WORLD BANK GROUP

CLIMATE INVESTMENT FUNDS

ESMAP
Energy Sector Management Assistance Program

UPSCALING MINI GRIDS FOR LOW COST AND TIMELY ACCESS TO ELECTRICITY

Proceedings of an Action Learning Event in Naypyidaw, Myanmar | February 6–10, 2017

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ABBREVIATIONS

AC	alternating current
ADB	Asian Development Bank
DC	distributed current
DFID	Department for International Development
DRD	Department of Rural Development
ESMAP	Energy Sector Management Assistance Program
EU	European Union
GIZ	Gesellschaft für Internationale Zusammenarbeit
IDA	International Development Association
JICA	Japan International Cooperation Agency
KfW	Development Bank—Kreditanstalt für Wiederaufbau
kVA	1,000 volt amps
kW	kilowatt
kWh	kilowatt hour
NEP	National Electrification Plan
NGO	nongovernmental organization
SE4All	Sustainable Energy for All
SREP	Scaling-Up Renewable Energy Program
USAID	United States Agency for International Development
VEC	village electrification committee

1 | INTRODUCTION

Mini grids are expected to play a critical role in meeting the Sustainable Energy for All (SE4All) goal of universal energy access by 2030. According to the International Energy Agency, 40 percent of the world's poor live in villages that are too far from the grid to be feasibly reached via grid extension in the near term. This problem is particularly widespread in Sub-Saharan Africa and developing Asia, where a majority of the population is expected to live in remote and rural areas in the near term.

In these load centers, decentralized mini grids are a practical alternative for a variety of technical and financial reasons. Mini grids are one of the main high-impact opportunities within the SE4All initiative. They are also a priority in most of the SE4All Action Agendas under development in Africa.

Many factors have constrained the proliferation or acceptance of mini grids as a credible energy access option. They include gaps in policies and regulations, a lack of long-term financing, and a lack of capacity or interest among power producers.

Technological and institutional innovations and cost reductions have made mini grids more attractive in recent years. However, lack of knowledge and exposure to global best practices continues to create policy and commercial barriers that impede the expansion of sustainable mini grids. Although mini grids have a long history and are widely used in several parts of the world, they are only now emerging as a viable option for meeting energy demand in Sub-Saharan Africa and South and Southeast Asia.

Several initiatives have been launched to address these challenges. In Myanmar, stakeholders are steadily realizing the potential of mini grids to help the country reach its electrification targets.

The Clean Technology Fund and the Scaling-Up Renewable Energy Program (SREP)—both funded by the Climate Investment Fund—are supporting the scaled up demonstration and deployment of renewable energy in middle- and low-income countries. Twenty-one projects supporting clean energy mini grids—based on renewable energy technologies, including storage in systems with variable renewables, or renewable energy/diesel hybrid systems—have been approved and are in start-up phases; another 14 are in the pipeline.

To accelerate the pace of electrification, the World Bank's Energy Sector Management Assistance Program (ESMAP) has leveraged core funding from the Department for International Development (DFID) to create a Global Facility for Mini Grids. The facility will mainstream least-cost mini grids into World Bank Group operations and develop the policy- and business-relevant knowledge and data needed to accelerate mini grid deployment.

Purpose of the Learning Event

The objective of this event in Myanmar, cohosted by ESMAP and the Clean Investment Fund, was to bring these initiatives/programs and related stakeholders together to discuss and isolate two or three issues for each stakeholder group. These issues would then be broken down to seek action plans to accelerate the uptake of mini grid technologies and business models for achieving low-cost and timely access to electricity. A facilitator ensured that a process of action learning was established and that continuity from a previous event in Kenya was maintained.

The technical conference in Kenya highlighted some global themes that were carried over to the agenda in Myanmar. They included the following:

- The private sector has an important role to play in bringing investment and innovation to the development of mini grid systems.
- To attract private sector investment and developers, governments need to create predictable grid expansion plans and workable arrangements with developers in advance of the arrival of the grid to protect mini grid investments and assets.
- Ideally, tariffs for end-users should be flexible to allow adequate revenue for sustainable projects. If the government implements universal tariffs, subsidies will be required to make mini grid development sustainable and viable.
- Productive uses/anchor loads that use daytime energy can be catalysts for expanding the size and economic impact of mini grid systems.
- Technical standards and quality of service will become increasingly important to developers, investors, and end-users as more mini grid systems are built and existing systems expanded. The challenge is to simultaneously improve quality, tailor the level of service to customers' needs, and keep electricity affordable.
- Building local capacity to manufacture, build, operate, and manage mini grid systems holds the potential to reduce the costs and amplify the economic benefits of mini grids.

This learning event expanded the opportunities to break into small groups, to better understand the barriers, and to then generate ideas for action by the government, the private sector, and development partners. The event also included field trips to two mini grid sites.

ESMAP and the Climate Investment Fund are committed to testing the key takeaways from the Kenya and Myanmar Action Learning Events in the form of projects and assistance as more experiences and insights from countries in Asia and beyond are gathered. The lessons generated will inform future efforts to scale up mini grids.

