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Mini Grids for Underserved Main Grid Customers

"Up to 2 billion people are fundamentally constrained in their ability to grow because the electricity access they have is erratic and unreliable." —Raj Shah, President, Rockefeller Foundation (2020)

The bottom line. Can mini grids help to solve the problem of poorly served main grid connected communities? A mini grid is an electricity generation and distribution network that supplies electricity to a localized group of customers. Mini grids can be isolated from or connected to the main grid. To date, most mini grids in Sub-Saharan Africa have been built in electrically isolated rural villages not connected to the main grid. Based on broad experience working with mini grid programs in more than 20 low- and middle-income countries and five detailed case studies, the authors offer observations and recommendations about mini grids in general and a new type known as "undergrid mini grids" being used in Nigeria and India to serve poorly served communities.

Why do main grid customers need mini grids?

Many households and businesses that are officially reported as connected receive poor service

Most discussions of scaling up electricity access in developing countries focus on a single number: the millions of people who have no access to electricity. In 2022, it was reported that worldwide 675 million people did not have any access to grid-supplied electricity, with 567 million of them living in Africa. But an exclusive focus on this number ignores the fact that many households and businesses that are officially reported as connected often receive very poor service.

Poor service occurs in different ways. The most common shortcoming is that the electricity service is not reliable. A 2019 IFC report estimated that two billion people suffered annual blackouts of 100 hours or more and that one billion suffered 1,000 hours or more (IFC 2019). And even when the electricity is supplied as promised, the quality (the voltage and frequency) is often below standard, burning out machines and appliances prematurely. Customers are, as the Nigerian electricity regulator (NERC) euphemistically describes, *underserved.*

With the growing realization that a physical connection does not automatically lead to good service, interest has grown in so-called undergrid mini grids that would serve areas

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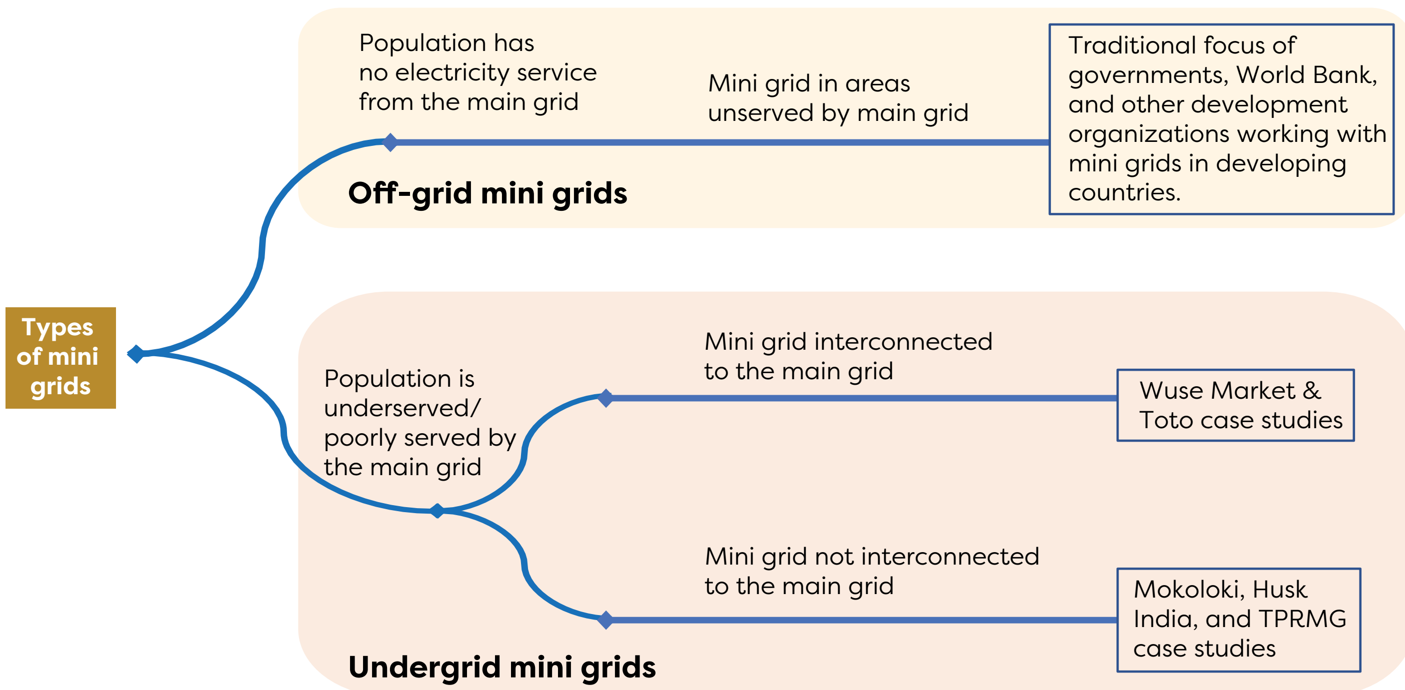
Figure 1. Types of mini grids and their relationship to the main grid



