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THE BOTTOM LINE

Mini-grids, an increasingly attractive complement to conventional rural electrification, provide electricity to communities that would have to wait years for the arrival of the main grid. Recent innovations have spurred private interest in mini-grids, but further development will require better regulatory frameworks. Properly structured, light-handed regulation can lower risks to mini-grid developers through transparent rules on issuing licenses, setting tariffs, and preparing for the arrival of the country's main grid.

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Scaling Up Access to Electricity: Emerging Best Practices for Mini-Grid Regulation

Why is good regulation for mini-grids important?

Mini-grids can play an important role in closing the energy access gap

One billion of the world's people live without electricity, more than half (589 million) in Sub-Saharan Africa. Of these, nearly 87 percent live in rural areas (World Bank and IEA 2015). While conventional grid extension is playing an important role in bringing electricity to those who live without it, its pace often proves to be inadequate, especially in Sub-Saharan Africa, where electrification rates barely keep up with population growth. Despite increasing commitments, government budgets in general and national utility budgets in particular are still stretched thin, and subsidies are insufficient to extend the lines, especially when new connections cost upwards of a thousand dollars per household. Some of this unmet demand is being satisfied by off-grid household solutions, such as solar home systems and solar lanterns. However, while solar home systems and lanterns are sufficient for powering efficient lighting and household electronics, they are generally too small for productive uses like agricultural milling and power tools or the larger appliances desired by many households, such as refrigerators.

The increasing potential of renewable energy mini-grids is driven by falling renewable energy (especially solar photovoltaics) costs; radical improvements in efficient appliances, such as robust LED (light-emitting diode) lighting; and the widespread deployment of cell phone-based payment systems (such as M-Pesa), pre-payment meters, and cell phone carriers' internet-based monitoring and control systems. These factors have greatly lowered the costs of energy services provided through mini-grids while improving reliability.

Meanwhile, in developed countries widespread distributed generation using customer-owned technology (such as solar roof panels) has opened up a range of safe, field-tested technology options that may either be connected to the main grid or integrated with mini-grids. Finally, recent policy changes leading to lower growth in renewable energy markets in the countries of the Organisation for Economic Co-operation and Development (particularly in Europe) have provided the impetus for companies around the world to pay greater attention to markets in developing countries.

Despite all these promising developments, renewable energy mini-grids in developing countries still face constraints related to policy, regulation, and financing. The "Mini-grid Policy Toolkit" produced in 2014 by the European Union Energy Initiative's Partnership Dialogue Facility (EUEI undated) provides an excellent overview of those constraints. Attributes of mini-grids are described in box 1.

This brief will focus on enabling regulations for mini-grids, providing an overview of key issues, options, and good practices. While appropriate regulations are not all that is needed to spur mini-grid development, regulation is usually one of the first obstacles that potential developers face and therefore the most urgent issue for governments. We draw on a case study of Tanzania, a pioneer in setting an enabling and light-handed regulatory framework for mini-grids. Given the urgency of leveraging private sector investments for reaching the universal access targets of the international Sustainable Energy for All initiative, we also focus on regulatory issues relevant to private sector entrepreneurs and investors.

Mini-grid entrepreneurs need to know that their investment of time and money will have a reasonable chance not just of being repaid but also of returning a profit. A clear and credible regulatory

Box 1. What is a mini-grid?

There is no universally accepted definition of mini-grids or their smaller version, micro-grids. The Mini-Grid Policy Toolkit produced by the European Union Energy Initiative's Partnership Dialogue Facility (EUEI undated) defines them as systems capable of generating from 10kW to 10MW, for mini-grids, and 1kW to 10kW, for micro-grids, and distributing electricity to a limited number of customers via a grid that can operate in isolation from national electricity transmission networks and supply relatively concentrated settlements. Those parameters allow for a very large number of variations.

