WORLD BANK GROUP

Supported by ESMAP
Energy Sector Management Assistance Program

Live Wire

A KNOWLEDGE NOTE SERIES FOR THE ENERGY & EXTRACTIVES GLOBAL PRACTICE

2019/98

THE BOTTOM LINE

As they mature, mini grid sectors evolve from marginally viable competitive entrants to potential monopoly providers of essential services. In early stages, overly stringent regulation can choke the sector's growth. In later stages, however, closer regulation is usually necessary to protect customers. Regulators can manage the regulatory evolution required of this sector by defining its growth phases and spelling out, in advance, the regulations that will apply at each stage.

This Live Wire was prepared by the Global Facility on Mini Grids, a program of the World Bank's Energy Sector Management Assistance Program (ESMAP).

Ensuring That Regulations Evolve as Mini Grids Mature

Why is this issue important?

Regulations that evolve with the mini grid sector can achieve policy objectives (such as rapid electrification) while protecting consumer interests

The timing and depth of economic regulation are key to the development of mini grid sectors. The two pillars of regulation are (i) "setting, monitoring, and enforcing maximum tariffs," and (ii) establishing "minimum service standards" (Brown and others 2006: 5).

Mini grid sectors grow through three stages. Stage 1 is startup. At this point, the sector consists of a handful of commercially viable mini grids serving relatively few customers. Growth occurs in Stage 2, as the sector replicates existing business models and creates new models to serve more customers. Localized market dominance is Stage 3. In this stage, mini grids are seen to be dominating their local energy markets.[1] This three-stage maturation process requires sensitive regulation keyed to the different stages.

During the startup and growth stages, when mini grids are entering the market and growing, light regulation is generally sufficient. Because they are operating in remote regions, where the main grid is unlikely to expand soon, mini grids face competition from traditional energy sources. This competition incentivizes mini grids to offer better service at lower tariffs, which reduces the need for regulation.

When mini grids become dominant in their respective markets, however, governments may want heavier regulation to ensure good levels of service at the lowest tariff. Mini grids may gain market power in the energy market as they replace traditional sources of energy. Without regulation, their monopoly position may allow them to raise their tariffs too freely.

Although a fully integrated power system remains the most efficient electrification solution for most countries, mini grids have an edge over main grid expansion as a means to rapid electrification. Because they can attract private financing and be deployed quickly, mini grids can help countries transition toward full integration in remoter regions, where the main grid is unlikely to arrive in the medium term, thus providing earlier access to many more people.[2]

The recent emergence and growth of mini grids in a handful of countries has drawn the attention of policymakers and regulators. In their efforts to increase social welfare and protect consumers, governments are looking into how to regulate mini grids to ensure reliable service at the lowest tariff. Some jurisdictions, such as Uttar Pradesh in 2016, have adopted regulations specific to mini grids. Rural electrification agencies are setting up technical assistance and subsidy programs to develop mini grids in rural areas and control their costs. For example, in Nigeria, the Rural Electrification Agency aims to provide developers with a database of potential sites and with connection subsidies.

Mini grid sectors are flourishing in many countries thanks to innovative business models coupled with cost and performance improvements in renewable and storage technologies. In Nigeria, the government plans to develop ten thousand mini grids by 2023

[1] "Market dominance" in this context refers to a mini grid that is providing an essential service in an area from which alternatives have been driven out.

[2] To meet Sustainable Development Goal 7 on universal access to clean and sustainable energy by 2030, an estimated 440 million people would need to be connected to mini grids (IEA 2017, figure 2.5). The 440 million figure is calculated based on the following data in IEA (2017): 150 million new mini grid connections under the New Policies Scenario (business as usual scenario); 290 million additional connections under the Energy for All scenario (based on 670 million people lacking electricity by 2030, and 40 percent of them served by mini grids as lowest-cost technology).

