaling. Skills in high demand are those which are highly specialised, such as design, installation, operations and maintenance, as well as business development and project management – domains where many young people currently lack practical, hands-on experience. This calls for more experiential learning opportunities, such as apprenticeships and simulation-based training. Training should include soft and managerial skills like client engagement, financial planning and project coordination.
- The desk research revealed that women make up only 8% of technical staff across the broader solar off-grid sector (Renewable Energy Association of Nigeria (REAN), 2021b).

This could be attributed to the gender disparity in the training institutions, where women represent only 7% of engineering and technology graduates and 6% of electrical installation and maintenance technical college graduates (Ihuoma, 2023). The gender gap limits both equity and innovation in the sector. Without targeted interventions to fix the pipeline, the energy transition risks reinforcing inequality.

- There are four sources of training in the sector:
  - Tertiary education provides general technical and non-technical skills that are transferable to mini-grid operational contexts. However, without hands-on application, its impact is limited. This calls for closer collaboration between universities and industry, including partnerships with companies for field placements and curriculum co-design to increase relevance and job readiness.
  - In-house, on-the-job training by senior staff and guest experts.
  - Training conducted by equipment manufacturers for mini-grid company staff during procurement.
  - Specialised training by external training institutions.

## Finance

Access to finance is rated as a critical priority for mini-grid companies and aspiring entrepreneurs. The following findings were made:

- Based on a lowest-cost electrification approach (where a country's mix of electrification technologies depends on the lowest cost for the technology for each population segment), the solar mini-grid sector may require up to USD 8 billion to connect 35.4 million people. To meet this need, the government and donors must attract private capital by de-risking investments and ensuring regulatory clarity and long-term planning.
- Companies need cash for project development, research and experimentation, capacity building, and workforce upskilling. This calls for a financing strategy that recognises human capital, innovation and local entrepreneurship as critical components of energy access.
- Grants from development finance institutions which come via the Rural Electrification Agency (REA) are the largest source of finance for the sector. The USD 410 million funding for mini-grids under the World Bank-funded Distributed Access through Renewable Energy Scale-up (DARES) project over the next five years (USD 82 million annually) exceeds the venture capital equity (USD 46.8 million) and debt (USD 27.6 million) financing (typically from foreign sources), or the paltry domestic commercial bank lending that entered into Nigeria's cleantech sector (as a whole) in 2024. Thus, the sector is still heavily donor-dependent, with insufficient private sector participation. While public funding plays a catalytic role, over-reliance on grants exposes the sector to political and donor shifts. For a move towards a more balanced funding landscape, there is an urgent call for strategies to inspire private sector confidence, especially those in the form of guarantees, blended finance and co-investment models.

- For early-stage mini-grid startups, grants with less stringent eligibility criteria remain critical. Smaller and newer companies struggle to meet the bureaucratic requirements of some traditional funders. Supporting these startups through streamlined, small-ticket, risk-tolerant grant programmes is essential for diversifying the market, supporting Indigenous entrepreneurship, and reaching underserved communities.
- Mini-grid companies require patient capital that can tolerate comparatively modest but steady returns over a long payback period (seven to ten years) that matches its slow revenue maturation and long-term impact timeline. Concessional debt, revenue-based finance or blended equity are ideal.

## Innovation

Respondents noted the importance of innovation for the survival, growth and scaling of the sector. However, the rate of innovation is uneven. The following findings were made:

- The right support mechanisms – such as funding for research and development, innovation-friendly policies and talent development – are needed to nurture and scale innovation.
- Up to 85% of mini-grid system components are imported. This heavy reliance on imports limits local manufacturing innovation and undermines the development of a resilient, locally grounded mini-grid ecosystem. Additionally, it makes the sector vulnerable to currency volatility, supply chain disruptions and foreign policy shifts. Encouraging local production through incentives, technology transfer partnerships and investment in manufacturing capacity is critical to building a self-sustaining sector.
- Innovations in the sector can be radical or incremental. Understanding the spectrum of innovation helps stakeholders identify where support is most needed. Incremental innovations are easier to adopt but may offer limited cost advantages, while radical innovations, though riskier, have the potential to reshape the economics of mini-grid deployment. Stakeholders, including investors and donors, must be willing to take calculated risks to back breakthrough innovations, not just small optimisations.
- Innovation in the sector is mainly needs-based, spurred by pressures to minimise costs and improve efficiency given the long periods until firms can recoup their investments (seven to ten years). This means innovation is reactive rather than proactive or visionary. Enabling more flexible capital, longer funding horizons and results-based incentives can free companies to explore more transformative innovations beyond immediate survival pressures.
- Innovation is concentrated in the skilled segment of the workforce, where testing of new business models, experimentation with new technology brands and trying out new deployment processes are often initiated. However, there is a risk of innovation being confined to technical teams and the leadership, while excluding semi-skilled workers and local actors who could contribute valuable on-the-ground insights. Broadening access to innovation processes, especially through inclusive training and community-based pilots, can unlock more diverse and context-specific solutions. Supporting more innovation labs or open testbeds across the country would democratise innovation access.

- Indigenous knowledge in the innovation process faces the biggest challenge at the basic research level (where innovations in tertiary education research facilities have weak pipelines into industry and further commercialisation) and at the manufacturing level (where innovations need to ensure product quality and cost competitiveness in Nigeria's volatile macroeconomic environment).

### Policy

The research sought to find out if existing policy promotes green jobs and if the policy space is responsive to young people's innovation and employment needs and priorities. The following key policies and regulatory frameworks were identified: the National Renewable Energy and Energy Efficiency Policy (NREEEP), the National Employment Policy (2017), the National Youth Policy (2019–2023), the Nigerian Electricity Regulatory Commission (NERC) Mini-Grid Regulations (2023) and the Environmental and Social Management Plan (ESMP) Guidelines for Solar Mini-Grid Projects (2022). The following findings were made:

- There is little coherence between national renewable energy policies, youth policies and labour policies. The lack of alignment leads to duplication, inefficiencies and gaps in programme design, resulting in missed synergies between skills supply (education/labour policy) and demand (energy policy). A coordinated policy approach, with cross-ministerial collaboration to create integrated strategies for green jobs and inclusive industrial growth, is essential.
- Policy and government programmatic support for youth-led mini-grid startups is weak, as these are often focused on the wider objectives of electrification and development. With the requirement for contractors on government programmes to have advanced capacity – which young startups typically do not possess – the opportunity to harness the demographic dividend in Nigeria's energy transition is being missed. Embedding youth targets, quotas and tailored support into mini-grid policies is critical to achieving equitable development and ensuring long-term sector sustainability.
- Without tailored support, youth-led startups are locked out of government-funded mini-grid opportunities, deepening inequalities and stifling innovation. This perpetuates a status quo where only established firms benefit from public programmes, while emerging local entrepreneurs are sidelined. To change this, procurement policies must include youth-access clauses, flexible eligibility requirements and dedicated funding windows for young founders.

## Key recommendations

The following recommendations are made for policymakers and stakeholders in the solar mini-grid sector wishing to support sustainable energy access, strengthen local communities and enhance growth.

## Skills

- **Invest in skills development and training**: Policymakers and development partners need to scale training for the workforce in solar design, installation, operations and maintenance. This should build on the National Board for Technical Education's (NBTE) recent development of a technical and vocational education and training (TVET) curriculum for solar photovoltaic (PV) skills. Actors should also ensure that the content of such programmes is aligned with industry needs and equips youth and women with hands-on, practical experience to meet the sector's technical demands.
- **Promote capacity building**: With the support of development partners, implementing agencies such as the REA, the National Information Technology Development Agency (NITDA) and the National Agency for Science and Engineering Infrastructure (NASENI) should invest in programmes that equip Nigerian stakeholders with the skills and knowledge to implement and maintain cutting-edge solutions.
- **Sponsor and encourage the creation of intensive incubation programmes**: Successful incubation programmes should be replicated for the mini-grid sector. Enterprise support organisations, development partners and implementing agencies should support incubation programmes to transition startups into mini-grid development and installation companies, and to make more local mini-grid companies investment-ready for large-scale mini-grid programmes. Long-term support should be provided by development partners to prepare the companies for the rigours of larger funding facilities that have stringent eligibility criteria. These programmes may be embedded as components in national electrification projects such as DARES.
- **Incorporate Indigenous knowledge and practices**: Mini-grid companies should leverage the knowledge and practices of local communities, including their insights into sustainable energy usage patterns and resource management, when designing and implementing minigrid projects. The REAN and/or the Africa Minigrid Developers Association (AMDA) should develop a framework and/or guidelines for Indigenous knowledge codification and incorporation into the mini-grid sector.

## Gender

- **Increase policy attention towards women in science, technology, engineering and mathematics (STEM) fields**: The REA, along with other public institutions – such as the Federal Ministry of Science and Technology, the Federal Ministry of Education and NITDA – should collaborate with higher education institutions, development partners and other organisations to increase enrolment of girls in STEM undergraduate programmes and create a pipeline of female workers and entrepreneurs for the sector.
- **Inclusion in incubation and enterprise support programmes**: Enterprise support organisations, development partners and implementing agencies should support incubation programmes to transition startups into mini-grid development and installation companies, and should be more explicit, proactive and systematic about encouraging female entrepreneurs. Such encouragement should address key barriers women face, from responding to calls for applications, to programme structure, delivery format and schedule, pedagogy and content, and post-programme support. Associations of ecosystem support organisations – such as the Innovation Support

Network and AfriLabs – should develop guidelines for gender mainstreaming in enterprise support programmes.

## Finance

- **Increase access to finance for local operators**: Financing mechanisms provided by development partners, private capital and public funding institutions should be tailored to the unique needs of mini-grid operators, particularly small-scale and youth-led enterprises. Low-interest loans, grants and subsidies should prioritise early-stage businesses and local community members to enable them to overcome capital constraints and scale their operations sustainably. Financiers may partner with enterprise support organisations and financial advisory firms to provide technical assistance in order to complement financing support for such businesses and mitigate risk for financiers.
- **Cater to the unique needs of youth and women**: Funding facilities should create sub-components that design funding that caters to the unique needs of youth and women. These may relax eligibility criteria for younger mini-grid companies, while providing complementary technical assistance and project evaluation to ensure project quality.
- **Expand climate finance for mini-grids**: The REA should aim to increase overall funding for mini-grid projects through international grants, concessional loans and partnerships, focusing on funding mechanisms that directly benefit underserved communities and small-scale operators.

## Innovation

- **Establish knowledge-sharing networks**: To foster innovation and collaboration, industry associations such as the REAN and AMDA, as well as implementing agencies such as the REA, should create opportunities for mini-grid operators, policymakers and communities to exchange best practices and lessons learned. These include industry forums, workshops and online knowledge hubs.
- **Promote technology transfer**: Facilitate the transfer of advanced mini-grid technologies and best practices to local operators, and link research to industry. This could be accomplished though the promotion of subcontracting between large foreign companies and smaller local companies; development partners funding open-source tools and supporting capacity-building programmes on the adoption and adaptation of such tools; and the REA encouraging the formation of equitable joint ventures and special-purpose vehicles between more and less technologically advanced companies.
- **Establish innovation hubs for renewable energy development**: Development partners should establish more renewable energy innovation hubs that provide young entrepreneurs with access to funding, mentorship and infrastructure to scale their ideas. These hubs could focus on integrating Indigenous knowledge with modern technologies to create innovative, localised solutions to energy challenges.

## Policy

- **Create policies for youth and gender inclusion in the mini-grid sector**: Targets (particularly the number of jobs created) contained in mini-grid policy documents developed by the REA and the Federal Ministry of Power (FMP) should be disaggregated by gender and age. This would ensure inclusivity for youth and women in the sector both in its formative years and as it matures and scales.
- **Institutionalise youth involvement in policymaking**: Youth organisations and youth chapters of associations in the sector, such as the REAN, should get a seat at the policymaking table.
- **Support community ownership and involvement**: The REAN, AMDA and REA should encourage greater levels of community ownership of mini-grid projects and involve residents in the planning, implementation and management of the projects to ensure long-term sustainability.
- **Encourage inclusive decision-making**: Ensure decisions reflect the priorities and needs of all stakeholders and create platforms for all those involved – including local governments, community representatives, operators and financiers – in the design and implementation of mini-grid projects.
- **Strengthen local institutions for better governance**: Enhance the capacity of local governments and regulatory agencies to oversee, coordinate and support the mini-grid sector. This includes providing technical assistance, streamlining licensing processes and ensuring compliance with national energy policies.
- **Mainstream mini-grids in national development plans**: Embed mini-grid development into Nigeria's broader development strategies and policies so that it can be aligned with national priorities, such as increasing energy access, reducing greenhouse gas (GHG) emissions and promoting economic development in rural areas.
- **Align international policies with local realities**: The FMP, the Energy Commission of Nigeria and the REA should work with the National Council on Climate Change (NCCC) to ensure that international energy policies and funding mechanisms developed through multilateral agreements in which the NCCC is involved are tailored to Nigeria's unique challenges, such as affordability, accessibility and local capacity constraints.

# SECTION ONE

## Introduction

## 1.1 Overview and context

African nations face three interconnected challenges: climate change, slow economic growth and widespread youth unemployment. In 2022, 25.7% of Africa's youth population, representing more than 72 million people aged 15 to 29, were not in education, employment or training (NEET). Two-thirds of these were young women, highlighting significant gender disparities (Karkee & O'Higgins, 2023). While global NEET rates declined between 2005 and 2022, sub-Saharan Africa experienced an increase (Karkee & O'Higgins, 2023). In Africa, 58% of jobs depend on sectors directly tied to the sustainable management of natural resources, such as agriculture, fishing and forestry, making a healthy environment critical to employment and livelihoods (Global Center on Adaptation, 2021).

Nigeria, Africa's most populous nation, is classified as a lower-middle-income country (World Bank, 2024). Despite its economic potential, about 40% of the population, equivalent to 82.9 million people, lives in income poverty (African Development Bank (AfDB), 2023), while a significant 63%, or 133 million individuals, experience multidimensional poverty (National Bureau of Statistics (NBS), 2022). As of 2023, Nigeria ranked 21st among 54 African countries in terms of per capita income, trailing its neighbours Ghana and Côte d'Ivoire (AfDB, 2023).

The country's unemployment rate, reported at 5.7% in 2024, appears low compared to other African nations (Statista, 2024), but this figure conceals significant employment quality issues. By mid-2023, 88% of workers were self-employed, and 92.7% operated in the informal sector, with youth (15–24 years) and women more heavily represented (NBS, 2023). Many informal workers face precarious conditions, and youth unemployment remains disproportionately high. Between 2012 and 2022, over 35% of workers and 40% of youth lived in working poverty (AfDB, 2023).

Green technologies, also known as clean technologies or environmental technologies, (hereafter referred to as 'green tech') offer a promising solution to the three challenges. Green tech involves applying scientific knowledge and innovation to develop products, processes and services that are both environmentally sustainable and resource-efficient (Rana et al., 2021). Green tech has the potential to create new job opportunities and income sources for young people across various industries, including renewable energy, waste management, agriculture and transportation. Additionally, it can drive the growth of businesses focused on producing and promoting these innovations, further contributing to economic development. For example, Nigeria's vast solar energy potential and the over 90 million people in the country without electricity make it the largest mini-grid market in West Africa and a key target for sustainable energy solutions (Sustainable Energy for All (SEforALL) & Bloomberg New Energy Finance (BNEF), 2020).

The potential for green tech to drive job creation in Nigeria aligns with the philosophy of Africapitalism, which emphasises the role of a vibrant private sector in generating both economic prosperity and social wealth (The Africapitalism Institute, 2015a).[3] An Africapitalist approach pays particular attention to how the solar mini-grid sector's growth can be structured to deliver not only commercial returns but also lasting social benefits for local communities, such as meaningful employment, entrepreneurial opportunities and strengthened local economies.

However, the Frontier Technology Index reveals that sub-Saharan Africa is the least prepared to adopt or adapt to cutting-edge technologies.[4] This is because it ranks low on most of the metrics used to calculate the index, such as number of patents filed on frontier technologies, expected years of schooling, share of high-technology manufactured exports and population share of internet users. This puts the region at risk of missing out on significant technological advancements (United Nations Trade and Development (UNCTAD), 2023).

To change course, African nations must establish robust legal, policy and infrastructure frameworks that support the development and adoption of green tech. To achieve the United Nations (UN) Sustainable Development Goals (SDGs), these frameworks should aim to mitigate and adapt to the impacts of climate change, promote inclusive and sustainable economic growth, and create meaningful green jobs for the continent's young and rapidly growing population (Africa Policy Research Institute (APRI), 2023).

## 1.2 Report approach

### 1.2.1 Purpose and scope

The main objective of the research was to understand the key actors, policy context, barriers and enablers in the nexus between green tech (i.e., the solar mini-grid sector) and youth employment in Nigeria, and how green tech is capitalising on Indigenous and traditional knowledge to enhance technological innovation for youth-led startups.

