

Five government approaches to promote solar hybrid mini grids in Africa: Which works when—and why?

The bottom line. Different private sector-led and government-led approaches to the development of solar hybrid mini grids are found around the world. Five approaches used in Africa are reviewed here. Each works better in some contexts than in others; each has advantages and disadvantages. In private sector-led approaches, private developers choose mini grid sites based on their own criteria; in government-led approaches, governments conduct competitive procurements to award individual sites or zonal concessions. In a variant of the government-led approach, utilities help private companies create and operate mini grids that are later absorbed into the utility's power system. All approaches involve capital subsidies.



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What is at stake here?

Rapid expansion of access to electricity depends on finding the best way to promote mini grids in countries with different starting conditions

Solar hybrid mini grids can be a cost-effective way to expand access to electricity as well as reduce carbon emissions.¹ At present, solar hybrid mini grids consist of (i) electricity generation through solar panels, battery storage, and a small diesel backup generator, and (ii) distribution via poles, wires, and meters. ESMAP estimates that a cumulative 1.2 billion tons of CO₂ emissions can be avoided if the global addressable market of 217,000 mini grids are built by 2030 (ESMAP 2022, p. 52).

1. Grid extension, solar mesh grids, and solar home systems may also be important options to consider in a comprehensive energy access approach. It is best to take a technology-neutral approach.



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To fulfill mini grids' full potential, a government's strategy to promote them must recognize the limits created by the country's conditions. But a government does not have to choose a single approach; different strategies can be deployed in parallel in the same country at the same time.

To date, the five most common approaches used in Africa have been:

1. Sites selected and developed by private developers
2. Competitive procurement for groups of individual sites selected by the government
3. Competitive procurement for zonal concessions selected by the government
4. Utility outsourcing of the construction and initial operation of new mini grids for eventual takeover by the utility
5. Government- and donor-gifted mini grids to communities, including those operated by cooperatives.

The choice depends on the fit between a country's socioeconomic circumstances and goals, on the one hand, and the features of each strategy, on the other.² The government's

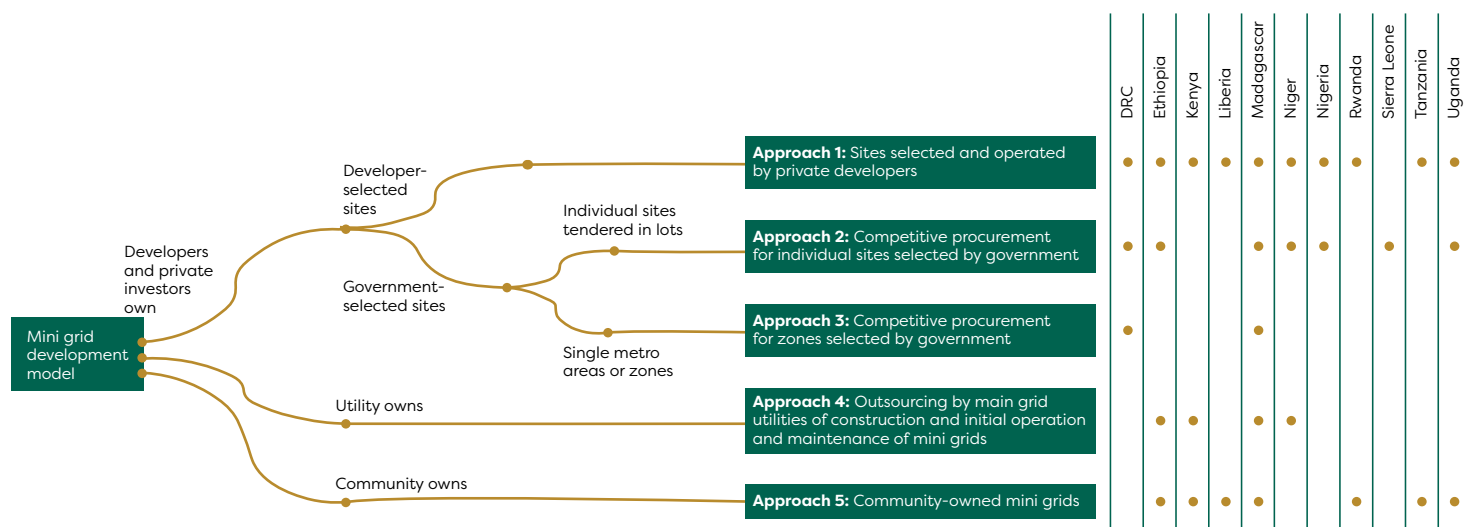
2. This note focuses on mini grid promotion strategies implemented by individual countries. A proposed multi-country approach is now under early discussion for a group of smaller countries in West Africa.

choices will be constrained by: the nature of its legal system (e.g., civil versus common law system), existing in-country options to finance new mini grids, available technical capacity, the competence of the national regulator and rural electrification agency, the main grid's existing reach, the geographic distribution of the population, the existence and capabilities of private sector operators, the political and security context in the country, and the size of the unserved population, among other factors.

The task of selecting an approach is especially relevant since the April 2024 announcement by the World Bank and the African Development Bank of a major new initiative to bring electricity to 300 million people in Africa by 2030. If this ambitious goal is to be reached, national governments will have to choose strategies that can produce on-the-ground results. *A successful strategy must combine both speed and affordability with technical and commercial sustainability.*

Figure 1 shows the five approaches currently being pursued in 11 Sub-Saharan African countries. Ten of the countries have decided to pursue concurrent approaches, though the different approaches may not always be pursued with equal effort or commitment.

Figure 1. Different government strategies to promote mini grids in Sub-Saharan Africa



Note: "Developer-selected" has also been described as a "private sector-led" or "bottom-up" approach. "Government-selected" is usually described as a "top-down" or "government-led" approach. DRC = Democratic Republic of Congo.

Let's dive in. What are the hallmarks of the first approach?

Sites are selected and operated by private developers

Mini grid developers, both domestic and foreign, choose locations based on likelihood of profitability. They often use geospatial data financed by governments and donors to assess the socioeconomic and physical characteristics of sites. Usually developers must obtain concessions, licenses, or permits to establish the mini grids. Regulatory approval for tariffs charged must also be secured. Approvals can be granted individually or for clusters of similar mini grids. Box 1 contains a discussion of the differences between concessions and licenses.

