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Lessons for Modernizing Energy Access Finance, Part 2

Balancing Competition and Subsidy: Assessing Mini-Grid Incentive Programs in Sub-Saharan Africa

Jonathan Phillips, Benjamin Attia, and Victoria Plutshack

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Author Affiliations

Jonathan Phillips, Director, Duke University, Energy Access Project. Benjamin Attia, Senior Research Analyst, Energy Transition Practice, Wood Mackenzie. Victoria Plutshack, Policy Associate, Duke University, Energy Access Project

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Review

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Lessons for Modernizing Energy Access Finance

The long-established approach for financing rural electrification via the grid does not work for distributed renewables. Scaling the deployment of these technologies to achieve their least-cost potential and reach last-mile customers requires adapting funding models to mobilize the private sector, support multiple implementers rather than a single utility, allocate subsidy effectively, and consider productive use and broader social benefits of energy delivery. The "Lessons for Modernizing Energy Access Finance" series aims to drill down on these and related challenges that cut across geographies in order to support program development, facilitate lessons learned, and unlock capital.

Executive Summary

Rapid technology development and falling hardware costs have made mini-grids a potentially game-changing platform for enabling universal electrification. With the capacity to power commercial and industrial loads and provide 24/7 service, mini-grids can bring reliable grid-level service to places that are unlikely to be serviced with a stable connection in the near future. Of the roughly 800 million people globally without access to electricity, mini-grids could represent the least-cost option for meeting the electricity needs of 490 million by 2030 (IEA 2020; ESMAP 2019). In response, governments and development partners are putting in place support programs to accelerate the scale-up of mini-grid deployments. These support programs aim to reduce risk and improve returns for private developers and lower connection costs for rural populations.

This policy brief summarizes a review of 20 such mini-grid incentive programs in sub-Saharan Africa, 17 of which are still being implemented. The programs analyzed primarily used one of two mechanisms to stimulate investment:

- **auction programs** that invite developers to submit bids for the construction and, in most cases, the operation of mini-grids at specific sites, typically awarding an up-front capital subsidy to the selected developers; and
- **results-based financing (RBF) programs** that have a set subsidy per connection that is paid to developers after verification that a household or business has been connected.

The recent surge of mini-grid programs invites a deeper look at current incentive and support mechanisms as well as a deeper consideration of initial lessons to inform the design of future programs. While there is extensive experimentation going on and it is too early to draw hard conclusions around impact and effectiveness, some clear trends are starting to emerge:

(1) Most African mini-grid markets are in their pilot phase and not mature enough to benefit from auction programs designed to prioritize competition and lower prices, an approach better applied to mature markets with a sufficient supply of experienced developers. Instead, the mini-grid market may be better served by viability gap subsidies, clear and consistent regulation, and capacity building. This approach may better support a scale-up phase that can bring new market entrants, drive down costs, and build the capacity of regulators to allocate market opportunity efficiently.

(2) Nevertheless, auctions are still the most common program design, in part, because they frequently offer developers upfront payment, larger projects, a chance to negotiate terms—and an opportunity to walk away.

(3) Even as the mini-grid market matures, competition paired with subsidy will likely be necessary to simultaneously achieve both commercial and social outcomes. Auction-RBF hybrid programs offer a promising path to doing just that.

(4) While mini-grid costs have historically ranged widely, stated subsidy levels across programs are remarkably consistent, with RBF payments of $350–$500/connection and auctions providing 60–80% of upfront capital expenditures. This reflects a narrowing range of expectations regarding the viability gap facing mini-grids.

(5) A review of program documents reveals relative consistency in assumptions around mini-grid capital expenditures ($4,400–$6,200/kW), but the allocated budget per planned connection varies widely ($348–$2,500/connection). Due to a lack of transparency in program budgets, it is unclear which components are driving overall program costs and impossible to compare country programs to each other or to other benchmarks.

(6) Technical assistance and capacity building support are large components of mini-grid programs, reflecting the extensive ecosystem development required to build rural infrastructure in emerging

markets. To date, more programs have focused on assisting program implementation, with fewer helping local developers participate in the program or assisting in policy and regulatory development, which favors developers with greater experience and the capacity needed to engage with complex programs.

(7) Nearly half of programs express support or preference for local developers. Still, most mini-grid programs remain focused on mobilizing experienced developers with established supply chains (i.e., international developers), with 14 programs either targeting international developers explicitly or making no distinction, which is likely a function of bid evaluation criteria prioritizing cost and quality of service track records that inherently favor international companies that have progressed further down the learning curve.

(8) Governments are playing a central role in selecting mini-grid sites. This is a good thing for last mile customers, but it comes with trade-offs. Government-selected sites often prioritize social or even political results, rather than cost optimization or revenue generating opportunities for private developers, including limited prioritization for value stacking related to productive use potential, water needs, or other adjacent services.

(9) The core question facing all mini-grid programs is whether the primary objective is commercial viability or maximizing high-quality rural access. Programs designed to simultaneously achieve both are unlikely to achieve either.

    (a) Programs aiming to support the drive to commercial viability must focus on identifying sites that can support higher load factors; work in tandem with programs targeting increased productivity at sites; and attract experienced developers that can procure equipment near global spot prices and deliver projects at lowest cost.

    (b) Programs aiming to maximize high-quality rural access with mini-grids could benefit from programs that prioritize more extensive capacity building and technical assistance efforts; offer up-front payments or other measures that expand access to capital for local firms; include more generous subsidies to support development at sites facing thin commercial demand and lower load factors; and offer opportunities to negotiate terms post-auction.

(10) Even when mini-grids reach cost parity with the grid, the tariffs needed to fully recover costs of a rural mini-grid will typically be much higher than the subsidized retail power from the grid. Of mini-grid programs analyzed, 78% are in regulatory environments that allow developers to charge a tariff that exceeds the grid tariff. That flexibility is important, but program subsidies must balance the ability to set cost-reflective tariffs with what customers can afford to pay.

Even in its nascency, the mini-grid sector can take lessons from other energy and infrastructure sectors: namely that in mature markets, well-designed and transparently implemented auction structures can be the purest form of efficient resource allocation to target private capital, scale a market, and achieve commercial and social outcomes. Likewise, even in mature markets, poorly designed and implemented auctions can lead to suboptimal market or social outcomes, fail to award a project, or fail to attract bidders. But even the best-designed competitive auction will fail the mini-grid segment without paired subsidy to bridge the viability gap and incentivize competition for service rather than cost. RBFs are perhaps the most promising design given the current state of the African mini-grid market and the mechanism's demonstrated effectiveness in other sectors. However, RBFs have a very short track record in the mini-grid space.

There is still more known about what does not work in the mini-grid sector than what does, so further experimentation, coordination, and transparency will be critical to determining the right balance of competition and subsidy to scale the market.

MOTIVATION AND BACKGROUND

In order to help scale up the deployment of mini-grids to reach their least-cost potential—serving up to 490 million people by 2030, mostly in Africa (ESMAP 2019)—governments and development partners are putting support programs in place that aim to reduce risk for developers and lower connection costs for rural populations. Traditionally, these programs have taken the form of auctions, otherwise known as competitive procurements or minimum subsidy tenders. However, recent programs like the Universal Energy Facility[1] and the Beyond the Grid Fund Africa[2] are scaling-up alternative models utilizing results-based financing (RBF), also known output-based aid or performance-based grants.