Nigeria was chosen for the study because of the combination of its vibrant startup ecosystem (Startup Genome, 2024), its status as the largest proven and fastest growing market for private mini-grids in sub-Saharan Africa (Alliance for Rural Electrification (ARE), 2024) and its marked youth unemployment problem (Virk et al., 2024). The emerging solar mini-grid sector has a prominent role in Nigeria's energy transition and offers ample scope for youth participation. It is estimated that Nigeria needs more than 6,000 mini-grids (Husein et al., 2024) in off-grid areas and 4,000 in the underserved ones (Graber et al., 2018). Only about 200 mini-grids had been installed by 2023 (World Bank, 2023), presenting a huge opportunity to shape youth inclusiveness in the emerging green tech sector.

To answer the core research questions, the report focuses on three elements in Nigeria's solar mini-grid innovation ecosystem: i) the tech startup players, ii) Indigenous knowledge (IK), and iii) youth participation in driving mini-grid sector innovation, entrepreneurship and job creation, with a cross-cutting focus on gender and education. Policy, skills, finance and innovation are identified in the literature review as critical for startup survival, growth and job creation.

### 1.2.2 Research questions

The study answers the following research questions:

a. What are the existing policy tools and regulatory frameworks and who are the stakeholders in green tech management and youth employment in Africa?

b. Do existing policy tools and rules promote green jobs for youth in the energy sector?

c. Is Africa's green tech policy space responsive to young people's innovation, employment needs and priorities?

d. What realities and challenges do entrepreneurs face in the green tech startup space or in supporting climate action solutions?

e. What are the opportunities for scaling up local innovation in green tech among African youth?

f. What realities and challenges do women face in the development of tech transfer and job creation in green tech?

### 1.2.3 Methodology

The report takes a mixed-methods approach to answering the research questions. It entails a literature review, document analysis, semi-structured interviews, qualitative surveys and the quantitative analysis of a novel dataset. (See the annex for a detailed report on the methodology.)

# SECTION TWO

## Solar mini-grid innovation and youth employment in Nigeria

This section provides an overview of the impacts of climate change in Nigeria which make global decarbonisation initiatives, including those in the energy sector, necessary. It further outlines youth employment challenges in Nigeria and examines the mini-grid tech startup ecosystem, its key stakeholders and employment trends in the sector.

## 2.1 Climate change impact in Nigeria and the imperative for a solar mini-grid ecosystem

Like other countries in Africa, Nigeria has experienced the negative impacts of climate change, including flooding along the Atlantic coast, aridification on the northern fringes of the country and irregular and unpredictable rainfall patterns (Federal Ministry of Environment, 2021). Consequently, it has launched a drive to mitigate the impact of climate change through adaptation, and to reduce its carbon emissions by decarbonising the energy sector and other contributing sectors.

In 2023, Nigeria emitted 128.5 million tonnes of carbon dioxide ($CO_2$), representing 0.34% of global emissions (Ritchie & Roser, 2024). The country was the world's 25th largest greenhouse gas (GHG) emitter in 2018 (Dunne, 2023) and the fourth largest emitter in Africa in 2021 (Sasu, 2024). Nigeria's energy sector accounts for the largest share (about 60%) of the country's total emissions (Regional Collaboration Centre, 2023). As a result, in its Nationally Determined Contribution (NDC), Nigeria committed to cut its GHG emissions by 45% by 2030, with the energy sector accounting for 57% of the proposed reduction (Access to Energy Institute, 2019).

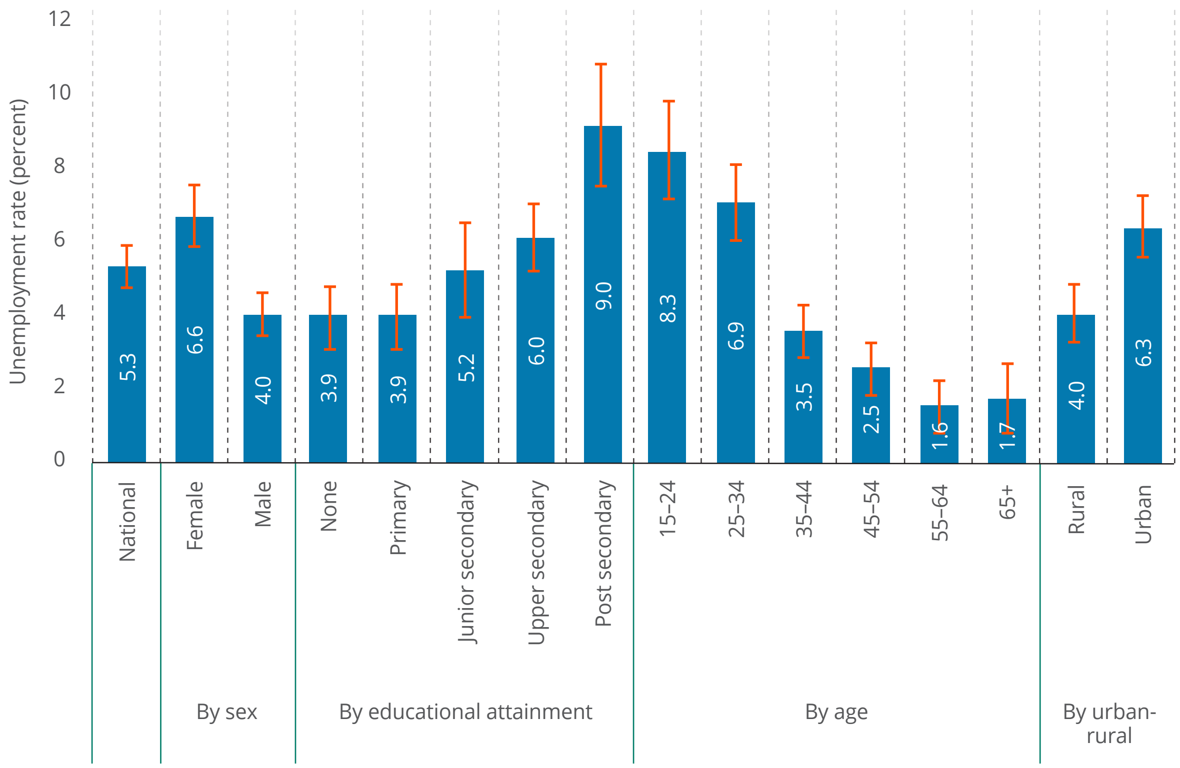
The decarbonisation agenda provides opportunities to adopt new technologies and build new technological and productive capabilities in new industries enjoying growing demand. Global investments made in more climate-friendly technologies are useful for solving problems beyond the climate agenda, such as energy poverty (Anabaraonye et al., 2025; Olisah et al., 2025; Anabaraonye et al., 2024). In fact, expanded access to clean energy, the seventh SDG, is linked to 65% of other SDGs (Nerini et al., 2018).

## 2.2 Youth employment

According to the World Bank classification, Nigeria is a lower-middle-income country (World Bank, 2024). About 40% (82.9 million) of Nigerians are income poor (AfDB, 2023), and 63% (133 million people) are multidimensionally poor (NBS, 2022). In 2023, in terms of per capita income, Nigeria ranked 21 out of 54 African countries, below its neighbours Ghana and Côte d'Ivoire (AfDB, 2023).

While Nigeria's unemployment rate seems low (5.7%) compared to other African countries (Statista, 2024), the figure masks the problem of the quality of employment. For instance, in the second quarter of 2023, about 88% of workers were self-employed, and 92.7% of the labour force was employed in the informal sector. More of those in self-employment and informal work were younger people (15–24) and women (NBS, 2023). The majority of those in the informal sector were working under vulnerable conditions (AfDB, 2023). Moreover, youth had the highest unemployment rates (NBS, 2023) at about 8.3% for those aged 15–24, and 6.9% for those aged 25–34 (see Figure 1).

**Figure 1**
Unemployment statistics in Nigeria (2023)




*Source: NBS (2023)*

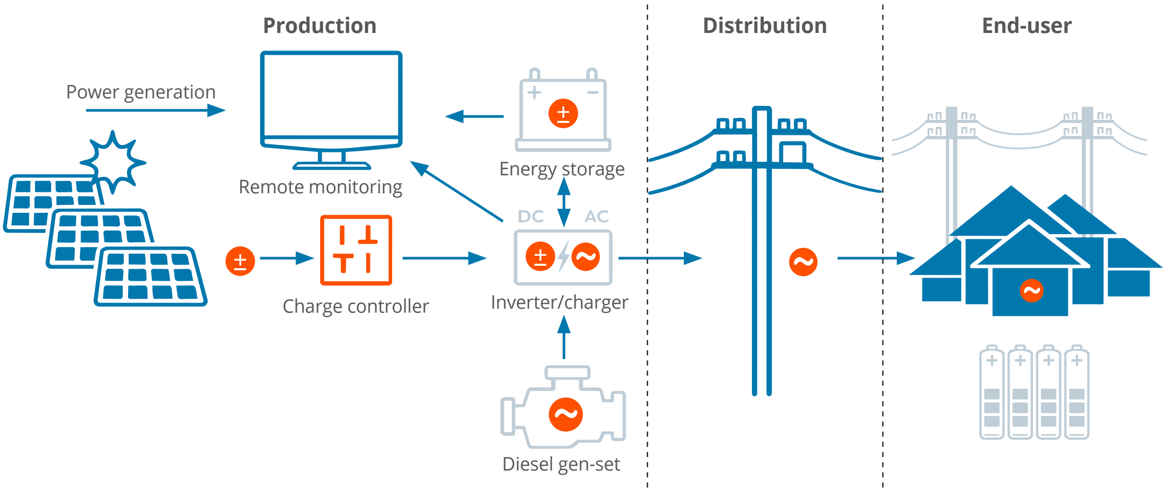
As a result of this employment profile, between 2012 and 2022, the working poverty rate (those employed but living below the poverty line) was around 35% and over 40% for those aged 15–24 (AfDB, 2023).

## 2.3 Overview of solar mini-grid technology

The Nigerian Electricity Regulatory Commission (NERC) defines a mini-grid as 'an integrated local generation and distribution system with installed capacity below 1 megawatt (MW), capable of serving numerous end users independent from the national grid' (NERC, 2023). Such a system may be 'isolated', without connection or energy exchange with the national grid, or 'interconnected' if it has such a connection (NERC, 2023).

While mini-grid systems can be powered by diesel generators, hydropower, wind power, biomass, solar and other energy sources, solar is the most common energy source for most of sub-Saharan Africa's third generation mini-grids (Energy Sector Management Assistance Program (ESMAP), 2022). The major components of a solar mini-grid system are ground-mounted solar panels, lithium-ion batteries, inverters, charge controllers, smart metres, distribution poles and cables, and balance-of-system components (see Figure 2).

**Figure 2**
Components of a solar mini-grid system




*Source: González-Garrido et al. (2024)*

Solar mini-grids have grown in popularity because they are the lowest-cost option for electrifying communities that are far from the grid, as it would be more expensive to construct transmission and distribution lines across vast distances. The decline in the cost of solar power generation over the past decade has also made solar mini-grids more cost competitive with diesel-powered mini-grids and off-grid generator sets (Power for All, 2019a). More importantly, they are cleaner sources of energy than petrol- and diesel-powered generators.

## 2.4 The solar mini-grid ecosystem in Nigeria

Nigeria has the largest unelectrified population in the world (SEforALL & BNEF, 2020). With over 90 million people lacking access to electricity, mini-grids are the lowest-cost electrification solution for approximately 27% of population clusters, translating to 14% of Nigeria's population (Husein et al., 2024). Nigeria's mini-grid sector is therefore set to play a pivotal role in addressing this acute energy access challenge. In fact, the significant solar energy potential and vast energy access deficit make Nigeria the country with the largest potential mini-grid market in West Africa and the second largest in sub-Saharan Africa (SEforALL & BNEF, 2020).

The mini-grid value chain in Nigeria comprises diverse actors, including original equipment manufacturers (OEMs), marketers, project developers and service companies. OEMs, predominantly located outside the country, supply solar mini-grid components, while marketers facilitate the importation and distribution of these technologies. Mini-grid developers and service companies handle critical roles, such as project implementation, system design and monitoring. These companies are fostering local innovation and building technical capacity. The Renewable Energy Association of Nigeria (REAN) lists 152 member companies specialising in solar products, ranging from pico-solar appliances and solar home systems to large-scale solar projects and commercial mini-grids (REAN, 2024).

Despite the sector's immense potential, it also faces significant challenges. Local developers rely heavily on imported components, exposing them to foreign exchange volatility and supply chain disruptions. Additionally, inadequate local manufacturing capacity and regulatory uncertainties hinder the rapid scaling of mini-grid projects. These barriers must be addressed to unlock the sector's potential to accelerate electrification, create jobs and foster inclusive economic development.

### 2.4.1 The origins, focus and scale of the Nigerian mini-grid sector

In 2010, students at the Federal University of Technology in Owerri built Nigeria's first solar mini-grid and founded Green Village Electricity Projects Limited (GVE) as a startup to drive off-grid renewable energy in rural communities (Pretz, 2023). Nayo Tropical Technologies installed the first metered solar mini-grid in Nigeria in 2010 and the first interconnected mini-grid in the country in 2019 (Nayo Tropical, 2022).

This entrepreneurial growth was partly driven by declining costs of the technology globally. The cost of installing a kilowatt (kW) of firm power output dropped from USD 8,000 in 2010 to USD 3,660 in 2023 (ESMAP, 2023). It is projected to decline by over 32% by 2030 (ESMAP, 2022), making mini-grids the lowest-cost option for rural electrification for half a billion people globally (Power for All, 2019a).

In 2013, the Nigeria Energy Support Programme (NESP), an initiative aimed at enhancing sustainable and reliable energy, was launched. The EUR 24.5 million programme was funded by the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ). By 2015, there were five mini-grid developers ARE, 2024), which were largely enabled by the first phase of the NESP (2013–2018) under which six mini-grids were eventually installed (Warren, 2018). In 2016, the government approved the Rural Electrification Strategy and Implementation Plan (RESIP), whose mandate was to rapidly expand electricity access in rural areas using both grid and off-grid approaches. That same year, the NERC approved the Mini-Grid Regulations, providing a conducive enabling environment for mini-grid companies to operate in. The REAN, an umbrella organisation representing entities working in the sector, was established in 2018.

The next major boom to the sector came with the disbursement of USD 550 million by the World Bank and the AfDB for the Nigeria Electrification Project (NEP). Implemented by the REA, the project provided subsidies of USD 350 per connection to mini-grid developers. Under the programme, 103 new mini-grids were installed, with a total capacity of 5.6 MW (Udo, 2023).

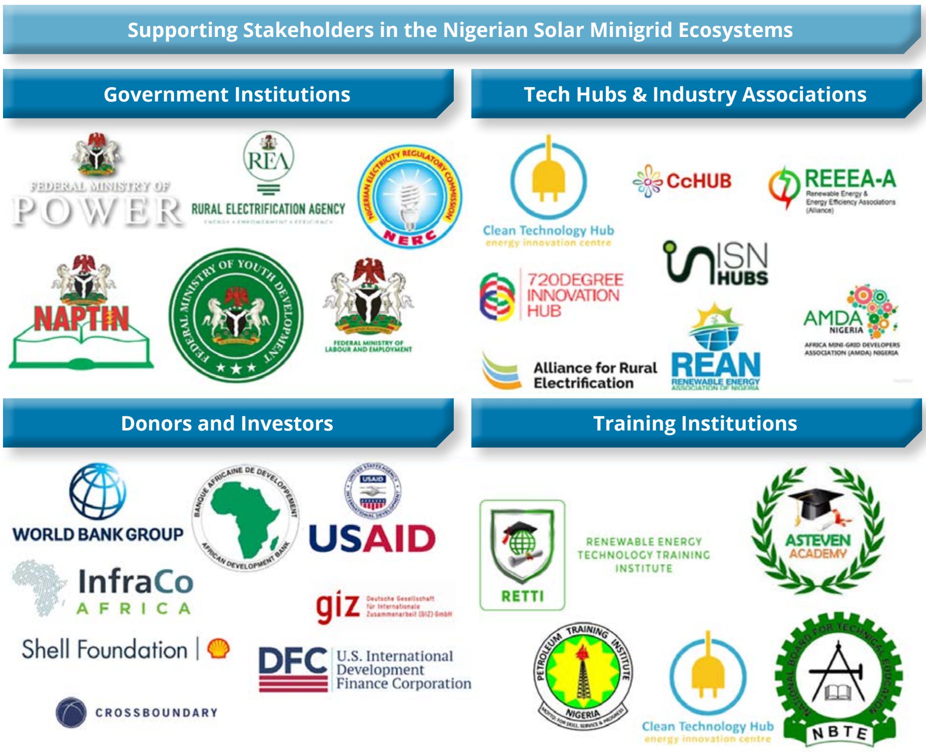
Today, there are almost 200 mini-grids in the country, most of them solar hybrid systems. In December 2023, the World Bank launched the USD 750 million Distributed Access through Renewable Energy Scale-up (DARES) programme, noted to be 'the largest-ever single distributed energy project by the World Bank globally' (Agbetiloye, 2023). The DARES project aims to raise the number of interconnected mini-grids from the current five to 25.