To enhance project viability, developers may receive performance-based grants from the national rural electrification agency or other entities, often funded by development finance institutions as loans or grants to the national government. Grants are typically allocated on a first-come, first-served basis and are subject to meeting technical and financial criteria. Disbursement is tied to specific milestones, usually some combination of preconstruction measures (proof of purchase orders, arrival of equipment at the site) and postconstruction measures (commissioning of the mini grid, connection of customers, and evidence of reliable service to connected customers after the mini grid is commissioned).

Box 1. Underlying legal systems

Mini grid developers will need to comply with a country's legal system regardless of the strategy a government pursues. The two most widespread legal systems in Sub-Saharan Africa are civil law and common law. In civil law countries, typically French-speaking, concessions are issued by a government authority. In contrast, common law countries, usually English-speaking, require licenses or permits issued by regulators.

These two legal approaches differ significantly. First, a concession is a contract between the government (usually signed by a ministry or a rural electrification agency) and a private mini grid developer. In contrast, a license or permit is simply an approval or authorization from a government regulator. It is not an enforceable contract between the government and the private mini grid developer. Second, concessions are generally broader in their coverage. In the case of a mini grid, a concession contract will establish the average tariff, determine adjustments over time, set the service requirements (e.g., reliability and stability of voltage and frequency), and define the other rights and obligations of the government and the operator. In addition, the concession may also cover land acquisition and permitting, options for the mini grid developer when the main grid arrives, political risk, and force majeure. In contrast, a license or permit is usually limited to tariff setting and service standards.

Mini grid investors generally prefer concessions over licenses since concessions are a contractual obligation of the sovereign government that can be potentially backed by guarantees from the World Bank's Multilateral Investment Guarantee Agency or similar entities. Guarantees are designed to provide greater certainty that the government and the national regulator will honor the commitments of the concession document. In contrast, governments in common law countries may be unable or unwilling to offer such commitments.

Recently, the AFUR mini grid regulatory project (AFUR 2024) began exploring the feasibility of creating simplified contractual arrangements (called mini grid project agreements) in common law countries. Creating individual agreements for each mini grid would be costly, but an umbrella agreement covering a developer's portfolio could be viable. (The Nigerian regulator already does this by issuing licenses and tariff approvals for the mini grid portfolios of a single developer.) They could boost developer and financier confidence in regulatory and government commitments, potentially backed by MIGA's breach of contract guarantees to reduce financing costs.

If a local power distribution company holds exclusive rights in the area, the mini grid developer may need approval from the current license holder or franchisee to build and operate the mini grid in its service area. In countries that issue existing utilities exclusive licenses for service territories, the mini grid will usually need the regulator's approval to become a sub-franchisee or sublicensee of the existing franchise or license holder.³ Regulators typically require sublicensees to adhere to the original licensee's obligations (except for tariff levels, which are likely to be higher for mini grids).

“The leading example of a private-developer-led approach is the performance-based grant program of the Nigeria Electrification Project (NEP) financed by the World Bank.”

Nigeria. The leading example of a private-developer-led approach is the performance-based grant program of the Nigeria Electrification Project (NEP) financed by the World Bank. NEP became operational in June 2019. As of November 2024, 173 mini grids serving more than 100,000 connections had been commissioned. Additionally, developers have signed grant agreements with Nigeria's Rural Electrification Agency (REA) for another 215 mini grids. These projects are at various stages of development under the existing regulatory and grant systems.⁴ The commissioned projects generally range in size from 50 to 100 kW of installed capacity. The total installed capacity of the 173 commissioned plants exceeds 13

3. Neither of these approvals is needed in India, where the mini grid regulatory system has two important features. First, the Indian mini grids are unlicensed. India's 2003 Electricity Act prohibits state electricity commissions from requiring private mini grids in designated rural areas to apply for a license. Second, state commissions are not allowed to set retail tariffs for mini grids because they are unlicensed entities. Taken together, Indian mini grids in rural areas are essentially deregulated. In recent years, more than 600 private-led mini grids have been developed and are operating in India's Bihar, Jharkhand, and Uttar Pradesh states. More information can be found in Tenenbaum, Greacen, and Shrestha (2024).

4. These projects were implemented by Nigeria's Rural Electrification Agency and the national electricity regulator. The 2023 Electricity Act now gives state governments the right to perform some of these functions at the state level. It is too early to know the effects of this potential transfer of regulatory and grant-giving authority.

MW. On average, the grants covered about 60–65 percent of projected capital costs. The average requested tariff for the first group of grant recipients was around \$0.40 per kWh at the time of the grant application. Most of the 57 developers that have submitted applications for grants are Nigerian companies, but at least five have some foreign ownership. *The fact that these mini grids have been commissioned is no guarantee that they will be commercially sustainable.*

Mini grids between 100 kW and 1 MW must apply for a permit from the national electricity regulator, the Nigerian Electricity Regulatory Commission. The permit is issued for five years, with the possibility of renewal. (In contrast, most mini grid concessions are good for 25 years.) The permit gives the developer the exclusive right to provide mini grid electricity to consumers in the specified geographic area. But the permit does not give the developer a legal monopoly to supply electricity with other distributed technologies like solar home systems and mesh DC grids.⁵ Other entities can freely compete with the mini grid developer to provide small-capacity and lower-cost electricity supply options within the mini grid service area.

NEP ended on December 31, 2024, but a new, even more ambitious project—the Distributed Access through Renewable Energy Scale-Up (DARES) project—was approved by the World Bank in December 2023 and became operational in November 2024. DARES will provide close to \$200 million in performance-based grants for bottom-up isolated and interconnected mini grids. The proposed parameters for non-interconnected mini grids will be: (i) commissioning of the mini grids and connection of the targeted customers, and (ii) achieving an average minimum consumption per customer to achieve a consumption target. After commissioning, customers that have received a DARES grant will be expected to consume at least 30 kWh per year. Developers that fail to achieve this consumption threshold may be ineligible for

5. Mesh grids are typically DC powered grids that can distribute electricity at lower voltages (50 to 60 volts) with lower-cost cables to dispersed households. The cost per connection is significantly lower than if an AC mini grid were built to serve the same households. The DC electricity can be converted to AC electricity when it reaches the customer's premises. Mesh grids, which have been described as the “middle child” between mini grids and solar home systems, are explored in a recent episode of the Inensus *The Mini Grid Business* podcast available at: <https://podcast.inensus.com/2233651/episodes/16115066-dc-mesh-grids>.