In order to glean some early lessons for mini-grid incentive design, this study reviewed 20 mini-grid programs, covering 18 countries in sub-Saharan Africa (see Appendix A) and reflects interviews with many developers, program designers, and administrators. These programs each represent, to varying degrees, a centralized and coordinated approach to developing significant numbers of mini-grids in which the government plays the lead role in determining the timing and location of mini-grid projects, and often includes a governmental role in the development and ownership of mini-grid assets. Three of these programs are complete, while the remaining 17 are still being implemented.

These incentive programs include auction programs, RBF programs and hybrid programs (Fig. 1). Auction programs typically identify sites or regions for mini-grid development and invite developers to bid on sites, paying a subsidy up-front that is usually calculated as a percentage of capital investment. They can select winning bids based on the lowest subsidy request but often include other considerations such as social return on investment. RBF programs have a set subsidy per connection that they pay out after verification that the developer has connected a household. Developers may be required to go through prescreening in order to participate in the program, but competition is generally not used to identify the subsidy amount. Hybrid programs borrow elements from both types.

Figure 1. Incentive Types Represented[3]

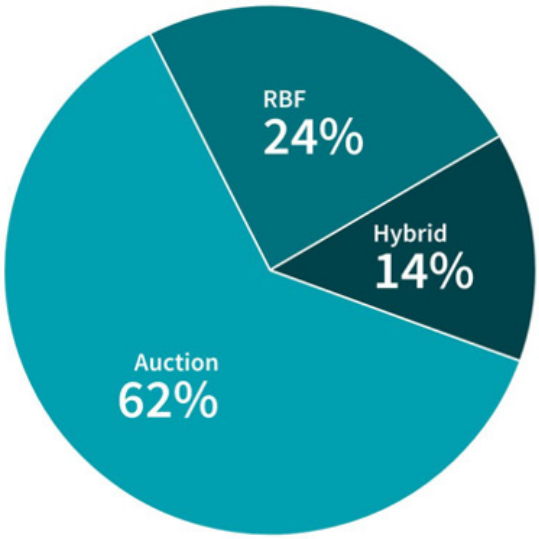
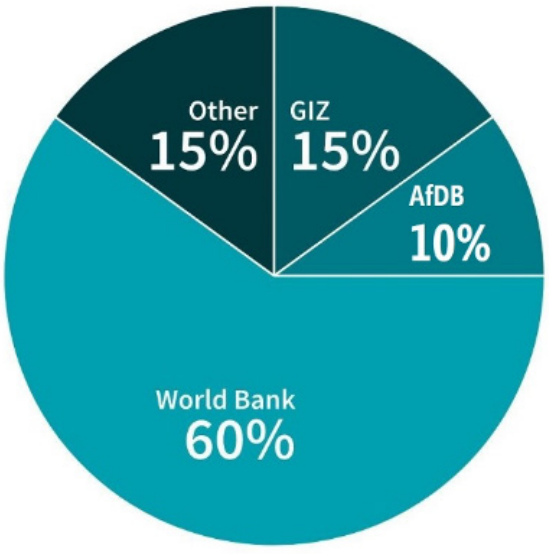


Figure 2: Primary Financing Body[4]



1. https://www.seforall.org/news/universal-energy-facility-opens-for-mini-grid-projects.
2. https://beyondthegrid.africa/.
3. Each graphic includes only those programs where the data are available. If one of the 20 programs analyzed in the study is not included in a graph, it means the information was not publicly available.
4. By program count.

The programs analyzed were primarily financed by the World Bank; the German development agency, GIZ; the African Development Bank; and others, including the Swedish International Development Agency (SIDA), the UK Foreign, Commonwealth & Development Office, and the U.S. Millennium Challenge Corporation (Fig. 2).

Most mini-grid incentive programs in Africa are still in their first few years of implementation, so it is premature to draw broad conclusions about their efficacy. However, as new programs are being rolled-out—at least eight new auction programs have been implemented since 2018 alone and many more are in design—it is useful now to take stock of how programs are being developed, the trade-offs between these different policy approaches, and issues that these programs are raising before the next generation of programs is launched. This report compiles findings from 20 programs in sub-Saharan Africa, exploring their costs, goals, rationales and some preliminary learnings from their implementation. The early evidence that we do have about how these programs have been designed can help us to make some initial comments about how and when to appropriately apply competitive procurement schemes and results-based financing to the nascent energy access mini-grid sector.

LESSONS LEARNED

Most African mini-grid markets are in their pilot phase and not mature enough to benefit from auction programs designed to prioritize competition and lower prices, an approach better applied to mature markets with a sufficient supply of experienced developers. Instead, the mini-grid market may be better served by viability gap subsidies, clear and consistent regulation, and capacity building. This approach may better support a scale-up phase that can bring new market entrants, drive down costs, and build the capacity of regulators to allocate market opportunity efficiently.

In the grid-scale solar PV and wind markets, generous incentives, generally in the form of feed-in-tariffs and tax credits, encouraged large-scale development of renewable energy projects. These first-generation public technology support programs, pioneered in early-adopter markets like Germany, Japan, and California—were the initial sources of demand growth that helped drive the scale up of OEM capacity and drove component prices down 70–90%. Once these scale-driven cost declines made renewables grid-competitive, the sector rapidly shifted from direct incentives to competitive procurement, typically through public auctions and tenders, which in stable markets are nearly always highly competitive and most often oversubscribed (Attia et al. 2020a).

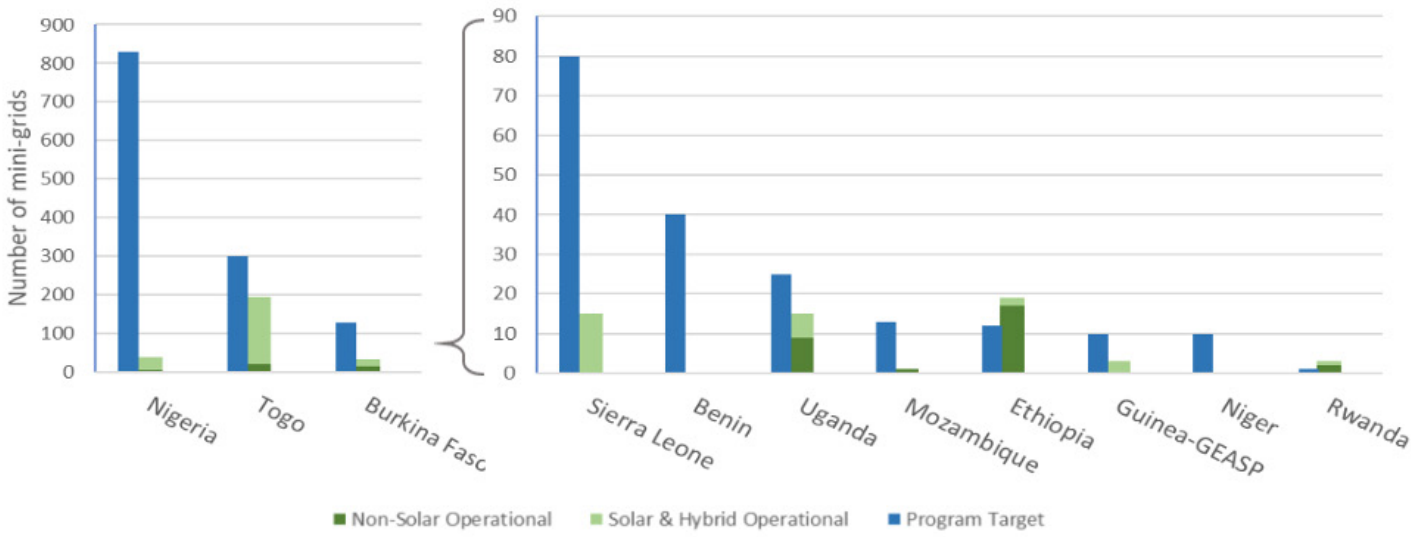
But top-down competitive auctions are designed for markets that are mature enough to benefit from competition, either for the purpose of scaling the market or in some cases, slowing its growth by capping the capacity on offer or reallocating incentives unfavorably to developers and investors (Attia et al. 2020a). There is a direct relationship between availability of competitive supply in the market (actual or potential) and the benefits of competitive procurement (Domberger and Jensen 1997; Entwistle and Martin 2005; Hefetz and Warner 2012; Girth et al. 2012). Under-subscribed auctions do not discover the true market clearing price, even where viability gap subsidies, which are subsidies offered to bridge the gap from negative commercial returns to acceptable returns for private investors, are offered. Auctions can be a powerful procurement tool but, applied in the wrong way or in the wrong market, can do more to inhibit a market than accelerate it.