already connected to the main grid but whose customers are receiving unsatisfactory service (figure 1, bottom panel).

As shown in the bottom panel of figure 1, undergrid mini grids can take two forms: interconnected and non-interconnected.[1] An interconnected mini grid's connection to the local electricity distribution company (Disco) allows for purchases of electricity by the mini grid from the Disco and, in some cases, sales of electricity to the Disco by the mini grids. In contrast, a non-interconnected (or isolated) undergrid mini grid has no electrical connection to a Disco's distribution system. Electrical isolation does not require geographic isolation. In India, more than 600 privately owned, non-interconnected, solar hybrid mini grids are operating in villages that are already being served by a Disco connected to the main grid.

Can undergrid mini grids provide commercially and environmentally sustainable electricity service for households and businesses in communities that are currently receiving poor service from a traditional government-owned or privately owned Disco? And if so, at what cost? These questions are addressed in five detailed case studies of both types in *Mini Grid Solutions for Underserved Customers: New Insights from Nigeria and India* (Tenenbaum, Greacen, and Shrestha 2024).

Table 1 highlights case studies from Nigeria and India that focus on privately owned and operated undergrid mini grids developed at sites chosen by developers without significant government involvement.[2] These studies concentrate on solar hybrid mini grids made up of combinations of solar power, batteries, diesel, and occasionally biomass. This blend of technologies is anticipated to predominate in upcoming

1. An interconnected mini grid is a type of distributed energy resource. A DER is "anything that generates, stores or manages electricity on distribution grids" (Roberts 2021). It can be a demand- or supply-side resource. DERs can take many forms: mini grids, rooftop solar, building storage, consumer batteries, distributed generation, demand response, energy efficiency, thermal storage, or electric vehicles and their batteries.

2. This is not the only possible government approach to promoting mini grids. A new forthcoming Live Wire will discuss the pros and cons of different government approaches used in other Sub-Saharan African countries to encourage mini grid development.

mini grid projects across Sub-Saharan Africa and Asia for the foreseeable future.

Nigeria has seen the recent establishment of a few interconnected undergrid mini grids, adding to more than 150 existing non-interconnected mini grids, while India reports more than 600 privately managed non-interconnected mini grids located in main grid–connected communities in Bihar, Uttar Pradesh, and Jharkhand. Scale-up of interconnected mini grids is underway in Nigeria. The country's new Distributed Access through Renewable Energy Scale-Up (DARES) program targets $127 million in performance-based grants funded by the World Bank for interconnected mini grids.

The table reveals two significant differences between the Indian and Nigerian mini grids. First, none of the Indian mini grids are interconnected to local Discos. This probably reflects the fact that rural mini grids in India fit into an essentially deregulated category (that is, no licenses are required and tariffs are not regulated). This is a surprisingly laissez-faire approach, given India's reputation for being bureaucratic. At present it is uncertain what state or national regulatory rules would apply if a mini grid and a Disco were to interconnect. In contrast, the regulatory regime for interconnected mini grids in Nigeria is spelled out in some detail in the country's 2016 mini grid regulations (modified in 2023). Second, Indian mini grids generally do not attempt to lease the existing distribution facilities of local Discos. This may reflect the fact that the existing facilities in rural villages are often in poor physical condition and also that mini grid developers find it difficult to negotiate with government-owned Discos. To paraphrase one private developer in India: "If our main selling point is a higher level of reliability, we need to be sure that we are operating with good quality and well-maintained distribution facilities. Most existing local Disco distribution facilities do not meet that standard." Hence, it is rational for a mini grid developer to build a new distribution system, but from a societal perspective, this leads to separate, overlapping distribution systems.