Box 2. Novel grid-interconnected approaches in Nigeria

Traditionally, mini grids have been viewed as off-grid solutions built and operated solely for isolated communities without prior formal electricity supply. Nigeria has pursued this conventional approach with considerable success (173 commissioned mini grids and 215 in the pipeline). Nigeria will continue to pursue electrification of isolated rural communities through mini grids and other technologies (mesh grids and solar home systems), but it will also test two novel approaches.

The first approach, under the new Distributed Access through Renewable Energy Scale-Up (DARES) project, involves mini grids serving communities that are also interconnected to and doing business with local distribution companies (Discos). These interconnected mini grids are designed to produce “win-win-win” outcomes for the Disco, the mini grid operator, and their customers. The developers and operators of a first round of 40 interconnected mini grids—at sites selected by seven Discos and prioritized by RMI (formerly the Rocky Mountain Institute)—will be chosen through an ongoing competitive tender. As of November 2024, two previously commissioned interconnected mini grids were operational in Nigeria.

The second approach, independent of DARES, will focus on commercial and industrial locations that intend to replace onsite diesel generation with solar panels and batteries. The generating systems will be located behind the customers’ meters and can either be connected to or disconnected from the local Disco. To date, most commercial and industrial entities in Sub-Saharan Africa have opted to be disconnected. RMI is now working with several Discos and their customers to determine whether onsite interconnected solar hybrid generating systems would be a better option than non-interconnected systems. A first project, an interconnected solar hybrid system at a furniture factory in Abuja, Nigeria, is expected to help the factory save 44 percent on its energy costs and 76 percent on its carbon emissions. The Disco has now reconnected the previously off-grid customer and is gaining additional revenue.

To support and scale these initiatives, RMI has created a toolkit for interconnected mini grids and other types of interconnected distributed energy resources. The toolkit provides curated, standardized resources and templates for key documents for project preparation, development, and implementation.

To learn more about novel interconnected approaches being piloted by RMI visit <https://rmi.org/insight/scaling-utility-enabled-distributed-energy-resources-in-nigeria/>

the last 20 percent of the grant. For interconnected mini grids, instead of an average customer consumption target, an average hours-of-supply target (that is, a measure of reliability rather than consumption) will need to be met. The interconnected mini grids may be deployed either through a competitive tender process for sites selected by the government or through a separate track for sites jointly selected by the distribution company (Disco) and the developer.

The new DARES project has three improvements that should help developers locate communities where they can build

and operate new mini grids. The first is access to a new, sophisticated geospatial platform known as VIDA, which merges satellite imagery and existing databases and will help developers improve site selection. Hosted by the REA, the platform contains detailed information on more than 25 socioeconomic characteristics for more than 10,000 settlements in Nigeria.

A second improvement is a new system of differentiated performance-based grants ranging from \$350 to \$600 per connected customer. Mini grids serving communities with

weaker socioeconomic attributes will receive higher per-connection grants than communities with better attributes, such as higher densities and higher income levels. (In contrast, the earlier NEP program offered a single grant of \$450 per verified customer connection, regardless of the community's characteristics.) The third improvement is separate smaller grants of \$300 per connected customer to install less costly DC mesh grids. Grants for standalone solar solutions for households are also available but are not discussed in detail here. Box 2 offers details on two other innovations being tested in Nigeria.

“A major advantage of the private sector-led model is that developers can move quickly once the regulatory and grant systems are in place. The chief disadvantage is that developers will choose bigger and more prosperous communities.”

Madagascar. The developer-led approach has driven the recent expansion of private sector mini grids in Madagascar. Almost 30 private mini grid operators have collectively built some 220 mini grids that serve more than 50,000 connections (more than 250,000 people), though only six developers have built a portfolio of five or more mini grids. Of the mini grids in operation by November 2024, more than three-quarters were developed through unsolicited (spontaneous) proposals for sites chosen by developers in a process managed by ADER (Madagascar's rural electrification agency), in parallel with a government-led tender-based approach. ADER did not provide results-based grants to mini grids developed under either approach. Instead, developers sought grants directly from other donor programs or from development partners in coordination with ADER.

More than 95 percent of the private mini grids are powered by renewable energy—either hydro or solar-hybrid. The average capacity is 261 kW for hydropower plants and 202 kW for PV-powered mini grids. The total installed capacity is about 21.5 MW, of which 9.5 MW are from solar, 8.4 MW from hydro, and 3.6 MW from diesel. Each mini grid serves

on average 475 consumers (2,375 people). Under the spontaneous (developer-led) approach, developers select their sites and sign a 25-year contract with ADER for generation and distribution, while seeking tariff approval from the regulator, ORE, which bases its decision on the developer's business plan and financial model. The concession contract cannot be approved by ADER until ORE approves the mini grid's tariffs. Tariffs average approximately \$0.50 per kWh, with operators permitted to propose their own tariffs. This flexible tariff regulation, combined with a relatively simple and efficient process for contracting with ADER, has enabled the rapid expansion of mini grids over the past few years: one of the leading mini grid developers in the country recently developed 120 mini grids over 12 months.

Kenya. Under proposed rules, the Kenyan electricity regulator, EPRA, will allow bottom-up development of mini grids at sites selected, owned, and operated by private developers outside a 15-kilometer zone surrounding existing medium voltage lines. As of December 2022, EPRA's data showed 82 operational mini grids with a total installed capacity of 2.14 MW, serving 15,700 customers (Ogeya and Lambe 2025). The 15-kilometer-wide buffer zone would seem to eliminate the possibility of interconnected (or even non-interconnected) undergrid mini grids, like the ones that exist in Nigeria. In April 2021, final rules were issued by EPRA, but they have not been officially published in the government gazette.