2 | MINI GRIDS IN MYANMAR

In 2014, 70 percent of Myanmar's population—including 84 percent of rural households—lacked access to grid electricity. Electricity shortages and supply disruptions were—and are—widespread, as a result of perennial underinvestment in the sector.

Mini grids using locally engineered and financed technology provide electricity for thousands of villages that are outside the limited national grid distribution network. These mini grids emerged largely thanks to the drive from the local private sector and community organizations, with little or no public sector support. They reflect the resolve and ingenuity of many local communities in finding alternatives to candles and kerosene. At the same time, given their limited access to engineering expertise and small budgets, most Myanmar mini grids have significant quality and reliability issues.

The Myanmar Department of Rural Development (DRD), under the Ministry of Agriculture, Livestock and Irrigation (MOALI), is the leading government agency implementing the off-grid component of the National Electrification Plan (NEP). The NEP covers part of project capital costs and funds a portion of feasibility studies. It also supports capacity building.

More than $600 million has been approved or committed by the government, the World Bank, other development partners, and the private sector to support implementation of the NEP. Significant opportunities exist to both upgrade existing mini grids and develop new sites with this support.

The NEP aims to electrify 7.2 million households and achieve universal access to electricity by 2030. In the long run, extension of the Myanmar national electric grid will play a major role in meeting the target: more than 95 percent of the population is expected to be connected to the national grid by 2030. Before then, mini grids will play an important role.

According to the 2014 Myanmar Population and Housing Census, the national grid provides electricity to only about a third of Myanmar's 11 million households. In rural areas, national grid

coverage is much lower, at only 15 percent. About 1 million households (9 percent) receive electricity from private diesel generators, 11 percent of households use solar home systems, and another 21 percent use batteries charged in local towns. Failing these options, households use kerosene and/or candles.

According to a DRD presentation from January 2015, more than 16,000 of the country's 64,000 villages get their electricity from diesel generators, micro-hydropower, or biomass.

Myanmar has two major business models for mini grids. Some mini grids are operated by a group of farmers selected by a village's village electrification committee (VEC). In this model, the leader of each 10-household block in the village collects the monthly tariff payments. Other mini grids are owned and operated by private entrepreneurs.

Diesel mini grids in villages are often powered by Chinese-made agricultural diesel motors that power inexpensive synchronous generators; they typically produce no more than 20 kVA of power.

Tariffs for diesel mini grids vary considerably and are often charged per light or appliance. A 2015 study by the Asian Development Bank found monthly charges of K 2,000 ($1.82) for a single 20 W compact fluorescent light bulb and K 5,000 ($4.55) for two lights and a television set (Tharakan 2015). A 2016 study of 10 diesel mini grids by the micro-credit nongovernmental organization (NGO) PACT found monthly tariffs of K 1,000–K 1,500 ($0.73–$1.10) for a single light bulb and K 2,500–K 4,000 ($1.83–$2.92) for lighting and a television set (PACT 2016). Equivalent per kWh tariffs vary from $0.37 to more than $1.00.

Hydropower mini grids are found largely in hilly communities, especially in Shan, Mandalay, and Sagaing states. The 2014 census reported that about 178,000 households received electricity from "private waterwheels," a category that includes both hydropowered mini grids and household-scale hydropower. Data for fiscal 2015/16 from the DRD estimate that more than 1,200 villages have electrified at least 70 percent of their households with micro-hydropower. Tariffs are typically lower than tariffs charged by diesel-powered mini grids, at about K 200–K 860 ($0.18–$0.78) per kWh (Kumara 2015).

Biomass gasifiers are common in the delta region, powering mini grids as well as rice mills, irrigation pumps, saw mills, and oil-pressing and ice-making operations.[1] DRD data show that 472 villages provide power to at least 70 percent of village households by biomass/biogas. A reference tariff for biomass gasification mini grids is K 400 ($0.36) per kWh (Royal Htoo Linn Manufacturing 2015).

Solar mini grids, either stand-alone or hybrid PV/diesel are much less common. The DRD estimates that 150 villages are powered by solar mini grids, and more are in the pipeline (ADB 2013; Eco-Business 2015). Most solar mini grids have been heavily subsidized as pilot projects commissioned by nongovernmental organizations or the DRD. Myin Chi Naing, for instance, charges K 1,500 ($1.09) for up to 100 watt-hours a day.

The vast majority of Myanmar's mini grids were built from scratch, with no government support and under conditions of acute material shortages. Given this constraint, the role they have played in helping achieve rural electrification is impressive.

[1] One company alone, the Royal Htoo Linn Manufacturing Co., had installed more than 733 units as of August 2015; 358 were used to power rice mills, and 145 were used for village electrification.

