Scaling the adoption of mesh-grids in sub-Saharan Africa

A practical route for faster last-mile electrification

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1 About the policy brief

This policy brief was developed by GET.invest and Okra Solar following the 'Unlocking Mesh-Grid Policy and Regulatory Frameworks to Scale from Nigeria to sub-Saharan Africa' side event at the ARE Energy Access Investment Forum (EAIF) 2026 in Nairobi (21-24 April 2026). The side event was co-hosted by GET.invest, CrossBoundary Group and Okra Solar. It brought together investors, developers and regulators (particularly representatives of various national rural electrification agencies) to discuss the scalability of mesh-grid technology for last-mile electrification in sub-Saharan Africa. The brief is based on three pillars. First, it intends to inform policymakers on the technology behind mesh-grids and the solution it offers for last-mile electrification. Second, it identifies the regulatory mechanisms that allowed its deployment, drawing on real-world cases. Third, it provides concrete calls to action to support regulators in deploying mesh-grids in their own countries.

2 In short

Mesh-grid technology places productive-use solar PV and battery assets with end users and uses low-voltage direct current (DC) power lines to share electricity between households and small businesses. Mesh-grids close the gap between the often insufficient power provided by solar home systems (SHS) for productive use and costly mini-grids, offering a solution for energy access in last-mile communities. Dedicated regulation for mesh-grid development is lacking in many African countries. Based on evidence from the DARES programme in Nigeria, this policy brief identifies four key recommendations for policymakers in sub-Saharan Africa to facilitate mesh-grid development and accelerate progress towards their energy access goals:

1) **Mesh-grid technology needs to be recognised as a standalone technology in least-cost planning, regulation and public financing.** The gap it fills between solar home systems and mini-grids is key, as mesh-grids offer productive use potential that solar home systems cannot, and can do so in areas too dispersed and too expensive to justify the viability of a mini-grid. Direct government-to-government exchanges can rapidly build technological and regulatory understanding and thereby accelerate the adoption of mesh-grids.
2) **Create a market-enabling regulatory framework for the first 10,000 mesh-grid connections in a given nascent market to enable immediate deployment at a meaningful scale.** Under light-touch rules, this framework should generate the local market data regulators need on cost-to-serve, tariffs, productive use and consumer protection, while donor funding accelerates early connections through milestone-based financing, including World Bank programmes and their dedicated innovation windows. In parallel, regulators should develop clear, permanent mesh-grid regulations, informed by deployment evidence and relevant regulatory precedents, to give private investors the certainty needed to enter and scale.

3) **Tariffs should be set through direct developer-community agreements, rather than being benchmarked against national grid tariffs.** Rural, isolated communities have specific needs and consumption patterns, and over-regulating tariffs at the national level may prevent energy access. Regulators should maintain the option to retroactively suggest adjustments in order to prevent unfair or unrealistic tariffs. This mirrors Nigerian practice under DARES for registered mini-grid operators, who have flexibility in setting tariffs agreed directly with the community rather than undergoing a full tariff-setting review.
4) **In advanced markets like Nigeria, mesh-grids should be eligible for results-based finance.** In nascent markets such as Mozambique, grants should be linked to crucial milestones such as equipment orders placed and customs clearance to alleviate developer financing challenges. Digital verification platforms such as VIDA, Odyssey and Prospect can strengthen this approach by providing remote meter data and performance evidence to confirm that public funding is supporting functioning, demand-responsive systems.

As the electrification of sub-Saharan Africa advances rapidly, now is the time for governments to find solutions for last-mile communities.[1] Doing so will streamline the use of public funds, support developers in reaching more people, and help investors understand the risk. Above all, it will secure reliable electricity access to more people.

3 What are mesh-grids?

Mesh-grids are a type of decentralised electricity system that connects several smaller solar systems. This forms a network consisting of anchor customers (or Hubs) that have solar panels, batteries and controllers. Hubs can produce, use and share power. Other smaller customers (or Spokes) can connect to the nearby system without having their own solar panel or battery.[2] Figure 1 schematically shows a mesh-grid setup.