### 2.4.2 Main actors

The key stakeholders in the implementation of solar grid policies include the Federal Ministry of Power (FMP), which is responsible for formulating and implementing national policies related to the power sector; the NERC, which regulates the electricity sector, establishes grid codes and standards and promotes competition within the market; and the REA, which drives rural electrification initiatives, including the promotion of off-grid and mini-grid solutions utilising solar power.

Additionally, the state institutions play a significant role in developing and implementing state-level policies and programmes that support solar mini-grid integration. Civil society organisations, development partners and private sector participants, including renewable energy developers, distribution companies and financial institutions, are also important stakeholders in the development of solar mini-grid and renewable energy policies.

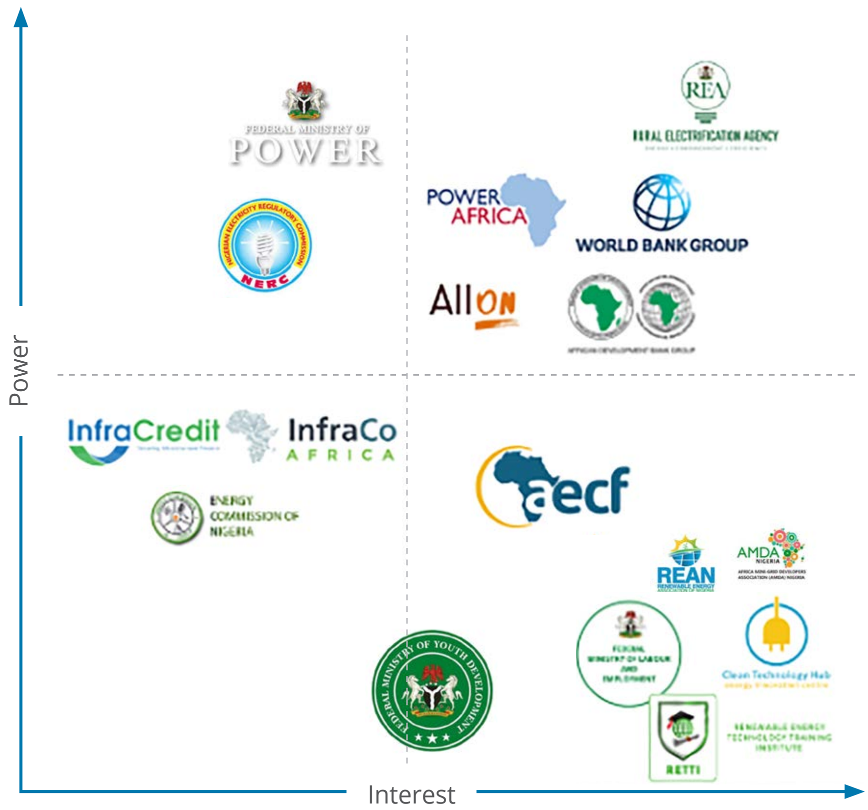
**Figure 3**
Map of stakeholders in the Nigerian solar mini-grid ecosystem that support startups




*Source: Authors' construct (2025)*

These stakeholders' interest in youth employment in the mini-grid sector varies. A stakeholder analysis using a power–interest grid identifies a small set of key actors involved in aspects of the ecosystem, including policy advocacy, policymaking and implementation, finance, skills building and enterprise support, and maps them according to their level of power and interest in promoting youth employment (see Figure 4).

**Figure 4**
Power–interest stakeholder grid for the Nigerian solar mini-grid ecosystem




*Source: Authors' construct (2025)*

Power, in this case, is defined in terms of power resources,[5] encompassing the:

- possession of legislative mandates over policymaking, regulation or public policy implementation;
- budgetary resources to implement programmes and projects and influence other actors;
- organisational capacity to mobilise industry actors in order to influence policy and programming.

The placement of stakeholders within the power–interest grid does not imply that any actor is opposed to youth employment. Rather, it reflects the degree of intentionality with which they currently engage with youth inclusion in the mini-grid sector. This categorisation is based on interview feedback, analysis of policy frameworks and observed patterns of institutional behaviour rather than formal mandates. Actors positioned in the high power/low interest quadrant generally hold significant influence over sectoral policy, regulation or finance, but do not yet deploy instruments that prioritise young people as beneficiaries or participants within their interventions. Their engagement with youth is therefore passive or indirect, rather than strategic. Conversely, organisations in the high interest category demonstrate deliberate commitment to youth integration through targeted programmes, partnerships or advocacy.

### 2.4.3 Employment trends

Employment in the domestic mini-grid sector is typically split between rural (or peri-urban) and urban areas. Here, jobs include those involving the initial construction and installation of the system and the powerhouse, which houses the batteries, inverters and other system components; basic operations and maintenance; and security (Economic Consulting Associates (ECA) & Africa Minigrid Developers Association (AMDA), 2020). Installation of the systems often takes less than two months and does not require many workers (ECA & AMDA, 2020). After installation, while security guards and electricity vendors may be employed, full-time technicians are often not retained at the project site, although a local technician may be trained to undertake minor troubleshooting, maintenance and repairs (ECA & AMDA, 2020; World Bank, 2023).

Urban jobs involve direct employment at the offices of the mini-grid companies, which includes jobs relating to core operations, management, customer service and payment collection, among others (ECA & AMDA, 2020).

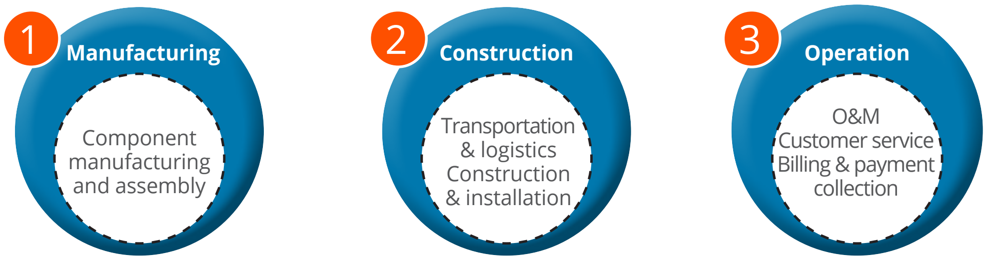
**Box 1**
Typical sequence of job creation

The following is a typical sequence of job creation for mini-grid companies in Nigeria (World Bank, 2023).

1. The mini-grid company employs full-time staff in its head office in a state. On the payroll are engineers and design personnel; business development officers; and customer service, payment collection and administrative staff (e.g., a human resource officer, a a and accounts officer, a legal and compliance officer and an office administration officer). The technical staff conduct desk research (using geospatial mapping tools) to identify potential project sites.
2. The work kicks off with an 'initiation stage', during which local personnel are recruited to scout potential mini-grid sites.
3. Once the site has been selected, the staff undertake project-related engineering, procurement and construction tasks in two teams: one focuses on the planning, design and operations components of the work, while the other oversees compliance and customer care. Once construction starts, new workers are hired to string cables, construct energy cabins and powerhouses, and erect poles, distribution lines and stanchions.
4. After installation, a few workers are retained for operation and maintenance roles, typically as site technicians and energy vendors. Since the systems are remotely operated, only a few people are required on site.

The jobs created in the sector are skilled (management, engineering, technical design), semi-skilled (customer relations, technicians, operators) and unskilled (manual labourers, security personnel).

**Figure 5**
The mini-grid value chain




*Source: ECA & AMDA (2020)*

While job opportunities exist in the manufacturing/assembly stage of the value chain (see Figure 5), African countries miss out on them because they lack the capability for domestic production of solar mini-grid components and rely on imports (Delavelle, 2022). In Nigeria, local contribution to solar-battery mini-grid equipment was only at 5% by 2017 (Swiss Resource Centre and Consultancies for Development (Skat), 2017), rising to 19% by 2021 (REAN, 2021a) and the country had only three manufacturers of solar panels by 2025 (Auxano Solar, Blue Camel and the National Agency for Science and Engineering Infrastructure (NASENI)). Our estimates of the number of jobs created are therefore focused on the construction and operation segments of the mini-grid value chain.

There are currently no global estimates of the share of young women and men in the clean energy sector International Labour Organization (ILO), 2022). Nonetheless, the largest jobs census on the off-grid distributed renewable energy sector (which includes pico-solar appliances, solar home systems (SHSs)), commercial and industrial standalone systems, and mini-grids) estimates that the sector has produced more jobs in Nigeria (75,000) than the oil and gas sector (65,000) (Power for All, 2022). This is up from nearly 50,000 people in 2021 (Power for All, 2022). While most of these jobs are from the SHS subsector, most mini-grid companies also sell SHS products, and the mini-grid sector creates more indirect and induced employment than direct employment, relative to the other decentralised renewable energy (DRE) subsectors (Power for All, 2022). Most of these are either direct full-time workers or informal workers (Power for All, 2022).

Based on estimates made by the Africa Minigrid Developers Association (AMDA), a mini-grid site creates between 0.14 and 0.16 full-time positions for every kW of installed generation capacity. Therefore, a small mini-grid of 20 kW creates three full-time jobs (ECA & AMDA, 2020). Estimates of how many mini-grids Nigeria needs vary. A recent study revealed that, since mini-grids are the lowest-cost electrification method for about 27% of population clusters in Nigeria (Husein et al., 2024), the country needs 6,128 sites. It has also been estimated that 35% of underserved rural areas could be better served by more than 4,000 commercially viable, interconnected mini-grids (Nana & Dioha, 2024).

Therefore, assuming an average of three full-time jobs per site, the potential job creation in the Nigerian mini-grid sector is at least 30,384 direct full-time jobs through both off-grid and under-grid mini-grids. Using the employment factors estimated by Power for All (2019b), this extends to an estimated 68,364 direct informal jobs and 113,940 productive use jobs (those created by the mini-grid and end users themselves as a result of newly acquired or enhanced electricity access).[6] Assuming that 10,128 mini-grids at an average of 20 kW are installed, this means a total of 212,688 jobs could be created in the mini-grid sector with the achievement of universal access to electricity by 2030. This may be a conservative estimate based on the assumption of an average of a 20 kW mini-grid per site, whereas in 2019 the REA considered the prospect of scale to be 100 kW per site (Nigeria Electrification Programme, n.d.c).

The available sources indicate that the mini-grid sector does relatively well when it comes to female and youth employment. The World Bank (2023) finds that, while no specific policies to promote female employment in the sector exist, female participation in mini-grid projects undertaken under the government's NEP was in line with global averages for the renewable energy sector, at approximately 32%. More data suggests that the share of female workers in the mini-grid sector ranges from 18% to about 35%, with the greatest representation in skilled jobs (Power for All, 2022). In companies interviewed for this study, women represent an average of 34% of full-time employees. This is progressive, given that women constitute around 21% of the overall workforce in energy utilities in African countries (Baldinger et al., 2020). Based on the previous estimate of the full-time job creation potential in the Nigerian mini-grid sector, we estimate that the employment potential for women is at least 3,309 to 6,434 direct full-time jobs and 16,546 to 32,172 total jobs.

**Figure 6**
Share of women workers across different skill levels and DRE technology


*Source: Power for All (2022)*

In terms of youth employment, a study of six mini-grid sites in Nigeria found that the percentage of youth among those employed directly in mini-grid projects in skilled, semi-skilled and unskilled roles varied widely across projects, from 10% to 100% (World Bank, 2023). From the companies interviewed, youth make up an average 82% of full-time staff.

Youth and women's leadership in the Nigerian solar mini-grid sector is limited. Based on our dataset, people over the age of 35 make up the majority (81%) of chief executive officers (CEOs) in the sector, while men make up 81% of CEOs. This is likely due to two factors. Firstly, the mini-grid sector in Nigeria emerged some 15 years ago, when the present CEO of GVE – who led the installation of Nigeria's first solar mini-grid – founded the company just after completing his undergraduate studies. Secondly, the mini-grid sector is more capital-intensive than other sectors within the green tech space, where decentralised solutions are deployed. For example, the median cost of a mini-grid in 2018 was USD 140,000 (Nigerian Economic Summit Group, 2018). This large capital requirement was also cited by the youth we interviewed as a barrier to their entry into the mini-grid sector.

An examination of the websites, profiles and portfolios of the 17 tech hubs listed by Africa Tech Schools (2024) as operating in Nigeria as of 2024 reveals that it is difficult to find mini-grid innovators among incubation and acceleration programme cohorts. While the REA's website had a list of 49 mini-grid companies that qualified under the NEP (REA, 2024), Ayo Ademilua, president of the REAN, noted that only 20 local companies were involved with the deployment of mini-grids under the NEP between 2019 and 2023.[7] This was attributed to the difficulty in getting companies investment-ready to access the subsidies provided through the REA.

The reason for weaker female leadership in the Nigerian mini-grid sector appears to be the greater premium placed on a science, technology, engineering and mathematics (STEM) background to lead a mini-grid company and the low number of women in STEM. This is indicated by the significant presence of CEOs with a STEM background in the sector (64%), estimated from our dataset. Due to the need to conduct energy audits and undertake rigorous and sophisticated energy modelling, system sizing, system monitoring and operations, a STEM background is prevalent. CEOs with a STEM background make up the majority in the Nigerian mini-grid sector (90% of male CEOs; 20% of female CEOs). Notably, youth accounted for 59% of the management staff in the companies studied for this research. This suggests that, although structural factors may prevent many young people from starting solar mini-grid companies, they may still be able to get managerial roles.

# SECTION THREE

## Tech startups, local innovation and youth employment: enablers and barriers

The mini-grid sector in Nigeria has emerged as a critical solution to the country's electrification challenges, particularly in underserved and off-grid rural communities. Tech startups play a vital role in driving this growth by introducing innovative solutions, such as smart metering (Ibrahim, 2024), battery storage (Innovate UK Global Alliance Africa & Hinckley Recycling, 2025) and digital payment platforms (Fritzsche et al, 2019), to improve the efficiency and affordability of mini-grids. These startups leverage local knowledge and cutting-edge technologies to design scalable and sustainable energy solutions tailored to Nigeria's unique energy needs (All On, 2023). Additionally, their efforts create opportunities for youth employment across various stages of the value chain, including construction, maintenance, logistics and operations.

Local innovation is another key enabler in the mini-grid sector, as Nigerian entrepreneurs and researchers harness Indigenous resources and culturally specific approaches to develop contextually relevant solutions. Partnerships with research institutions and international development organisations have fostered innovation hubs, providing funding and technical support for startups working in the clean energy space. For instance, collaborations with global organisations such as the REA and the World Bank have enabled small-scale developers to scale their mini-grid projects, driving sectoral growth while equipping youth with technical skills for green jobs (World Bank, 2023).

Youth appear to be most prioritised in areas where they are organically predominant. Thus, under the NEP, the Energizing Education programme trained students in solar technology at the universities where solar photovoltaic (PV) installations were deployed as part of the programme. Such initiatives align with Nigeria's broader goals of sustainable economic development and job creation, as highlighted in the country's Energy Transition Plan REAN, (2022).

## 3.1 Practical realities and challenges of solar mini-grid tech startups

The literature review identified six factors that directly encourage or impede the employment of youth in mini-grid companies. These are: the policy and regulatory environment, financing conditions, company growth and expansion, skills requirements, technical assistance, and the dynamics of innovation. This list of factors was further validated by thematic outcomes from the interviews described in the annex.

## 3.2 Policy and regulatory challenges and impact

Globally, there is a growing movement towards mainstreaming youth perspectives into renewable energy and green economy policies. For example, the EU engages young people in shaping climate and energy policy through mechanisms such as the EU Youth Dialogue (European Union. (n.d.). In Kenya, initiatives like the Youth in Energy Empowerment Program (YEEP) provide platforms for young professionals to influence the national energy discourse, while South Africa's Youth Energy Indaba engages youth in national planning for the just energy transition (Department of Mineral Resources and Energy, 2021).

One representative of a company stated during an interview that when companies participate in policy consultations or validation events – where the focus is on the implications of policies on the well-being of the companies and communities – the assumption is that what is good for the communities is good for the youth. However, in Nigeria, the study found no evidence of structured platforms or youth associations in the energy sector engaging in policymaking. Instead, as revealed by an interviewee, the youth invited to consultations and validation events are from non-governmental organisations focused on general youth issues, and do not have the expertise to speak about youth dynamics and challenges within the renewable energy sector. This situation may change as youth-led organisations emerge that specifically focus on increasing youth voices in the renewable energy space. An example is Green Energy Mission Africa, founded by a young Nigerian, which launched the 'YouthVoltAfrica' initiative aimed at building the capacity of Africa's youth to contribute to the continent's energy transition (Green Energy Mission Africa, 2023).