Advantages of the private sector-led model. Developers can move quickly once the regulatory and grant systems are in place. They can replicate a basic mini grid design in numerous locations to achieve lower capital costs. Regulations on retail tariffs usually allow for cost recovery if the mini grid is built and operated by a private company. Private developers will have a strong incentive to undertake programs to stimulate electricity consumption by their customers—households, businesses, and agricultural operations—since the developers bear the demand risk and know that operating subsidies after commissioning are unlikely. Developers' initiatives to stimulate demand increase the likelihood that the mini grid will improve socioeconomic conditions in the community. Positively, the failure of any one developer will not compromise the larger effort to electrify the country. Finally, this model is more likely to accommodate the presence of domestic mini grid developers.



Husk non-interconnected mini grid in Akura community, Nasarawa State, Nigeria.

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Disadvantages. If developers are free to choose where they will develop mini grids, they will understandably choose bigger and more prosperous communities. Hence, they will generally not target poorer and more isolated communities that are a priority for the government. Recognizing this natural economic incentive, the DARES project in Nigeria is planning to give higher per-connection grants to developers who choose to build and operate mini grids in communities with weaker socioeconomic characteristics (World Bank 2023, p. 12). Another disadvantage is that, if left entirely to spontaneous private sector development, mini grid development may not occur at the government's desired pace (although to date the developer-led approach has had the fastest pace of mini grid deployment of any of the approaches seen in Africa).

The number of developer-led mini grids constructed in Nigeria and Madagascar is larger than anywhere else in Sub-Saharan Africa. In Nigeria, it took off rapidly once the regulatory and grant systems were in place. But the numbers are still small compared what is possible; the Global Electrification Platform indicates a potential of more than 3,000 mini grids in Madagascar, and Nigeria has a potential of around 8,500 mini grids viable with partial subsidy, as estimated during preparation for the DARES project. Most developers, whether domestic or foreign, still struggle to attract commercial financing. The projects built to date have largely relied on grants and concessional capital, which is difficult to scale to the needed levels.

And now for the second approach. How does it work?

Governments lead competitive procurements to promote private ownership and operation of groups of mini grids

In this approach, the government selects sites, conducts competitive procurement, and awards a license or concession to a private company to build, own, and operate groups of mini grids for a set period. The targeted sites are generally grouped in small- or medium-sized geographic zones to maximize efficiencies and improve profitability. Developers typically bid on either proposed tariffs (less common) or minimum required subsidies (more common) after prequalification based on technical and commercial competency. The main difference between this method and zonal concessions

(Approach 3, discussed below) is that Approach 2 consists of individual sites in nearby locations, whereas Approach 3 involves tendering for one or more larger metro grids in urban zones and their surrounding area.

Nigeria. In addition to the developer-led approach described earlier, Nigeria also initiated a top-down, government-led approach to encourage private investment in mini grids. In 2017, with support from the World Bank's NEP, Nigeria's Rural Electrification Agency conducted a detailed survey prioritizing more than 200 potential mini grid sites across five states. The selection criteria included (i) sufficient load/density; (ii) potential productive uses of electricity; (iii) flexible loads and daytime loads; (iv) supportive local and state government; and (v) community engagement and accessibility.

The plan was to bundle these potential off-grid sites into separate lots. Potential bidders were to be prequalified based on their proposed business plans and their technical and financial capabilities. The prequalified bidders would then compete on several factors: the technical merits of their proposals, the prospects for commercial sustainability, and the amount of subsidy required per connection. The winning bidders would design, build, own, and operate the mini grids in their assigned lots. This competitive bidding process was expected to provide market-based information on mini grid capital and operating costs that could be used to develop capital cost subsidies for performance-based grants under the bottom-up approach (Approach 1).

While this initiative was intended to jump start private mini grid development in Nigeria, it was never concluded. Significant delays arose in securing approvals from both the World Bank and the Nigerian government owing to the procurement's novel features, especially bidding on the lowest sought subsidy per connected customer rather than on a more typical total cost bid. Ultimately, the bidding process was canceled because of delays, poor site selection, and limited private sector interest. The funds initially allocated for the exercise were redirected to other components of the NEP. In stark contrast, Nigeria's bottom-up, developer-led approach (Approach 1) has brought 173 mini grids into operation, with an additional 215 in the pipeline waiting for replenishment of grant funding in the DARES project.



Ms. Boluwasop Ogboye enjoying e-mobility on an electric motorcycle in Idadu, Nasarawara state, Nigeria.

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The AfDB minimum subsidy tender. In February 2023, the REA, with support from the African Development Bank, launched a second minimum subsidy tender for the development of 150 solar hybrid mini grids spread across seven states and packaged into seven lots. To avoid the delays encountered in completing the NEP tender just described, the second tender was structured as a single-stage procurement (without an earlier prequalification step). The downside of a single-stage procurement is that it may lead to many implausible bids from firms that are technically or commercially unqualified. As of November 2024, the outcome of this tender was pending.

A third minimum subsidy tender. Under the DARES project, the REA (with World Bank support) plans a new attempt at competitive procurements for portfolios of both interconnected and isolated mini grids. The REA, with assistance from RMI, has identified around 40 sites for competitive procurements for interconnected mini grids in seven of Nigeria's eleven Disco territories. The sites were shortlisted from a long list of sites proposed by the Discos themselves. These interconnected mini grids are expected to rely mainly on a modified minimum subsidy approach. Bidders are expected to compete based on the lowest subsidy required, either as a percentage of capital cost or in absolute terms, rather than on a per-connection basis. For isolated mini grids, site selection will be more focused, targeting communities with significant productive loads. Both types will benefit from improvements to geospatial planning tools, providing more accurate data that will be shared with prospective bidders.

“An advantage of the competitive procurement model is that grouping multiple mini grids into lots can lower costs. A danger is that the process of satisfying the procurement rules of bilateral and multilateral donors may introduce delays that try developers’ patience.”