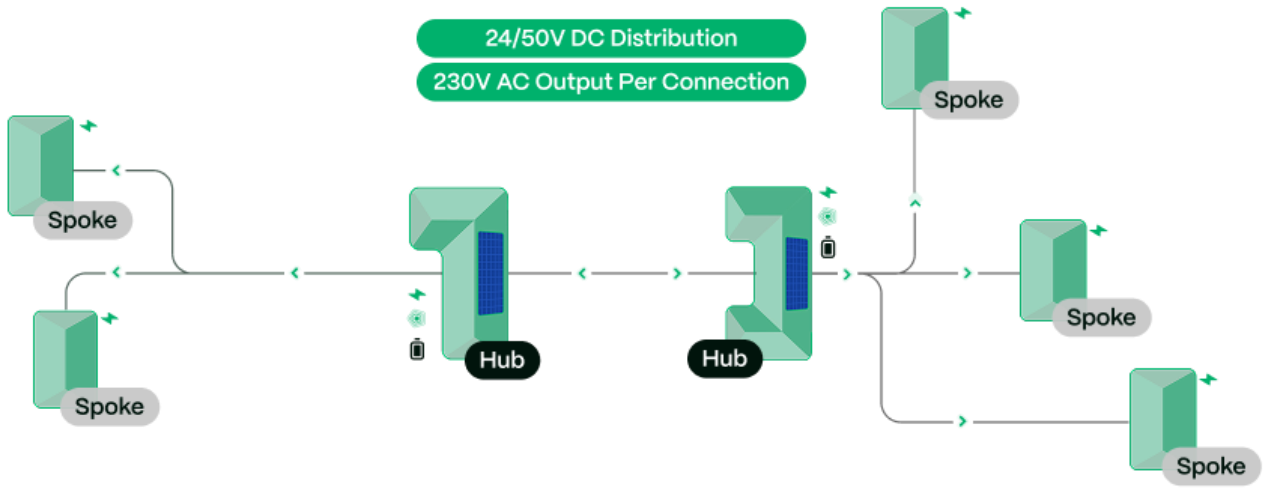
In a mesh-grid, electricity is distributed between Hubs and Spokes using low-voltage DC power lines, while the system provides AC power output within homes and businesses. The low-voltage networks are safer than high-voltage lines, do not require large overhead conductors and are easy to repair without a skilled technician. The networks in mesh-grids are flexible and can adapt to demand growing over time.

[1] Global Energy Alliance (2025), *Powering the Last Mile*
[2] Okra Solar (2025), *Mesh-Grids*

A Spoke can become a Hub, and a system can adopt new connections with relative ease. Because Hubs share power across the network, mesh-grids enable communities to support productive-use loads like machinery or refrigeration in a way that a single solar home system cannot, and without requiring the scale that makes a mini-grid economically viable.

The unique combination of size, flexibility and reliable power production makes mesh-grids useful for rural, low-density communities where houses and businesses are few and far apart.[3] Many last-mile communities do not yet have large businesses or anchor loads.

Figure 1: Mesh-grid structure showing electricity transfer between productive 'Hubs' and consuming 'Spokes'