It is true that mini-grids are not new; historically, mini-grids have been the fundamental building blocks of national grids. Indeed, the technologies utilized in "third-generation" systems—solar PV, battery energy storage, remote management systems, smart metering, etc.—are scaled and mature technologies in grid-connected market segments globally (Korkovelos et al. 2020). However, the private mini-grid sector is, by most counts, still an immature market: an underfunded space with a narrow landscape of competitive market participants, persistent regulatory barriers, and challenging unit economics (Attia et al. 2020a; Attia et al. 2020b; Davies and Tilleard 2019).

And yet, 62% of the mini-grid programs captured in the analysis rely on auction mechanisms to allocate risks and opportunities between the developers, off-takers, and regulators. Program implementation documents for mini-grid scale-up programs in Zambia, Togo, Ethiopia, Guinea, the Democratic Republic of the Congo, Niger, and Sierra Leone specifically describe programs as "pilots" or "demonstrations" and markets as "nascent" and "immature" (see Appendix B). But these programs also have big ambitions; of the programs using auctions captured in the analysis, 41% have targets to at least double the number of installed third-generation mini-grids, and 28% have targeted at least a quadrupling of installed systems by the end of the program (see Fig. 3).

Given the early stage of nearly every mini-grid market in the region, it is likely that the sector would benefit less from competition than from clear subsidies, bankable regulation, and capacity building. This would support a scale-up phase in the market, which could bring new market entrants, drive costs down, and build the capacity of regulators to allocate market opportunity efficiently. Many of these programs have admirably big ambitions, but some may be seeking to leverage auctions as a scale-up mechanism without the underlying market fundamentals necessary for auctions to successfully attract competition yet present.

Figure 3. Mini-Grid Program Targets[5, 6]



Nevertheless, auctions are still the most common program design, in part, because they frequently offer developers upfront payment, larger projects, a chance to negotiate terms—and an opportunity to walk away.

Despite evidence that the mini-grid market may not be ready for auction programs, auctions are still the most common incentive-type represented. Of the programs we reviewed, 62% use auctions (See Fig. 1), and in the past two years, at least eight African countries released tenders for mini-grids (ESMAP 2019, 79). The popularity of auction mechanisms might not reflect their ability to lower prices as there is little emphasis on the role of auctions for lowering prices in the program documents. Only the programs in Nigeria and Sierra Leone

5. Source: State of the Global Mini-Grids Market Report, which focuses primarily on renewable hybrid mini-grids that are predominant among projects installed in the last five years and represent recent market trends. See Appendix A of the Report for more details about the database. It is also worth noting that relatively large volumes of installed capacity are not necessarily indicative of a robust private developer ecosystem.
6. Ethiopia's ELEAP initially planned for five mini-grids, but eventually 12 mini-grids were tendered for.

explicitly discuss it (World Bank 2018a, 79; DFID 2016, 43). Instead, the popularity of auctions may reflect other features that appeal to developers, namely, that they offer upfront payment, large project sizes, and a chance to negotiate terms.

Upfront payments, usually in the form of a CAPEX subsidy, provide critical funding that developers need to begin implementation. Given the immaturity of the mini-grid market, small and medium-sized developers—especially local developers—may not have the necessary capital to wait for back-loaded RBF payments, and must search for additional financing (MGP 2020, 79). This is not the case for auctions.

Auctions also tend to offer large concessions in an attempt to reach economies of scale for mini-grids. The Niger Solar Electricity Access Project, for example, plans for the program to "evolve through the bundling of several small concessions into a larger one with lower investments and operation costs through economies of scale" (World Bank 2017, 28). The expectation in other programs is that large lots will "encourage economies of scale in procurement and efficiency in O&M" (World Bank 2018a, 63). Larger concessions are also designed to attract international actors, as in Nigeria's auction program, whereby "increasing the deal size, [the] window aims to attract some of the international private developers to enter the mini grid market in Nigeria" (World Bank 2018a, 63).

Finally, developers participating in auction programs can enter into negotiations with the government on the terms of the contract and withdraw at any time before signing, with varied degrees of penalty. This gap between being awarded a bid and signing a contract is an inherent feature of auctions. By giving developers the option to walk away with a relatively low sunk cost (sometimes a penalty fee), auction programs introduce uncertainty into the procurement process (Attia et al. 2020a; Attia et al. 2020b). This has the potential to lead to delays and protracted negotiations, as inexperienced companies may encounter unforeseen challenges and costs in following through on a winning bid. At the same time, it allows an opportunity for developers to consider their options or re-negotiate terms before committing large resources.

Even as the mini-grid market matures, competition paired with subsidy will likely be necessary to simultaneously achieve both commercial and social outcomes. Auction-RBF hybrid programs offer a promising path to doing just that.

The reality is that even when the mini-grid sector matures, mini-grids will still be rural infrastructure. Developers are going to make rural infrastructure returns—traditionally a low-risk, low return investment—while trying to balance serving rural, low-income populations (Attia and Guay 2018; Ellsmoor 2019; MGP 2020, 28). These are the same challenges faced by grid extension programs, which commonly face rural connection costs of $1,500 per connection or more, but which frequently enjoy connection subsidies covering 70–100% of those costs (Phillips et al. 2020).

This means that the mini-grid market will need both competition and subsidies in order to lower prices and reach the last mile. Interestingly, several new programs (see Fig. 4) are using a variety of hybrid incentive models that incorporate key auction elements (like competition) with RBF elements (like output-based payments).