Can interconnected mini grids lower costs?

Interconnected mini grids offer a promising avenue for reducing energy costs and enhancing electricity reliability and service quality for retail customers

These systems offer a symbiotic relationship in which customers, Discos, and mini grid developers all stand to gain.

Customers can benefit from electricity supply at a significantly lower cost, as evidenced in the Wuse market in Abuja, Nigeria, where energy expenses for a first group of mini grid customers dropped by about 65 percent once the need for personal backup generators was eliminated and service became more reliable.

Discos can reduce losses by handing off money-losing customers to mini grids. A 2018 Rocky Mountain Institute report estimated that a typical Nigerian Disco lost an average of $0.21 per kilowatt hour because the tariffs Disco are allowed to charge are set artificially low for political reasons. Leasing

Table 1. Features of the mini grids in the case studies

Case study	Service area	Country	Type of undergrid mini grid	Makes bulk electricity purchases from Disco	Leases some or all existing distribution facilities
Mokoloki	Rural town	Nigeria	Non-interconnected	No	Yes
Toto	Rural town	Nigeria	Interconnected	Yes	Yes
Wuse	Urban market	Nigeria	Interconnected	Yes	Yes
Tata	Rural town/ village	India	Non-interconnected	No	No
Husk	Rural town/ village	India and Nigeria	Non-interconnected	No	No

their poles and wires to mini grid operators can earn rental payments of $0.006 to $0.013 per kilowatt hour. Discos can also sell electricity to mini grid operators at bulk supply tariffs. The Abuja Electricity Distribution Company (AEDC), which previously served the Wuse market, predicted that its total revenues from the market would increase by 70 percent once it becomes a wholesale supplier to the mini grid.

For interconnected mini grid operators, connection to the main grid can reduce operational and capital expenditures if operators can purchase electricity at rates lower than the cost of self-generation by the mini grid, especially during non-peak solar hours when it would otherwise be necessary to resort to a diesel generator. Purchasing electricity from the main grid also allows for a reduction in the investment needed for equipment like batteries and generators, further driving down the levelized cost of electricity and making the venture more sustainable and cost-effective in the long run. The cost reductions will be greatest if the Disco is able to commit to a firm power supply. PowerGen estimates that the availability of six hours of robust grid supply purchased from AEDC for its Toto mini grid will help lower its initial capital costs by an estimated 15–20 percent by enabling it to reduce the amount of battery capacity it must install. If a Disco is only able to provide a non-firm power supply commitment, the savings will be about half, assuming the wholesale tariff is unchanged.

What is the role of regulation?

Regulatory processes—the formal and informal procedures regulators use to make their decisions—are especially important for mini grids, which typically live on the edge of financial viability

The transaction costs of complying with regulatory processes are as important for a mini grid's commercial viability as the prices that the mini grid is allowed to charge. In many countries the reality is that the formal framework of laws and regulations printed in a government gazette may often not be implemented as written (Foster and Rana 2020).

Regulation of interconnected mini grids

Table 2 shows the key commercial building blocks for interconnected and non-interconnected mini grids. An interconnected mini grid will be affected by the regulatory rules that are specific to its interconnection as well as other regulatory rules that apply to all mini grids. In the "Commercial element" column, the threshold question for regulators of interconnected mini grids is: Which of these commercial elements need to be regulated? The regulatory issues specific to interconnected mini grids are shown in bold in the table.

Table 2. Commercial elements of undergrid mini grids that could potentially be regulated

	Type of undergrid mini grid	
Commercial element	**Interconnected**	**Non-interconnected**
Licensing/permitting	✓	✓
Tariffs for retail sales	✓	✓
Cost recovery of costs to promote productive and household uses of electricity	✓	✓
Compensation when the main grid arrives	n.a.	✓
Length of the agreement	✓	✓
Tariffs for bulk purchases by the mini grid	✓	n.a.
Tariffs for bulk sales by the mini grid	✓	n.a.
Leasing of an existing distribution system	✓	Sometimes
Compensation for energy not supplied by the Disco	✓	n.a.
Compensation if the Disco takes back a subconcession	✓	Sometimes

Note: Regulatory issues specific to interconnected mini grids are shown in bold.
n.a. = Not applicable.