Source: Okra Solar

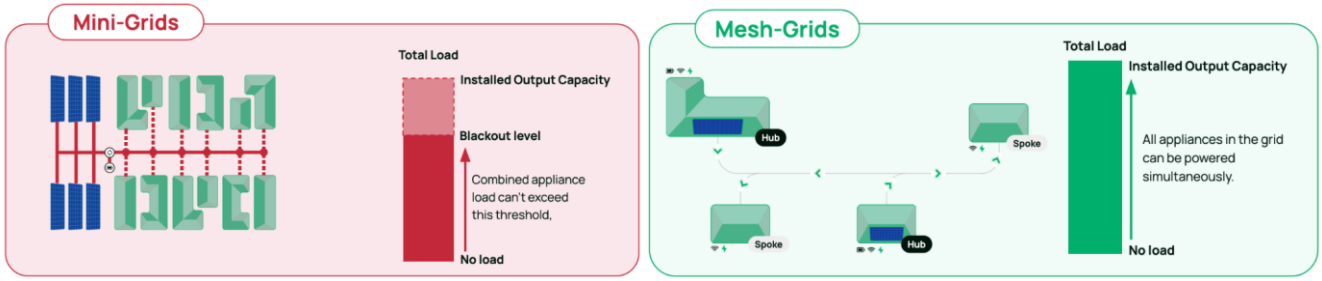
Another key advantage of mesh-grids is the ability to power all loads within the network simultaneously (Figure 2). Distributing power evenly over the network allows a mesh-grid to operate at its maximum installed output capacity, without the blackout threshold that is common in mini-grids.

Mesh-grids differ from solar home systems and mini-grids. While a solar home system normally serves one home or business, it typically provides insufficient power for more intensive productive use and does not allow power sharing of excess energy. This means that solar home systems have to be sized to purpose.[4]

[3] FAO (2026), *FAO Showcases Innovative Mesh Grid Tool to Strengthen Rural Energy Resilience in Jamaica and Beyond*

[4] Global Energy Alliance (n.d.), *Rural Electrification: Are Mesh Grids a Game Changer?*

Figure 2: Mesh-grids can power all loads simultaneously



Source: Okra Solar

A mini-grid serves a whole community from one larger power system. It can support businesses and productive uses, but it requires land, heavy poles and a distribution network, and a large upfront investment. While mini-grids are only economically viable in places with sufficient demand and connection density, mesh-grids have been shown to be commercially viable in low-density areas, with a cost-per-connection reduction of up to 40%[5] and distribution costs reduced by up to 90% compared to mini-grids in the same communities.[6]

Mesh-grids are complementary to mini-grids and solar home systems, not a replacement for either.[7] On a continent where millions of people remain without reliable access to electricity, mesh-grids should function as a possible answer to the question of which power solution is the best fit, at the lowest cost, for a specific context. The World Bank has also begun to include mesh-grid technology in least-cost planning and off-grid electrification support under ASCENT-related programmes from 2025 onward.[8] For example, in Mozambique mesh-grids are being scaled up through the +ENERGIA Off-Grid Financing Facility, implemented by FUNAE under the World Bank's ProEnergia project.

4 Evidence from Nigeria's DARES programme

"This is the black swan moment for energy access. Mini grids are going to energise a lot of big, densely populated communities, interconnected grids are going to provide reliability to struggling areas, and for the hundreds of thousands of more communities that would otherwise get left behind, now we can energise them with mesh-grids." - Abba Aliyu, CEO, Rural Electrification Agency (REA) Nigeria

[5] CrossBoundary Group (2025), *Mini-Grid Innovation Insight*

[6] Climate & Capital Media (2026), *Skip the power plant: the decentralized 'mesh-grid' tech making clean energy profitable*

[7] Havenhill (2025), *Mini-Grids vs Mesh-Grids: Understanding the Future of Off-Grid Power in Africa*

[8] World Bank (2025), *International Development Association Project Paper*

Nigeria's DARES programme is a $750 million public initiative to boost rural electrification that builds on earlier World Bank-backed rural electrification work and is implemented in collaboration with various development partners.[9] It is among the first national electrification programmes to include mesh-grids as part of its implementation framework, using public funds to mobilise private investment. Mesh-grids were included in geospatial and least-cost planning to help determine which technologies fit which sites, alongside mini-grids and solar home systems. The Nigerian model can serve as a guideline for other countries but should be adapted using local data. The adoption journey of mesh-grids under DARES consisted of five steps.

4.1 Understanding the technology

Previous least-cost electrification work in Nigeria compared grid extension, mini-grids and solar home systems. Based on this, a technology gap was identified by policymakers who remarked that some rural communities are too dispersed or too small for mini-grids, while requiring more power than a solar home system can provide.