Mini grids usually take root in communities lacking an electricity grid. But these communities have access to other sources of energy—kerosene, car batteries, or diesel self-generators. In this competitive market, mini grids' tariffs cannot exceed households' willingness to pay.

(REA 2017). Most of the mini grids being developed today in the World Bank's client countries are solar hybrids—solar photovoltaic (PV) systems coupled with battery storage and backed up by a diesel generator. The costs of such systems have plunged over the past ten years (IRENA 2016: 4), displacing diesel-based systems that have long been used in the same off-grid environments. Operators have set up attractive business models that rely on service equal to or exceeding that offered by the main grid (where the main grid is available), accompanied by convenient payment options, such as mobile money.

The challenge is to design a regulatory framework that promotes good service at the lowest cost-recovery tariffs throughout the sector's three stages of development. Such a regulatory framework needs to be flexible enough to evolve while maintaining predictability for developers.

Why should regulations evolve with mini grid sectors?

Evolutionary regulation can mitigate the risks inherent to each stage of the mini grids' trajectory by keeping development costs low in incipient markets and protecting customers in mature ones

An evolutionary regulatory approach would allow mini grids greater initial freedom, becoming more stringent as they gain market power. A light approach in an early stage recognizes that whereas some regulation may be appropriate and even help attract investors (for instance, by answering questions about what happens when the grid arrives), conventional regulation of tariffs and service standards may impose costs and reduce flexibility, making it harder for mini grids to get established. Regulation can start to put upper limits on tariffs and lower bounds on service standards once mini grids begin to gain market power and become a dominant supplier of an essential service.

The startup and growth phases. Mini grids usually take root in communities lacking an electricity grid. But these communities have access to other sources of energy—kerosene, car batteries, or diesel self-generators. These sources of energy compete with mini grids in that they enable people to use appliances that would otherwise be powered by electricity. Kerosene lamps provide light at night; car batteries power radios. Entrepreneurs have established phone-charging centers running on diesel generators or solar panels.

In this competitive market, mini grids' tariffs cannot exceed households' willingness to pay. When a mini grid enters a market, it often cannot charge more per month than what households were spending on the energy sources the mini grid is seeking to replace.

Although mini grids can offer a higher level of service than traditional sources of energy, enabling households to run a fan, a fridge, a TV, or a computer, people in low-income communities may not own such appliances or be able to afford the energy required to run them.On balance, however, incipient mini grids increase social welfare by supplying electricity more efficiently than traditional sources of energy. They offer better service than these sources, at the same or lower cost. Figure 1 shows the difference between the monthly cost of electricity from mini grids (dark blue bars) and the monthly expenses of nonelectrified households on energy consumption that can be replaced with electricity (that is, excluding energy for cooking) in Bangladesh, Cambodia, Kenya, Nigeria, Tanzania, and Uttar Pradesh (India). The difference can be as much as 4–12 percent of these countries' monthly GDP per capita.