New regulators tend to overregulate because they are afraid that they will be criticized by ministers and members of parliament for not doing enough to protect retail consumers. But the problem with this micro-regulatory approach is that it can become a major impediment to the launch of a mini grid project. A separate review by the regulator of each major element of a tripartite interconnected mini grid agreement will be complex and time consuming. Changes mandated by the regulator to one or more elements of a negotiated agreement can affect the balance of interests in the agreement. This could cause the Disco, or the mini grid developer, to walk away.

A light-handed regulatory approach that lets Discos and mini grid developers arrive at their own commercial arrangements for individual contractual elements is generally preferable. Rather than separately judging each element of the interconnection agreement on a stand-alone basis, the regulator should judge the overall project based on the answers to two questions: Will the interconnection agreement lead to lower end-use tariffs for retail customers relative to non-interconnected mini grids? Will technical and safety requirements be met?

Blanket tariff approvals for portfolios of similar mini grids

In Nigeria, retail tariffs of all mini grids with more than 100 kilowatts of installed generating capacity must be approved by NERC. Until recently, NERC conducted a separate tariff review for each proposed mini grid project, based on a prespecified, online cost-of-service methodology. A tariff-setting system based on a project-by-project cost-of-service calculation imposes considerable transactions costs on both the regulator and developers. In 2023, NERC modified its regulations to allow a mini grid permit holder “to file a single tariff application for all sites under a portfolio of isolated mini-grids or a portfolio of interconnected mini-grids” (NERC 2023).

Cost-of-service versus benchmarking

Most African regulators currently regulate proposed mini grids on a cost-of-service basis. This is the traditional approach to regulating large utilities, so it is not surprising that it was chosen as the tariff-setting method for new mini grids. But cost-of-service regulation has two weaknesses; one is substantive and the other administrative. First, a mini grid’s incurred costs may not be efficient costs. The fact that a cost appears in an invoice is no guarantee that it is an efficient cost. Second, project-by-project cost-of-service reviews are not administratively practical in countries like Nigeria that hope to create hundreds or thousands of mini grids.

Once a country goes beyond 20–30 operating mini grids, it would make sense for a regulator to switch to a benchmarking approach. Benchmarking requires comparing either costs or prices across a group of comparable mini grids and typically involves setting a price cap based on this empirical data. We have heard that staff members of some regulatory agencies informally benchmark even when presented with a cost-of-service filing that would seem to justify a higher tariff.

A light-handed regulatory approach that lets Discos and mini grid developers arrive at their own commercial arrangements for individual contractual elements is generally preferable.

If a regulatory agency decides to formally adopt a benchmarking system, the agency will need to make a second decision: should the benchmark be a hard or soft benchmark? A hard benchmark means that the benchmark price sets the maximum price that the mini grid will be allowed to charge: no exceptions. A soft benchmark is different. If the regulatory agency adopts a soft benchmarking system, it is saying as follows, in words compiled from the comments of several interviewees:

> Based on our review of many mini grid projects, here is the price cap we believe will cover your costs and allow you to earn a reasonable profit if you build and operate with average efficiency. If you request approval for a tariff that is equal to or below the price cap, the approval will be fast-tracked and approved within a short period of time. But the soft benchmark does not prevent you from asking for a higher tariff. If you think that your project’s circumstances are unique because you have higher costs that are beyond your control, feel free to request a higher tariff. However, you should recognize that the review process will take longer.

What lessons can we draw?

Our experience in preparing the five case studies and working with mini grid programs in more than 20 low- and middle-income countries, including Nigeria and India, has taught us much

Most currently used least-cost planning models do not project any role for undergrid mini grids for urban and peri-urban locations. The typical least-cost planning models usually conclude that incumbent Discos are best positioned to provide expanded service to their existing customers and to reach new customers through densification and line extension to nearby unserved areas. But these conclusions are based on assumptions that are often not satisfied in many developing countries.

These assumptions are (1) that Discos will be motivated and efficient operators; (2) that an adequate upstream supply of electricity is available, and Discos have the money to pay for it; (3) that the upstream transmission grid needed to deliver electricity to a downstream Disco is working well; (4) that the Disco will be allowed to charge cost-recovering retail tariffs; and (5) that it does not matter if the generation connected to the main grid is fossil fueled and the generation connected to the mini grid is from renewable sources.