Beyond the Grid Fund (BGFZ) – Zambia

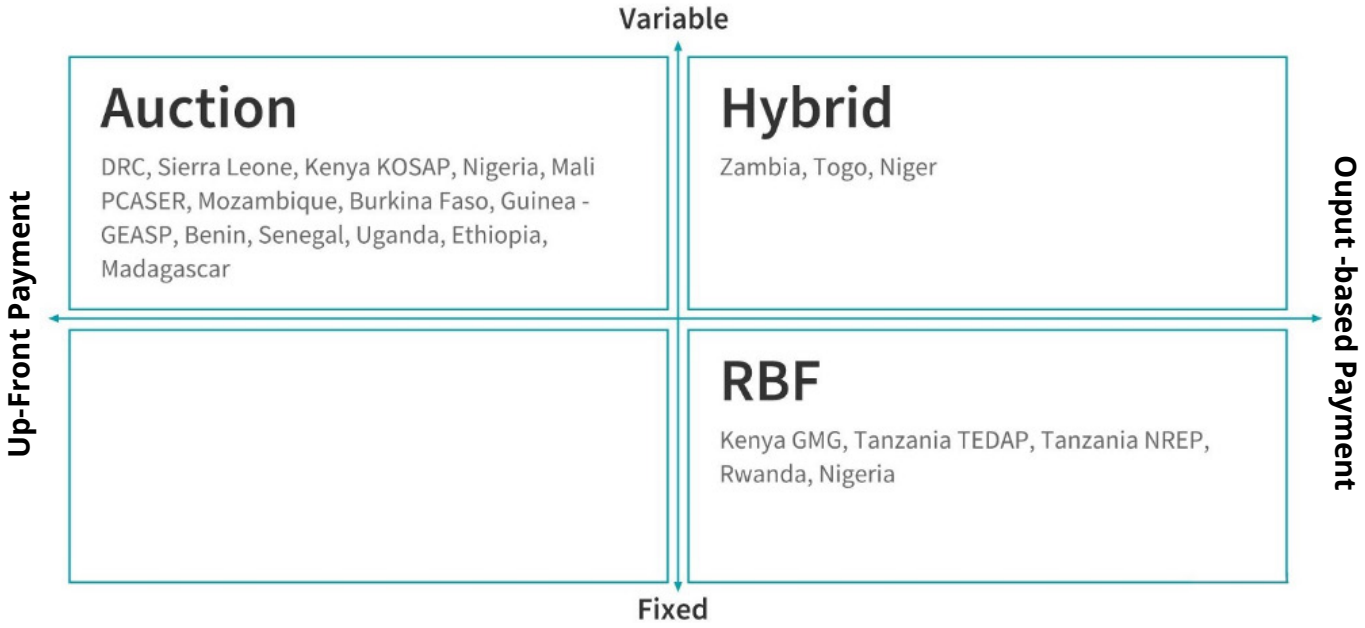
The BGFZ program closes the viability gap by disbursing a grant on a per-connection basis but selecting participants on the front-end through competitive bidding for the value for money on social impacts. Companies can submit a bid to BGFZ, committing to the provide energy services to a certain number of customers. Winners are selected based on value for money, described as "the social impact they commit to delivering per $ of public funding" (BGFZ 2019b). The BGFZ used a "reverse auction" mechanism to identify the price, on a per-connection basis, that the private sector would need to support market expansion (BGFZ 2019a).

This innovative program has already connected over 170,000 new customers in Zambia and is being scaled up, with new programs initiating in Mozambique, Liberia and Burkina Faso (Edison 2020).

Solar Electricity Access Project (SEAP) – Niger

The bottom-up window for the SEAP encourages developers to submit unsolicited proposals to the Niger Rural Electrification Agency (ANPER). These unsolicited proposals will have to comply with technical and economic standards approved by ANPER, so that they meet a minimum scale to guarantee competition. These proposals are subject to competition for the selection of the most appropriate and cost-efficient proposals. Subsidies will then be disbursed on an output basis (World Bank 2017).

Figure 4. Mini-Grid Support Programs, Categorized by Payment Approach[7]



While mini-grid costs have historically ranged widely, stated subsidy levels across programs are remarkably consistent, with RBF payments of $350–$500/connection and auctions providing 60–80% of upfront capital expenditures. This reflects a narrowing range of expectations regarding the viability gap facing mini-grids.

The World Bank's recent survey of 53 mini-grids found costs per unit of firm power output ranged from $1,420 to $22,689/kw (ESMAP 2019), with the costs of key components varying by factor of two or three across different countries. Given this vast range, African mini-grid programs analyzed had relatively consistent subsidy levels across programs. These subsidy levels were specified for two of the RBF programs analyzed, two auction programs and one hybrid program. For the RBF programs, Tanzania's TEDAP program offers $500 per connection while Nigeria's RBF program offers $350 per connection. Mali and Niger offer up to 80% of investment costs, while Guinea offers around 60–80% of initial investment costs. There were no tariff rate subsidies present in the programs.

7. Togo's program incorporates both RBF and pilot auctions, but the relationship between each mechanism is unclear at the time of writing.

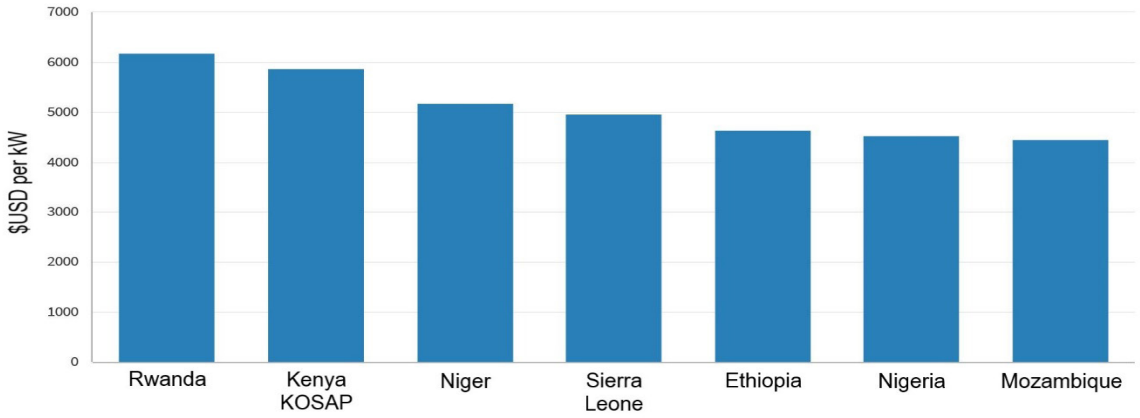
Table 1. Stated Subsidies[8]

Program	Type	Subsidy
Tanzania TEDAP	RBF	$500 per connection
Nigeria	RBF	$350 per connection
Mali	Auction	up to 80% amount of the investment
Niger	Hybrid	up to 80% of subsidy on the investment cost
Guinea	Auction	around 60–80% of the initial investments

A review of program documents reveals relative consistency in assumptions around mini-grid capital expenditures ($4,400–$6,200/kW), but the allocated budget per planned connection varies widely ($348–$2,500/connection). Due to a lack of transparency in program budgets, it is unclear which components are driving overall program costs and impossible to compare country programs to each other or to other benchmarks.

Programs tended to report projected capital expenditures (CAPEX) within a relatively narrow band, reflecting the fairly well-understood costs of mini-grid equipment and the local variables that might impact CAPEX. As seen in Figure 5, CAPEX ranges from $4,454 per kW to $6,180 per kW with an average of $5,118 per kW, which is in line with recent studies (ESMAP 2019, 21).