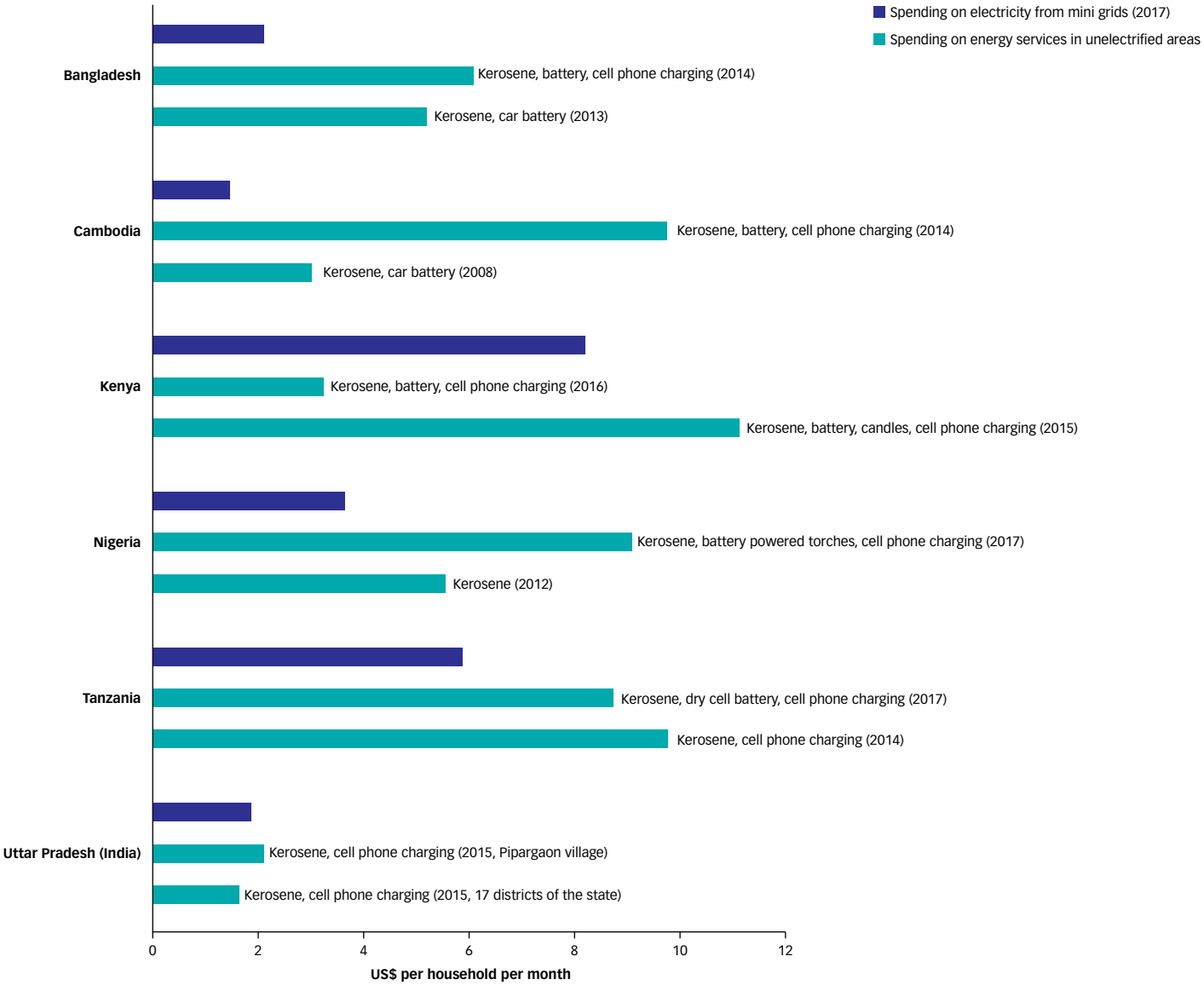
Mini grids in remote areas face high development costs. It is expensive to bring in equipment and staff over rugged road systems. New mini grids struggle to recover these costs, and they are already constrained in their pricing by limited budgets and the prices of traditional sources of energy.

In a market characterized by such nascent mini grids, regulation can stifle investment. For that reason, a light approach may be more appropriate. Overregulation can undermine the commercial viability of incipient markets in three ways:

- By setting tariffs too low to allow the developer to recover costs
- By setting excessive service and technical standards, thereby raising the developer's costs too high
- By increasing startup costs—that is, costs incurred in reviewing the regulatory framework, acquiring authorizations, or negotiating contracts.

Mini grids increase social welfare by supplying electricity more efficiently than traditional sources of energy. They offer better service than these sources, at the same or lower cost.

Figure 1. Comparison of household spending on electricity from mini grids and on other energy sources



Notes: The labels to the right of the bars describe the energy products households consumed during the year indicated. For Cambodia and Kenya, the sources include electricity in households' consumption of energy. This is consistent with an approach to analyze the consumption of nonelectrified households, since these electrified households lack availability and quality of supply and must compensate with other energy products.