Four key issues constrain the scale-up of mini grids in Myanmar:

- **Low technical quality.** Some mini grid distribution systems in Myanmar are built with high-quality concrete poles and wires built to national grid standards. Many, however, consist of informal networks of wires strung on untreated bamboo poles or trees. Thin wires, inappropriate conductor metal (e.g., galvanized steel), and poor splices have led to considerable line losses. These systems can also be dangerous and failure prone: poles rot and fall over, thin wires break easily, and poor splices corrode and fail. The generators (diesel, micro-hydro, and biomass) that energize Myanmar mini grids are often inefficient, failure prone, and unsafe.
- **Lack of regulatory framework.** A regulatory framework for mini grids would address the uncertainties developers and investors face about their investments. Such a framework should cover safety, quality of service, tariff regulation, and provision for what happens to the mini grid when the main grid arrives. Mini grids would benefit from the creation of an independent regulatory authority. Until that happens, local DRD offices could handle basic functions such as registration of mini grid project sites to avoid competition for the same load centers.
- **Uncertainty concerning grid expansion.** Under the NEP, the national grid is expanding quickly in some areas; other areas will not be connected to the grid for at least 15 years. Mini grid developers are reluctant to invest if they suspect the national grid is arriving soon. To ensure that investment in mini grids is made in the right places, NEP maps must be updated and made available to stakeholders, including mini grid developers and village decision makers. Regulations need to be put in place that provide opportunities for integration with the grid when it arrives—through transfer of assets or co-existence agreements, for example.
- **Lack of attractive financing.** Many mini grid developers find it difficult to get loans. When financing is available at all, the loans have short tenors (such as one year) and very high interest rates (40 percent or higher), making it nearly impossible for mini grid developers to charge affordable tariffs and still earn a profit. A consequence of the high cost of financing is that the private sector has built less robust and less reliable mini grids that may have lower up-front costs but cost more in the long run, because of inefficiencies and frequent breakdowns. The financial sector in Myanmar is underdeveloped. However, some major banks are becoming interested in building capacity to support mini grids.

3 | MYANMAR MINI GRID ROUNDTABLE

Water pumping is one of the productive uses that can be modernized when the mini grid arrives.

The Department of Rural Development (DRD) is the agency in charge of implementing the off-grid component of the National Electrification Plan (NEP). It estimates that more than 16,000 mini grid systems are operating in Myanmar, most of which have been developed without public funding. According to U Khant Zaw, DRD's director, the government cannot reach the goals for continued mini grid development alone; public-private partnerships (PPPs) are critical.

Overview of Mini Grid Expansion in Myanmar: Status, Opportunities, and Challenges

Chris Greacen, a World Bank consultant, gave an overview of mini grids, drivers, and challenges in Myanmar, discussing diesel, hydro, biomass gasifier and solar, and hybrid solar/diesel mini grids (see Greacen 2017). He lauded the accomplishments of communities and the private sector in developing the know-how to design, fabricate, install, operate, and maintain mini grid systems, as well as their commitment to continued improvement. He summarized the challenges in upgrading existing and developing new mini grid systems (table 1).

Table 1 | Challenges facing mini grid development in Myanmar

TYPE OF CHALLENGE	ISSUES
Technology	• Generators are often inefficient and old, with poor voltage and frequency regulation. • Some distribution networks have inadequate wire size and rot-prone poles. • Many systems are not metered.
Financing	• Loans, where available at all, have onerous terms (one-year tenor, 40 percent interest). • Equity investors are rare.
Regulatory framework	• No framework exists for licensing. • Investors have no protection when the main grid arrives. • Tariffs are uncertain. • Technical standards are low.

What Role Can/Do Development Partners Play?

Seven speakers talked about the role of development partners in mini grid development.

Sakai Mamoru, of the Japan International Cooperation Agency (JICA), spoke about JICA's commitments and investments in improving transmission and distribution lines in other countries. It has had limited experience in Myanmar. It is partnering with Electricity Supply Enterprises (ESE) on diesel off-grid electrification.

Development partners could play three main roles:

- Work with the DRD to develop a regulatory framework. JICA would like the regulatory system to allow communities to continue to use the mini grid systems after the grid arrives.
- Build the capacity of local people. Village electricity committees (VECs) play an important role, but they need more training. The DRD might be able to play a role.
- Provide financial *assistance to consumers.* Rice cookers and refrigerators can lead to higher consumption levels, but consumers need financial support to invest in such appliances.

Regine Dietz, of GIZ, described mini grid projects GIZ is implementing in 12 countries and noted that the willingness to pay for energy services is high. Many of Myanmar's mini grids have been built and financed by communities. The DRD's request for proposals has seen new companies entering the market. Training is also available, and there are many opportunities for exposure trips and capacity building, which GIZ can support.

Development partners could play several roles:

- Solidify the strong partnership between the government (DRD) and private companies, which is needed to push projects and help them get completed in seven months.
- Help the government develop a regulatory framework for mini grids.
- Facilitate interaction between regional teams, particularly in Asia, and tap other experience.

Christa Avery, of Infra Capital Myanmar (funded by DFID), explained DFID's focus on attracting private sector investment to develop socially responsible and financially successful mini grids. Infra Capital evaluates how the business model looks at the supply side, demand balance, and long-term risk. Its priority is to develop long-term projects and commercial business models, which in turn trigger more investments. Development partners could help build a cooperative and collaborative community.

Bui Duy Thanh, of the Asian Development Bank (ADB), described ADB's focus on building off-grid renewable energy demonstration projects and its commitment to helping the government reach its energy access goal by 2030. ADB is helping develop viable business models and working with the DRD to build capacity for business model support. With the DRD's help, it recently completed solar mini grid projects in 12 villages, including Myin Chi Naing, working with a local energy service company (ESCO). Acceptance from the village was high. The government has taken complete ownership of the project and is hoping to replicate the model. ADB is looking for a revolving fund for initial investment and a willing village.