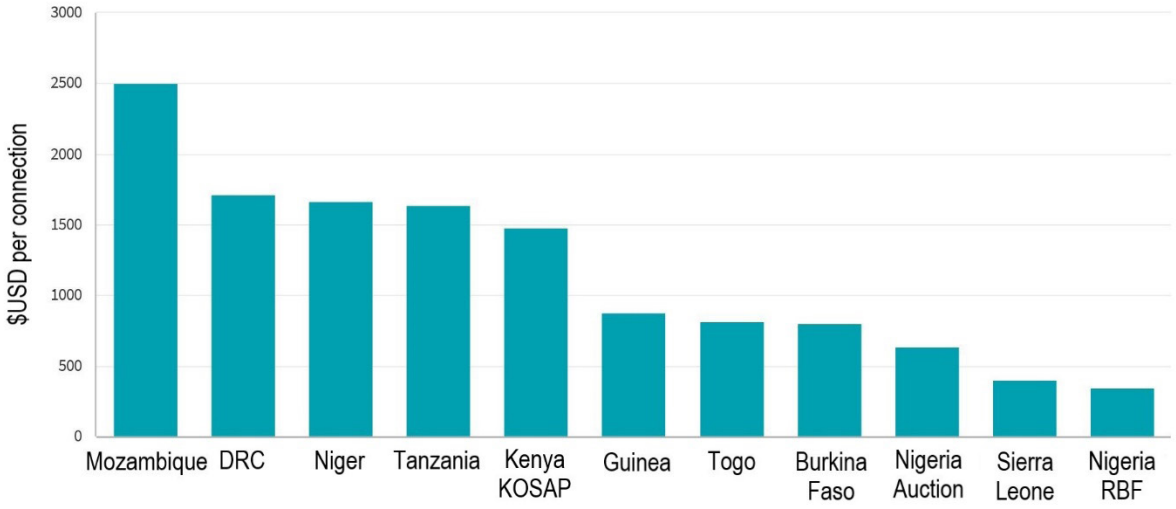
Figure 5. Capital Costs ($USD per kW)[9]



8. CAPEX subsidies are clearly intended to lower tariffs, but only the Guinea program was explicit that the capital subsidy was intended to lower the tariff to $0.20/kWh.
9. Rwanda's Hybrid mini-grid in Gatsibo district program offers a range of cost/kW. Mini-grid assumptions from AfDB-GCF Green Mini-Grid Program for the DRC were not included in this chart given their capacity (3–10 MW). The DRC program is not included, as the 10 megawatt average system size makes it an outlier for considering costs.

However, the amounts that programs are investing in technical assistance and capacity building, CAPEX subsidies, and administrative costs are frequently lumped together and reported as a single "program cost." If we compare these program costs on a standardized basis across countries—for example Figure 6 illustrates program costs per planned connection--we see program costs range much more widely—from $348 to $2,500 per connection. It is unclear which cost components are driving overall program costs and impossible with the available data to compare country programs to each other or other benchmarks.

Figure 6. Program Cost/Connection ($USD)[10]



Technical assistance and capacity-building support are large components of mini-grid programs, reflecting the extensive ecosystem development required to build rural infrastructure in emerging markets. To date, more programs have focused on assisting program implementation, with fewer helping local developers participate in the program or assisting in policy and regulatory development, which favors developers with greater experience and the capacity needed to engage with complex programs.

In addition to financial support, the nascent mini-grid market also requires support in the form of capacity building or technical assistance, which is incorporated into most programs. The World Bank's report, Mini-Grids for Half a Billion People, identifies the need for capacity building as one of its key recommendations for the sector (ESMAP 2019, 10, 43). This need is particularly acute in the case of auction programs, which may require greater institutional capacity (Prager 1994; Archibugi et al. 2003, 52). Current projects from major multilateral institutions and past programs that we reviewed expressed the need for capacity building, for government agencies and for the private sector (World Bank 2018b, 49; GEF 2019; GIZ 2020).

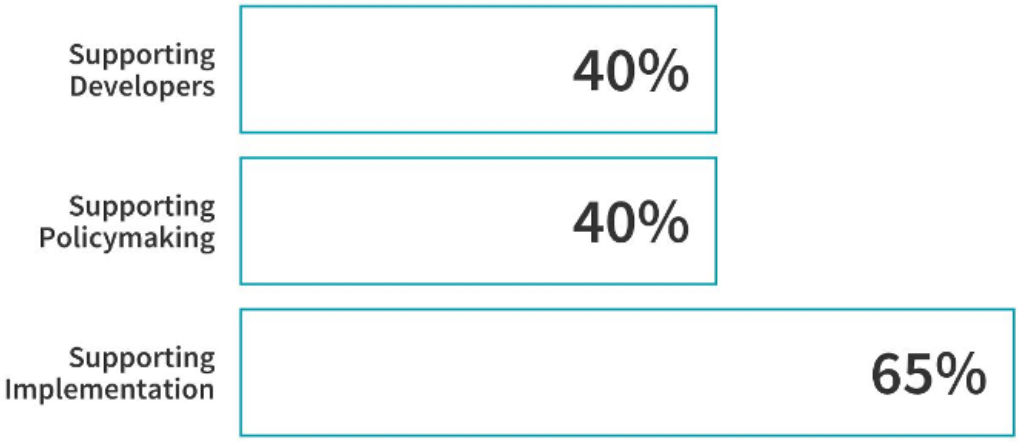
Capacity building can take three forms: assisting in policy and regulatory development, supporting implementing agencies, and helping developers participate in the program. For example, in Togo's Rural

10. For this figure, where mini-grids were addressed in a separate component, that component was taken as the program cost.

Electrification Project, a review of regulatory framework is included in the initial implementation phase (AT2ER 2018, 28). In terms of supporting implementing agencies, Tanzania's TEDAP program includes money for "(i) training needs assessment for TANESCO with subsequent selected capacity building implementation; and (ii) increasing the Government of Tanzania's capacity to develop public and private generation projects through the provision of legal, technical, financial, environmental, and social advisory services" (World Bank 2007, 8). For developers, the Nigeria Electrification Program "will also build capacity of existing mini-grid developers and other private companies interested in entering the mini-grid market to identify sites viable for mini-grid development, mobilize community engagement, establish business relationships with reputable vendors, develop bankable business plans with realistic load models and revenue forecasts, and ensure implementation of E&S safeguards" (World Bank 2018a, 83).

Within the programs we reviewed, 65% of programs supported implementation. 40% of programs included some efforts to assist developers and help policymakers develop mini-grid appropriate policy and regulation (Fig. 7), which indicates local developers in many countries may be without technical support to engage with these new programs. The complexity of new multi-year government or donor-led programs using auctions often favors larger developers over small, local players (Plutshack et al. 2019).

Figure 7. Percentage of Programs That Incorporate Specific Capacity Building Activities[11]



Most mini-grid programs remain focused on mobilizing experienced developers with established supply chains (i.e., international developers), but nearly half of programs express support or preference for local developers.

Properly designed auctions are effective mechanisms for allocating risk and opportunity between parties. Elements of auction design can also target or favor participants with a minimum track record, certified technology partners, or the ability to attract their own financing. Within the private mini-grid sector, these criteria generally segment local developers and international developers, the latter of which will have deployed projects in multiple countries, have established supply chains, can procure equipment closer to global spot prices, and are more likely to have raised international or strategic capital.

11. Figure 7 is based on which activities are described within the program documents. One limitation of this approach is that implementation activities are more likely to appear in program text than policy activities, which more often happen on an ad hoc basis.