Sierra Leone. Sierra Leone's initial efforts to develop mini grids were spearheaded by the Renewable Rural Energy Program, funded by the U.K. Foreign, Commonwealth, and Development Office and implemented by the United Nations Office for Project Services. In its first phase, a government steering committee, led by the Ministry of Energy, selected 54 villages for development, with a primary focus on providing electricity to community health centers. To be eligible, villages needed to have a health center and land on which the mini grid could be built. In return for the land, each health center received up to 6 kWh per day. All Phase 1 mini grids were completed by 2018.

In a second phase, private companies were invited to bid and negotiate agreements with the Ministry of Energy to operate the mini grids developed in Phase 1. They were also invited to co-invest in the electrification of an additional 44 rural communities, with mini grids ranging in size from 36 kWp to 200 kWp. Under this split-asset model, the government retains ownership of all distribution assets, while the private mini grid developers are responsible for building the generation assets. This split reduces the capital needs of private developers because the government finances the distribution infrastructure.

Prequalified companies were given the opportunity to bid on four lots, covering the 54 villages from Phase 1 and the 44 additional villages in Phase 2. The three winning bidders—Winch Energy, PowerGen, and Power Leone—began supplying electricity to the Phase 1 communities in the fourth quarter of 2019. Each developer was granted a 20-year license to manage and operate the mini grids, after which all project assets will be turned over to the government.

Uganda. In 2016, the Ugandan government, with the assistance of the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and with co-funding from the German Ministry for Economic Cooperation and Development (BMZ), created two rural village clusters (25 in the north and 15 in the south) for mini grid tenders that would have been expensive to electrify using conventional grid extension. After prequalification, bidders were invited to submit bids based on price per kilowatt-hour to serve all the communities in either the northern or southern group. The

winning firms would be required to build mini grids powered solely by solar PV panels and batteries (no diesel generators provide electricity for more than 16 hours a day). In mid-2019, Winch Energy was announced as the winner for both the northern and southern portfolios after the original southern portfolio winner withdrew. At \$0.52 per kWh, the initial bids were deemed to be politically unacceptable, however, so the Ugandan government and the European Union increased subsidies to cover 65–75 percent of the capital costs, lowering the price to about \$0.30 per kWh. The government also financed the distribution systems, following a split-asset model like the one used in Sierra Leone. To further reduce costs, the Ugandan electricity regulator streamlined the licensing process by issuing a single exemption for generation, distribution, and sales. It also waived the requirement for separate environmental impact assessments for each site, allowing a single project brief for all mini grids. All 25 mini grids in the northern Lamwo district have been operational since their commissioning and installment in June 2022, roughly six years after the project began. The 25 mini grids serve more than 2,500 households and 150 businesses.

Advantages of competitive procurement. The chief potential advantage is that a single tender can trigger the development of many mini grids. The larger tender could attract developers and financiers who have been on the sidelines. This, in turn, could enable more rapid scale-up. A second advantage is that grouping mini grids into lots can lower costs. Data collected on more than 350 mini grids built between 2012 and 2021 (ESMAP 2022) showed that mini grids built as part of a portfolio had substantially lower soft costs than did one-off projects. (Soft costs include project development, general administration, planning, engineering, partnership, public relations, permits, approvals, licenses, community engagement, logistics, and installation.) While scale advantages can also be achieved through developer-led initiatives, competitive procurement provides a structure to force scale site aggregation, which may not happen under the developer-led approach. A third potential advantage, compared with developer-led initiatives, is that the developer has greater assurance that the government-selected sites are at lower risk of takeover by the national grid. Finally, the competitive-tender approach provides governments with the flexibility to seek bids for minimum subsidies or tariffs.

“To date, competitive tenders for government-selected groups of mini grids have been much less successful than anticipated.”

Disadvantages of competitive procurement. To date, competitive tenders for government-selected groups of mini grids have been much less successful than anticipated. In some instances, the tenders have been terminated after several years without yielding any operational mini grids. Governments may be slow in selecting the communities and acquiring the necessary land. This has been the case in Kenya. The lack of success may also reflect the fact many government agencies do not have much experience in conducting tenders for relatively small investments, in contrast to tenders for a large transmission line or a single hydro-electric dam. Also, developers may be discouraged from participating because of the detailed procurement rules of bilateral and multilateral donors. Finally, governments may face the risk that a winning bidder may bid an unrealistically low subsidy on the expectation that they will gain a good bargaining position to negotiate a higher subsidy after the initial bid is selected.

And the third approach?

The government chooses to award concessions for large mini or metro grids within a specified geographic area or zone

Democratic Republic of Congo (DRC). The leading examples of top-down zonal concessions in Sub-Saharan Africa are the planned concessions for Mbuji-Mayi and Kananga, cities in the Central Kasai region of the DRC, with a potential installed capacity of close to 150 MW and about 200,000 possible connections. The DRC mini grid concessions will constitute the first major project of the World Bank Group’s Scaling Mini Grid initiative. If these two zonal concessions are successful, similar concessions will be considered for DRC’s other provincial capitals.

The DRC government is expected to use competitive procurements to award the concessions. As a first step, it has been proposed that technical offers of competing firms should be evaluated on a pass-or-fail basis. The firms, or consortia, whose technical qualifications are deemed acceptable will then compete based on the amount of subsidy requested. To encourage realistic subsidy bids, it is anticipated that the tender proposal specify a ceiling average tariff. The DRC's Ministry of Hydraulic Resources and Electricity, or provincial governments, will award the concessions and act as the government guarantor, ensuring that concession agreements be implemented as written. It is also anticipated that a detailed tariff-setting formula with automatic adjustment provisions will be included. None of the targeted cities have ever been connected to the national grid. Several had been supplied with electricity by the national utility using diesel generators, but these failed due to lack of proper operation and maintenance.