Xiaoping Wang, of the World Bank, noted how the Bank is building on the ADB and JICA experience on the ground in Myanmar. Through its Energy Sector Management Assistance Program (ESMAP), the World Bank has been instrumental in providing resources for technical assistance. It disbursed $2.65 million in 2014–17 to inform policy and support institutional strengthening. The International Development Association (IDA) has invested $400 million in Myanmar's National Electrification Project.

Development partners can play two main roles. They can (a) facilitate collaboration between the public sector, the private sector, development partners, and bilateral donors and (b) share lessons with one another and others.

Pariphan Uawithya, of the Rockefeller Foundation/Smart Power India, spoke about his institution's experience in helping set up 95–100 mini grids in India (4 MW cumulative). He highlighted the importance of mini grid operators having a strong operational focus and the role of concessionary debt to attract more commercial loans. The inflection point occurred when Smart Power India set a more ambitious goal from 5 pilots to 1,000 projects.

Public water facilities became available in the village when the pumps powered by the mini grid were installed.

Development partners can play two main roles. They can secure long-term commitment to support mini grid upscale for private developers and improve the understanding of rural markets and supply chains.

Richard Harrison, of PACT, noted that PACT is the largest microfinance institution in Myanmar, with 20 years of experience. It has used microfinance to support 83 townships in Myanmar. PACT balances the supply side and the demand side by creating strategic partnerships with communities to build on existing structures and cultural contexts and by helping communities understand their role in the development and operations process.

Insights from the Myanmar Roundtable

1. Interconnection to the Grid: U Tint Myint (Suntac Technologies) and Tony Kalupahana (DRD consultant)

Issue #1: Lack of regulatory framework

Proposed solution: Implement one pilot interconnection This is when the mini grid gets connected to the main grid in partnership with the Ministry of Electricity and Energy, the DRD, and development partners.

- **What can the government do?** The government can expedite the finalization of the draft rural electrification law.
- **What can the private sector do?** The private sector can address the challenges of designing and implementing the project with the government.
- **What can development partners do?** Development partners can provide technical support on up-to-date technology and experiences.

Issue #2: Lack of grid code and grid interconnection standards

Proposed solution: Draft a grid code and technical standards, with technical support from development partners.

- **What can the government do?** The Ministry of Electricity and Energy and distribution companies can draft a grid code and technical standards. The government can give private sector developers access to distribution standards.
- **What can development partners do?** Development partners can share the experiences of establishing a grid code and technical standards from other countries. They can also provide technical support on up-to-date technology and experiences.

2. Business Models to Support Community Ownership and Private Sector Developers: U Zaw Min (Win-Thet-Di Hydro Power) and Matthew Tiedemann (PACT Myanmar)

Business models for mini grids fall into three groups: community ownership (self-financed or grant), cooperatives (self-financed with developer and community), and private owned (self-financed by the developer).

Issue #1: Affordability of higher quality technical standards under different models

Proposed solution: Establish minimum quality standards.

- **What can the government do?** The government can develop, approve, and regulate quality standards, creating a level ground for competition for different mini grid business models.

- **What can the private sector do?** The private sector can upgrade or adopt new standards where feasible.
- **What can development partners do?** Development partners can structure and make available affordable financing and facilitate stakeholder conversations around cost and suitability of technical standards.

Issue #2: High tariffs and low ability/willingness to pay

Proposed solution: Introduce flexibility in the setting of tariffs.

- **What can the government do?** The government can allow for flexibility in tariffs to allow return on investment for investors, as well as ensure affordability and equity for community members.
- **What can the private sector do?** The private sector can encourage electricity use by small and medium-size enterprises by offering lower daytime tariffs or considering a tariff that provides lower rates for higher load customers. It can also promote productive use, income-generating activities, financial education, and capacity building.
- **What can development partners do?** Development partners can promote productive use, income-generating activities, financial education, and capacity building.

3. Reducing Capital Expenditures for Mini Grid Systems: Pol Arranz (Trama TecnoAmbiental)

Issue #1: Cost of solar mini grids

Proposed solution: The design of the system has a direct impact on cost. There are three elements of cost: capital expenditure (capex), system cost (battery replacement), and operations and maintenance. Capex (storage, distribution grid, generation, conversion) and logistics play into the decision, services, and local market maturity. Batteries are one of the biggest cost components of the system. Improving efficiency in design, innovation, and flexibility would help reduce the costs of mini grids.

- **What can government do?** The government can facilitate land access, regulate the market (including permitting), and conduct research and development.
- **What can the private sector do?** The private sector can design modular units and develop multiple similar projects simultaneously to leverage economies of scale. They can also use remote monitoring and hybridization with diesel.
- **What can development partners do?** Development partners can facilitate ownership and strengthen partnerships, engage in matchmaking, disseminate lessons learned, and create adaptive and flexible financing mechanisms.

Issue #2: Cost of mini grid components

Proposed solution: It is important to understand the relative weight of each cost component. A *need* for innovative and flexible designs isn't a challenge. A *lack* of flexible and innovate designs would be a challenge. ISO standardization for various components could be helpful.