Mini-grids can be run by utilities, private companies, communities, or local governments. The support structure needed to develop and operate different types of mini-grids depends on the mini-grid's characteristics. For example, hydro- or solar-powered mini-grids face significant upfront cost barriers compared with diesel mini-grids, although these high upfront costs are compensated by much lower and predictable costs of operation and maintenance (O&M), making them more sustainable. Privately operated mini-grids require rates of return high enough to repay investors, whereas the main challenge of community-run mini-grids is to make sure that tariffs stay high enough to cover O&M. Mini-grids may offer grid-quality service or basic, intermittent service for several hours a day—facts that governments and donors need to have in mind when thinking about financial support for mini-grids.

The U.S. Department of Energy and the National Renewable Energy Laboratory (NREL) are currently developing a quality assurance framework that will differentiate mini-grid performance levels based on the international Sustainable Energy for All framework for measuring energy access (World Bank and IEA 2015) and provide quantitative yardsticks for assessing the power quality and reliability of mini-grid electricity services.

"Mini-grid entrepreneurs need to know that their investment of time and money will have a reasonable chance not just of being repaid but also of returning a profit. A clear and credible regulatory framework that makes and enforces fair and efficient decisions in a timely manner helps entrepreneurs make informed investment decisions."

framework that makes and enforces fair and efficient decisions in a timely manner helps entrepreneurs make informed investment decisions. The key characteristics of such a framework, described below, include licensing and registration, tariff setting, and what happens when the main grid reaches the mini-grid. Boxes 2 and 3 provide examples of how a light-handed regulatory framework may be applied to various types of mini-grids.

How do licensing and registration work with mini-grids?

In practice, licensing is required only of large mini-grids; smaller project need only be registered

A license is a government-granted right to conduct a specified business, based on a determination that the licensed entity has the technical and financial capacity to carry out the business. Utility-sector licenses are primarily a form of consumer protection, especially in situations where the business is a monopoly provider. Mini-grids are a grey area in this regard. Even if a mini-grid operator owns the only wires in town, it is also true that customers have other options for lighting (kerosene, candles, solar lamps) and power for electrical appliances (solar home systems or diesel generators). In addition, as mini-grid markets develop, competition may develop for unelectrified villages (villagers may be unwilling to subscribe to a mini-grid that provides less attractive service than a mini-grid in a nearby village).

Recognizing that applying for and issuing licenses imposes costs both for the licensee and for the granter of the license, licenses are generally required only of larger mini-grids. In Tanzania licenses are required only for projects that exceed one megawatt (MW). Smaller projects are allowed to *register* their businesses rather than apply for a license. Unlike licensing, registration does not require the approval of the regulator. Instead, registration simply allows the regulator and other government agencies to know that the enterprise exists and is providing service.

In some cases, however, mini-grid developers *may seek* a license, even if one is not required by the regulator. An optional provisional license can secure a site from competition for a limited period of time and communicate the legitimacy of the planned mini-grid project to lenders or other key stakeholders.

License duration should be at least as long as the duration of the power purchase agreement (PPA), if the mini-grid is selling a part of its electricity output to the national utility, and at least as long as the length of bank loans. In Tanzania, initial regulations set license duration at 15 years, but after a few years of experience

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with the country's small power producer (SPP) program, this is being expanded to accommodate licenses up to 25 years with an option to renew within six months of expiration. In Sri Lanka and Uganda, license duration for SPPs is 20 years. The license application process includes a requirement that the public be notified via local newspaper and that there be a public comment period (two weeks in Tanzania). A public comment period is also warranted if a license is sold or transferred. Application forms for licenses, tariff approval, annual reporting, and the like should be clear and readily accessible—for example, over the Internet. Rules should specify the period within which the regulator must act on a license application (in Tanzania, it is 30 days after the public comment period ends). Sometimes licensing can be linked to approvals for funding—e.g., from rural energy agencies and similar bodies. Close coordination between funding agencies and regulatory bodies is necessary to avoid potential conflicts and unnecessary duplication of processes—which raises costs for entrepreneurs and investors.

How should regulators handle tariffs?