"Light bulbs dim like tired, resentful candles. Robust fans slow to a sluggish limp. Air-conditioners bleat and groan and make sounds they were not made to make, their halfhearted cooling leaving the air clammy. In this assault of low voltage, the compressor of an air-conditioner suffers—the compressor is its heart, and it is an expensive heart to replace." —Chimamanda Ngozi Adichie, *New York Times*, January 31, 2015.

Undergrid mini grids have come into existence because these modeling assumptions are not realistic in the electricity sectors of many developing countries.

Privately owned and operated undergrid mini grids perform several key functions better than government-owned Discos and some privately owned ones. Preliminary anecdotal evidence from the five case studies in Nigeria and India and elsewhere suggests that privately owned and operated mini grids generally excel in (1) accurately metering usage, billing, and collecting payments from customers through prepaid metering and billing systems; (2) providing a more reliable supply of electricity with fewer harmful variations in voltage and frequency; and (3) increasing growth in customer demand through financing options for appliances and machinery.

Incentives matter. Discos and mini grid operators have different incentives to increase rural sales. A Disco manager may have been ordered by a ministry (often backed by donor financing) to connect new communities. However, if the Disco is limited to charging non-cost-recovering tariffs—which is the norm in many developing countries—a rational Disco manager will say privately: "Why should I encourage my staff to increase sales in rural areas if I know that I will lose money on every additional kilowatt hour I sell there?" In contrast, a manager of a privately owned mini grid will say: "As a privately owned company, I may get an initial capital grant, but unlike the Disco I don't have the cushion of continuing government subsidies after I start operations. So, unless I increase sales to achieve profitability, I won't survive." Most new privately owned and operated mini grids in India and Nigeria have active, on-the-ground programs to increase the electricity consumption of their commercial, agricultural, and residential customers. In contrast, very few Discos in either country have similar programs to increase consumption.

Some mini grid companies are already achieving significant cost reductions from economies of scale and standardization. Data from the African Mini Grid Developers Association shows that established mini grid companies in Africa tend to have lower average costs than newer ones. In India, developers like Husk Power and TPRMG have accomplished cost reductions by grouping together small, standardized mini grid projects located near one another. Husk has reported levelized costs of electricity (LCOE) of $0.25 per kilowatt hour at its newer sites in India and has set a target of $0.17 by 2030. In January 2023, Husk announced that with these cost reductions it had achieved operating cost profitability in India and Nigeria, an intermediate milestone to full cost recovery.[3] To date, it appears that these cost reductions have been limited to older, more-experienced foreign firms that can readily scale up and employ standardized modular systems. This creates political problems for national governments that want to promote domestic mini grid companies.

Interconnection can reduce the LCOE of a mini grid. A cost analysis of six proposed interconnected mini grids in Nigeria projects that the lower operating and capital expenses of the mini grids can yield LCOE savings of up to 20 percent compared with a non-interconnected mini grid. The actual savings will depend on the cost of wholesale electricity from the Disco, the cost of diesel fuel, the hours per day that the Disco can provide electricity, and whether the Disco is willing to be contractually obligated to provide firm electricity at the same time every day. The cost savings will be lower if the Disco is only willing or able to supply electricity to the interconnected mini grid on an "as available" basis.

Subsidies for mini grids (usually delivered as capital grants) are a work in progress. Subsidies are needed for most rural communities because there is a viability gap between what it costs to serve these communities and what many rural households can afford to pay. But even if one accepts that subsidies will be needed, as has always been the case for traditional main grid extensions into rural communities, this still leaves many implementation questions open.[4] Should interconnected mini grids receive the same level of subsidies as isolated mini grids? Do mini grids built to serve commercial and industrial (C&I) customers need subsidies at all? Under what circumstances, should capital cost subsidies be keyed to the number of connections or to a certain percentage of capital costs? What are the milestones for disbursements? Should the grantor wait for the customer to be fully connected and enjoying demonstrably reliable service? If so, for how long? What about partial disbursement for intermediate milestones such as delivery of equipment to the mini grid site to reduce developers' need for construction finance?