Although recent programs in Benin, Sierra Leone, and Nigeria have explicitly stated their commitment to supporting local developers, international private developers have traditionally been the recipients of subsidies through mini-grid incentive programs (LUA 2019; Tsagas 2019; Takouleu 2020).

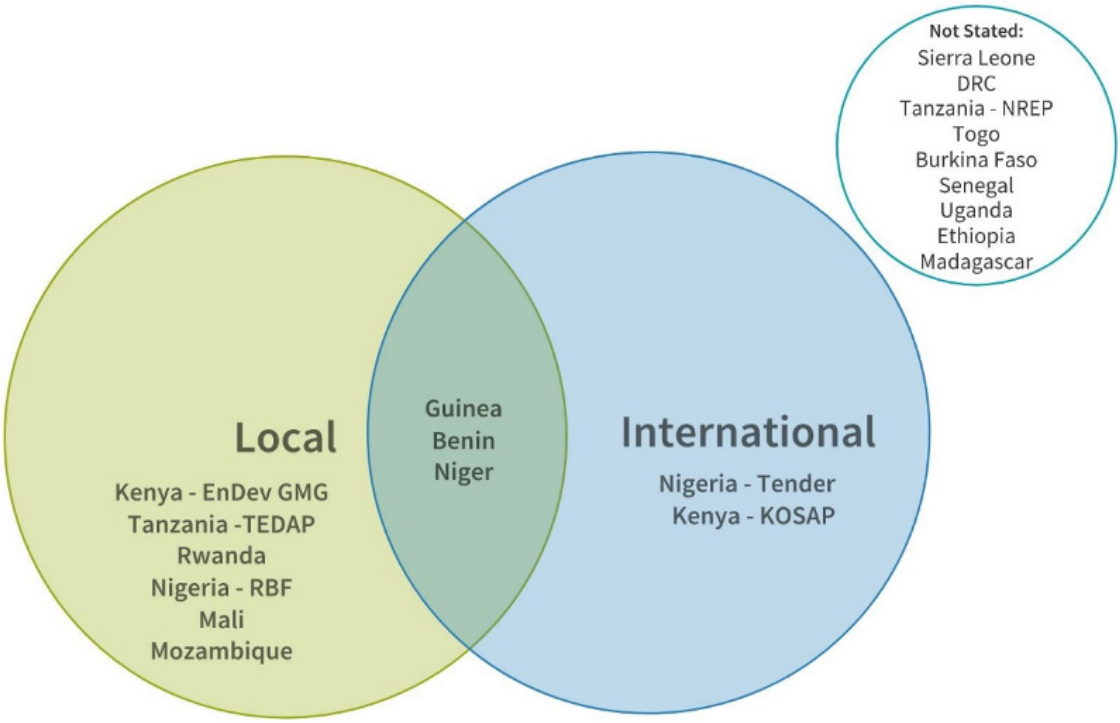
Still, 14 programs either target international developers explicitly or make no distinction, which is likely to be a function of bid evaluation criteria prioritizing cost and quality of service track records that inherently favor international companies who have progressed further down the learning curve.

Attracting international players requires the promise of sufficiently attractive returns in comparison to competing markets. Consequently, the least profitable sites or concessions may be left for local firms, a suboptimal and inequitable outcome. Likewise, concessions or site portfolio offerings must be sized large enough to achieve minimum ticket size, reduce transaction costs, and take advantage of scale economies in order to attract international capital.

In order to target local developers, programs must generally be paired with technical assistance and capacity building budgets specifically designed to promote smaller local firms and value—and subsequently leverage—their local expertise (World Bank 2018a, 15). Additionally, if the value of bids were to be interpreted more broadly than hard metrics like cost and quality to include local market and social development benefits and other metrics, local energy access mini-grid developers could be specifically favored (Loader 2007). It is also worth noting that RBFs require developers to find up front capital, which is easier for companies that can tap broader financial markets but can be a significant constraint for companies limited to local banks (Endev 2020).

This dichotomy is clear in the Nigerian NEP, where the minimum subsidy tenders and the performance-based grant programs specifically and separately target international and local developers, respectively. During the formation of the NEP, the government and ESMAP teams determined two aims: accelerated universal electrification and supporting the organic growth of the local energy access mini-grid sector in Nigeria. The former would be achieved by incentivizing the entrance of "natural aggregators" who had the capacity to execute on ambitions to deploy mini-grids by the hundreds through the minimum subsidy tender rather than a few sites at a time. The latter aim would be achieved by supporting the scaling of the local developer ecosystem through the performance-based grant on a site-by-site basis (Dhingra 2020).

Figure 8. Type of Developer Targeted



Governments are playing a central role in selecting mini-grid sites. This is a good thing for last mile customers, but it comes with trade-offs. Government-selected sites often prioritize social or even political results, rather than cost optimization or revenue generating opportunities for private developers, including limited prioritization for value stacking related to productive use potential, water needs, or other adjacent services.

A key design component of any mini-grid program is how sites are determined. Generally, the most attractive sites for any type of electrification project are areas with higher building and population densities, greater commercial and industrial loads, and higher incomes. These sites tend to equate to higher power demand, better bill payment, and lower per capita capital expenditure on distribution networks. They also tend to be in and around cities and existing grid infrastructure, making them prime targets for connecting to the main grid. On the other end of the siting spectrum are the most rural and remote communities, where densities tend to be lower, there are fewer commercial/industrial loads, and incomes are lower. Much of the least-cost electrification modeling that has been done identifies these types of sites as targets for mini-grid development because they can be connected sooner and at a lower cost than extending the distant grid.

It is along this site and customer spectrum that programs determine which customers will be targeted with mini-grids and how much those systems will cost. Strong government-led siting can support equity and other socially valued objectives by steering mini-grid development to last-mile communities or important public facilities like health centers and schools. However, this approach is also more susceptible to politicization, making an open and transparent program and site selection process even more critical.

On the other hand, providing mini-grid developers maximum flexibility in determining sites—and assuming there are policies in place to address grid encroachment or future interconnection—leaves site selection to the

market. Sites will be chosen based on where profits can be maximized; that is, more peri-urban settings with favorable density, demand, and wealth profiles. Stronger market-driven siting is also more likely to identify opportunities for bundling electricity delivery with other services, like water provision or equipment leasing. This type of "value-stacking" can create alternative revenue streams for the developer, leverage additional investment into underserved rural communities, and/or lead to innovative cross-subsidy models that make electricity more affordable.

Among the mini-grid programs reviewed, site selection policy followed one of the three general approaches outlined below. RBFs and auctions can be applied under any of the three site selection approaches, although different combinations of approaches and incentive structure present different challenges.