Most mini-grid companies focus more on government programmes and projects than on policies. Yet the design of the government-run programmes for mini-grids (such as the NEP project from 2018 to 2023, and the DARES project from 2025 to 2028) is broadly shaped by policy. Mini-grid companies also pay more attention to, and may be more involved in, influencing the content of regulations, which require compliance and are embedded within the project management process. Conversely, companies are indifferent to policy documents because of the assumption that the government produces many good policies, but often lacks effective implementation (Obona, 2016). These companies show more interest in the programmes and regulations which affect them directly. For example, a company must meet the specifications of the Mini-grid Regulations 2023 to complete a mini-grid project. Likewise, since the NEP offers financial subsidies, more interviewees were aware of its requirements than of those of the National Renewable Energy and Energy Efficiency Policy (NREEEP). This is expected, since policies provide general indications of government direction, while programmes like the NEP reflect the actual implementation of such policies and directly provide the private sector players with tangible benefits. In addition, due to staff focus on business operations, many companies cede policy advocacy to representative industry associations.

Young interviewees seeking to move into the sector as entrepreneurs and skilled workers expressed a need for policy support for early-stage entrepreneurs and innovators. Such support could include innovation sandboxes or regulatory testbeds, where startups can pilot advanced technologies in mini-grids under flexible rules before full-scale regulation applies, and streamlined licensing and approval processes for early-stage companies piloting new energy technologies, reducing bureaucratic delays.

Some of the interviewees attributed the absence of more youth-focused policy and programme content to the relatively young age of the sector. A lot is happening: as frameworks, financing, models and projects that enable the sector to survive and mature are being put in place, social goals like youth and gender inclusion have become secondary. The danger is that the opportunity to ensure youth and women get a more solid presence and positioning in the sector may be missed. While the REAN, which has 90 member companies listed on its website, contributes to policy formulation, the association does not have a youth wing or working group. The study found no examples of youth-focused recommendations by the REAN for government policy or even programme design.

In sum, there are notable gaps between the policies on renewable energy and the realities of the sector as it pertains to youth employment. Below are examples:

- **Skills mismatch**: Renewable energy policies provide training that does not match the industry's specific demands, highlighting a gap in practical competencies.
- **Gaps in infrastructure**: Representatives of two companies mentioned the need to address the infrastructural bottlenecks that prevent the piloting of new technologies that would foster innovation. For example, advanced artificial intelligence applications in mini-grid operations are constrained by limited infrastructure for high-speed internet access in rural and peri-urban areas.
- **Divergent objectives**: While renewable energy policies aim at broader energy access, youth employment strategies target general sectors. There is therefore a 'missing middle' where a specific green-jobs-for-youth policy that addresses industry needs is lacking. As a result, the House of Representatives Committee on Renewable Energy has announced plans to introduce new legislation that will mandate the creation of green jobs across the country, with clear targets for the inclusion of women and youth in Nigeria's renewable energy sector and to mainstream green jobs into the national planning and budgeting processes (Kalu, 2025).
- **Funding disparity**: Many green policies include provision for improving access to finance for industry actors, but accessing funds remains a challenge, particularly for young companies (REAN, 2020). This hinders local initiatives and youth employment.
- **Policy alignment**: The Nigerian Youth Employment Action Plan (NIYEAP) emphasises employment creation and equal opportunities, but gaps exist in employability and entrepreneurship development, limiting local innovation and entrepreneurship.
- **Implementation challenges**: Inconsistencies in policy implementation and monitoring pose obstacles to green energy initiatives and job creation.
- **Fragmented policies**: Policies are fragmented across sectors and lack cohesive integration with youth employment needs. They are failing to adequately address gender inclusivity.
- **Regulatory complexities**: High regulatory hurdles and licensing requirements impede renewable energy deployment and youth employability.

Thus, to align renewable energy policies and youth employment needs, Nigeria must match training with industry demands, bridge funding disparities, enhance policy integration and implementation, and simplify regulatory processes to foster green energy initiatives and youth employment.

## 3.3 Financing

Mini-grid developers in Nigeria adopt diverse financing models to meet their funding needs. These models include debt financing, equity investments, grants and blended finance mechanisms (AMDA, 2025). Debt financing is sourced from international financial institutions, while equity investments come from venture capitalists, private equity firms and angel investors. Grants are provided by development agencies or government programmes to support early-stage projects or to incentivise developers in remote areas. Blended finance, combining concessional funding with private capital, has gained traction as an effective tool for de-risking investments and attracting additional private sector funding (Mutambatsere & de Vautibault, 2022; CrossBoundary, 2023a).

Nonetheless, the sector still grapples with funding challenges (Power for All, 2024). These include limited access to affordable local financing, as high interest rates and short repayment periods offered by Nigerian banks deter developers (REAN, 2021a). Foreign exchange volatility increases costs for developers relying on imported components (Oladipo, 2024) owing to limited local manufacturing (Olawin, 2025). Insufficient awareness of available funding opportunities and a lack of technical expertise in grant applications and fund management also hinder startups from securing capital.

Regulatory uncertainties, including delays in project approvals and inconsistent tariff structures, create additional risks for investors (Renewable Energy Performance Platform (REPP) et al., 2022). In comparison to 12 other western, central, eastern and southern African countries, Nigeria had the fifth-longest regulatory approval times, with a cross-country average approval period of about 50 weeks. This alone makes it impossible to deploy mini-grids at the scale required to achieve universal energy access by 2030 (AMDA, 2025). Addressing these challenges is critical to unlocking the potential of Nigeria's mini-grid sector as a driver of inclusive and sustainable development.

### 3.3.1 Financial needs

The solar mini-grid sector requires up to USD 8 billion to connect 35.4 million people (Global Electrification Platform, 2025). This amount is needed for system installation, maintenance and scaling operations. Most of the cash needed is for capital expenditure as mini-grid projects require substantial upfront investments for equipment, installation and site development costs. According to the REA, the average cost of developing a 100 kW mini-grid is about USD 300,000 to USD 500,000, depending on the location and complexity (Udo, 2023). A smaller solar hybrid mini-grid of 20 kW costs USD 96,000 (Greacen, 2019), compared to a relatively affordable e-bike priced at USD 1,700 in Nigeria (Alagbe, 2023) or a clean cookstove at USD 15 (Women's Earth Alliance, n.d.).

As long-term investments, mini-grids require patient financing. They need substantial capital upfront to install, but income from installations is low because the target market is often rural and peri-urban areas with lower incomes than urban regions. This results in payback periods of up to seven to ten years (CrossBoundary, 2020). Therefore, financing should be able to tolerate modest returns on investment over a long payback period which will only yield double-digit returns over a 15–20-year horizon (CrossBoundary, 2020). This explains why there is not a lot of domestic commercial financing available to scale the sector (REAN, 2021a; Chakamba, 2022).

Furthermore, because there is no secondary market for mini-grid assets, banks are unwilling to provide lending backed by mini-grid assets. Currently, entities interested in investing in mini-grids have to finance the company themselves (corporate financing). This exposes them to risks external to the project (i.e., those associated with the mini-grid company's other projects and portfolios). Project financing would require the mini-grid company to create a special-purpose vehicle to deploy and profit from the specific project an investor is interested in. Lending institutions are adopting this approach in financing the mini-grid sector. For example, Sterling Bank's Renewable Energy Project Finance offers project finance loans of up to four years with a one-year moratorium and a minimum equity contribution of 20% of the total project cost (Odyssey, 2025a).

Representatives of two companies also mentioned the need to fund the training and upskilling of staff to make use of the latest mini-grid planning, financial modelling and other tools. Similarly, testing new technologies, business models and delivery approaches requires time and resources. Indeed, CrossBoundary's Mini-Grid Innovation Lab[8] acknowledges that 80% of tested solutions fail, and that companies must subsidise the failures until they reach the 20% that succeed (CrossBoundary Group, 2022).

### 3.3.2 Sources of funding

Globally, most mini-grid developers have relied on public funding, such as grants from governments, development finance institutions, donor agencies and foundations (SEforALL & BNEF, 2020). In Nigeria, the USD 150 million mini-grid component of the NEP supported 175 mini-grids. The recently launched DARES project has also allocated USD 410 million for the development of 1,100 mini-grids.

The REA reports that every dollar of the USD 150 million funding leveraged USD 1.50 of private capital, resulting in USD 225 million of private capital catalysed under the NEP. If a similar leverage ratio is achieved by DARES, the sector will have more than USD 1 billion by 2029 (when the DARES project ends). Before the NEP, the largest local mini-grid company, GVE, was able to raise only around USD 4 million between 2013 and 2019 for mini-grids (SEforALL & BNEF, 2020).

In a review of 85 mini-grid companies operating in Africa, and their sources of funding from 2012 to 2024, AMDA (2025) found that the mini-grid developers had accessed around USD 640 million in funding across debt, equity and grant support at the corporate level. About 68% of the funding amount was equity financing, 20% was debt and 12% was grant funding to support core operations. These figures exclude project-specific grant financing, such as the previously mentioned NEP in Nigeria.

An evaluation of the profiles of a set of mini-grid companies reveals that there are two ways in which local mini-grid businesses tend to start in the mini-grid sector.[9] Many local mini-grid developers enter into the solar business by selling and installing standalone solar products and SHSs, whose cost is lower than that of mini-grids. This allows the startups to build capital from the lower segment of the renewable energy sector and then have the capacity to diversify into the mini-grid space. This is viable because of the relative ease of knowledge and experience transfer, as several components (solar panels, metres, inverters and batteries) which are required for a mini-grid are present in an SHS system (Energy and Environment Partnership Africa, 2018).

For example, Bolade Soremekun, CEO of Rubitec Solar, founded his company in 2004 and began by supplying solar-powered refrigerators to the Nigerian Federal Ministry of Health to store vaccines. Later installing solar street lights and solar pumping systems (Anyaogu, 2020), Rubitec Solar then diversified its operations in 2018 by developing its first solar mini-grid in the off-grid rural community of Gbamu Gbamu, under the Nigerian Energy Support Programme, funded by the German Agency for International Cooperation (GIZ) (Faleye et al., 2022). Similarly, Alex Obiechina founded ACOB Lighting Technology Limited in 2016 and started by deploying LED lighting and energy-efficient street lighting for individuals and state governments (All On, 2019). In April 2016, ACOB became the pioneer LED lighting distributor for Everlite LED Lighting Co. Ltd in Nigeria and the West African region (ACOB Lighting, 2016). In April 2017, the company completed its first mini-grid – a 16 kW system at Ihuama community in Rivers State (ACOB Lighting, 2017).

Another example is Hannah Kabir, one of the earliest female founders of an SHS company. Kabir founded Creeds Energy in 2012 by providing SHS solar-powered appliances and products to small businesses and households (Creeds Energy, 2012). Creeds received an initial grant from the Federal Government's YouWin! Initiative, and received a subsequent grant from Sterling Bank (Onyekwelu, 2020). In 2018, Creeds was one of the winners of the All On Nigerian Off-Grid Energy Challenge grant under the SHS category. In the last quarter of 2018, Creeds flagged off the first phase of its mini-grid projects (Onehi & Sunday, 2018). It is the same story for many of the prominent mini-grid companies, such as Sosai Renewables – founded by Habiba Ali in 2010 – which began by selling solar lanterns before upgrading into SHS and mini-grid systems (Esposito, 2018).

None of the 11 mini-grid companies interviewed (out of 34 in the dataset) exclusively offers mini-grid services. Most also offer solar home system products, a few additionally offer solar irrigation technologies, while larger companies offer solar solutions for commercial and industrial customers. There is therefore room for subsidisation across product categories and reinvestment of profits from one product category to another.

The stringent conditions for eligibility to the large grant programmes, such as the NEP and DARES, may prove prohibitive for youth seeking to enter the mini-grid space. Three of the entrepreneurs interviewed received technical and financial support before qualifying for the larger grants. All three companies were awardees of the United States African Development Foundation (USADF) and All On Nigerian Off-Grid Energy Challenge grants.

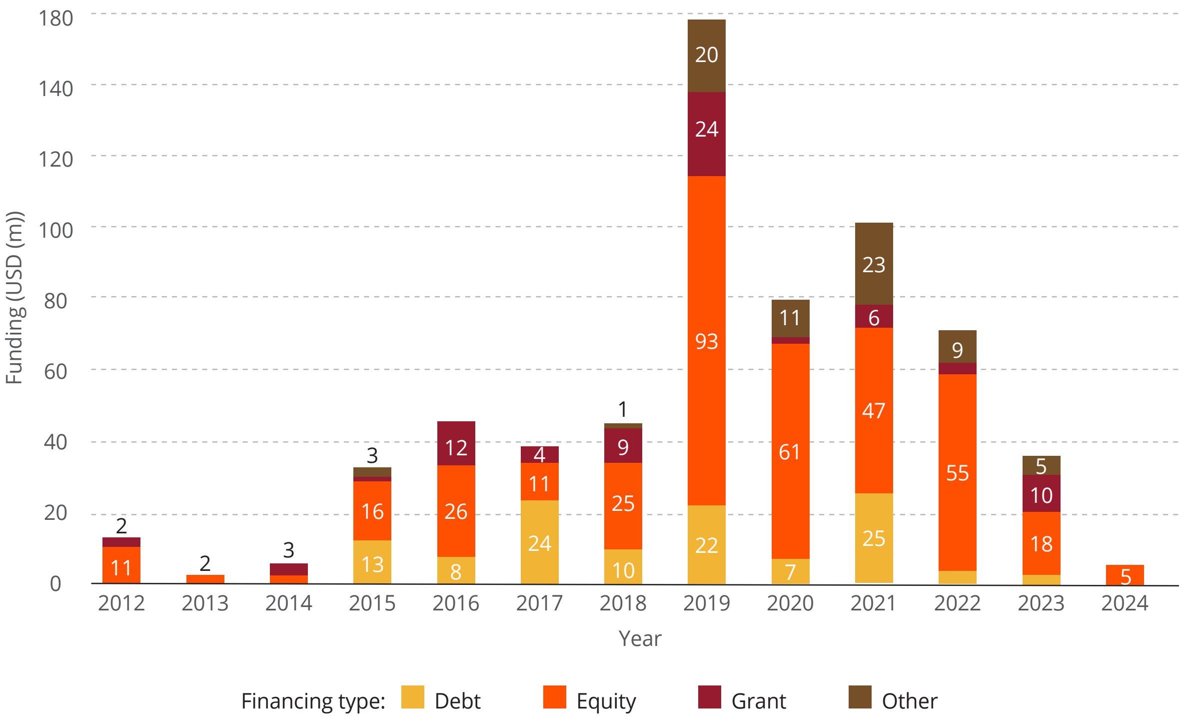
Financiers such as the NEP and DARES often focus on early- and growth-stage businesses. For example, All On, an impact investor funded by Shell, has supported early-stage developers in Nigeria through grants and equity investments (All On, 2023). In 2018, All On and USADF awarded grants to ten companies under the Nigerian Off-Grid Energy Challenge. USADF provided USD 50,000 in seed capital and technical assistance, while All On provided USD 50,000 in convertible debt and governance support (Uzoho, 2018). The challenge has been held annually since 2018. Funders such as the Tony Elumelu Foundation, which provides sector-agnostic support, may also provide seed funding, mentorship and entrepreneurship training to young African entrepreneurs, including those in the green energy sector.[10] GVE's first grant of USD 44,521, obtained under the 2009 Institute of Electrical and Electronics Engineers' (IEEE) Presidents' Change the World Project Competition for students who had developed solutions to real-world problems (Pretz, 2023), is another example of an early grant that served as seed funding for a Nigerian mini-grid startup.

The most active providers of equity financing for African mini-grid companies include ElectriFi, All On, InfraCo Africa, CrossBoundary Access, Gridworks, Norfund and the Renewable Energy Performance Platform (REPP/Camco) (AMDA, 2025). The most active providers of debt financing include ElectriFi, the European Investment Bank, InfraCredit, InfraCo Africa and REPP/Camco (AMDA, 2025). Six of the 11 companies interviewed have received subsidies under the NEP.

### 3.3.3 Types of financing adopted

Besides grant funding, which accounts for most of the funding in the sector, mini-grid developers have funded their projects off their balance sheets (SEforALL & BNEF, 2020), and obtained cash from sources such as private equity and debt financing (provided by financiers such as All On CRE Venture Capital) and credit guarantees (provided by institutions such as InfraCredit). It is estimated that 31% of venture capital (VC) funding for tech startups raised in 2024 was in the form of debt, while 69% was in the form of equity financing (Benrubi et al., 2024). The largest beneficiary of this VC debt financing in Africa was cleantech, at 40% of the funding (Benrubi et al., 2024). In Nigeria, only USD 69 million was raised (compared to USD 382 million raised in Kenya) by 11 tech companies. Between 2012 and 2024, financing obtained by African mini-grid companies was made up of 68% equity financing, 20% debt and 12% grant funding to support core operations (AMDA, 2025).

**Figure 7**
Funding by financing type in the African mini-grid sector (2012–2024)




*Source: AMDA (2025)*

In 2024, across African tech sectors, cleantech accounted for only 8% (37) of private equity deals and 9% (USD 192 million) of private equity investments (Benrubi et al., 2024). Nonetheless, the percentage of private equity investments grew from 1% in 2020 to 9% in 2024. Only 7% of equity funding went to female-founded startups, and only 18% of equity deals were closed by such startups. The latter figure for Nigeria is 19%, compared to 41% in Ghana and 34% in Kenya.