Interconnected mini grids can serve different target markets. Target markets for interconnected mini grids include rural and peri-urban towns and villages, large urban market centers, C&I installations, and universities and hospitals. The five case studies were limited to the first two. The other target markets raise different implementation and regulatory issues. In countries like Nigeria, where utility power is intermittent or nonexistent, the solar C&I market—whether served by interconnected mini grids or other models of interconnected distributed energy sources (DERs)—is in the early stages of rapid growth.[5] This growth is taking place on a commercial basis, with few if any subsidies.

Mini grids, whether interconnected or isolated, are not a silver bullet. They are a good "point of entry," but they should not be viewed as the "end point" in power sector reforms.

Mini grids, whether interconnected or isolated, are not a silver bullet. Modern day mini grids in Sub-Saharan Africa and India typically use a single technology combination consisting of solar panels, batteries, and diesel generators. But it is naïve to believe that this single technology mix will

3. The reported profitability was on an EBITDA basis—that is, earnings before interest, taxes, depreciation, and amortization.

4. A Duke University study of seven countries that expanded electricity access through main grid expansion found that the governments provided average subsidies of $1,500 per connection (Phillips, Plutshack, and Yeasel 2020). In Nigeria, the current subsidy per connection under the World Bank's NEP 1 program is $450 disbursed to developers in dollars.

5. As the number and types of DERs expand, one challenge will be to efficiently and safely integrate DERs into existing Disco systems that currently operate within an existing, top-down bulk power system. One recent proposal is to encourage Discos to become neutral distribution system operators that interact with a higher level independent system operator at the transmission and distribution interface between the two. This is described as a layered bulk power system architecture (Roberts 2024).

be the best solution for all potential customers in a community. For example, isolated or meshed solar home systems will be a more affordable solution for poorer households or households in more isolated or sparsely settled areas of a community.

Regulatory rules should be designed to give mini grid operators the flexibility to offer different technology solutions to a single community, either on their own or through joint ventures with others. The regulatory system should also be designed to allow successful mini grids the possibility to become small Discos or other forms of DERs through joint ventures, subfranchising, or other commercial arrangements. The regulatory system should allow for these transformations without necessitating complicated and costly work-arounds (for example, building two separate generating systems to stay under a mini grid size limit). Mini grids are a good "point of entry," but they should not be viewed as the "end point" in power sector reforms.

Privately owned, interconnected solar hybrid mini grids will be commercially, technically, and politically viable only if they create a win-win-win economic outcome for the mini grid owner-operator, the Disco, and the customers served by the mini grid.

Interconnections will not be made unless there is a win-win-win solution for the three players directly affected by interconnection. Privately owned, interconnected solar hybrid mini grids will be commercially, technically, and politically viable only if they create a win-win-win economic outcome for the mini grid owner-operator, the Disco, and the customers served by the mini grid. It is not enough for an interconnected mini grid to be commercially viable for its private developer alone. It must also provide commercial benefits for the Disco to which the mini grid proposes to connect. The customers already served by the Disco must also see some benefit in switching over to become customers of a mini grid.

What recommendations can you offer?

Our recommendations fall into four categories: regulatory frameworks, tariff regulation, support for developers and Discos, and pilot programs

Regulatory framework and licensing

Regulators should approve licenses and tariffs for portfolios of mini grids. Regulators should issue blanket licenses or permits for portfolios of mini grid projects with similar characteristics to streamline the approval process. This approach should include long-term licenses or permits to support project financing, combined with clear criteria for license transfers. It is crucial that safety and technical standards should be part of these frameworks.

Interconnections should be voluntary. The interconnection of mini grids with existing distribution networks should be a voluntary process that benefits all parties involved: the end-use customers, Discos, and the mini grids themselves. This will ensure that Discos see the value in these connections through direct commercial benefits and improved customer service. The Discos should not feel coerced into signing agreements that may not be in their best interest. If a Disco is unconvinced that an interconnection with a mini grid will benefit itself and its customers, it can easily use subtle and difficult-to-detect means (such as complicated interconnection processes) to undermine policy or regulatory mandates that it finds objectionable.

Incentives for Discos. Regulators should consider new regulatory frameworks to incentivize Discos to interconnect to mini grids. If the Discos are currently regulated on a cost-of-service basis, the regulator could introduce elements of performance-based regulation into the regulatory system to incentivize Disco connections to mini grids and other forms of DERs. This approach is being tested in the United States and the United Kingdom, among other countries. Elements of Nigeria's regulatory framework, such as a requirement that 10 percent of electricity distributed by Discos come from distributed sources, is encouraging grid-connected solar DERs in the country. Ideally, regulatory mandates should also be accompanied by financial incentives. The goal is to encourage Discos to collaborate with, rather than oppose, mini grids and other types of DERs.