DARES considers mini-grids the main power solution for denser communities of over 500 end-users and/or stronger commercial or anchor loads. Mesh-grids were adopted for dispersed communities with fewer than 500 connections. The connections used by mesh-grids under the DARES programme range from 150 W AC domestic connections to productive-use connections of up to 3.6 kW AC.

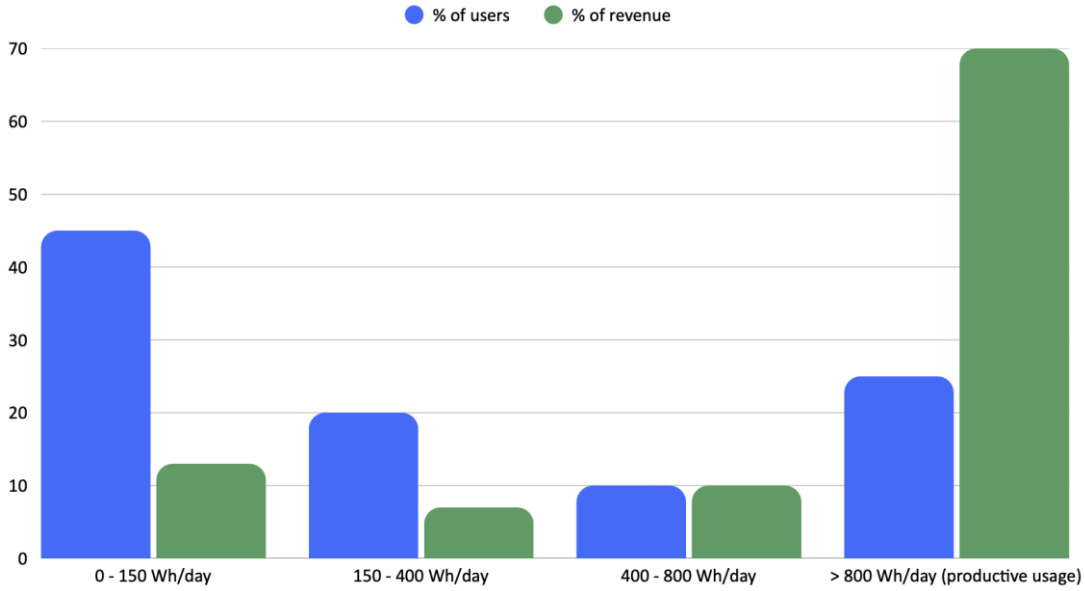
Including mesh-grids in energy access planning in this way allowed the Nigerian rural electrification agency to identify sites where a modular mesh-grid makes sense with current demand. The mesh-grid can connect current domestic and productive users and expand as demand grows.

4.2 Testing pilots and real-world data

Small-scale deployments were used to generate data in support of the mesh-grid case in Nigeria. These pilot projects were organised in a regulatory sandbox and provided evidence on cost, service quality and customer demand. Real-world data assesses technology performance and economic viability in a way that supplier promises and market projections cannot. Pilots in Nigeria already suggested that productive usage of mesh-grid electricity accounted for a disproportionately large share of revenue generated, with later real-world data underscoring this. Figure 3 contains data from Okra Solar, showing that productive users represented only 25% of total end users while accounting for 70% of total revenue.

[9] REA-NEP (2026), *DARES: Scaling-Up Nigeria's Energy Access*

Figure 3: Share of real-world end-user type vs. revenue share (Nigeria)



Source: Okra Solar

As part of the DARES adoption process, pilots and site visits were organised to monitor whether mesh-grid technology performed as expected. The Nigerian REA and NEMSA reviewed installations, technical quality and customer experience.

Governments need this kind of deployment data before setting permanent rules. In Nigeria, the pilots demonstrated that mesh-grids deliver useful electricity, that customers understand the service, that end-users consume enough power to support the business model, and that maintenance can be handled locally.