The top-down, government-led approach in the DRC differs from the bottom-up, private sector-led approach used elsewhere in Sub-Saharan Africa in four major ways. First, the size of the DRC mini grids will be much larger than mini grids elsewhere. The Mbuji-Mayi and Kananga mini grids are projected to have installed capacities ranging from 60 MW to more than 100 MW, which is quite different from mini grid projects where the installed generating capacities are usually 1 MW or less. Second, the zonal mini grids are expected to provide service to large numbers of customers (from 50,000 to 3 million inhabitants in the case of Mbuji-Mayi and Kananga). Third, early indications are that the DRC concessions will attract large, well-capitalized international companies as bidders rather than local firms. Fourth, the DRC zonal concessions will include a first-of-its-kind minimum revenue guarantee. If there is a revenue shortfall relative to pre-agreed business plan projections, the developer may submit a claim to the government for the difference. In most other mini grid projects, existing and planned, the developer bears the full risk of revenue shortfalls arising from insufficient demand.

Advantages of the government-led zonal concession approach. One advantage of the zonal concession approach is that the concession document can be used to allocate risk more precisely among the different parties: government,

developer, financiers, and customers. A second advantage is that the concession contract, if issued by a national ministry, has greater potential to be backed by risk-insurance products from the Multilateral Investment Guarantee Agency (or another insurer) to reduce the level of risk for private developers and their investors. A third advantage is that the financing needs of “metro grids” will be larger. It has been estimated that the planned zonal concessions will need financing of \$50 million or more. This larger ticket size is likely to attract international entities that would not otherwise invest in mini grids.

Disadvantages of the government-led zonal concession approach. A disadvantage of the approach is its complexity. It requires extensive site preparation and studies, documentation, and buy-in from many separate domestic and international stakeholders.

Since the pool of qualified bidders is likely to be dominated by large foreign companies, the zonal concession approach will probably not directly support the advancement of domestic mini grid developers. However, it is likely that some domestic firms will be brought in as minority partners or contractors. Given the scope of the transaction, buy-in is necessary from several government agencies that may not always be inclined to cooperate with each other.

Moving on to Approach 4 ...

In the fourth approach, utilities contract with private companies to build and operate new mini grids with a transfer back to the utility

In some countries, the national utility may not want to see the emergence of retail service competitors because it wishes to retain a monopoly on all retail sales of electricity throughout the country. But if the national utility has little or no experience in building and operating mini grids for unserved communities, it may be willing to outsource the construction and initial operation of new mini grids to private companies. To varying degrees, Kenya and Ethiopia have chosen this approach.

Kenya. Kenya initially proposed a variation of this top-down approach for 120 off-grid communities in 14 northern counties, using \$40 million funding from the World Bank approved

in July 2017 (World Bank 2017). The government proposed the creation of six service areas, or lots, each consisting of 20 or more contiguous mini grids, with each serving about 100 to 700 prospective connections. The 14 counties, categorized by the government as marginalized areas, accounted for 72 percent of Kenya's land area and 20 percent of its population.

The original plan was for a public-private partnership in which the winning private bidders would finance the construction of the mini grid's generation assets. Public funds would be used to finance the mini grid's distribution facilities. Separate from the financing, the private company would be responsible for building the mini grid's generation and distribution systems. Once the mini grid was commissioned, the winning private company would operate both systems for 7–10 years under two contracts with Kenya Power and Light Company (KPLC). The first contract would be a power purchase agreement that obligated KPLC to pay for the electricity generated by the private mini grid developer. The second would be a customer service contract to compensate the developer for operating the distribution grid during the transition period. During this period, the mini grid's customers would be KPLC customers and would receive their electricity under the KPLC's national tariffs. At the end of the transition period, all privately owned assets would be handed over to KPLC.

In April 2023, the project was restructured. At the request of the Kenyan national government, the basic design of the project was converted from a public-private partnership to full public ownership, operation, and financing. The tenders were revised to reflect this major change. As of November 1, 2024, seven years after the project was approved, no mini grids had been built.

Ethiopia. With World Bank funding of \$217 million (World Bank 2021), the Ethiopian Electric Utility (EEU) will select private companies to undertake the engineering, procurement, and construction of 100 greenfield solar hybrid mini grids and to shoulder the hybridization of EEU's existing diesel-fired mini grids. When the mini grids are completed, it is expected that they will be operated by the developer or a subcontractor for several months before full handover to EEU. Apart from two tenders for full construction and operation of 30 mini grids, EEU is also experimenting with other tenders for different

combinations of generation, distribution, construction, and operation for 70 other sites. As of November 2024, EEU had signed contracts with the selected EPC firms. The original target was 201 mini grids, but it has been lowered to 100.

“In some countries, the government has decided that the national utility should be the owner and eventual operator of some or all mini grids. But if the national utility has little or no experience in building and operating mini grids for unserved communities, it may be willing to outsource the construction and initial operation of new mini grids to private companies.”

Advantages of the engineering, procurement, and construction approach. On the plus side, the approach allows national utilities to retain full control over electricity distribution in the country, whether provided through the main grid or mini grids. Customers in the new mini grid communities will pay the same subsidized tariffs that the national utility charges customers connected to the main grid. It is easier to provide cross-subsidies to a mini grid owned by the national utility than to a mini grid that is privately owned and operated.

Disadvantages of the engineering, procurement, and construction approach. Absent considerable pressure from government, national utilities will be reluctant to expand the use of mini grids if they are required to charge the same retail tariffs charged to their main grid connected customers. Or if they do serve these customers, there is the risk that the new mini grid clients will receive poor and unreliable service from the utility.

This disincentive to take on new rural customers and serve them well can be overcome if the main grid utility can be assured that the government—or the utility's other customers—will make up any revenue shortfalls that result from

building and operating loss-making mini grids. However, the assurance of being protected from revenue shortfalls unlocks a further potential perverse incentive: oversizing. Many national utilities operate under a regulatory regime that fixes profits at a percentage return on invested capital. Under this cost-plus model, the more utilities spend on assets, the higher their allowed returns. This provides an incentive to overinvest (known as “gold plating” in the regulated utility world). In contrast, the one-time, per-customer-connection grant model is the opposite of gold plating because it incentivizes customer connections and stretching generation and storage over as many customers as possible. The difference between these two approaches shows up in the example of the first 37 mini grids built by Ethiopia’s EEU, which built mini grids with an installed solar capacity of 300 watts per customer, compared to around 100 watts per customer in the privately built mini grids in Nigeria. The EEU mini grids have struggled to develop load commensurate with their installed capacity.