Tariff regulation and customer protection

Avoid micro regulation. Regulating each element of the commercial agreements (see table 2) between Discos and interconnected mini grids is likely to be time consuming and counterproductive. Regulators should adopt a light-handed approach that lets Discos and mini grid developers arrive at a balancing of the different elements of their commercial arrangements if this leads to lower end-use tariffs for the mini grid's customers and satisfies technical and safety requirements for reliable operation of the main and mini grids. Unlike households, C&I customers are often sophisticated and knowledgeable electricity consumers. With a growing number of companies offering to build mini grid or DER installations for such customers, it is not obvious that those customers need a regulator to protect to protect their interests. The interconnected C&I market could be a good candidate for tariff deregulation, but with continued technical and safety standards.

Move from calculating mini grid tariffs on a project-by-project cost-of-service basis to price caps. Once a national regulator has obtained detailed cost information on 20–30 mini grids, the regulator should adopt price caps in place of individually calculated tariffs for each mini grid project. The price caps should be soft rather than hard. If a mini grid developer believes that the costs of operating a particular mini grid justify a higher tariff, the developer should be allowed to make a request to the regulator for a higher tariff.

Encourage tariff differentiation based on time of usage and level of reliability. Mini grid operators should be encouraged to provide customers with tariffs based on time of use and contracted reliability levels. This simply reflects the fact that a mini grid's costs will vary according to when the electricity is produced and with what promised level of reliability.

Facilitate automatic tariff adjustments. If tariffs are regulated, implement timely automatic tariff adjustments to account for general cost changes, such as inflation and currency fluctuations that are beyond the control of the mini grid operator.

Recommendations on technical and commercial support

Technical assistance should be given to both developers and Discos. To date most technical assistance has gone to mini grid developers promoting isolated and non-interconnected projects. For emerging interconnected mini grid projects, Discos will need support, too, as they often lack experience negotiating with nonaffiliated suppliers. They also may not fully understand the financial and technical benefits that interconnection can bring to their operations. Hence, governments and donor organizations should offer technical assistance to Discos, as well as to developers. The support should include advice on operating protocols for interconnection, transfer of power between the two, and likely financial impacts. Neutral facilitation by technical and economic consultants can speed up the negotiation process and ensure balanced and beneficial agreements.

Recommendations on pilot programs and evaluation

Governments and donors should support interconnected mini grid pilots in other market segments. The five case studies focus on mini grids in rural and peri-urban communities and large urban marketplaces. However, interconnected mini grids and other distributed energy options are also feasible for C&I customers, public institutions such as universities and hospitals, and urban residential communities.[6]

Perform follow-ups to the case studies of interconnected mini grids studied to learn whether they have achieved commercially viability. It would be useful to perform updates on the Toto, Wuse, and Mokoloki interconnected mini grids after they have been in operation for at least a year. What worked? What didn't? This will provide insights into factors that will affect their long-term performance and success.

Evaluate whether mini grids have improved economic and social development in communities where they operate. It has been stated that "(e)nergy access is the 'golden thread' that weaves together economic growth, human

6. RMI (formerly the Rocky Mountain Institute) and Daystar Power have recently issued a report that examines the potential for creating and operating interconnected mini grids/DERs for C&I facilities in Nigeria, creating a win-win-win arrangement for customers, the Disco, and developers (Meng et al. 2023). With more than 170,000 C&I enterprises in Nigeria, this is a big DER market in early stages of takeoff. If the market potential is realized, it could lead to major reductions in CO_2 emissions.

development, and environmental sustainability" (IEA 2017). Can this be documented in communities that are served by mini grids? Business activity in the Mokoloki and Toto communities has reportedly increased significantly since the mini grid was commissioned (RMI 2024). This raises several questions: Is this true in other new privately owned and operated mini grids? Is the increase in business activity an increase in existing businesses in the community or simply a movement of businesses from other nearby communities with a less reliable electricity supply, or both? How does this compare with communities that are newly connected to the main grid?

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Make further connections

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