By spurring productive growth in their community, mini grids enable new businesses to develop as households and businesses come to rely on computers, telecommunications, and other services that require larger quantities of always-on power. Kerosene and car batteries will not be able to meet demand.

Even as mini grid markets develop, regulation is not always appropriate. Even as mini grids gain market power, they may still be struggling to compete against solar home systems. In addition, competition between mini grid providers for unelectrified villages may develop (Greacen, Nsom, and Rysankova 2015).

The localized market dominance phase. At some point, however, successful mini grids gain market power in their communities, driving traditional sources of energy out of the market as people become dependent on electricity provided by the mini grid. This is a good thing: By spurring productive growth in their community, mini grids enable new businesses to develop as households and businesses come to rely on computers, telecommunications, and other services that require larger quantities of always-on power. Kerosene and car batteries will not be able to meet demand. Residents would in any case not revert to the inconvenience of kerosene or to carting their electricity home in a battery.

But once mini grids gain excessive market power, tighter regulation may well be warranted to limit the operators' ability to charge prices above full cost (including reasonable profits) and collect monopoly rents at the expense of consumers. At this stage, too loose a regulatory framework can lead to costly and even less-reliable service (if the operator no longer feels compelled to maintain the system).

Cambodia's regulatory framework evolved alongside changes in its own mini grid sector. Cambodia gradually began regulating its mini grid sector in 2001, after a period of laissez-faire. The Electricity Law of 2001 requires mini grids to obtain a license, charge tariffs approved by the regulator, and meet service and technical standards. The regulator incentivized mini grids to comply with the standards and extend service by giving longer licenses to those that made progress and by allowing tariffs to cover the investments required to upgrade their distribution systems. In parallel, the government distributed subsidies. This approach succeeded in increasing the number of mini grids from 130 in 2006 to some 340 in 2016 (Electricity Authority of Cambodia 2007, 2017).

Nigeria adopted a multi-tier framework that differentiates between small and large mini grids. This framework allows developers to know what will trigger a change in the applicable regulatory regime—in this case, the size of the mini grid's installed capacity. Mini grids under 100 kW of installed capacity are subject to registration that leaves them freedom regarding location and tariff setting; those above 100 kW must apply for a permit that requires proof that the area requested for service is actually unserved, calculating tariffs following the regulator's cost-plus methodology; those above 1 MW must apply for a license.

How should regulations evolve as mini grid sectors mature?

Tighter regulations should be triggered by defined transitions between the stages of development of mini grid sectors

Evolutionary regulation combines flexibility with predictability for investors. Predictability, of course, allows investors to make plans based on expected revenues. In Cambodia again, the regulator modified the regulations governing mini grids after the market evolved, but without planning for it. This forced investors to adapt to the changes as they were being implemented and caused them to worry about their ability to sustain investments. In 2016, Cambodia's regulator adopted a national uniform tariff below mini grids' cost-recovery tariff, thinning distribution margins despite subsidies issued through the main utility's budget.

One way to ensure regulatory predictability for investors while allowing regulation to evolve is to define the regulatory stages at the outset, setting thresholds for transitions from one stage to the next. With the help of table 1, the text that follows suggests three phases and two thresholds for regulation of market entry, tariffs, service standards, technical standards, and subsidies.

At the outset, when a mini grid operator enters the market, only light regulation need apply. In the entry phase:

- The regulator requires only registration, since more burdensome regulation, such as permitting or licensing, may hinder market entry.
- The regulator allows mini grids to set their tariff freely, under a "willing buyer, willing seller" regime.