With the technology gaining maturity and being adopted in nascent markets like Mozambique and Madagascar, regulatory flexibility is key to not slowing down innovation.

In Nigeria, 10,000 mesh-grid connections have received grant agreements under the DARES programme with systems averaging 97% up-time across all deployments.

4.3 Engaging regulators and technical authorities

Mesh-grid deployment falls under multiple government entities at once in Nigeria: the REA for implementation, NERC for licensing and tariffs, NEMSA for inspection and the Federal Ministry of Environment for environmental requirements. Aligning regulatory mandates at an early stage results in a clear route towards project approval.

Questions to be answered at this stage include what counts as a mesh-grid, who may operate one, what licence is required, what voltage and safety rules apply, how tariffs are agreed, how customers are protected, and what happens if the main grid later reaches the site.

In the Nigerian case, smaller isolated mesh-grids can follow a lighter process than larger mini-grid projects, while still remaining subject to regulatory review, monitoring and spot checks. Under DARES, a mesh-grid was defined as a DC system of 'prosumers' able to share excess energy bidirectionally, with mandatory registration below 100 kW, distribution capped at 120 V DC, a floor of 20 W per connection and distribution losses below 10%.

Mesh-grids are expressly deployed as systems below 100 kW in Nigeria. Under DARES, developers are required to register with NERC, after which tariffs may be set directly with the community through a community-developer agreement. This avoids long tariff-setting procedures for every small rural site. Mesh-grids do not yet have protection in case the national grid extends to these rural communities, and NERC and the private sector are currently discussing how to provide it. Such a protection mechanism already exists for mini-grids in Nigeria, through an additional and optional NERC permit.

4.4 Defining technical and service standards

Under the DARES programme, a DC mesh-grid is defined as a system of 'prosumers', with solar PV, batteries and controllers located at their premises, while other end-users connect as 'consumers' without PV or battery installed on premises. Prosumer systems must be able to share excess energy bidirectionally, and all end-users must receive 230 V AC at the premises, with optional DC output. Distribution between Hubs (prosumers) and Spokes (consumers) should not exceed 120 V DC.

Supply quality and reliability were specified in direct consultation with service providers. A minimum of 20 W is allocated per end-user under DARES regulation, while the system must reach 95% service up-time and provide annual energy availability ranging from 4.38 kWh to more than 3,000 kWh per end-user. These measurable requirements give regulators a practical basis for assessing service delivery without prescribing one fixed technical design.

Metering and control systems must also adhere to strict guidelines that enable remote operation and quality control. Maintenance rules focus on local technicians, as mesh-grids' low-voltage DC power transfer reduces the associated risks.

Under DARES, mesh-grids remain subject to environmental and social screening. For a DARES Performance-Based Grant (PBG) mesh-grid project, the developer is not exempt from DARES environmental and social safeguards as a whole. At the qualification stage, PBG applicants still have to demonstrate an Environmental and Social Management System (ESMS), stakeholder-engagement plan, labour-management plan, workers' code of conduct and compliance with the DARES ESMF. At the site-specific stage, the PBG application also requires E&S screening information and a risk classification for the proposed sites.

Nigeria's REA has offered to exchange documentation on regulation and technical standards. It also sees direct government-to-government exchanges as a key enabler of quick adoption and is open to hosting visiting government delegations from other countries at operating sites.

4.5 Adapting the programme for mesh-grid scaling

Financing and programme rules had to be adapted to move mesh-grids from a pilot technology to a scalable least-cost option under DARES.

Performance-based grant funding is the main tool for this. When mesh-grids meet DARES' safety and service requirements, they receive a grant of $300 per connection, significantly less than the typical $500 per connection for mini-grids. Mozambique's +ENERGIA facility, by contrast, sets its mesh-grid grant at $500 per connection.