- **What can government do?** The government can set minimum quality standards, facilitate scalability, support capacity building, make regulation more accommodating, and remove duties and give tax exemptions.
- **What can the private sector do?** The private sector can be responsible for revenue collection and automatization. Specialization could reduce costs. The cost of distribution can be reduced by focusing on areas where population concentration is high.

A household who chose to not connect to the mini grid uses an individual solar system to produce power.

- **What can donors do?** Donors can help promote cost benchmarking for mini grid components.

4. Attracting Private Investment in Mini Grids: Subodh Mathur (World Bank Consultant)

Local banks are reluctant to lend to mini grids, which they view as a risky business, and both banks and borrowers have limited experience with mini grids. The terms of loans include short repayment periods and high interest rates. In addition, financial markets are underdeveloped. Three changes would help promote debt-financed mini grids: (a) make loans available in local currency, (b) make long-term loans available, and (c) increase borrowers' understanding of how banks make loans, which would reduce time, effort, and frustration.

Issue #1: Lack of specialized financial services

Proposed solution: Provide different types of loans and terms for distribution system and generation on the one hand and operations and maintenance costs on the other. Enable financing mechanisms for economies of scale.

Issue #2: Uncertainty and cost associated with currency exchange risk

Proposed solution: Include a risk-sharing mechanism in the loan agreement.

- **What can government do?** The government can partially index the tariff to the exchange rate (as Kenya has done).

- **What can development partners do?** Development partners can facilitate this mechanism and possibly have a credit agency monitor it.

5. Training Centers and Capacity Building: Vishwa Amatya (Practical Action)

Issue #1: Lack of adequate and fit-for-purpose training resources

Proposed solution #1: Establish new training centers, and strengthen existing one, including academic institutions and private sector providers. Development of local vocational training centers is critical. They could focus on resource assessment, technical design, and manpower training. Training at each location should be tailored (fit-for-purpose) to local needs (e.g., textile training in textile-producing area). Funding from all sectors (government, donors, private sector) are needed to support training.

Proposed solution #2: Find innovative ways to impart skills. Digital troubleshooting and on-line courses could leverage existing telecom infrastructure.

- **What can government do?** The government can allocate resources to fit-for-purpose training.
- **What can the private sector do?** The private sector can pool resources to support training and hire graduates of training programs.
- **What can development partners do?** Development partners can influence training policies and provide resources.

Issue #2: Brain drain of trained manpower

Proposed solution: Train women, including older women, who are less likely to leave communities. Companies like Solar Sister in East Africa focus on women.

- **What can government do?** The government can support policies to incentivize women to become technicians and mobilize long-term resources to support training.

- **What can the private sector do?** The private sector can provide financial support and engage women in all aspects of project planning, development, and operations.
- **What can development partners do?** Development partners can provide gender training to governments and companies to influence policies to increase retention as well as provide financial support for trainings.

6. Mini Grid Developers Panel

Mini grid operators participated in the panel that discussed the challenges developers face in expanding mini grids in Myanmar.

U Sai Htun Hla, of Sai Htun Hla Brothers, identified the following issues and possible solutions:

Issue #1: Uncertain future of mini grids when main grid arrives

Proposed solution #1: Issue grid interconnectivity regulations.

Proposed solution #2: Projects with a focus on small and medium-size enterprises

Issue #2: Lack of shared technical standards

Proposed solution: Establish standards, following collaboration by the private sector, government, and development partners.

Issue #3: Lack of know-how for scalability

Proposed solution: Learn from countries such as Indonesia, Nepal, and Sri Lanka.

U Soe Tint Aung, of Royal Htoo Linn, spoke about the need to improve the environmental performance of biogas facilities, create technical specifications for the arrival of the grid, and develop a more specialized workforce for implementing these systems.

Andrew Schroeter, of Sunlabob, has implemented 11 mini grids (in Shan state), with funding from JICA. He noted that Myanmar's private sector is still weak; the role of private sector developers needs to be better defined. He encouraged the government to convene a stakeholder roundtable to develop goals for the private sector's contribution. He spoke about high installation costs, the urgent need to develop standards, and the need to use good quality batteries and inverters (currently, when batteries die at some project sites, they are not replaced). Connection fees are often a burden to potential end-users.

U Aung Myint, of Renewable Energy Association of Myanmar (REAM), spoke about the Renewable Energy Policy and Act, which is under preparation. REAM participated in a countrywide survey on renewable energy potential in 2002, funded by the Ministry of Electric Power and JICA. He noted that local practitioners use a Burmese phrase (*Go tu Gota,* which means "self-reliance electrification"). He emphasized the importance of talking to communities to encourage off-grid power supply systems along with the national grid expansion plan.

Afternoon Breakout Sessions

1. Two-Tier Tariff Structure: Peter Lilienthal (Homer)

There are three main principles in designing tariffs: (a) affordability for consumers, producers, and the government; (b) equity; and (c) efficiency. In a flat rate per kilowatt hour tariff, wealthy households receive a larger subsidy, and there is no incentive for energy efficiency.