Table 1. Evolutionary regulation in three phases

Regulatory issue	Startup	Growth	Localized market dominance
Market entry	Registration	Registration	Permit/license
Tariff	Willing buyer, willing seller	Price cap defined with reference to costs of "efficient new entrants"	Individualized cost-based tariff
Service standards	Reporting	Differentiated regulated standards	Grid level standards
Technical standards	Safety standards Optional grid-compatible standards	Safety standards Optional grid-compatible standards	Safety standards Optional grid compatible standards
Subsidies	Implicit subsidies (information, land, favorable tax treatment) Optional capital cost subsidies	Capital cost subsidies, and/or connection subsidies	Connection subsidies, and/or energy subsidies

Threshold 1 might be defined as being reached, say, five years after first mini grid was registered, once a set number of customers had been reached, and once average power consumption per customer had reached a certain level for the majority of mini grids (e.g., 40 percent of average main-grid consumption).

Threshold 2 might then occur some 10 years later, once another set number of customers had been reached, and once average power consumption per customer had reached a specified higher level for the majority of mini grids (e.g., 80 percent of average main-grid consumption).

One way to ensure regulatory predictability for investors while allowing regulation to evolve is to define the regulatory stages at the outset, setting thresholds for transitions from one stage to the next.

- The regulator does not set service standards, limiting the regulation of technical standards to issues of safety and grid-compatibility (and, to limit upfront costs, enforcing these only when mini grids move to connect to the main grid). Competition from traditional energy sources incentivizes mini grids to offer better and safe service.
- The government need not provide significant subsidies, given that light regulation is already saving developers money. The government may consider implicit subsidies[3] and possibly viability-gap subsidies if customers are not willing and able to pay a cost-recovery tariff. Implicit subsidies reduce capital costs without direct funding, for example, through tax exemptions; capital-cost subsidies provide a known amount of funding early in the life of the project to close part of the equity gap.

The transition from startup to growth may be triggered by one or more criteria, possibly the number of years since the first mini grid is registered (for instance, five) or market-penetration statistics for registered mini grids. Market penetration may be measured by indicators such as number of customers reached by all mini grids compared with the total population of all communities served by mini grids, the market share of mini grid electricity used for lighting and phone-charging in areas served by mini grids, or average power consumption per household (for example, 40 percent of average main grid household consumption).

In the growth phase—when existing mini grids are gaining market power and more are coming online—regulation of tariffs and service standards kicks in. In the growth phase:

- Entry regulation still need be no more than simple registration, because tariffs and standards can be imposed through regulation without the need for greater control over entry.
- The regulator may consider capping the tariff. The cap would set a single benchmark tariff for all mini grids at a level estimated to be the cost of service of an efficient new entrant in the business.
- The regulator may consider setting minimum service levels but leave the regulation of technical standards unchanged, since changing the latter would oblige mini grids to rebuild their systems to different standards, with attendant costs.
- The government may choose to provide capital-cost and connection subsidies. These would help mini grids comply with tariff and service-standards regulation and expand the market. Connection subsidies enable households to connect to mini grids by funding the shortfall between their willingness to pay and the cost of connection.

[3] An implicit subsidy is a subsidy that is not a cash transfer. Implicit subsidies range from tax breaks to the provision of land, technical assistance, or information.

Evolutionary regulation offers investors predictability and a measure of certainty. Developers know how they will be regulated at each stage of the sector's development because the regulatory regime in each phase, and the trigger for moving from one phase to another, is defined.

The transition from the growth phase to the localized market dominance phase may be triggered by criteria similar to those applied in the first transition, but at higher levels—for instance, 15 years after the first mini grid is registered, or 95 percent market share for lighting and charging services in areas served, or average consumption per household at 80 percent of average main-grid household consumption.

In this long-term phase, regulation of tariffs and service standards may be further tightened:

- The regulator uses individualized, cost-based tariff limits, since an efficient-new-entrant price cap can leave a degree of monopoly pricing.
- The regulator may opt to require grid-level service standards to ensure that service for all customers is equal.
- Mini grids may not need capital-cost subsidies to develop in new communities. But the government could continue to provide connection subsidies for low-income customers to connect to mini grids. In addition, the government could decide to provide energy subsidies if it sought to reduce the cost of electricity for all mini grid customers; alternatively, it could choose to align mini grid tariffs with those of the national grid. Energy subsidies are those provided per kWh delivered, so they lower energy costs for customers; they are not paid upfront.