Among tech sectors, cleantech has one of the lowest rates of female-led deals in Africa, at 11% (and 7% of equity funding) compared to agritech's 40% (and 51% of equity funding) and mobility at 31% (and 37% of equity funding) (Benrubi et al., 2024). This is consistent with our data, which estimates the percentage of female CEOs in Nigeria's mini-grid sector at 19%, lower than the corresponding figures for the e-mobility sector in Kenya and the agritech sector in Ghana.

These figures suggest that grant financing remains the predominant source of financing for the Nigerian mini-grid sector. The DARES' USD 410 million for mini-grids over five years exceeds the estimated USD 46.8 million in equity financing or USD 27.6 million in VC debt financing that entered into Nigeria's cleantech sector (as a whole) in 2024.[11] Since these VC debt and equity funding estimates include industries beyond the mini-grid industry, it is possible that the DARES' annual funding exceeds the 2024 combined VC debt and equity funding for the mini-grid sector. However, while larger, older and more experienced companies may enjoy the subsidies provided under the NEP and DARES programmes, smaller and early-stage companies rely more on balance sheet financing obtained through equity and debt investment.

As with most other countries in sub-Saharan Africa, commercial debt financing for mini-grid companies from the Nigerian commercial banking system is limited (AMDA, 2025). This is due to a combination of inabankers' inadequate knowledge about the renewable energy sector, the perception of the sector as high risk and a mismatch of the financial needs of the sector with the typical lending conditions of banks. For instance, while the return on investments in solar mini-grids can reach 12.5%, commercial banks offer loan facilities at interest rates of 22% and above (REAN, 2021a). As mentioned above, mini-grid projects often have seven- to ten-year payback periods, yet banks provide loan tenors of only two years at best (SEforALL & BNEF, 2020).

### 3.3.4 How companies seek funding

Securing funding requires extensive networking and proposal development. It often involves participating in competitive funding programmes, pitching to venture capitalists and leveraging connections in the renewable energy ecosystem. Developers also collaborate with international development organisations to access grants or concessional loans. Additionally, renewable energy investment platforms, hosted at summits and conferences, offer opportunities for mini-grid startups to showcase their projects and attract institutional investors. These funding avenues are complemented by partnerships with local communities and state governments, which often co-invest or provide land for mini-grid installations. Through several major foreign-funded structured financing facilities, a mini-grid company may initiate a finance-seeking process by applying through an online portal.

Financiers require extensive information at the application stage. For example, for debt guarantee, InfraCredit's Climate Finance Blending Facility requires the applying company to fill out its Mini-grid Project Readiness Assessment form on its website (Climate Finance Blending Facility, 2022). The form solicits detailed information, including corporate and compliance conditions, satisfaction of legal and regulatory requirements, technical specifications of the project, environmental and social conditions, and financial information. Financial information includes audited accounts and directors' reports for the last five financial years, financial projections of the company for at least the next ten financial years, the impact of the proposed debt to be guaranteed, bank statements for the past three months, and copies of asset registers of the business, including land, buildings, equipment and vehicles.

Similarly, in applying for DARES funding (or the preceding NEP funding), mini-grid developers are expected to initiate the process on the DARES portal (Nigeria Electrification Programme, n.d.a). To register, companies must first confirm that they satisfy the basic requirements, which include the ability to provide financial statements for three years and information on past experience in designing, building and operating at least three mini-grids of not less than 10 kW or a single mini-grid of at least 50 kW capacity since January 2014 (which remain in operation).

These stringent criteria may be compared to those of financiers who focus on supporting early- and growth-stage businesses. The African Enterprise Challenge Fund (AECF), for example, operates a Renewable Energy Innovation Fund (with an online application process) that offers project co-financing (in non-repayable grants) of between USD 100,000–200,000 per company to cover a minimum of 30% of the project cost and up to 70% of the total project cost (AECF, n.d.). The eligibility criteria are more accommodating and include:

- possession of a minimum viable product/service (a product/service that has already gone through a prototyping phase);
- market research demonstrating the need for innovation in the selected geography;
- demonstration of sales and/or a tangible demand for the proposed innovation.

### 3.3.5 Enablers for successful funding

For an early-stage mini-grid company, successfully securing funding is largely a function of the company's business development team, which often comprises senior management, a business development officer and a finance officer. The team must stay abreast of the latest openings in funding application windows and pitch at competitions for challenge-based awards. It must ensure key documentation is available, like internal policy documents, financial statements, financial projections and legal compliance documents. When the time comes, the team is responsible for developing and designing convincing pitch decks and writing persuasive proposals that contain a clear presentation of the problem, the company's solution, impact metrics, website and media links, and other relevant information.

Successful funding applications are also enabled by partnerships between developers and local stakeholders, which enhance project viability by fostering community buy-in and reducing operational risks. The increasing availability of these kinds of blended finance mechanisms has made it easier for developers to access large-scale funding.

### 3.3.6 Challenges related to funding

Commercial bank financing for the solar mini-grid sector remains elusive because of an institutional lack of interest in the sector and prohibitive interest rates. Other challenges to raising commercial financing include the lack of scale in the mini-grid market. Developers may also have limited project track records (especially young mini-grid startups), which means that project risks are not yet fully transparent. Additionally, residential consumers may have limited power demand as well as limited ability to pay compared with industrial customers with which an electricity supplier can sign a power purchase agreement (PPA) to guarantee payment for electricity (SEforALL & BNEF, 2020).

Similar challenges exist for foreign sources of commercial debt, with one added constraint: most foreign-sourced debt remains denominated in US dollars with high interest rates (Benrubi et al., 2024). This has created a substantial increase in the number of defaults in the ecosystem as most tech startups have their revenues and liabilities in local currency (Benrubi et al., 2024). Before 2022, the Nigerian Bank of Industry Benrubi et al. was the only institution able to provide naira-denominated commercial financing for mini-grid developers under its '6 billion naira' solar fund (SEforALL & BNEF, 2020). In late 2022, the first-ever blended, local currency, green-certified debt issue for a solar mini-grid project in Nigeria was secured by Darway Coast. This was through a co-financing arrangement with the GBP 10 million Climate Finance Blending Facility funded by the UK's Foreign, Commonwealth and Development Office under InfraCredit's clean energy funding programme (Egwuatu, 2022).

On the difficulty faced by many local mini-grid entrepreneurs in getting their companies investment-ready to access the subsidies provided through the REA, a policymaker stated that the stringent terms had been tweaked ahead of the launch of the financing programme. He said there was a provision for firms to partner if they did not have sufficient capital or an adequate portfolio of past projects.

## 3.4 Growth and expansion

Various factors account for the rate of growth and expansion of Nigerian mini-grid companies. These may be categorised into factors internal to the company and factors external to the company. The latter may be further divided into foreign external factors and domestic external factors.

### 3.4.1 External domestic factors affecting company growth

A critical factor is the regulatory environment provided by the NERC, which offers clear guidelines on mini-grid development, streamlined licensing and tariff-setting processes. The World Bank's Regulatory Indicators for Sustainable Energy (RISE) ranks Nigeria first in Africa in terms of the quality of its mini-grid framework, and among the best for its off-grid systems framework (ESMAP, 2024). Interviewees were also complimentary of Nigeria's mini-grid regulations. According to AMDA, Nigeria is a leading mini-grid market 'due to its conducive policies and large-scale concessional funding' (AMDA, 2025, p. 3). Additionally, the sector owes much of its growth to the availability of subsidies under the NEP programme via World Bank and AfDB funding.

However, challenges such as high inflation, currency depreciation and limited access to affordable financing from domestic financial institutions often constrain the growth of mini-grid companies. Poor infrastructure, including poor road networks in remote areas, also hampers the deployment and maintenance of mini-grid systems.

### 3.4.2 Internal factors

Internal factors include organisational efficiency, workforce capacity and access to technical expertise. Firms with strong operational frameworks, robust project management capabilities and an adaptive approach to business models are better positioned to scale their operations (International Renewable Energy Agency (IRENA), 2022).

The ability to leverage innovative financing mechanisms, such as public–private partnerships (PPPs) and pay-as-you-go energy solutions, further enhances growth potential. Companies that invest in innovation to optimise system efficiency and reduce costs remain competitive in an increasingly crowded marketplace.

Another essential factor that drives mini-grid company growth is business development capabilities (Energy 4 Impact & Inensus, 2018). Interviewees noted that strong skills in business development were critical when scoping for funding opportunities, developing competitive proposals and business plans, engaging investors and financiers, and networking. These specialised skills are in high demand (Energy 4 Impact & Inensus, 2018).

## 3.5 Sources of skills and their requirements

Skills requirements in the mini-grid sector are diverse and dynamic, reflecting the technical and operational complexity of the industry. Key skills include electrical engineering, renewable energy system design, project management and data analytics for energy monitoring, all of which must be performed effectively from a commercial, technical and customer management and payment perspective (Energy 4 Impact & Inensus, 2018). Soft skills, such as community engagement and customer relations, are equally critical, as mini-grid operators interact with residents. Top management positions require knowledge and skills in business models, regulations, financing and staff management (Energy 4 Impact & Inensus, 2018). The sector has also seen an increasing demand for specialised roles in battery storage technology and software development for energy management systems, driven by technological advancements (IRENA, 2022). Skills requirements and training sources differ according to the tripartite division of skill profiles (unskilled, semi-skilled, skilled) in the mini-grid sector (Energy 4 Impact & Inensus, 2018; World Bank, 2023).

Unskilled jobs involve menial work that requires general physical and mental capabilities and some easily learnable specialised skills. Project developers often provide daily on-site training for community members during installation and construction, such as clearing land, fetching water and cleaning the powerhouse (World Bank, 2023).

Semi-skilled jobs require training in solar installation, which is offered in various institutions across the country. According to an interviewee from the National Power Training Institute (NAPTIN), solar installation is the most sought-after course. About 90% of students are young people, about 60% hold bachelor's degrees, mostly in engineering, while 40% are artisans who have developed prior skills in general electrical work through informal apprenticeship arrangements.

Skilled jobs provide the greatest level of stability and remuneration in the sector (Power for All, 2022). From the interviews, it was established that the required skills for this category of workers could be attained through university education as well as in-house training. Those involved in engineering and design require a degree in engineering (civil or electrical). Universities and polytechnics in Nigeria have introduced renewable energy-related courses to address the growing demand for technical expertise. Additionally, training programmes supported by international organisations, such as the Power Africa initiative, and local capacity-building schemes by REA have enhanced workforce development.

However, according to a 2024 report jointly produced by the National Board for Technical Education (NBTE) and the INCLUDE knowledge platform[12] less than 5% of the country's technical and vocational education and training (TVET) programmes are aligned with renewable energy skills (Kalu, 2025). It was therefore only in August 2025 that the NBTE revised the National Diploma Renewable Energy curriculum, and developed Higher National Diplomas in Solar PV and Solar Thermal Systems, as well as National Occupational Standards Levels 4 and 5 for Solar PV and Power Backup Systems (Asaolu, 2025).

Some companies conduct training for staff on various aspects of mini-grid project management. According to interviewees, these sessions are facilitated by senior staff and, occasionally, external experts. Interns also get practical training. Some of these individuals are absorbed into the workforce upon completion of their courses.

OEMs also equip staff with specialised skills related to the use of procured equipment or software. However, this training is product-specific: while it can enhance technical precision, it is typically narrow in scope and dependent on procurement cycles. Another route to skills building is specialised training from external training service providers. In this instance, a company may pay for a worker to undertake a specialised course.

**Figure 8**
Sources of skills for workers in the mini-grid industry

| Skilled jobs | Semi-skilled jobs | Unskilled jobs |
| --- | --- | --- |
| • Tertiary education<br>• In-house training<br>• OEM training<br>• Specialised external training | • Solar training programmes<br>• Informal apprenticeship arrangements | • Light on-site training by project developer |

*Source: Authors' construct, 2025, based on interviews, and Energy 4 Impact and Inensus (2018).*

Interviewees identified limitations to these sources of skills. Eight cited the poor quality of education in some universities, saying it impeded graduates' employability. Consequently, employers must spend time and resources to upskill new workers. Six interviewees said institutions offering solar installation training were not focusing enough on the quality of installation, but rather on teaching and issuing certificates of completion. A lack of structured apprenticeship systems and inadequate exposure to technical and managerial skills were also cited as challenges.

Removing these barriers requires strategic policy interventions, including targeted funding schemes for startups, streamlined regulatory frameworks and comprehensive capacity-building initiatives. This would enable the sector to unlock its full potential as a driver of innovation, youth employment and sustainable development (All On, 2023; IRENA, 2022).

## 3.6 Technical support and assistance

Until 2016, there was no structured training in the country for renewable energy. What sporadic training did exist lacked relevance, recognition and alignment to industry and market needs (Energypedia, 2017). The NESP, funded by the EU and Germany, sought to address this challenge by introducing seven clean energy qualifications into Nigeria in 2016 (Energypedia, 2017). Two years later, Energy 4 Impact and Inensus researched mini-grid sector technical assistance needs (Energy 4 Impact & Inensus, 2018), drawing on interviews with 11 mini-grid developers, AMDA, 20 training providers, desktop research on 33 other training providers and 47 training programmes, and the authors' on-the-ground experience of providing technical assistance to over 100 developers in sub-Saharan Africa. It concluded that most programmes had a narrow focus on technical training for engineers and did not adequately cover other mini-grid topics. This was partly because there were no commonly agreed-upon best practices for developing, constructing and operating mini-grids besides those for mini-grid technology and policy.

Training on local mini-grid regulations was also lacking, which was probably a reflection of the lack of clarity and transparency around mini-grid regulations in most African countries. Topics like mini-grid business models, capital raising, tariff setting, technical system sizing and distribution grid design, local policies and regulations, health and safety, performance monitoring and evaluation, and operations and maintenance (O&M) process management and software were not well covered in existing training programmes. Developers' lack of the core skills of project and enterprise management, financial modelling, risk assessment and proposal writing were not being addressed by existing courses (Energy 4 Impact & Inensus, 2018).

Since 2016, there has been a proliferation of mini-grid sector-focused training programmes provided by private entities and public institutions. In addition, key stakeholders such as the REA, NAPTIN and development programmes like NESP are focused not only on supporting the technical aspects of mini-grid development but also on creating opportunities for youth employment. These programmes often incorporate training modules to build a local, skilled workforce capable of installing, operating and maintaining mini-grid systems. For example, NESP collaborates with universities and vocational institutions to offer specialised training programmes, creating a pool of young professionals who can directly engage in the mini-grid sector. By fostering youth employment through technical training, these programmes ensure the long-term sustainability of mini-grid systems while reducing Nigeria's reliance on external expertise. This growing sector provides young Nigerians with job opportunities in fields like engineering, installation, maintenance and operations of renewable energy systems.

The need for local expertise in mini-grid systems is even more pressing given Nigeria's vast rural areas, where the lack of skilled workers poses a challenge to effective system maintenance and operation (Energy 4 Impact & Inensus, 2018). Company representatives we interviewed were unanimous that it is most cost-effective and logistically convenient to train local technicians within project communities in conducting system maintenance and operation, while more complex troubleshooting and repairs may be done by full-time engineering staff deployed from the company offices. In other words, while international expertise has helped drive initial installations, long-term sustainability hinges on developing local skills. Nigeria can overcome this barrier by incorporating youth into the sector through specialised training and employment.

The establishment of training programmes that equip youth with renewable energy skills also helps to address unemployment and supports national energy security goals. Programmes such as the Global Environment Facility's (GEF) green job initiatives have made strides in integrating youth into the clean energy workforce. However, there remains a need for greater emphasis on creating more localised opportunities and expanding these programmes to rural areas, where mini-grid systems are most needed.

Technical assistance in the mini-grid sector goes beyond upskilling the workforce. One of the oldest providers of technical assistance in the Nigerian mini-grid sector is the German Agency for International Cooperation (GIZ), which is funded by the EU and Germany. The GIZ supported the development of the Mini-grid Regulations 2016 and the drafting of the Rural Electrification Strategy and Plan (GIZ, 2016). It also provided financial and technical assistance for mini-grid developers to launch mini-grid pilot projects; prepare bankable business plans (including site identification, demand assessment, system design and financial modelling); contact federal and state governments to ease the process of acquisition of regulatory approvals; and contact investors and financiers to access debt and equity to cover part of their projects' capital costs (Moller, 2016). In a report on technical assistance that draws on 15 years of technical assistance experience for mini-grid advancement across 12 African countries, including Nigeria, the GIZ notes that the role of technical assistance in the sector includes:

> *The promotion of successful mini-grid pilots, rural electrification and energy access planning, the development of mini-grid regulation in cooperation with the government, capacity building with the public sector, as well as the private sector, the development of country-specific tender mechanisms, the acquisition of funding for large-scale mini-grid roll-out, and the promotion of productive use of electricity and new business model development. (GIZ, 2020, p. 5)*

Interviewees from the public sector agreed with this wide scope for technical assistance.