Grant amounts depend on market context, so authorities in other countries should base their calculations on local data such as equipment and logistics costs, consumption levels, willingness to pay, import duties and the local cost of capital. Under DARES, grants are paid in two milestones: 80% after installation and connection, and the remaining 20% within 12 months, based on performance and consumption targets. Digital verification supports this process: applicants link meters to the VIDA or Odyssey platform through public APIs, allowing public agencies to confirm that systems operate as intended before grant payments are released.

For other markets, testing grant levels against local costs across a small number of sites can help define realistic subsidy levels and verification requirements. Loose initial regulations and clear subsidy commitments by authorities can help approved projects reach bankability faster. Under a regulatory sandbox, the first 10,000 connections in a market should receive 50% of grants upfront to encourage developers to ramp up with minimal access to finance, after which the remainder of subsidies is tied to milestones.

Scaling can be further supported if financial incentives allow developers to submit bids or proposals for earmarked mesh-grid locations. Under DARES, REA determines which sites are eligible for mesh-grid development through VIDA geospatial screening and discloses these results and per-connection grant levels to qualified developers via the programme platform. However, Okra Solar reports that REA has confirmed eligibility for additional off-grid sites not captured by the VIDA screening.

5 Call to action

Nigeria's DARES programme has capitalised on the unique technical offerings of mesh-grids to the benefit of potentially thousands of communities. Its successful adoption of this new technology paves the way for other sub-Saharan countries to do the same. To support the scaling of mesh-grids to other countries, policymakers and regulators are advised to take the following four steps:

1) Include mesh-grids in national electrification frameworks

Policymakers should recognise mesh-grids as a standalone technology in planning, regulation and public financing. Mesh-grids should be included in least-cost electrification planning alongside grid extension, mini-grids and solar home systems. Their potential is strongest for low-density communities with fewer than 500 connections and limited large-scale anchor loads. Platforms like VIDA and Odyssey can perform least-cost analysis and help governments include mesh-grids in rural electrification plans. A deeper technological understanding can be built through regulatory and technological exchanges, as well as site visits. Nigeria's REA has indicated that it is open to both.

2) Create a market-enabling regulatory framework

Create a market-enabling regulatory framework for the first 10,000 mesh-grid connections to enable immediate deployment at a meaningful scale. Under light-touch rules, this framework should generate the local market data regulators need on cost-to-serve, tariffs, productive use and consumer protection, while donor funding accelerates early connections through milestone-based financing, including World Bank programmes and their dedicated innovation windows. In parallel, regulators should develop clear, permanent mesh-grid regulations, informed by deployment evidence and relevant regulatory precedents, to give private investors the certainty needed to enter and scale.

3) Set tariffs through community consultation

Allow developers to set tariff agreements in direct consultation with local communities. Cost-to-serve, operations and energy consumption patterns in rural, isolated communities differ fundamentally from those in grid-served areas. Therefore, rural energy tariffs should not be benchmarked against national grid tariffs. A direct developer-community tariff agreement enables quick deployment and swift energy access improvement. Regulatory oversight can be ensured when regulators are enabled to retroactively suggest tariff changes in case the tariffs are deemed unfair or unrealistic, which is the approach that Nigeria used under the DARES programme.

4) Finance mesh-grids first through milestone-based financing

Mesh-grids should be eligible for results-based financing when they are identified as the least-cost solution for a site. That said, a more developer-friendly milestone-based grant programme with an upfront component should be employed to kickstart the ecosystem in nascent markets. Digital verification can support grant disbursements by using remote meter data to confirm connections, service quality and system performance. This also unlocks the pathway to level-of-service incentives for developers who are deploying effectively. Nigeria's DARES grant structure offers a useful reference but should be adapted to local market, regulatory, and institutional conditions before being replicated.

We invite stakeholders to engage in regulatory dialogue and investment opportunities that can accelerate mesh-grid deployment across sub-Saharan Africa. Timing is critical, as the World Bank is replicating aspects of DARES and innovation-window models through its ASCENT energy access programme. With country programmes currently being developed, the World Bank and governments should actively assess mesh-grid opportunities and support their integration into national electrification frame.