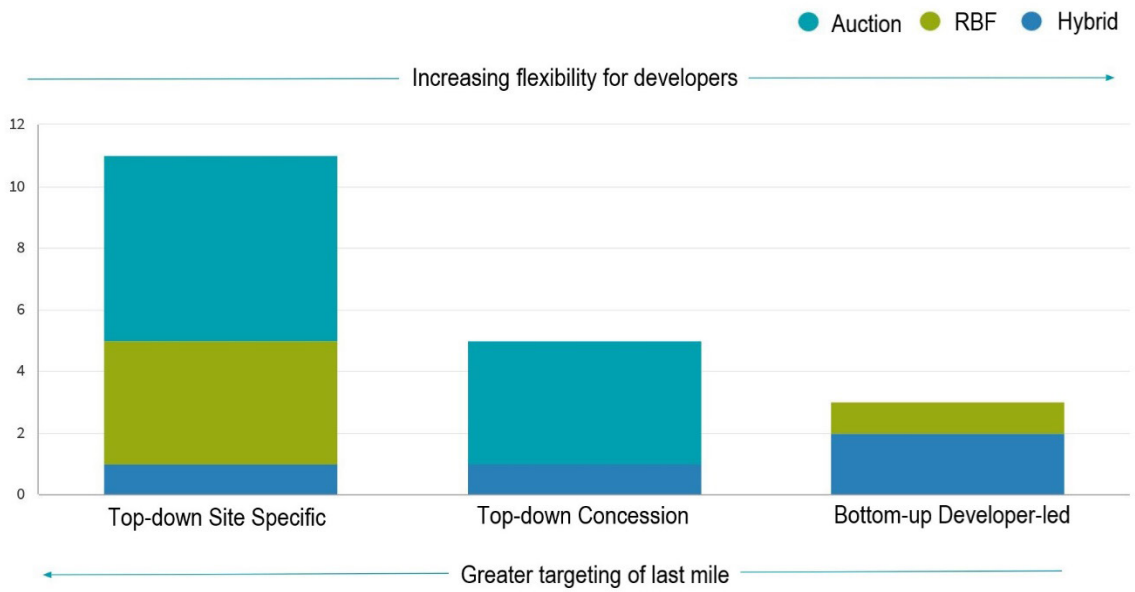
(1) "Top-down, site-specific"—Government chooses mini-grid sites for development. This allows the government to select the populations that they want to electrify, along with other economic and social sectors they aim to support through the program. For example, increasing rural incomes and agricultural productivity is a primary objective of Ethiopia's National Electrification Plan 2.0 so it makes sense that the scale-up of the latest World Bank mini-grid program there aims to support irrigation, processing, and other productive and income-generating activities in the sector (World Bank 2019b, 8).[12] One component of Nigeria's mini-grid program, the $70 million Minimum Subsidy Tender, uses this type of site selection approach, paired with an auction. The Rural Electrification Agency selects 250 sites in areas where, among other things, they have gauged private sector interest exists (World Bank 2018a, 16).

(2) "Top-down concession"—Government designates a concession area, usually with many sites for mini-grids, and developers are given some flexibility in proposing sites within the concession. This "in-between" option allows governments to focus mini-grid development in regions where the grid is not likely to reach in the near term, while giving developers an opportunity to assess where their mini-grid approaches are most viable. For example, Sierra Leone's Rural Renewable Electrification Project tendered four separate mini-grid concession areas to three companies: Winch Energy, PowerGen, and Energicity.

(3) "Bottom-up, developer-led"—Developers select sites for mini-grid development, subject to approval from the program and/or national regulator. This allows developers to independently assess where their mini-grid business models are most appropriate, including complementary services they may want to offer. One example of this is the Beyond the Grid Fund for Zambia, through which developers can submit a bid to BGFZ for any location, committing to the deployment of energy services of a certain power level, to a certain number of new connections, for a specific amount of funding that is provided in the form of an RBF payment (BGFZ 2019b).

12. This program is not on list of reviewed programs because it is slated to be initiated after 2020.

Figure 9. Program Site Selection



From a programming perspective, any of these siting approaches can work effectively. The important trade-off to keep in mind is that the greater the centralization of siting and the more the government aims to target mini-grids in remote areas far from the grid, the more likely that higher subsidy levels will be required to make the projects viable. On the other hand, giving greater flexibility to developers in site selection may lower the cost of the program and increase opportunities for value-stacking adjacent services, but leave last-mile communities without service. As illustrated in Figure 9, 80% of the analyzed mini-grid programs utilized one of the top-down approaches for determining sites. This tells us a few things:

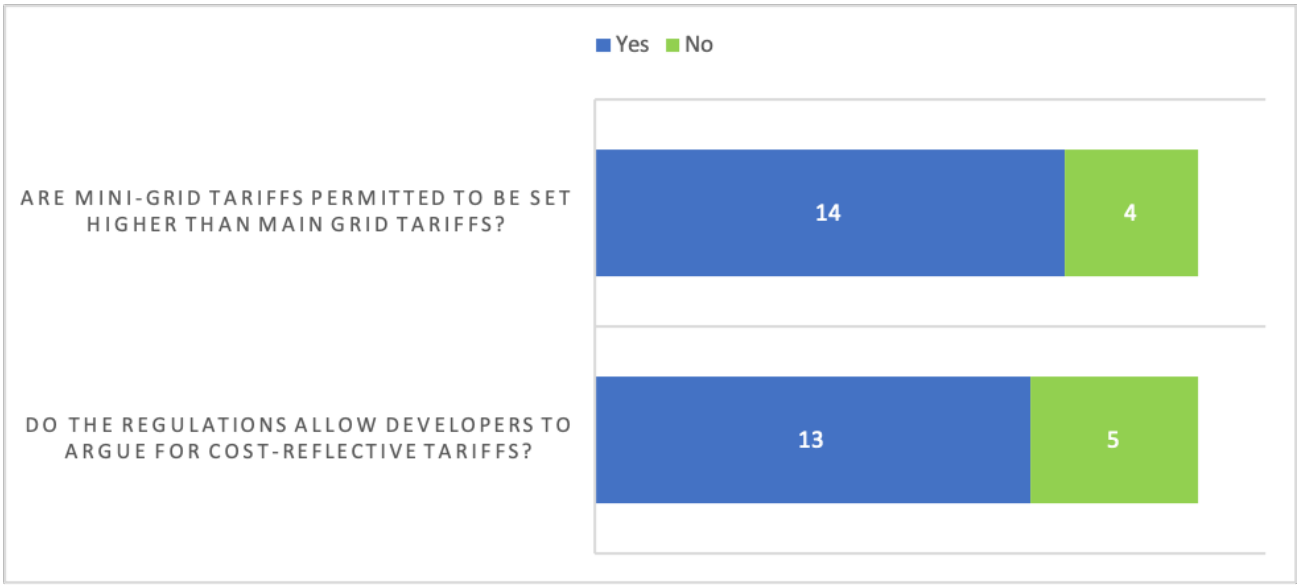
- The dominance of the top-down approach, in combination with stated objectives across many programs, suggests that mini-grids are being used extensively to reach lower-income, rural customers who are gaining electricity access for the first time.
- Strong government-driven site selection means that most programs are pushing mini-grid development towards less commercially viable markets. Sites are generally not being selected based on their potential to achieve lowest possible costs.
- Countries prioritizing equity and last-mile service delivery over lowest cost in site selection makes evaluation of trends in "all-in" mini-grid costs difficult and cost comparisons across countries potentially misleading. This dynamic may, in part, explain why African mini-grid costs appeared to rise in 2019. After seeing average costs decline from $1,555 per connection in 2014 to $733 in 2018, costs rose to roughly $1,300 per connection in 2019 (AMDA 2020). While the industry association attributed this rise to a huge influx of new, inexperienced developers entering the space, it also underscores how volatile year-to-year indicators are likely to remain, and how different programming objectives and site selection approaches may significantly shift costs.
- Some opportunities for value-stacking are likely being foregone. Productive use potential, water needs, or other adjacent service opportunities are frequently not prioritized in government-led site selection.