# SECTION FOUR

## National policy and regulatory framework

Nigeria’s power sector has faced persistent challenges since the first electricity plant was established in 1896, making it unable to meet the nation’s growing electricity demand. Over the years, several policies and frameworks have been introduced to address these challenges and accelerate the adoption of renewable energy, with a particular focus on solar mini-grid systems. This section provides an overview of the policy and regulatory environment.

## 4.1 Policy frameworks for solar mini-grids

The development of policy frameworks for the solar mini-grid sector began in the early 2000s when Nigeria was a few years into civilian rule under the Fourth Republic. The policy frameworks below anchor broader renewable energy visions, including those for decentralised energy systems.

- **The Renewable Energy Master Plan**

  The Renewable Energy Master Plan (REMP), developed with support from the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), sets out a comprehensive strategy to enhance Nigeria’s electricity supply and grid reliability. The plan aims to increase renewable energy generation capacity by 10% by 2025 and achieve a solar energy capacity of 500 MW by the same year. It targets an overall renewable energy generation capacity of 36% of total electricity generation by 2030.

  To achieve these objectives, the REMP employs a mix of fiscal and supportive action instruments. Fiscal tools include import duties on renewable energy technologies, tax credits, credit facilities and investment grants to encourage the adoption of renewable energy solutions. Supportive measures, such as pilot and demonstration projects and the training of extension workers in solar energy applications, installations and maintenance, have been introduced to build capacity and increase awareness of solar energy systems.

- **National Renewable Energy and Energy Efficiency Policy**

  Enacted in 2015, the NREEEP seeks to accelerate the adoption and deployment of renewable energy technologies, with a specific goal of increasing solar electricity’s contribution to Nigeria’s energy mix by 6% before 2030. A notable aspect of this policy is its emphasis on SHSs for rural and off-grid electrification, which are vital for improving energy access in underserved areas.

  The NREEEP introduces several fiscal and regulatory tools, including tax credits, tax holidays, licence waivers, soft loans and excise duty exemptions. Feed-in tariffs and simplified licensing procedures have also been implemented to encourage private sector participation in solar energy projects. Additionally, the policy prioritises public awareness campaigns, extension programmes and workforce training to ensure the successful implementation of solar energy systems. A significant innovation under this policy is the development of a web-based solar prospecting tool, which identifies and harnesses Nigeria’s solar energy potential.

- **Off-Grid Electrification Strategy**

  Launched in 2017 by the REA, the Off-Grid Electrification Strategy aims to address energy access challenges in rural and underserved communities by promoting decentralised renewable energy solutions. The strategy sets ambitious targets, including the development of 10,000 solar mini-grids and the deployment of five million standalone solar systems for households and small and medium enterprises (SMEs) by 2023. These initiatives aim to power approximately 14% of the Nigerian population, thereby improving energy accessibility and sustainability.

  The policy instruments supporting this strategy, as outlined in RESIP, focus on fiscal incentives, such as tariff policies, tax breaks, investment capital allowances and low-interest loans for local manufacturers of renewable energy equipment. Furthermore, the NEP, partly funded by the Solar Hybrid Mini Grid Fund, has been instrumental in driving the implementation of off-grid solutions.

- **National Economic Sustainability Plan**

  The National Economic Sustainability Plan, introduced in 2020 as part of Nigeria's COVID-19 recovery strategy, integrates renewable energy development into the broader framework of economic recovery. The plan is globally recognised as one of the initiatives that most extensively addresses pandemic-induced economic challenges while promoting clean energy.

  The plan includes monetary incentives for private solar installers, with the dual goals of creating over 250,000 jobs in the renewable energy sector and expanding energy access.

- **National Energy Policy 2022**

  The National Energy Policy 2022, developed by the Energy Commission of Nigeria, positions solar energy as a primary energy option for rural and peri-urban areas with high solar potential. This policy aims to capitalise on Nigeria's abundant solar resources to address energy access challenges in underserved regions. However, the policy lacks specific provisions for promoting youth employment in the solar mini-grid sector, representing a missed opportunity to harness the demographic dividend in advancing renewable energy goals.

## 4.2 Regulatory framework for solar mini-grids

A well-defined regulatory framework is essential for fostering investment, youth inclusion, employment and an enabling environment for the growth of solar mini-grids in Nigeria. The regulatory framework in the country is designed to facilitate private-sector participation, balance affordability for end-users and establish guidelines for integrating mini-grids into the broader energy ecosystem.

- **Nigerian Electricity Regulatory Commission Mini-Grid Regulations (2023)**

  The NERC Mini-Grid Regulations 2023 are a revision of the 2016 framework. They constitute the primary regulatory framework for mini-grids, enabling their development, operation and sustainability. The regulations define mini-grids based on capacity, distinguishing between isolated systems serving remote areas and interconnected systems linked to the national grid. By simplifying licensing requirements, the regulations encourage investment and innovation. Systems below 100 kW require simple registration, while those between 100 kW and 1 MW need permits. This balances oversight and ease of entry. Additionally, the NERC regulations provide for a flexible tariff framework that allows negotiated, cost-reflective tariffs or the use of NERC's approved methodology, ensuring both affordability for consumers and financial viability for developers.

  The regulations also address grid interaction by granting mini-grid operators the right of first refusal for system upgrades and offering compensation if the national grid absorbs their infrastructure. This guarantees investment security while fostering collaboration between public and private sectors. The regulations support financing through streamlined permitting, PPPs and alignment with national energy policies, such as the Rural Electrification Strategy and Sustainable Energy for All (SEforALL) agenda. By promoting reliable service standards, consumer protection and dispute resolution mechanisms, the NERC Mini-Grid Regulations accelerate universal energy access and position solar mini-grids as a cornerstone of Nigeria's renewable energy transition.

  The NERC Mini-Grid Regulations 2023 are demographically neutral, as they neither place requirements on, nor incentivise, mini-grid projects to be gender-inclusive or youth-inclusive. The focus is on providing the regulations required to encourage mini-grid investments, prevent conflicts between distribution companies and mini-grid companies, and between mini-grid companies and project communities.

- **Environmental and Social Management Plan Guidelines for Solar Mini-Grids (2022)**

  The Environmental and Social Management Plan (ESMP) Guidelines for Solar Mini-Grids allude most strongly to social impact within the mini-grid regulatory space. The guidelines were introduced by the Federal Ministry of Environment in March 2022 to address the environmental and social challenges associated with the increased deployment of solar mini-grids, particularly in rural and underserved areas. These projects, while critical for addressing the nation's energy crisis, pose potential risks to ecosystems and local communities. The ESMP Guidelines align with the Environmental Impact Assessment Act, empowering the ministry to set mitigation, monitoring and institutional frameworks that ensure solar mini-grid projects are environmentally and socially sustainable (Federal Ministry of Environment, 2022).

The ESMP Guidelines simplify the Environmental and Social Impact Assessment process, making it easier for developers to be compliant while emphasising sustainable practices. They provide detailed measures to mitigate environmental impacts, such as managing waste and preserving natural resources, alongside safeguards to protect social well-being, including community inclusion, equitable benefit sharing and conflict resolution. By streamlining compliance, the guidelines encourage investments in renewable energy while ensuring projects contribute to environmental protection and social equity (Federal Ministry of Environment, 2022).

In line with other laws, the guidelines allow mini-grid companies to hire workers who are at least 15 years old, but stipulate that no one under 18 should perform hazardous tasks (REA, 2018). In addition, a developer is required to state the baseline employment conditions of the community and the employment opportunities that the project would bring. The focus is on mitigating social risks rather than maximising employment opportunities. In its Environmental and Social Management System Template for Mini Grid Developers, CrossBoundary Access (2024) provides examples of labour issues, which include gender discrimination in employment, forced and child labour, employment of only legal migrant workers, occupational health and safety, and maintenance of proper human resource policies and procedures.

## 4.3 Policy frameworks for youth employment

Nigeria's population is currently estimated at 199 million people. Approximately 42% of the population falls within the age group of 15 and below, and 29% are aged between 15 and 29. The population is projected to expand by 2.5% by 2050 (NBS, 2023). In view of the growing youth population and the high unemployment rates, the government is focusing on policies and frameworks to facilitate youth employment. These include:

- **The National Employment Policy (2017)**

  This policy aims to establish a conducive environment for growth that is both productive and employment intensive. The strategy delineates plans for the generation of decent work, involving the revitalisation of the private sector, the transformation of agriculture, the provision and upkeep of physical infrastructure, and the enhancement of access to markets and credit facilities for businesses. The policy identifies specific programmes and initiatives geared towards creating quality jobs in pivotal sectors of the economy. It also encourages the private sector to invest in skills development, employment and production.

  Additionally, it recommends measures to improve the employability of workers, enhance enterprise productivity and foster inclusive growth. Specifically, the policy notes the relevance of green jobs in the renewable energy sector for informal workers, comprising mostly women and youth. These include importation and distribution of equipment, construction, solar panel installation and maintenance of renewable energy power systems. Policy tools to accomplish this include fiscal instruments such as subsidies and zero-interest loans, and supportive action like skills training for youth.

- **The National Youth Policy (2019–2023)**

  This policy aims to establish a suitable framework aimed at safeguarding the fundamental human rights of all young individuals, fostering their optimal development and well-being, and encouraging their active participation across various domains of national development. It mentions that one of the strategies for expanding youth employment would be building their entrepreneurial capacity and skills in Indigenous technologies to produce solar panels and renewable energies. To achieve this, financial measures and supportive actions are specified, including funding research and innovation commercialisation, engaging qualified young people to provide supply services in at least 20% of contracts – with emphasis on locally produced goods – and providing access to low-interest loan facilities and startup grants for young entrepreneurs.

## 4.4 Policy coherence between solar mini-grids and youth employment

The Federal Ministry of Labour and Productivity has the mandate for youth employment in the traditional sectors, while the objective of SEforALL is the responsibility of the FMP and the REA. With the issues of youth unemployment and solar mini-grid development domiciled in different ministries, the need for more policy cohesion is apparent. For example, the NREEEP highlights the role of solar mini-grids but pays little attention to youth employment. The National Economic Sustainability Plan and National Energy Policy both address this gap. However, the sustainability plan does not refer to the energy policy, despite having been developed three years after it, and even though the Federal Ministry of Labour and Productivity, which developed the policy, is mandated to create jobs for youth in relevant priority sectors within the plan.

Another example is N-power, an initiative within the NIYEAP policy framework that aims to address both the scaling up of job opportunities and skill development. However, it is unclear if this policy tool aligns with the strategic objectives of green initiatives, primarily due to its bifurcated sectoral focus. Although the NIYEAP outlines the four Es (employment creation, equal opportunities, employability, entrepreneurship) as the foundation for youth employment, the only alignment between these identified policies and youth employment pertains to 'employment creation' and 'equal opportunities'. This suggests that attention to climate action is not bureaucratically universalised in Nigeria – an issue that the supra-ministerial National Council on Climate Change (NCCC) seeks to correct.

**Table** 1
Summary of content of selected national policies in Nigeria

| Policy | Green content | Solar mini-grid content | Youth content |
|---|---|---|---|
| Renewable Energy Master Plan (REMP) | ✓ | ✓ | ✗ |
| National Renewable Energy and Energy Efficiency Policy (2015) | ✓ | ✓ | ✗ |
| Off-Grid Electrification Strategy | ✓ | ✓ | ✗ |
| National Economic Sustainability Plan (2020) | ✓ | ✓ | ✓ |
| National Employment Policy (2017) | ✓ | ✓ | ✓ |
| National Youth Policy (2019–2023) | ✗ | ✗ | ✓ |

*Source: Authors' construct, 2024*

## 4.5 Policy environment and Indigenous knowledge

Within the policy documents assessed and among the policymakers interviewed, IK is conceptualised in terms of local skills and knowledge applied to the mini-grid project planning process, local production and innovation. In these documents, IK is harnessed through government support for the entry of locals as technology providers, as well as promotion and support for research and development activities for the local adaptation of technologies (FMP, 2015). IK is incorporated in the projects to ensure stability and self-reliance (FedFMP, 2015). This challenges the status quo whereby 'private sector presence, technological input and value added in energy sector activities have hitherto been overwhelmingly foreign' (FMP, 2015, p. 23).

# SECTION FIVE

## Innovation in the solar mini-grid sector

Innovation may be defined as 'the creative process whereby new or improved ideas are successfully developed and applied to produce outcomes that are practical and of value' (Taylor, 2017, p. 131). This section identifies key drivers and patterns of innovation in the solar mini-grid space, the role of IK in innovation and key ways to scale mini-grid technologies and address gaps that hinder technology diffusion and gender equity in innovation.

## 5.1 Types of innovation

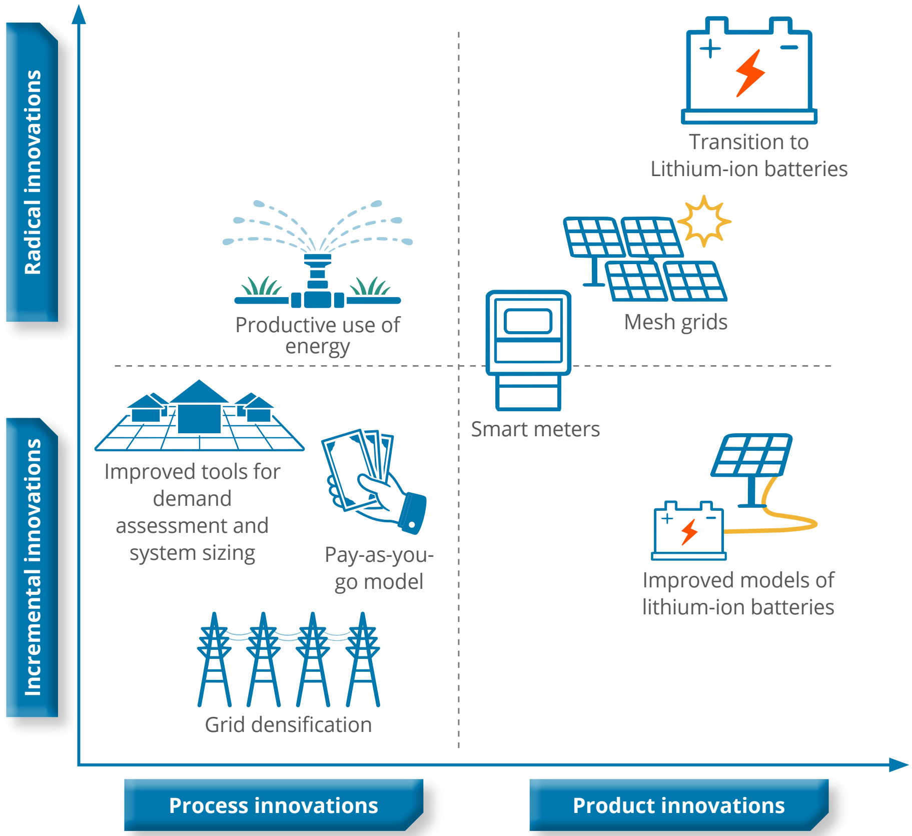
Innovation trends in the mini-grid sector may be mapped onto a matrix of incremental and radical innovations on the one hand, and product and process innovations on the other. Both incremental and radical innovations are often categorised according to the degree of novelty. Incremental innovation involves 'slight improvements to existing technologies, products and services that can increase a company's market share, improve competitiveness and strengthen its market position' (Chen et al., 2024, p. 1). Radical innovation involves 'developing new technologies, products or services and making existing ones obsolete, completely changing the competitive landscape and creating new business prospects' (Chen et al., 2024, p. 1).

Within the mini-grid sector, radical innovations are those that represent a major break from the status quo, often with substantial cost reduction implications over the lifetime of a system. Radical innovations include the transition from lead-acid to lithium-ion batteries, the introduction of mesh grids as an intermediary between mini-grids and SHSs, the adoption of smart metering, and the adoption of pay-as-you-go models to reduce energy access costs for customers. These radical innovations, however, are often developed in Europe, North America and East Asia, and then imported for novel application within Africa. Home-grown radical innovations within the African solar energy sector are rare. This is due to a combination of a lack of manufacturing capabilities, weak basic and applied research capabilities, and weak linkages between local academic research and industry applications (Africa Clean Energy Technical Assistance Facility & World Resources Institute, 2021; Ssebuwufu et al., 2012).

Incremental innovations include new and improved open-access site feasibility assessment tools such as:

- those developed by the World Resources Institute (the Energy Access Explorer), Fraym (the Nigeria Integrated Energy Planning Tool) and the Reiner Lemoine Institute (Offgrid Planner);
- open-source smart metres suitable for smaller mini-grids, developed by First Electric with support from EnAccess Foundation (Komolafe, 2022);
- grid densification practices that marginally lower capital expenditure, tested by CrossBoundary Energy Access in partnership with mini-grid companies (CrossBoundary, 2023b).