This approach also has the disadvantage of making it more difficult for private operators to develop mini grids in other communities because potential customers in these communities will want to be charged the same tariffs as consumers in communities served by mini grids built and operated by the national utility. So far this approach has yielded some mini grids, but at a much slower pace than what the governments initially wanted. It remains to be seen whether the current tenders under preparation will achieve results any faster. To date, both Kenya and Ethiopia have experienced significant delays in implementing this approach.

And, finally, Approach 5 ...

Community-owned mini grids make up the fifth approach

Community-owned mini grids are still new in Africa (NRECA International 2023). Ownership can range from full community ownership to minority community ownership in a privately owned and operated project. The basic problem for any ownership model is how to ensure competent and motivated management and operation after the system is commissioned. The degree of professionalism in management strongly predicts whether community projects will succeed or fail. Success requires accountability rooted in clear roles, clear contracts, implementation of standard

operating procedures, regular audits, and compliance with regulatory standards. Operational efficiency, supported by preventive maintenance, data-driven decision-making, and remote monitoring technologies, helps ensure reliability. Financial sustainability requires tariffs that provide sufficient revenues for O&M costs and for a maintenance reserve fund for repairs and replacements. In cases where these are firmly in place, community-owned mini grids, whether partially or fully owned by the community, can show successful results. On the other side of the spectrum, problems often emerge when mini grids are installed as a gift by a government or a donor and left to the community to figure out how to sustain operations with insufficient attention to the elements of professional management listed above.

Liberia. In 2016, NRECA International engaged with the leadership of Totota, a town in Bong County, to discuss development of an electrification project. In 2018, USAID provided \$700,000 to design and build a community-led solar mini-grid system. At the start of the project, local leadership—selected by newly registered cooperative members—established the Totota Electric Cooperative to own and operate the mini-grid generation and distribution system with technical support, training, and mentoring provided by NRECA International. Phase 1 was completed in 2018. After an expansion in 2021, the project included a 72 kW solar array, 120 kWh of lithium-ion batteries, an 80 kVA diesel generator, and an eight-kilometer distribution network that provided service to up to 400 of the 600 households and businesses. The project was financially self-sufficient by 2020, meeting operational costs, amassing a modest cash reserve (Kelly 2020), and generating \$438,000 of revenue (Payma 2024) in five years of operation by December 2023.

In 2021, the Liberia Electricity Regulatory Commission granted the Totota Electric Cooperative its utility license to operate as a service provider. The cooperative is the second recognized electricity service provider to receive such a license.

Nigeria. A different approach to community-owned mini grids is being tested in Nigeria (RMI 2023). Instead of the full community ownership and operation that exists in the Totota case, RMI is testing different forms of co-ownership between private developers and the community. In each of the four targeted communities, the original mini grid

was built and continues to be operated by a private developer. However, after the mini grids were commissioned, the communities were given ownership interests ranging from 11 to 20 percent, sometimes accompanied by voting rights in the governance of the mini grid. It is too early to know whether these co-ownership arrangements—a private mini grid owner and operator combined with minority community ownership—will be successful (RMI 2023).

Some empirical evidence about community-based mini grids. A 2021 statistical study of 105 mini grids in the Americas, Africa, and the Asia-Pacific regions found that community-based mini grids where “a local community or cooperative builds, owns, and operates the mini grid, or in some cases, a donor funds the mini-grid project and gives sole ownership to the community” had lower project costs and a higher likelihood of success than purely public ownership (Duran and Sahinyazan 2021). We have not been able to find statistics on cooperatively managed projects in Africa as a whole. But in Liberia, just two of nine clean energy mini grids built (2014–18) with public grants to fund capital costs and community cooperatives in charge of operations and maintenance remain operational (Totota, and a pico-hydropower

project in the town of Yandohun) (Payma 2024). Totota may embody lessons from these earlier failures.

Overall, community-owned mini grids have been slower to scale up in Africa than privately owned and operated mini grids. They have had more success elsewhere.

Electric cooperatives have long served most of the United States (56 percent by land area). U.S. electric cooperatives benefit from debt financing for their construction and expansion, largely through long-term government loans at low fixed interest under the U.S. Department of Agriculture’s Rural Utilities Service, as well as USDA grants and credit guarantees. In Bangladesh, more than 80 electric cooperatives serve some 20 million customers; in the Philippines 119 coops serve more than 56 million people in 36,000 rural villages and towns, helping bring the rural electrification rate to 95 percent (US International Trade Administration 2022; NRECAa). The world’s largest rural electric cooperative serves more than 600,000 customers in Santa Cruz, Bolivia (NRECAb).



Toto interconnected mini grid in Nigeria.

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Advantages of community-owned cooperatives. If financing can be secured and professional management provisions are in place, community mini grids can be viable at sites that are more remote, or otherwise less commercially viable, than privately owned sites. This is because they do not require a return on equity, as the communities are motivated not by profit but by the benefits that accrue directly from electrification. The construction and operation of community-owned mini grids can also provide opportunities for communities to develop managerial and technical capacity that is useful for other local projects in their communities and beyond.

Disadvantages of community-owned cooperatives. Financing the scale-up of community-owned mini grids has proved challenging. On the one hand, communities themselves have limited resources and assets to offer as collateral. Community-owned mini-grids are generally designed to provide access to affordable energy rather than to generate profits. This social enterprise model conflicts with traditional financing mechanisms, which focus on return on investment. Lenders are hesitant to fund projects without clear, predictable cash flows and profit potential, making it hard for cooperatives to access capital.

Even if subsidized financing becomes more available, another challenge to community mini grids is that communities will generally require considerable assistance over months or years to develop the managerial capacity to operate at the level required. This challenge is compounded by the fact that community members, once trained, may leave the community to earn more money elsewhere. Even though it seems unlikely that community-owned and -operated mini grids will be a main pathway to the United Nation's SDG 7 goal of affordable clean energy for all by 2030, all methods are needed, and coops should be encouraged where they appear to be well suited.