Issue #1: Affordability and equity of the two-part tariff (lifeline rate, social tariff)

Proposed solution: A two-tier tariff could include one inexpensive card per month, with subsequent cards purchased for a higher fee.

- **What can government do?** The government can provide regulatory certainty, so that developers are comfortable expanding the system.
- **What can the private sector do?** The private sector can deploy smart meters.
- **What can development partners do?** Development partners can restructure grants into innovative instruments that incentivize private investment. They can share best practices and aid in capacity building.

Issue #2: Lack of efficient mini grid appliances

Proposed solution #1: The government and other partners should develop and encourage efficient appliances.

Proposed solution #2: Cost should be rebranded (not use kWh).

- **What can government do?** The government can implement efficiency standards, require labeling, and allow for cost-recovery tariffs.
- **What can the private sector do?** The private sector can develop smart appliances.
- **What can development partners do?** Development partners can promote and finance energy efficient appliances.

2. Regulation without a Regulator: Bernard Tenenbaum (World Bank Consultant) and Dr. Soe Ohn (DRD)

Myanmar could initially pursue a bottom-up approach to regulating new mini grids by allowing the DRD to implicitly regulate them through a model tripartite agreement. For existing mini grids, the DRD could use a light-handed approach to permit pure private, joint public-private, and VEC-owned mini grids.

Issue #1: Regulation of new mini grids in the absence of a national regulator

Proposed solution: The DRD can produce template tripartite agreements similar to those already in use. The agreement between the developer, the government, and the financier or development partner would outline the terms for tariffs, technical standards, interconnection with the grid, and other important parameters for mini grids receiving grants or subsidies. A tripartite agreement might make it easier for mini grids to obtain funding.

Issue #2: Regulation of mini and microgrids

Proposed solution: The government should aim to enable, rather than disable, regulations. Even small mini grid developers may want some legal recognition without overregulation.

3. Improvements in Safety and Service Delivery: U Khun Aung Myo (Small Hydro Association of Myanmar) and Patrick Pawletko (GIZ)

Issue #1: Appropriate degree of safety in service delivery through regulation

Proposed solution #1: Negotiate safety and reliability standards on a case-by-case basis. They should be identical to national grid standards.

- **What can government do?** In collaboration with the Ministry of Industry, the government can set standards that are responsive to the technical and financial challenges of private sector developers.
- **What can the private sector do?** The private sector can provide input to relevant ministries.
- **What can development partners do?** Development partners can help create an enabling environment.

Proposed solution #2: Standardize safety and service regulations for two categories of mini grid sizes (small and large systems).

- **What can government do?** The government can set an inclusive standard regulation for micro- and mini-scale systems that reflect the safety priorities of the national utility.
- **What can the private sector do?** The private sector can create informal safety and reliability standards through experiences in the field.

Issue #2: Lack of awareness about the safety of mini grids

Proposed solution: Develop a safety awareness raising campaign.

- **What can government do?** The government can invest in public service announcements and train trainers. (Myanmar does not currently have a lead agency responsible for safety awareness.)
- **What can the private sector do?** The private sector can begin awareness raising and community capacity building from the start of implementation.
- **What can development partners do?** Development partners can share experiences and examples from other countries.

4. Rebranding Mini Grids as a Sustainable Solution for Myanmar: Adriana Karpinska (PACT) and Ashish Dhankhar (Yoma Mandalay)

Rural population in Myanmar compares mini grids to the main-grid and considers it an inferior solution. Rebranding the role of mini grids as an intermediary solution until the main-grid arrives could help regain trust in the product. Investors could rebrand to minimize the risk and allow larger investments. Donors and the government could rebrand mini grids as a durable and money saving alternative rather than a temporary solution.

Issue #1: Limited technology knowledge of mini grids

Proposed solution: Educate consumers about mini grids and the costs of energy.

Issue #2: Need to attract investments in areas that are not regulated under the government's rules.

Proposed solution: Most budgets for mini grids come from Village Development Funds or other grants. Improving the technical aspects, reliability, and electricity levels and thus the status of the mini grids could be improved.

- **What can the government do?** The government can require that contracts specify minimum requirements and provide template tripartite agreements.
- **What can the private sector do?** The private sector can build good quality standard mini grids and budget for operations and maintenance. It could also integrate technology (smart meters), focusing on enabling productive use.
- **What can development partners/financiers do?** Development partners can provide technical assistance to the government.

Issue #3: Poor perception of service offered by mini grids

Proposed solution #1: Launch public awareness campaigns.

Proposed solution #2: Explain the differences between options (solar home systems, mini grids, the national grid).

Proposed solution #3: Allow developers to come up with mini grid models that are most suitable for particular regions or demographic groups and help identify successful models within Myanmar.

- **What can government do?** The government can provide exposure to technology through field visits and set up demonstration installations. It can also design social media campaigns.
- **What can the private sector do?** The private sector can install demonstration installations and facilitate field visits.
- **What can development partners do?** Development partners can provide technical assistance to showcase experience. They can also provide flexible financing for pilot projects to test different business models and create working groups/centers for sharing experience and information.