**Figure 9**
Innovations in the mini-grid sector




*Source: Authors' construct, 2025, based on the classification of innovations identified through desk review.*

Incremental innovations involve more local participation, albeit unevenly. For example, while Nigeria-based Powerful Tech came up with smart metres to enable direct purchase of electricity vouchers without the need for a physical vending kiosk, and Africa-based CrossBoundary Energy Access tested business model and deployment model interventions, most of the geospatial mapping, techno-economic feasibility and financial assessment tools for mini-grids were initially developed by foreign consultants with foreign funding and local partner involvement, often in the form of data input and post-development validation. For example, the Energy Access Explorer was developed by the US-based World Resources Institute, and the Nigeria Integrated Energy Planning Tool was developed by US-based Fraym.

Indeed, the most popular tools within the African and Nigerian mini-grid sector for techno-economic analysis (e.g., HOMER) and geospatial mapping (e.g., Village Data Analytics) were developed by firms based in the US and Germany. As listed on the Nigeria Off-Grid Solar Knowledge Hub (Energypedia, 2024a, 2024b, 2025), out of the 18 open and commercial licence tools available to African mini-grids for data collection, techno-economic and financial feasibility assessment, and system design, only one (6%) was developed by an organisation headquartered in Africa (First Electric, Lagos). About 33% of the remaining organisations are headquartered in the US, while 44% are headquartered in Germany, with the remaining in the UK, Australia and France.

This uneven distribution of incremental innovation is further reinforced by funding incentives, as initiatives such as the USADF Nigerian Off-Grid Challenge provide funding for innovations in business models, rather than innovations in planning tools. Due to the fledgling nature of the sector and the significant logistical, financing, revenue and other business challenges that mini-grid companies face in financing their operations, deploying solutions, collecting payments from users and managing user relations, funding for business model innovations is more widely available. These innovations are aimed at improving how business is conducted in order to ultimately reduce costs, improve revenue and maintain the stability of revenue generation. They are broader in the sense that any company can undertake such innovations and not always with the need for technologically advanced tools.

Project planning tools, on the other hand, are often more technology-heavy, and require developed information and communication technology (ICT) skills, in which there is a large gap in capabilities between local and foreign ICT players. As a result, even the Federal Government makes use of internationally developed tools in its own programmes (e.g., Fraym's (US) Nigeria Integrated Energy Planning Tool), as does REA (which uses VIDA and Odyssey[13] (also US)). This reliance on internationally developed tools, many of which are regarded as among the best in the sector, is occurring within a paradigm that prioritises renewable energy adoption to address energy poverty over renewable energy production localisation.

While some support for early-stage local innovation exists, the areas with the clearest potential for scaling are incremental process innovations and eventually incremental product innovations. This is based on an assessment of the existing capabilities and scale of support for innovation. Scaling current innovation requires addressing several key challenges, including access to funding, regulatory hurdles and infrastructure. Funding mechanisms that target youth entrepreneurs alongside policy support could bridge this gap. Additionally, the establishment of innovation hubs and incubators that go beyond light and short-term innovation support could provide the necessary infrastructure and mentorship for young innovators to experiment and scale their ideas. Nigerian youth have the capacity to build sustainable energy systems that can transform the mini-grid sector, but this potential can only be realised if they are supported with adequate resources, training and opportunities (Gberevbie, 2025).

The scaling of local innovations in the mini-grid sector could be further supported by linking youth employment with local innovation hubs, providing pathways for young entrepreneurs to turn their ideas into market-ready solutions. These innovation hubs could be co-funded by international organisations, local governments and the private sector to create job opportunities for youth in both urban and rural areas. Additionally, there is a need for more PPPs that focus specifically on training youth for the renewable energy sector. This would create a thriving ecosystem of local innovation and youth employment in the mini-grid sector, ensuring energy access and economic development go hand-in-hand.

## 5.2 Sources of innovation

Interviewees associated youth with innovativeness, agreeing broadly that young people tend to be more open to trying out and adopting new technologies once provided with training. They also mentioned that innovation in the solar mini-grid sector is largely driven by need and profit opportunities. Rural areas, due to their non-electrified status and their distance from the national grid, which makes grid extension comparatively expensive, make up a large part of potential mini-grid markets (SEforALL, 2022). Yet, rural areas are also characterised by lower income levels and weaker commercial activity than cities and towns. As a result, mini-grids deployed in rural and remote areas tend to be less profitable than electricity systems deployed in cities and towns (Daggash, 2024). According to the interviewees, who identified drivers for innovation within their companies, economic constraints put mini-grid companies under pressure to cut costs, find more efficient ways to operate, constantly seek out cost-saving technologies and experiment with new deployment models that reduce capital and operating costs. As a result, mini-grids are still largely dependent on donor financing and government subsidies (Wearne & Tiwari, 2021).

Innovations occur along the entire chain, from site selection (e.g., using more sophisticated geospatial mapping tools to identify more lucrative potential project sites), installation (e.g., testing out grid densification approaches) and operations and maintenance (e.g., adopting technologies that permit fully remote monitoring of system performance to reduce labour costs). Interviewees gave examples of innovation across these stages, although most reported innovation occurring at installation, operations and maintenance stages.

Innovation is also driven by occasional shocks. For example, when the Central Bank introduced new currency notes and banned the use of the old ones during the run-up to the 2023 elections, some mini-grid companies experienced a decline in their revenue collection by up to 50%, as most customers commonly paid for electricity in cash. The co-founder of a youth-led company that provides these developers with digital services to manage their billing and collections said the startup was founded to provide value to mini-grid companies navigating the lack of cash flow. The startup also sought to curb fraud, which was prevalent in the agent-based system.

Most mini-grid developers do not have dedicated research and development (r&d) departments (Mejabi et al., 2022).[14] Instead, as interviewees reported, the innovation process is more dispersed, with ideas introduced and evaluated by technical, procurement and leadership teams. Innovation hubs have been established as one way of creating a more systematic innovation process, based on regular experimentation with business models. One of the best-known innovation labs dedicated to the mini-grid sector is CrossBoundary's Mini-Grid Innovation Lab (CrossBoundary Group, 2022). The lab describes itself as 'Africa's first R&D fund, exclusively focused on testing new business model innovations from mini-grids' (CrossBoundary Group, n.d.). It states that it has launched 11 business model prototypes with 27 mini-grid developers and one public utility in nine countries. It convenes these developers in person or virtually every quarter to brainstorm new innovations. The developers then test the innovations at mini-grid sites. The lab analyses the data and shares the findings with the public.

## 5.3 Indigenous knowledge for innovation in solar mini-grids

Indigenous knowledge practices are 'based on an understanding of what works for the landscape within resource constraints and cultural contexts' (APRI, 2023, p. 14). The concept of IK has most conventionally been applied in primary, and some secondary, sectors where the Indigenous use of natural resources preceded the introduction of modern technologies and practices such as agriculture, mining and pharmaceuticals.

For secondary and tertiary industries, which involve the application of technologies that were not present locally, IK has a narrower scope. One of the few studies on the application of IK in the renewable energy sector emphasises IK most strongly in relation to natural resources exploited for energy (Mawere & Mukonza, 2024). The study gives the example of Eskom in South Africa, which undertook research into biomass energy and incorporated Indigenous techniques, such as rotational wood harvesting, aligning with contemporary sustainable forestry practices.

The application of the IK concept within the literature is often highlighted in cases where the source of renewable energy input is a terrestrial natural resource (such as biomass for biomass mini-grids and rivers for hydroelectricity). In the solar mini-grid industry, in contrast, the source of energy (the sun) is not terrestrial, limiting the application of IK. The fact that all components of the solar mini-grid, other than land, are from outside the community, with most being imported (REAN, 2021a), means that IK cannot be applied in the inclusion of locally sourced material.

The interviewees described the concept of IK as foreign versus local technology production. While up to 85% of technologies used in the sector are imported mainly from China, the US or Europe (REAN, 2021a), the interviewees noted that skills and workers in the sector are local. They interpreted IK as the local equivalent of foreign talent and knowledge of foreign contexts. This is also reflective of the industry literature. The Green Mini-Grid Help Desk notes, for instance, that while international mini-grid companies might have better access to technologies, networks and private and public capital than their local counterparts, many do not possess experience working in rural Africa and lack in-depth knowledge of local customs, standards, policies and regulations (Energy 4 Impact & Inensus, 2018). In contrast, the Help Desk states that local developers might have a practical understanding of how things work, but may not be as technically and financially capable as international companies (Energy 4 Impact & Inensus, 2018).

Three expanded areas of application of IK in the solar mini-grid sector were identified from the interviews. The first is that of basic research conducted in local higher learning institutions. In science and engineering departments of universities and other centres of higher education across the country, research into renewable energy innovations is conducted by young people, who have produced a variety of promising prototypes. Some of these attempt to use locally available raw materials to produce innovations that range from local variants of foreign innovations to wholly Indigenous innovations. Yet, the absence of a strong technological pipeline from academia to industry poses a challenge to the subsequent development and commercialisation of such innovations. One interviewee gave the example of a young man who, in 2003, came up with a method to generate electricity for lighting using salt and water, but struggled to develop this further within Nigeria. It was not until he got the opportunity to travel to China in 2023 that he was able to manufacture the product (Lawal, 2024).

The second area where interviewees said IK is applied is the local manufacturing of components. So far, the only component that has seen significant growth in local manufacturing is that of metres. This is because a shortage of metres resulted in several government programmes to encourage an increase in their installation. The Meter Asset Provider and National Mass Metering Regulations 2021 contained a requirement that metre providers source at least 30% of their contracted volumes from local metre manufacturing companies (NERC, 2021). As a result, while there are only three functional, local solar panel manufacturing companies in the country as of 2025, there were 15 local metre manufacturers licensed by NERC by 2021 (Esiedesa, 2021).

The third area of application of IK is during the project management process for the installation of a mini-grid. IK applies at two levels: the first is semi-skilled, where young technicians without formal higher education qualifications operate. The other is skilled, where more sophisticated digital, engineering, financial and business skills are most relevant, in combination with local experience and knowledge of local resource and procedural constraints.

While local semi-skilled technicians may have localised knowledge, mini-grid companies highlight that they often do not have a full understanding of the theory behind the many components found in power systems. Their involvement in mini-grid projects is therefore often limited to construction-phase activities, such as panel installation, planting poles, stringing distribution lines and internal wiring. The scope for innovation in these tasks is limited (even more so for activities such as bricklaying, welding and painting), given the standardised and routinised nature of the installation process. Rather, incremental adaptations to resource limitations or temporary stop-gap measures for technical problems occur.

For skilled workers, as some interviewees note, Indigenous innovation is embedded in internal company activities and communication, from casual problem-solving tasks and brainstorming meetings to spontaneous suggestions and recommendations during staff meetings and team retreats. Innovative ways to address challenges are part of day-to-day activities. Occasional suggestions to try out new products, or to test new business models, deployment models, or procedural innovations that have been piloted elsewhere, also occur. Radical innovation happens in the labs, which produce industry-specific technology and products by applying IK and lessons learned from other countries or sectors.

## 5.4 Potential for scaling Indigenous knowledge in local innovation

The full potential of IK can be realised by developing structured frameworks for its integration into energy solutions. This includes incorporating traditional knowledge systems into vocational training and university curricula related to renewable energy. Providing platforms for young people to collaborate with local communities will allow them to see first-hand how traditional knowledge can complement and enhance modern technologies. This collaboration can lead to the development of hybrid systems that are reflective of local cultures and practices. Training programmes should encourage youth to combine their technical skills with IK to create energy systems that meet community needs.

However, challenges to the realisation of the potential of IK in innovation must first be addressed. One is the scarcity of makerspaces, where young people can develop prototypes and start companies to commercialise them.[15] Incubation and acceleration programmes are sometimes not helpful, as many focus on short-term outcomes. This is partly a reflection of the short-term nature of the donor funding they receive, which emphasises the number of companies incubated and seed-granted, rather than more long-term outcomes, business growth and survival (Chawla et al., 2019; International Trade Centre, 2022). The support given to these startups also tends to be limited to programmes that last a few months (usually three to six) and are focused on regular classes rather than life-cycle support that takes each promising company through different milestones in its journey towards maturity.

Potential for the application of IK also exists in the local manufacturing of mini-grid components. Companies like Auxano Solar, Blue Camel and NASENI, which produce solar panels, as well as those that manufacture metres and inverters, hold promise. However, importation of components is still the norm in the sector, with mini-grid companies saying that locally manufactured products do not reach the level of quality and cost competitiveness of imports.

Scaling the assembly and manufacturing of local innovations so that they become competitive requires a combination of technical assistance for quality improvement and product distribution, and policy support, such as tax incentives and supply-side subsidies. The main areas for scaling innovation lie in piloting new technologies, testing new combinations of technologies and developing business models in ways that demonstrate their utility in terms of capital and/or operational cost reduction, efficiency enhancement and reduction of transaction costs. An example of this is Okra Solar's introduction of mesh-grid technology as a solution companies can deploy in areas that are viable for mini-grids, but which are too far apart, raising the cost of distribution (Okra Solar, n.d.a). Okra Solar piloted the technology and documented its impact on cost (Okra Solar, n.d.b).

The technology has now been approved by the REA for deployment under the World Bank-funded DARES project (SolarWorX, 2024). A similar process of technology diffusion occurred with the shift from lead-acid to lithium-ion batteries. Lithium-ion batteries took over the market from lead-acid batteries because of the life-cycle savings and increased performance and resiliency, despite the higher upfront costs (Onyenwe & Orah, 2022), demonstrating that it is generally easier for such diffusion to occur when the cost reduction implications are clear.

In addition to these general challenges, there are gender-specific constraints. Women make up only 23% of researchers (Okafor, 2019), 7% of engineering and technology graduates, and 6% of electrical installation and maintenance technical college graduates in Nigeria (Ihuoma, 2023). These disparities carry through to industry. A survey conducted by REAN, in which 50% of respondents were solar PV manufacturing companies, showed that women made up only 22% of the sector's workforce (REAN, 2021a). It is noteworthy that 52% of renewable energy companies in Nigeria lack gender-friendly recruitment policies, and 56% of these companies lack promotion and career development policies targeting women (REAN, 2021b). Women in renewable energy companies report that the greatest barriers they face are work–life balance, finding the right mentorship opportunities, getting experience in the field and a lack of training opportunities (REAN, 2021b). This calls for programmes and interventions that address barriers for women in the sector.

# SECTION SIX

## Scaling local innovation in solar mini-grids: the way forward

The solar mini-grid sector in Nigeria holds immense potential as a frontier for green jobs and technological innovation, particularly for young people. In recognition of this opportunity, a spectrum of stakeholders, including proponents of concepts like Africapitalism, are calling for mini-grid business models that deliver shared value. This study therefore set out to investigate how the interplay of skills, finance, policy and innovation shapes youth employment outcomes in the emerging green sector. Drawing from a literature review, policy analysis, company-level data and stakeholder interviews, we observe that strides have been made in expanding the mini-grid ecosystem.

Driven by government policies, international development initiatives and rising local demand for reliable energy, Nigeria's mini-grid sector has experienced remarkable growth over the past decade, fuelling the creation of over 10,000 direct and indirect jobs spanning engineering, installation, maintenance and customer service. In particular, the growing emphasis on renewable energy has fostered the creation of green jobs, aligning with the global shift towards sustainable development. These employment trends demonstrate significant socio-economic impacts, particularly in rural and underserved areas. However, substantial gaps persist in aligning the policy and operational landscape with the aspirations and capabilities of Nigeria's youth.

**In response to the first core research question – whether current policy tools and regulatory frameworks promote green jobs for youth – the evidence indicates a mixed outcome.** On one hand, Nigeria has developed a robust suite of energy policies and regulatory tools that have facilitated rapid growth in mini-grid deployment. However, youth employment remains largely incidental to policy design. Existing mini-grid frameworks, such as the NERC Mini-Grid Regulations 2023 and the Off-Grid Electrification Strategy, are primarily geared towards expanding electrification without integrating targeted youth employment mandates. Likewise, labour and youth policies make scant reference to renewable energy or mini-grids, highlighting a significant policy coherence gap.

**On the second research question – regarding policy responsiveness to the needs of youth and local innovation – our findings show that current frameworks fall short of enabling a nurturing environment for youth-led green innovation.** While the sector is youth-intensive (82% of the full-time employees in the companies we surveyed are young people) ownership and leadership are dominated by older people. This is attributable to high capital entry barriers, stringent eligibility criteria for accessing public funds and the technical sophistication demanded in the mini-grid industry. Women are also underrepresented in CEO roles, and few support mechanisms exist to change the status quo. Although training opportunities exist across tertiary institutions, the fragmented nature, limited coverage and lack of standardisation among OEMs and company-based programmes undermine their scale and impact.

**The third question – concerning practical realities faced by startups – underscores systemic challenges in finance, innovation and technical support.** Mini-grid companies (especially those led by young people) encounter significant difficulty accessing early-stage patient capital. The dominant funding model remains grant-based, with limited domestic VC involvement or commercial lending. Innovation, while present, is largely incremental and necessity-driven, constrained by market risk, technological uncertainty and the absence of mature R&D-commercialisation pathways. Local innovation also struggles to break through due to weak pipelines from tertiary institutions and poor integration of IK systems. Scaling these innovations remains challenging due to funding gaps, regulatory barriers and limited infrastructure. Addressing these challenges through targeted investments, policy support and the establishment of innovation hubs could unlock the full potential of locally driven solutions.