A similar model, applied on a per-mini grid basis, provides a grace period devoid of any regulation (Tenenbaum and others 2014: 320–22). If an operator were to seek an extension of the grace period, the regulator would conduct a review to consider extending the grace period or moving a mini grid into the regulatory regime. The grace-period model is simpler than evolutionary regulation, but the path it provides is not as well tailored or predictable.

In sum, how does evolutionary regulation foster the development of mini grid sectors?

It protects customers while giving investors certainty and predictability

Evolutionary regulation protects customers from the risks they face at different stages of development of the mini grid market. At the start, light regulation may suffice, as customers face few risks. To attract customers, mini grids are obliged to offer better service at the same or lower prices than traditional energy sources. Light regulation allows mini grids to develop rapidly and efficiently in a low-cost, nonintrusive regulatory environment. Mini grids can adapt their service offerings and prices to the market. As mini grids gain localized market power, heavier regulation is introduced to protect customers; tariffs are kept at cost-recovery levels and service is maintained at reliable and good-quality levels.

Evolutionary regulation also offers investors predictability and a necessary measure of certainty. Developers know how they will be regulated at each stage of the sector's development because the regulatory regime in each phase, and the trigger for moving from one phase to another, is defined. But defining phases of regulation and triggers for transition is not enough in itself. A government needs to commit to following through with the plan, abstaining from regulating until the trigger is reached, and regulating as planned thereafter.

To succeed, evolutionary regulation requires significant resources from regulators, developers, and customers. Designing and enforcing a regulatory regime that will be relevant ten years from now, one that is both flexible and predictable, requires substantial regulatory capacity.

MAKE FURTHER CONNECTIONS

Live Wire 2015/38. "Integrating Variable Renewable Energy into Power System Operations," by Thomas Nikolakakis and Debabrata Chattopadhyay.

Live Wire 2015/44. "Mapping Smart-Grid Modernization in Power Distribution Systems," by Samuel Oguah and Debabrata Chattopadhyay.

Live Wire 2015/51. "Scaling Up Access to Electricity: Emerging Best Practices for Mini-Grid Regulation," by Chris Greacen, Stephanie Nsom, and Dana Rysankova.

Live Wire 2017/76. "Increasing the Potential of Concessions to Expand Rural Electrification in Sub-Saharan Africa," by Richard Hosier, Morgan Bazilian, and Tatia Lemondzhava.

Live Wire 2017/86. "Data as an Enabler in the Off-Grid Sector: Focus on Tanzania," by Christopher Arderne, Yann Tanvez, and Pepukaye Bardouille.

Live Wire 2019/97. "Investing in Mini-Grids Now, Integrating with the Main Grid Later: A Menu of Good Policy and Regulatory Options," by the Global Facility on Mini Grids.

Find these and the entire Live Wire archive at https://openknowledge.worldbank.org/handle/10986/17135.

References

Brown, Ashley, Jon Stern, Bernard Tenenbaum, and Defne Gencer. 2006. *Handbook for Evaluating Infrastructure Regulatory Systems.* Washington, DC: The World Bank. http://documents.worldbank.org/curated/en/428111468177849284/pdf/364990Handbook101OFFICIAL0USE0ONLY1.pdf.

Electricity Authority of Cambodia. 2007. "Annual Report on Power Sector of the Kingdom of Cambodia 2006." https://eac.gov.kh/site/viewfile?param=annual_report%2Fenglish%2FAnnual-Report-2006-en.pdf.

———. 2017. "Annual Report on Power Sector of the Kingdom of Cambodia 2016." https://eac.gov.kh/site/viewfile?param=annual_report%2Fenglish%2FAnnual-Report-2016-en.pdf.