5. Experiences of Mini Grid Operators in Myanmar: Matthew Tiedemann (PACT)

Mini grid operators in Myanmar experience many challenges:

- The village fund is not sufficient for purchasing a generator and sustaining the operation.
- Information is lacking.
- Technical support is lacking.
- Once a generator or other equipment is damaged, it is hard to repair or replace.
- It is difficult to mobilize communities to purchase or repair a generator.
- Not sufficient revenue—affordability as well as lack of access.

4 | PRIVATE SECTOR ROUNDTABLE

Opportunities for the Private Sector in Asia: Lessons from the Field

The discussion focused on three themes:

- What does it take to move from a few projects to many?
- What can bring private sector development to scale in a country?
- What is the global corporate strategy for rolling out mini grids to 1,000 load centers?

Ricky Buch, from GE Power, shared his vision of a grid system that is built to provide average power, not peak power, with mini grids taking up the remaining share. He detailed the GE concept of providing "utility in a box" standardized technologies, which hold the potential to reduce capital, training, and operating costs.

Two factors are critical to scaling up mini grids. The first is customized solutions. GE has developed a 30 kW mini grid system that can be stacked over another system. The second is data (the "new currency"), which can streamline the operation of mini grids.

The success of mini grids will also depend on moving from the limited service (two to three hours a day) needed by most residential customers toward the anchoring of systems with more industrial and commercial customers and the construction of systems capable of exporting power to the grid. A virtuous cycle needs to be created in which power leads to economic growth, which then increases demand for power.

U Soe Tint Aung, of Royal Htoo Lin, has built many biomass gasifiers powered mini grids in Myanmar. He contrasted the Myin Chi Naing PV mini grid system (visited by conference

attendees) with the biomass gasifiers he sells. The Myin Chi Naing PV mini grid system provides about 50 W per household. It electrifies 200 households (out of 500 in the village), with plans to serve more households. Each household has one socket and two light bulbs. The connection fee per household is K 80,000 ($58.60), paid in two installments—one at commissioning and the second after one year of operations. Electricity is provided for approximately 10 hours a day (5–11 P.M. and 7–11 A.M.), at a cost of about K 500 $0.38 per KW unit).

Royal Htoo Lin's biomass gasifier system also charges about K 500/kWh ($0.38). But it also provides electricity for small commercial uses (sewing machines, lighting, rice cookers, washing machines, water pumps). Voltage is relatively stable. In the last 25+ years, Royal Htoo Linhas implemented more than 800 mini grids, using three different biomass gasification technologies. It is now developing a fourth technology that produces zero water pollution.

Kyaw Min Tun, of SolarRiseSys, spoke about his company, which was founded in 2010 to build subsidized mini grids. Funds are available for mini grid development, but private developers need a better regulatory framework to support investment. That framework should cover (a) the legal right to sell electricity to the village, (b) cost of service tariffs, (c) guarantees of the number of years developer can sell to a region/village, and (d) what happens to mini grids when the grid arrives (the ideal scenario is that the mini grid can sell power to the grid). Development partners can play a role in providing technical assistance and helping draft laws and regulations.

Anjal Narula, of Gham Power, described his company, which was established in 2010. It has installed about 2 MW of solar generation in two villages (Harkapur and Cayasmitar) in Nepal. The grids provide power to 55 households, 87 businesses, and 2 telecom towers. The businesses include a grinding mill (1.8 kW), petrol station (3.5 kW), a computer center (2.5 kW), and a restaurant (2.5 kW). There are about 10–15 investors from each village. Commercial banks provided debt-based asset financing. Gham Power also received financial assistance from Asian Development Bank (ADB), the Mobile for Development (M4D) Utilities programme (GSMA), and the DOEN Foundation. The systems will be handed over to the community in 10 years.

Key takeaways from Gham Power's experience include the following:

- Internet and mobile services are the major driver of expanded demand for electricity.
- Community ownership is difficult to manage.
- Developing energy infrastructure should not be the only concern; developing capacity is also vital.
- There is a need to develop other goods and services, including appliances, mills, pumps, communications, and banking.
- The poorest of the poor will not be the initial beneficiaries; businesses and productive energy use loads are needed to develop community cash flow.
- A bootstrapped approach based on productive energy use is easier to scale. It has low project development costs, can be replicated with little donor support, has a shorter payback period, and is of immediate value to users.
- Developers need to move from one-off projects to reliable models.
- Developers need to target areas with higher load potential, such as tourism routes and pilgrimage sites.
- Developers need to bundle multiple services to manage latent times.

Andrew Schroeter, of Sunlabob, spoke about how the Pacific islands and Africa, where people pay $60 a month for electricity, are becoming increasingly attractive for mini grid investment. Sunlabob is working on bringing costs down by investing in its own AC/DC hybrid battery technology. There is a need to focus on operational models and materials used, not just on costs. He also spoke about the need to determine how many projects financed by donor groups are still working. He believes that donor support will be needed over the long term to ensure private sector sustainability.

Enamu Karim Pavel, of IDCOL, explained that his company is a large private sector infrastructure investment firm, established in 1997 with funding from the World Bank, the ADB, JICA, Interamerican Development Bank, Development Bank—Kreditanstalt für Wiederaufbau (KfW), Gesellschaft für Internationale Zusammenarbeit (GIZ), United States Agency for International Development (USAID), DFID, and Global Environment Facility. He spoke about the state of mini grids in Bangladesh, where 100–250 kW solar PV models with diesel genset backup are operating. Eight such plants are in operation, 17 are under construction, and 30 are in the pipeline. He projected that IDCOL will be running almost 50 projects by 2018 and about 200 by 2021.