**On the fourth research question – the realities and challenges faced by entrepreneurs in the green tech startup space – the evidence reveals a landscape marked by high entry barriers and structural constraints.** Entrepreneurs must navigate long approval timelines, limited access to affordable capital and heavy dependence on imported components, which exposes them to currency volatility and escalating project costs. Early-stage firms, particularly those run by young founders, struggle to meet the eligibility requirements of major financing windows, leading to a concentration of public subsidies among more established companies. The absence of dedicated innovation testbeds and weak technical assistance further constrain experimentation and product development. Collectively, these challenges limit the ability of emerging entrepreneurs to scale solutions, participate in government programmes and contribute more fully to the growth of the mini-grid ecosystem.

**On the fifth research question – opportunities for scaling local innovation among African youth – our findings point to significant untapped potential.** The sector's youthful workforce creates a strong foundation for cultivating a new generation of green tech innovators, especially when supported by structured pathways for hands-on training, incubation and technical mentorship. Innovation hubs, university–industry partnerships and community-focused pilots offer promising platforms for youth to test business models and adapt technologies to local conditions. The growing demand for mini-grids also opens space for innovation around software, productive-use appliances and service delivery models. However, unlocking this potential requires targeted financial instruments tailored to youth-led ventures, as well as stronger linkages between research institutions, local communities and industry. With deliberate support, youth-driven innovation could become a central engine for accelerating mini-grid deployment and expanding green jobs.

**On the sixth question – the realities and challenges women face in tech transfer and job creation – the findings highlight persistent gendered constraints across the skills, finance and innovation ecosystem.** Women remain significantly underrepresented in STEM pathways, which limits their access to the technical and engineering roles where most innovation and technology transfer takes place. This structural imbalance carries into leadership, as few women occupy founder or CEO positions within mini-grid companies, partly due to limited access to capital, networks and sector-specific mentorship. Gender-blind programme design also restricts women's participation in incubation, training and field-based technical work, while social norms further constrain mobility and opportunities in rural project sites. Without targeted interventions – including more inclusive STEM pipelines, gender-responsive enterprise support and dedicated financing windows – women risk being sidelined in the emerging green tech economy despite the sector's potential to contribute meaningfully to job creation and inclusive growth.

**In sum, while the Nigerian policy landscape is evolving and the solar mini-grid sector is expanding, the environment is not yet fully enabling inclusive green entrepreneurship.** The policy regime lacks demographic specificity. Institutional arrangements are yet to be systematically youth-inclusive, and the finance-innovation-skills ecosystem remains skewed against young and early-stage actors.

The disconnect between potential and practice calls for deliberate, systemic interventions. The imperative is clear: if the full developmental promise of Nigeria's mini-grid sector is to be realised – particularly its potential to absorb and empower the country's growing youth population – then a more intentional, integrated approach is required. To reap the employment and innovation dividends of the mini-grid sector, and to overcome the challenges identified, Nigeria must make targeted shifts across the four interrelated domains of i) policy realignment, ii) finance innovation, iii) skills and capacity building, and iv) innovation and knowledge systems.

## 6.1 Recommendations for policymakers

Given the opportunities, challenges, strengths and weaknesses identified in relation to youth employment in the Nigerian solar mini-grid sector, we make the following recommendations, which cover the focus areas of the report (skills, finance, innovation and policy):

- **Create explicit policy targets for youth and gender inclusion in the mini-grid sector**

  Policy targets in the sector typically focus on broad metrics, such as the number of mini-grids installed, the number of households and SMEs connected, the number of jobs created and the number of people connected. To ensure that women and youth are adequately included, certain targets (particularly the number of jobs created) should be disaggregated by gender and age. This would enable youth and women to gain presence and strong positioning (e.g., as company owners, managers or workers) in the mini-grid sector in its formative years, so that, as the sector matures and scales, it will organically be youth- and gender-inclusive.

- **Institutionalise youth involvement in policymaking**

  The REA and FMP should encourage the establishment of youth-focused organisations with expertise in renewable energy that contribute to policymaking. For example, the REAN should be encouraged to create a youth wing or working group.

- **Support community ownership and involvement**

  The government should support and promote community-driven mini-grid projects to increase job creation at the community level. By enabling local communities to create electricity cooperatives that own mini-grid assets, more jobs will be created, building on the benefits of energy access and productive use derived from the installation. This model has been tested and proven in other countries, including Tanzania and Uganda.

- **Strengthen vocational training and capacity-building programmes**

  Sector-wide training should be standardised, decentralised and made more inclusive. A national solar workforce development programme that targets youth and women, and is jointly administered by public agencies, industry associations and technical institutions, could serve this function. Policymakers and donors should invest in robust vocational training and capacity-building programmes tailored to the technical and operational needs of the mini-grid sector. Collaborations between the government, private sector and educational institutions can establish renewable energy-focused curricula in universities, polytechnics and vocational schools. These programmes should emphasise practical skills, such as electrical engineering, renewable energy system design and maintenance, ensuring that youth acquire the competencies needed to secure employment in the sector. The programmes should be extended to rural areas to ensure inclusivity and equitable access.

- **Establish innovation hubs for renewable energy development**

  Strengthening the R&D-to-market pipeline is essential. Innovation hubs dedicated to renewable energy and climate technologies should be scaled up and incentivised to recruit youth and women. Tapping into IK must be conceptualised and operationalised through partnerships between local communities and research institutes. Hubs could focus on integrating IK with modern technologies to create innovative, localised solutions for energy challenges. By offering financial incentives and technical support, these hubs can empower youth to develop market-ready solutions that address the specific energy needs of communities, while generating employment opportunities. Innovation hubs should also create pathways for tertiary-level innovators to further develop their prototypes, and pipelines for commercialisation.

- **Promote public–private partnerships for youth-focused initiatives**

  Policymakers should encourage collaboration between government agencies, private companies and international development organisations to create targeted employment and internship opportunities for young people. Such partnerships could also support youth-led businesses through grants, loans and mentorship programmes, fostering entrepreneurship in the renewable energy space and ensuring that young innovators contribute meaningfully to the sector.

- **Facilitate access to finance for youth entrepreneurs**

  The government and financial institutions should develop youth- and women-focused funding mechanisms, such as low-interest loans, grants and credit guarantee schemes, to support their entry into the renewable energy market. This includes blended finance models with concessional components, and early-stage facilities that combine capital with mentorship and de-risking mechanisms. Additionally, international development organisations could establish dedicated funds to assist youth-led businesses in scaling their operations, creating more jobs and driving innovation in the sector.

- **Integrate youth employment into rural electrification programmes**

  Policymakers should mandate that rural electrification initiatives prioritise youth employment in project design and implementation. Programmes like the NEP and those managed by REA should include clauses that require mini-grid operators to hire and train young people from local communities. This approach will not only create jobs but also ensure that the workforce is geographically dispersed, addressing unemployment challenges in rural areas and fostering economic inclusion.

- **Incentivise green job creation through policy support**

  The government should develop policies that incentivise the creation of green jobs within the mini-grid sector. Tax breaks, subsidies and other financial incentives can be offered to companies that prioritise hiring youth and investing in workforce development programmes. Additionally, creating a national green jobs strategy that aligns with global sustainable development goals can position the mini-grid sector as a key driver of employment, ensuring that Nigeria's youth benefit from the growing demand for renewable energy solutions.

## 6.2 Recommendations for development partners

- **Sponsor and encourage the creation of incubation programmes**

  Incubation programmes should be supported to transition solar product startups to mini-grid project development and installation. Acceleration programmes should be designed to make more local mini-grid companies investment-ready for large-scale initiatives like DARES. These programmes should provide long-term support that proactively prepares companies for the rigours of larger funding facilities that have stringent eligibility criteria. The needs of women entrepreneurs should be taken into consideration when designing the programmes.

- **Create sub-components within funding facilities that cater to the unique needs of youth and women**

  Funding facilities should not categorise components only by type of technology or type of assistance, but should also include sub-components that design funding catered to the unique needs of youth and women. Such sub-components may relax eligibility criteria for younger mini-grid companies, while providing complementary technical assistance and project evaluation to ensure project quality.

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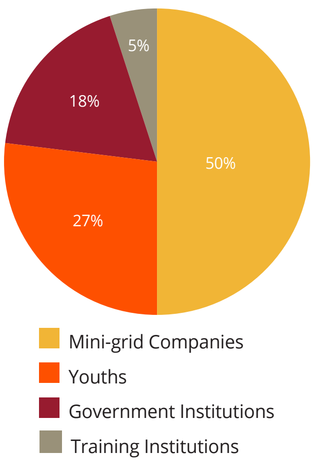
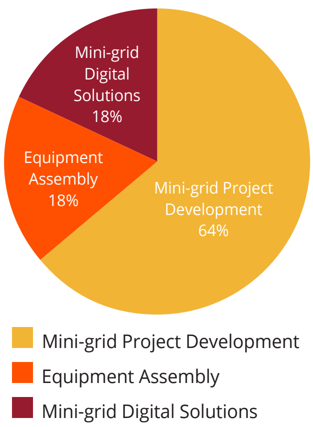
# Annex: methodology

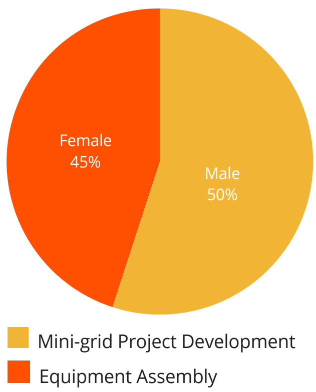
The report takes a mixed-methods approach to answering the research questions. It entails a literature review, document analysis, semi-structured interviews, qualitative surveys and the quantitative analysis of a novel dataset.

- *Desk review:* A review of existing literature was conducted to understand the job opportunities in the green tech sector, with a focus on solar mini-grids in Africa. Academic papers, books and grey literature, including industry and company reports, press releases and news reports, were reviewed.
- *Document analysis:* An in-depth analysis of policy documents relevant to the solar mini-grid sector, employment and youth was undertaken to identify the extent to which policies provide for inclusion of youth and women in the sector.
- *Semi-structured interviews:* Interviews were conducted with 22 stakeholders who included managers and senior officials of private companies, officials of government institutions, researchers, consultants, industry associations, youth working in the sector and those looking for employment in the sector. Participants were selected through purposive sampling and snowballing. We relied substantially on interviews conducted with mini-grid companies, policymakers and related actors (researchers, training institutions, young employees and job seekers) located mainly in Lagos and Abuja (where the head offices of most of the mini-grid companies are). The companies include those supplying mini-grid developers with components for installation, those that install mini-grids and provide operation and maintenance services, and those that provide digital solutions for mini-grid operation. Women represented 45% of the interviewees.

**Breakdown of interview sample**



- *Dataset building:* A dataset containing information about 35 mini-grid companies, including year of founding, CEO gender, academic background, age and number of employees was built. The companies were selected based on their experience of deploying at least one mini-grid in Nigeria and the availability of public information about them – such as year of founding, gender and age of company leadership. The information was obtained from company websites, venture networking platforms, news reports, press releases and publicly available company reports.

**Primary data analysis:** The primary data was analysed in three ways: qualitative analysis, stakeholder mapping and analysis, and quantitative analysis.

- *Qualitative analysis:* Qualitative data analysis software was used to conduct a thematic analysis of the information obtained through key informant interviews (KIIs). This was aimed at identifying major and secondary themes. Interview questions were designed to elicit information about the perceived needs of young entrepreneurs, innovators and workers; the extent to which young people are involved in the policymaking process; the promotion of Indigenous knowledge by policymakers; and, finally, the assessment by respondents of the extent to which policies cater to the stated needs and incorporate youth involvement. Responsiveness was assessed in relation to the skills, finance, motivation and other key variables identified in the entrepreneurship literature as factors influencing the success of clean-tech startups (Bjornali & Ellingsen, 2014).
- *Stakeholder mapping and analysis:* Stakeholders were mapped through a combination of desk research and KIIs. A stakeholder analysis was conducted using a power-interest grid, which depicts where each stakeholder stands in relation to the level of power they hold within the ecosystem and the degree of interest they have in mini-grid sector youth engagement.
- *Quantitative analysis:* Quantitative data obtained from secondary sources and the dataset was analysed using descriptive statistics and correlation analysis. The insights gained were triangulated with information obtained through the desk research, document review, interviews and surveys.

# Endnotes

1 ‘Productive use of energy’ refers to the utilisation of renewable energy for commercial, productive and/or business purposes (e.g., grain milling, cold storage, beauty care, food retail). A ‘productive use job’, therefore, is one created as a result of economic activities being powered by electricity from the mini-grid system.

2 This estimate is based on our novel dataset and interview responses. It reflects the relatively small size of the sector, where management teams are lean and women are often recruited into finance, administration and community liaison roles that are categorised as management.

3 Tony Elumelu, a Nigerian philanthropist, multimillionaire and former commercial banker, coined the term ‘Africapitalism’ in 2011. He advocated for a turn away from viewing African development through the lens of aid, resource deals, geopolitics, nationalisation or government policies, to seeing development as achievable primarily through private sector commitment to economic transformation (Elumelu, 2013).

4 The Frontier Technology Index, developed by UN Trade and Development (UNCTAD), ranks 166 countries by their capacity to adopt, adapt and use new and advanced technologies. It is based on five building blocks: information and communications technology (ICT) deployment, skills, research and development (R&D), industry activity, and access to finance. Each is measured by a specific indicator(s) (e.g., ICT deployment is measured by internet users per cent of population and mean download speed; skills is measured by expected years of schooling; high-skill employment as a percentage of the working population) (UNCTAD, 2023).

5 Power resources are resources that ‘actors can mobilise to amplify their capacity to promote, accommodate or resist societal change in accordance with their interests’ (Refslund & Arnholtz, 2025, p. 9).

6 More informal jobs (unskilled and semi-skilled) are created during a mini-grid project than formal jobs, but these jobs are often temporary and lower paid (e.g., NGN 4,000/USD 2.6 to NGN 6,000/USD 3.9 per day or NGN 30,000/USD 19.2 per month) than formal jobs (World Bank, 2023), while the jobs with longer contract durations (such as electricity vending and security) tend to be part-time. A mini-grid project may hire 10 to 20 artisans. For large projects (e.g., 60 kW to 230 kW), hires may reach 27 to 32 (World Bank, 2023).

7 Ademilua revealed this during a speech he made at a closed-door workshop titled ‘Rethinking Mini-Grid Projects in Nigeria: A Path to Sustainable Energy Access and Economic Development’. Held on 18 July 2024 in Abuja, the workshop was organised by the REA in collaboration with the Heinrich Böll Foundation Abuja, the International Centre for Energy, Environment & Development (ICEED), and Support for Improvement in Governance and Management (SIGMA).

8 CrossBoundary Group is a mission-driven investment firm that unlocks capital for sustainable growth and strong financial returns in underserved markets. It has 25 offices across the world, including in seven African countries.

9 This excludes foreign companies which had already built a base in other countries’ mini-grid markets and therefore possessed the financial capacity to invest in the Nigerian mini-grid business. Examples of such companies are Husk Power (founded in 2008 in India; launched its first Nigeria mini-grid in 2021), Powergen (founded in 2011; now a leading developer in East Africa; commissioned its first Nigeria mini-grid in 2019) and Renewvia (founded in 2008 in the US; commissioned its first Nigeria mini-grid in 2020).

10 Founded in 2010, the Tony Elumelu Foundation ‘is an African-based, African-funded philanthropic organisation dedicated to transforming the continent through entrepreneurship’ (The Africapitalism Institute, 2015b, p. 2).

11 Equity is estimated by multiplying the USD 520 million total equity funding in Nigeria by 9% (the percentage attributed to cleantech), while debt is estimated by multiplying the USD 69 million total debt funding in Nigeria by 40% (the percentage attributed to cleantech based on the Africa-wide figure) (Benrubi et al., 2024).

12 INCLUDE is an independent knowledge platform comprising platform members, a steering group and a secretariat. It is dedicated to advancing evidence-based policymaking for inclusive development, with a primary focus on Africa (INCLUDE, n.d.).

13 Odyssey is the official digital platform for DARES (Odyssey, 2025b).

14 The absence of an R&D manager is also indicated by the management team composition of the mini-grid companies in our dataset.

15 In this context, a makerspace is a collaborative workspace inside a public or private facility for making, learning, exploring and sharing products and/or services using high-tech to no-tech tools. Makerspaces are open to entrepreneurs (**Makerspaces**, n.d.).

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The Mastercard Foundation is a registered Canadian charity and one of the largest foundations in the world. It works with visionary organisations to advance education and financial inclusion to enable young people in Africa and Indigenous youth in Canada to access dignified and fulfilling work. Established in 2006 through the generosity of Mastercard when it became a public company, the Foundation is an independent organisation separate from the company, with offices in Toronto, Kigali, Accra, Nairobi, Kampala, Lagos, Dakar, and Addis Ababa. Its policies, operations, and program decisions are determined by the Foundation's Board of Directors and leadership.

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