A mini-grid developer should be allowed to propose a tariff structure appropriate for the project

Providing electricity to rural customers via mini-grid is almost always more costly than electrifying urban customers connected to the national grid. And even among mini-grid solutions, costs vary widely. A multi-MW hydropower project supplying electricity to local industry and thousands of households will generally have much lower costs than will a small solar or diesel mini-grid serving a village of a hundred households in a remote area.

In light of these variations, how should regulators treat tariffs? Emerging experience suggests that any attempt by a regulator to create a mathematical formula to prescribe tariffs for each and every possible case would be overly complicated and would squelch innovation. Instead, developers should be allowed to propose not only retail tariffs that are appropriate for their project, but also tariff structures (flat rate, energy charge, demand charge, pre-pay, post-pay, and so forth)—all subject to regulatory approval. This may appear counterintuitive to regulatory agencies accustomed to very detailed regulation of large utilities, but extending the detailed approach to mini-grids would likely hurt the final customers most—by penalizing innovative business models that are leveraging energy efficiency gains and focusing on providing energy services to their users.

Tariffs should not be restricted to the "national uniform tariff" common in many countries, which requires that city dwellers and rural residents be charged the same tariffs. Again, this may appear counterintuitive, as mini-grid users often operate in poorer areas, but in the absence of sustainable cross-subsidies (from grid customers to mini-grid customers), variable tariffs are often the only way to ensure sustainable service. For rural households, the choice is not between grid and mini-grid supply, but rather between mini-grid and kerosene. However, if funding is available, governments may also decide to subsidize the upfront costs of a mini-grid in order to reduce the end-user tariff.

In the case of Tanzania, the Tanzanian Energy and Water Utilities Regulatory Authority (EWURA) encourages mini-grids to submit proposed tariffs using a simple, standardized cost-of-service spreadsheet (tinyurl.com/SPPevaluator) to help the regulator make tariff-approval determinations. The regulator has the power to reject tariffs for being too high if profits are excessive. Regulators may also wish to retain the power to reject tariffs for being too low (a problem with many community projects) if the project cannot cover its costs even after several years of adding customers. The rationale, of course, is that a chronic failure to cover costs will affect the project's sustainability in the long run, leading sooner or later to a suspension of service. In Tanzania, projects under 100 kW do not require prior regulatory review or approval of retail tariffs, but EWURA reserves the right to review retail tariffs if it receives complaints from customers.

Developers should be permitted to build cross-subsidization into tariff schedules. For example, in Tanzania, high-consumption customers are charged more in order to help electrify smaller poorer customers; in Peru, by contrast, tariffs are set lower for productive uses than for other customer classes. Mini-grids should be encouraged to use anchor customers (telecommunications companies, agricultural processors) to help guarantee load. For example, EWURA allows mini-grids to enter into power sales contracts with business customers without regulatory approval.

"One key risk to mini-grid developers is that the main grid will reach their service area, taking away customers and rendering their investment useless."

How should regulators prepare for the day when the main grid reaches the mini-grid?

Regulators must allow for at least five different situations

One key risk to mini-grid developers is that the main grid will reach their service area, taking away customers and rendering their investment useless. Regulators need to prepare for the day when top-down grid extension and bottom-up decentralized electrification meet.

Rules should account for at least five different possibilities:

- The mini-grid continues to generate and to distribute to retail customers, while purchasing electricity from the national grid to meet peak loads and selling the surplus electricity it generates.
- The mini-grid ceases generation and becomes a distribution-only company, purchasing electricity at wholesale for resale through its distribution network.
- The mini-grid stops distributing but continues to generate, selling electricity to the national grid.
- The national grid purchases the assets of the mini-grid.
- The mini-grid abandons the site and moves its assets to another location.

If the mini-grid is to purchase wholesale electricity from the main grid (possibilities 1 and 2), it must be built to standards that are safe for utility-power distribution, including pole height and construction, conductor dimensions, and spacing. These specifications are typically included in a utility's distribution code and should be made available to mini-grid developers. The regulation also needs to specify what will happen to retail tariffs at the time of interconnection. May the developer still charge a differentiated tariff, or will a uniform tariff apply and will a transition phase will be established?