Even when mini-grids reach cost parity with the grid, the tariffs needed to fully recover costs of a rural mini-grid will typically be much higher than the subsidized retail power from the grid. Of mini-grid programs analyzed, 78% are in regulatory environments that allow developers to charge a tariff that exceeds the grid tariff. That flexibility is important, but program subsidies must balance the ability to set cost-reflective tariffs with what customers can afford to pay.

It is important to note that levelized cost figures cited in the report and any comparisons between grid and mini-grid costs do not necessarily translate into parity in terms of tariff rates or the cost to consumers. Different forms of grid subsidies allow African utilities to charge tariffs that have been, on average, 41% below their levelized cost of generating power (Trimble et al. 2014; Kojima and Trimble 2016).

As seen in Figure 10, by different measures, developers do frequently have flexibility to offer tariffs above grid levels, which is important. However, in practice, just because regulations allow for higher tariffs does not mean regulators will approve a higher tariff, as tariff rates are often a contentious political issue. In many countries, there is a widely known but unofficial rate that developers know not to exceed when filing for their service license. Regulations permitting cost reflective tariffs also bump-up against the reality that customers may not be able to afford higher tariffs. Navigating this complicated context of engrained grid subsidization, affordability constraints, and limitations on cost-reflective tariffs will be a unique and sensitive challenge for every country aiming to ensure mini-grids are both useful for rural communities and workable investments for developers.

Figure 10. Tariff Regulations[13]



13. Data from (Wood Mackenzie 2020).

CONCLUSION

The core question facing all mini-grid programs is whether the primary objective is commercially viable, unsubsidized mini-grids or maximizing high-quality rural access. Programs designed to simultaneously achieve both are unlikely to achieve either.

Both are worthy objectives, and both are clearly needed. However, it is a critical distinction. Consider the first objective: commercially viable mini-grids. In terms of cost competitiveness with the grid, mini-grids have already reached parity in some parts of Africa, depending on the specific site, country in question, and experience of the developer. The World Bank estimates the median levelized cost of electricity (LCOE) for mini-grids globally to be about $0.66/kwh, similar to the levels of utilities in Liberia and Comoros, which are the highest in Africa (Kojima and Trimble 2016). This LCOE level is based on an average mini-grid load factor of just 22%, meaning that systems are being designed to meet peak evening residential load and, across time, just one-fifth of the system's capacity is being utilized on average. The World Bank has mapped out how cost declines from technology development and scale, combined with increasing income-generating uses of electricity—like irrigation, agriculture milling, or other commercial uses—mini-grid systems could boost load factors to 40% and drive down LCOE to $0.22/kwh by 2030. This would be cheaper than 23 of 39 utilities in Africa (ESMAP 2019).

Programs aiming to drive mini-grids to commercial viability must focus on identifying sites that can support higher load factors, work in tandem with programs targeting increased productivity at sites, and attract experienced developers who can procure equipment and deliver projects at lowest cost.

Even the largest mini-grid developers today are unable to procure components at global spot prices yet. For Tier 1 equipment, minimum orders are at least a few MWs of solar and inverters. Many mini-grid markets have VATs, import duties, and tariffs on electrical equipment (though many have recently passed exemptions for solar and battery equipment). Currency alignment and hedging—from local currency to the currency of account, and then often to renminbi to pay Chinese suppliers—is a huge challenge for developers in many markets, as is port access. Experienced developers who bring scale will be better positioned to overcome many of these barriers in the medium-term.

However, there is a huge universe of communities where load factors are unlikely to get so high, where local incomes and commercial opportunities are too limited to yield much from demand stimulation efforts, and where supporting local companies outweighs the potential cost savings of international suppliers. Mini-grids could still be a very attractive, and potentially lowest-cost solution for many communities like these.

In these circumstances, governments and donors must take a wider view and prioritize their objectives. Where the objective is maximizing high-quality rural access, cost is still an important factor, but a recognition of the need for subsidy will be essential, at least in the near- to medium-term, to delivering affordable power to rural populations.

Countries aiming to maximize high-quality rural access with mini-grids, rather than hitting narrow cost targets, could benefit from programs that prioritize capacity building and technical assistance efforts; offer up-front payments or other measures that expand access to capital for local firms; include more generous subsidies to support development at sites facing thin commercial demand and lower load factors; and offer opportunities to negotiate terms post-auction.

In addition to expanding the areas suitable for mini-grid development and helping align domestic politics, emphasizing these priorities over a strict focus on low price and developer competition could help establish a domestic industry capable of delivering mini-grids at scale over the longer term.

APPENDIX A

Country	Program Name
DRC	AfDB-GCF Green Mini-Grid Program for the DRC – Phase One
Sierra Leone	Rural Renewable Electrification Project
Kenya	EnDev GMG Kenya
Tanzania	TZ-Energy Development and Access Expansion Project
Tanzania	Rural Electrification and Expansion Program
Rwanda	Hybrid mini-grid in Gatsibo district
Zambia	Beyond the Grid Fund Zambia
Kenya	Kenya Off-Grid Solar Access Project for Underserved Counties
Nigeria	Nigeria Electrification Project (RBF & auction components)
Togo	Rural electrification project of 317 localities by solar mini-grids in Togo
Mozambique	Renewable Energy for Rural Development – Phase 2
Niger	Niger Solar Electricity Access Project
Burkina Faso	Burkina Faso Electricity Access Project
Guinea	Guinea Electricity Access Scale Up Project
Benin	Off-Grid Clean Energy Facility
Senegal	Senegal Rural Electrification Program
Uganda	Promotion of Mini-Grids in Northern Uganda
Ethiopia	Ethiopia Electrification Program
Madagascar	Least-Cost Electricity Access Development Project
Mali	Projets de Candidatures Spontanées d'Electrification Rurale

APPENDIX B

Country	Program Description	Source
Zambia	"In looking at the situation in Zambia, BGFZ noted that the market for off-grid, distributed energy systems was extremely immature and lacked investment and new commercial activity for a number of reasons – monetary instability, highly dispersed populace, nascent state of financial services, and so on."	(BGFZ 2019a)
Togo	"minigrid pilot auction"	(AT2ER 2018)
Ethiopia	"ELEAP will support pilot-scale off-grid service delivery activities"	(Word Bank 2018c)
Guinea	"pilot"	(World Bank 2019a)
DRC	"The program will demonstrate a viable model for private-led mini-grid financing in urban areas"	(AfDB 2018)
Niger	"Demonstrate"	(World Bank 2017)
Sierra Leone	"Demonstrate"	(DFID 2016)

APPENDIX C

Selection Type	Examples
Top-down, site-specific	AfDB-GCF Green Mini-Grid Program for the DRC, EnDev GMG Kenya, Tanzania TEDAP, Tanzania NREP, Rwanda Hybrid mini-grid in Gatsibo district, Nigeria Electrification Project, Togo Electrification Strategy, Mozambique Renewable Energy for Rural Development, Burkina Faso Electricity Access Project, Guinea Electricity Access Scale Up Project, Benin Off-Grid Clean Energy Facility, Ethiopia Electrification Program
Top-down concession	Sierra Leone Rural Renewable Electrification Project, Kenya KOSAP, Senegal Rural Electrification Program, Madagascar LEAD
Bottom-up, developer-led	Beyond the Grid Fund Zambia, Nigeria Electrification Project, Mali PCASER

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