We have reached some initial conclusions

In several Sub-Saharan Africa countries, the private sector is successfully scaling up deployments of solar hybrid mini grids (Approach 1)

However, we lack clear evidence on their operational and commercial sustainability, because most mini grids built under this approach are relatively new. Examples of rapid scale-up observed in Sub-Saharan Africa include 173 mini

grids built under the Nigeria NEP program (with 215 more in the pipeline) and 220 private mini grids in Madagascar constructed and operated by 29 private companies. Similar results have been observed in India, where more than 600 bottom-up, privately owned and operated mini grids have been developed over the last six years in the states of Uttar Pradesh, Bihar, and Jharkhand. Nigeria is now experimenting with mini grids in peri-urban and urban areas connected to the local distribution company from the outset. It is also noteworthy that deployments under Approach 1, remain well below levels needed to reach SDG 7 targets of universal electrification by 2030.

Speed of development is not the only measure of success: Operational and commercial sustainability is a must for any mini grid. Unfortunately, data on sustainability is difficult to obtain. Developers and governments are understandably reluctant to draw attention to projects that no longer operate. Our best current estimates are that nearly all the 220 private sector-led mini grids deployed in Madagascar continue to operate. Similarly, we estimate that all of the 173 built privately in Nigeria are operational. We do not know, however, how many of them will prove sustainable over the medium- and long-term. Nor do we know if the successes of Approach 1 in Nigeria and Madagascar can be replicated in other Sub-Saharan African countries.

The results of competitive tenders to promote mini grids have been a mixed bag. On paper, competitive bidding for mini grids is appealing. The approach can jump start development for many more mini grids. It can also provide market-based information on capital and operating costs. Competitive bidding has been the standard approach for many World Bank-financed electricity projects, transmission lines, and major generating stations. So, it is not surprising that it has been recommended for mini grids.

Unlike these larger projects, however, mini grids are smaller investments at many different locations (except for the metro grids of the DRC described in Approach 3). To date, the results have been less than impressive. In Nigeria, competitive bidding for ownership and operation of 57 mini grids was terminated after two years of preparatory work, though it will be attempted again in an improved form in the new DARES project (World Bank 2023). In Kenya, a competitive tender to select contractors to build and initially operate 120+

mini grids to be owned by KPLC (the national utility) has yet to produce any mini grids after seven years of preparation. In Uganda, it took about six years to commission 25 mini grids through a competitive tender.

It is unclear whether these failures or long delays represent early-stage problems or reflect more fundamental issues.

“Too often, government agencies are insensitive to the impact of long delays on private companies.”

One likely problem is that the tendering process is typically run by one or more government agencies that must comply with complex government (or donor) procurement rules. Too often, government agencies are insensitive to the impact of long delays on private companies. The bottom line is that we need to know more about successful and unsuccessful mini grid tenders in Sub-Saharan Africa.

The competitive tenders being proposed in the new DARES Nigeria project will test whether changes in tender design, including improved targeting of sites through the use of geospatial tools to collect data on prospective sites and simplification of procurement processes, may be able to fulfill the promise of speed and scale of this approach.

Solar hybrid mini grids are not a “silver bullet.” Solar hybrid mini grids are a major technological breakthrough for rural electrification. They can provide reliable grid-quality electricity to isolated rural villages that otherwise would have little hope of being connected to a main grid supplier. But while prices are going down for such service, it may still be too expensive for poorer rural customers who initially may need only small amounts of electricity. Government policies and regulations must be technology neutral to serve poorer customers at lower cost through a range of renewable energy technologies. Private developers should be given the flexibility to mix and match technologies to serve customers with more affordable electricity services. Specifically, developers should not be forced to offer only a mini grid solution for all service-area customers when other solutions may be available at lower cost (e.g., solar home systems and DC mesh grids) and may work just as well for disadvantaged and dispersed customers. To spread fixed costs over a larger

customer base, private developers should be allowed to offer other services, such as solar-generated electricity for mobile phone towers, rental of battery-operated motorcycles, and grid-connected solar installations for commercial and industrial customers. Finally, where private mini grid companies have been successful at the individual community level, they should be encouraged to expand their operations to larger geographical areas. This is more likely to happen if the local distribution company is privately owned and sees a potential financial win for itself.

Mini grid customers are likely to benefit from lower tariffs if developers and those who finance projects have more confidence that the regulatory rules will be implemented as written. Mini grid (and other regulatory) policies may look good on paper but may not be implemented as written (Foster and Rana 2020). Hence, it is understandable that private developers seek assurances that mini grid policies and rules are more than words printed in the government gazette. In civil law countries, it is possible to give these assurances by embedding the regulatory rules in a concession agreement that can be backed by external guarantees issued by the Multilateral Investment Guarantee Agency or another guarantee entity. Concessions are generally not available in common law countries, but it may be possible for those governments to enter legally enforceable contracts (rather than full concessions) that support mini grid regulations and policies (AFUR 2024). If this hybrid approach were to be implemented, it could benefit both the mini grid developer and its customers: the developer will be able to tap into new sources of financing at lower cost, and customers could benefit from lower tariffs.

More systematic monitoring of the pace of mini grid deployments, mini grid performance, and socioeconomic impacts is needed. Energy access has been described as “the golden thread that weaves together human development and environmental sustainability” (IEA 2017). But more recent empirical assessments of increased energy access have found that its predicted outcomes are not always achieved. However, one important caveat is that most of these studies have been limited to assessing the effects of increasing energy access through extension of the main grid (Lee, Miguel, and Wolfram 2020). In future research, it would be useful to systematically compare the outcomes of different approaches to mini grid deployment in terms

of the pace of deployment, performance, and socio-economic impact. Future research should also study the effects of access expansion through private mini grids versus main grid expansion. Our expectation is that mini grids developed under the private sector-led model will be deployed faster and will show a stronger positive local economic and social impact. Furthermore, private mini grids generally have stronger incentives to expand electricity consumption than do

government-owned main-grid operators backstopped by continuing subsidies.

This Live Wire is based on *Mini Grid Solutions for Underserved Customers: New Insights from Nigeria and India* (Tenenbaum, Greacen, and Shrestha 2024, Appendix A). It benefited from numerous suggestions from many colleagues inside and outside the World Bank Group.

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