Connecting the distributed generator to the main grid to sell electricity (possibilities 1 or 3) requires that the regulator adopt a set of commercial and technical rules that facilitate safe and reliable grid interconnection for SPPs and that the generator and utility comply with these rules. An SPP program typically includes, in addition to interconnection rules, a standardized PPA between the utility and the generator and a standardized tariff. Together, these documents provide a streamlined approvals process and provide assurances to the mini-grid developer that the utility will purchase the SPP's electricity at a fair tariff. Examples

Installing electrical poles to bring electricity to households on the Mwenga mini-grid

Photo: Chris Greacen.

Box 2. Devergy solar PV micro-grid in Tanzania

Devergy started operations in 2012 and has successfully electrified more than 800 households in six rural communities in Tanzania's Bagamoyo and Morogoro districts. Devergy's micro-grids use distributed, networked solar PV with battery storage together with prepayment meters to provide small amounts of electricity (up to 250 watts per household) for lighting, mobile phone-charging, television, fans and other household and small business appliances. Each micro-grid provides 24-volt DC electricity to between 60 and 400 households. Small inverters can be purchased to allow use of small AC appliances. Devergy is expanding at a rate of about 500 households per month.

Licenses versus registration. Devergy falls below the 1 MW threshold and therefore is not required to obtain a license. The implications of one company installing numerous micro-grids that add up to more than 1 MW will eventually have to be considered by EWURA, the country's power regulator.

Regulation of tariffs. The micro-grids do not exceed the 100 kW limit and thus are exempt from prior regulatory review and approval of retail tariffs. Devergy sets its tariffs at 10 to 15 percent below what people pay currently for kerosene, dry-cell batteries, and local phone-charging service, recognizing that a single LED light they sell can replace several kerosene lights. The energy services are offered in packages (daily, weekly, and longer). While Devergy's tariff expressed as a charge per kWh is a multiple of the national tariff, the company is serving areas that the grid may not reach for years while providing electricity that is generally more reliable than the service provided by the grid in the rural areas that it has reached. In addition, Devergy's energy packages provide additional benefits to its users, such as access to energy-efficient appliances, including television sets, fans, and refrigerators. Direct comparison with the national tariff can therefore be misleading.

The main grid arrives. The distribution network of the Devergy micro-grids is not built to the standard of the AC grid and so could not be assumed by the utility. When the main grid does arrive in an area served by Devergy, the company will either have to remove its equipment and deploy it elsewhere or gamble that enough customers will prefer their Devergy service to a grid connection. This may not be an unreasonable gamble because the grid connection fee—especially if not subsidized—is still significant for poor rural households. In addition, Tanzania's national grid, TANESCO, suffers from frequent outages during the dry season, whereas Devergy's micro-grids provide reliable 24-hour power.

"Sales of mini-grid assets to the national utility should be subject to regulatory intervention to ensure that a reasonable price is paid for the assets."

of SPP regulatory documents in a variety of countries are discussed by Tenenbaum and his colleagues (2014). If the grid-connected mini-grid both produces its own electricity and purchases from the main grid, then it should have the option of intentionally isolating itself from the grid—a practice known as "intentional islanding"—provided it can disconnect and reconnect safely and without disturbing power quality. Islanding makes power more reliable for customers and provides better revenue opportunities for the mini-grid operator.