Government of Uttar Pradesh. 2016. *Uttar Pradesh Mini-grid Policy 2016*. http://upneda.org.in/sites/default/files/all/section/Mini%20Grid%20Policy%202016.pdf.

Greacen, Chris, Stephanie Nsom, and Dana Rysankova. 2015. "Scaling Up Access to Electricity: Emerging Best Practices for Mini-Grid Regulation." *Live Wire* 51, World Bank, Washington, DC. http://hdl.handle.net/10986/23137.

IEA (International Energy Agency). 2017. *Energy Access Outlook 2017: From Poverty to Prosperity*. Paris.

IRENA (International Renewable Energy Agency). 2016. *Innovation Outlook: Renewable Mini-Grids.* Abu Dhabi.

REA (Rural Electrification Agency). 2017. *The Off-Grid Opportunity in Nigeria*. Abuja, Action Learning Event, "Upscaling mini-grids for least cost and timely access to electricity," 4–8 December.

Tenenbaum, Bernard, Chris Greacen, James Knuckles, and Tilak Siyambalapitiya. 2014. *From the Bottom Up: How Small Power Producers and Mini-Grids Can Deliver Electrification and Renewable Energy in Africa.* Washington, DC: World Bank Group. https://openknowledge.worldbank.org/handle/10986/16571.

This Live Wire was prepared by the Global Facility on Mini Grids (GFMG) with inputs and significant contributions from the team of Castalia Strategic Advisors, and specifically David Ehrhardt, Gianmarco Servetti, Lisa Tessier, Charly Missirian, and Laurie Hervot. Their support is gratefully acknowledged. The GFMG is a program of the World Bank's Energy Sector Management Assistance Program (ESMAP). The Facility helps mainstream mini grids into World Bank lending projects and national electrification programs and supports the development and dissemination of knowledge and learning on mini grids. To share and exchange the latest developments, the GFMG hosts annual Action Learning Events.

Get Connected to Live Wire

"Live Wire is designed for practitioners, policy makers, and planners inside and outside the World Bank Group. It is a resource to share with clients, colleagues, and counterparts."

The *Live Wire* series of online knowledge notes, an initiative of the World Bank Group's Energy and Extractives Global Practice, offers rich insights from project and analytical work done by the World Bank Group.

Every day, Bank Group experts apply their knowledge and expertise to solve practical problems in client countries. *Live Wire* captures the rich insights gained in the field, allowing authors to share their findings with other practitioners, policy makers, and planners.

Shouldn't you be connected to Live Wire?

Since 2014, the 80 briefs in the series have dealt with vital topics such as energy demand and supply; renewable energy; energy efficiency; energy policy; economic growth; environmental protection; climate change mitigation; power systems; rural and urban development; access to energy; infrastructure economics; private sector participation; access to finance; and regulation.

- **Topic briefs** offer technical knowledge on key energy issues.
- **Case studies** highlight lessons from experience in implementation, often with insights from private sector engagement.
- Briefs on **global trends** provide analytical overviews of key energy data and developments.
- **Bank views** portray the Bank Group's energy and extractives sector activities.

The format is accessible, rigorous, and concise enough to be easily shared. The 4–12 pages of each brief make ample use of graphics. Briefs are peer-reviewed by seasoned practitioners within the World Bank Group and professionally edited and produced. While their main channel of dissemination is online, Live Wires are available in print-ready files for specific client needs.

Live Wire briefs are designed for easy reading on the screen and for downloading and self-printing in color or black and white.

For World Bank Group employees: Professional printing can be done on a customized basis for meetings and events by contacting GSDPM Customer Service Center at (202) 458-7479, or sending a written request to cgsdpm@worldbank.org.

Printing & Multimedia Services
General Services

Please visit the World Bank Group's Open Knowledge Repository to browse the Live Wire collection and download the issues important to you: www.worldbank.org/energy/livewire

OPEN KNOWLEDGE REPOSITORY