In situations where the mini-grid is connected to the main grid but continues to operate independently of the main grid (as an SPP), the issue of tariffs for backup power also arises. A backup or standby tariff compensates the national utility for providing electricity to an SPP when it is not generating enough electricity to meet its loads. The tariffs that most utilities apply for SPPs are identical (or at least very similar) to typical industrial power tariffs. These include a hefty "demand charge" and somewhat lower energy charges than average customers pay. The demand charge measures the peak amount of power (kW) or apparent power (kVA) drawn from the utility at any time during a predefined period (typically several monthly billing cycles). Utilities are concerned about peak power, because they must size infrastructure to meet peak loads. Energy charges measure cumulative energy (kWh) consumed over a billing period. As a result, for SPPs, which may need backup electricity only for a very short period of time, the demand portion of the backup power can be prohibitively costly. Countries in which SPPs go offline frequently because of instability on the national grid should consider implementing a backup power tariff that has no demand charge, counterbalanced by charges for energy (kWh) that are similar to what regular (nonindustrial) customers pay.

Sales of mini-grid assets to the national utility (possibility 4), should be subject to regulatory intervention to ensure that a reasonable price is paid for the assets. Compensation should reflect

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the residual value of the asset (after depreciation) and also take into consideration the fact that that mini-grid assets are more likely to be useful to a utility if built to utility standards.

Finally, a developer may elect to abandon the site and move the mini-grid to another location (possibility 5), particularly if the assets are moveable and the developer wishes to expand to new villages. Some small solar-powered mini-grids providing direct current, such as the Devergy example presented in box 2, can recover most of their assets and reuse them in another location. This is not possible for a large alternating-current grid built according to the utility grid code, such as the Rift Valley example discussed in box 3, would have to leave assets behind if it moved and therefore needs to be able to choose one of the other four possibilities.

The attractiveness of the five options just described will depend on specific country circumstances, the type of mini-grid, and the developer's business strategy. It is preferable to set rules for all five possibilities, rather than expect one solution to fit all cases.

Beyond regulation, however, the best way to avoid the clash between grid electrification and mini-grid development is to set and adhere to transparent and publicly available plans for grid electrification. Doing so allows mini-grid developers to plan investments in areas that are not scheduled for electrification within a period that is long enough to allow them to recover their investments.

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Box 3. Rift Valley Energy's Mwenga hydropower mini-grid in Tanzania

Rift Valley Energy's Mwenga mini-grid near Mafinga, Tanzania (www.riftvalley.com/energy/), was commissioned in September 2012. By September 2015, the project had connected more than 1,400 customers in 14 villages, with another 700 applications awaiting completion of the planned network extension. Electricity is either three-phase or single-phase alternating current delivered to pre-paid meters through 204 km of distribution line (160 km high voltage; 44 km low voltage) at standards that exceed those of the national utility. The 4 MW hydropower plant also sells electricity to the national grid, pumping stations that irrigate tea plantations, and a large tea factory. The company intends to grow to serve 5,600 customers in 32 villages. It received a $500/connection grant from Tanzania's Rural Energy Agency, plus a European Union grant.

License versus registration. The Mwenga mini-grid project exceeds 1 MW and has obtained the necessary generation and distribution licenses from EWURA.

Regulation of tariffs. Mwenga far exceeds 100 kW in capacity and thus requires regulatory approval for tariffs. Rift Valley Energy chose to set household tariffs at a level close to TANESCO's then-retail tariffs. Residential customers who use up to 50 kWh per month pay Tsh 60/kWh (about 3 US cents). Once these customers exceed 50 kWh in any month, their tariff rises to 273 Tsh/kWh (about 13 US cents) for subsequent units used in the course of the month. Commercial users, or customers who typically expect to use more than 50 kWh per month, are charged 234 Tsh/kWh (about 11 US cents) for all of their power requirements.

The decision to charge national tariffs greatly simplified the regulatory approval process by reducing the risk of political opposition to the project.

When the main grid arrives. The distribution network is built to main-grid standards and is already connected to the main grid for wholesale electricity sales. With customers well served by the Mwenga mini-grid project at national utility tariffs, TANESCO has no reason to expand lines into Mwenga's service territory. Indeed, TANESCO officials have reported that the Mwenga hydropower project is a win-win case for them—relieving pressure from rural communities to expand TANESCO's rural distribution network and providing valuable end-of-the-line voltage support to help TANESCO serve the nearby town of Mafinga.

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