Zaw Zaw Aung, of Schneider Electric, talked about the three pillars of successful mini grid development: a solid business model, vocational training, and investments. Schneider operates the Solar Home Solutions Center and has installed distributed current (DC) mini grid systems in three villages. With DRD's help, it is providing power to 700 households. Among the lessons learned is the importance of creating a bridge between the developer and development partners, collating knowledge products to share, and ground truthing them in the field.

Alakesh Chetia, of Micropower International, outlined a number of factors that can help bring mini grids to scale:

- working with investors that can scale
- showing a profit margin
- making designs modular (offering three of four "flavors")
- strengthening human resources
- providing supply chain support for local services and long-term credit
- engaging communities, by working with partners with good relationship with the community (e.g., PACT)
- understanding demand (many communities use diesel engines for water pumps; Micropower International seeks to help them convert to electric pumps)
- building around anchor loads (telecom towers, for example, can make village mini grids viable).

Csilla Kohaimi-Monfis, of ENGIE, identified the three tenets of her company: decarbonization, decentralization, and digitalization. ENGIE is no longer investing in coal; it is beginning to sell the coal it owns.

The past was about large-scale power plants; the future will be much more about distributed energy and consumers becoming producers. ENGIE is developing Internet-based networks to facilitate remote monitoring and predictive maintenance. In Europe, where the grid already exists, it is building microgrids for other reasons (hospitals, military compounds, and buildings, etc.). Mini grids can coexist with the grid.

Adriana Karpinska, of PACT Myanmar, discussed the types of information PACT is collecting to better understand the mini grid market and existing systems. It hopes to document the following:

- existing and potential mini grids costs (capital expenditures and operating expenditures)
- supply chains (qualified engineering and installer companies, market price of components locally/regionally available)
- productive uses in villages (naturally existing, developed, and potential)
- socioeconomic baseline survey of villages
- demand-side analysis, including willingness to pay, actual spending on appliances after they are connected, and current spending on energy sources
- power quality issues and levels of electricity service available.

The Role of Associations in Supporting Private Mini Grid Developers

Several industry associations in Africa and Asia support different parts of the mini grid sector. Representatives of some of these organizations talked about what they are doing to facilitate collaboration and alignment in the sector; magnify their voices and priorities; and provide research, capacity-building services, and other resources to their members.

1. Africa Mini Grid Developers Association (AMDA): Catherine Morris (Consensus Building Institute)

At the last learning event in Kenya, small private sector developers in Africa agreed that they needed to work more closely together to have a stronger and more unified voice on the role of the private sector. Since then, a small and focused group of developers drafted

a charter for a mini grid industry association and developed principles for a vibrant private sector and accelerated private investment. About a dozen developers in Kenya and Tanzania recently endorsed the charter and principles. The principles are already being used to support recommendations to government officials on proposed regulations. Next steps include developing a work plan for the activities needed to support its members.

2. Alliance for Rural Electrification (ARE): Katarina Hasbani

ARE started with four members; it now has hundreds. It has helped bring the private sector into an arena dominated by NGOs by:

- helping put pressure on governments to include the private sector
- matchmaking between investors and the private sector
- creating a new European Union (EU) financing instrument
- conducting research.

Cost and uncertainty are the industry's biggest challenge.

3. Hydropower Network: Dipti Vaghela

The Hydropower Network serves as a bridge between developers, development partners, government, researchers, and others interested in promoting micro- and mini-hydropower. It engages in the following activities:

- collating knowledge products from 14 countries and making them publicly available
- documenting field realities, progress, and challenges
- hosting in-person exchanges, including training and practice-to-policy exchanges
- providing post-exchange support to achieve tangible results
- recommending that development partners visit projects and dialogue with practitioners who have long worked on the ground.

4. Renewable Energy Association of Myanmar (REAM): U Aung Myint

REAM works to understand stakeholders, especially rural communities, in order to provide practice-to-policy inputs for policy making. It engages with union and state government agencies; coordinates between ministries to find ways to address the gap left behind by the recently annulled National Electrification Management Committee; and works closely with leading social entrepreneurs who have implemented mini grids at scale, trying to gain the trust of local communities.

Ignite Session: Mini Grid Innovations and Solutions around the Globe

The last session allowed other participants to share their experiences and innovations. Links to their presentations are provided below:

- Incentivizing Private Investment for Upgraded Energy Services: Kamalesh Doshi (Simplified Energy Solutions)
- Lessons Learned from PV Hybrid Microgrid System in Chaungtha, Ayeyarwady Region, Myanmar: Dr. Aung Ze Ya (West Yangon Technological University)
- Electro-Water Bottle: A Tool for Community Education on Off-Grid Electricity Systems: Eric Youngren (Capillary Systems)

- Research and Data Needed to Support Mini Grids: Adriana Karpinska (PACT Myanmar)
- Myanmar Leapfrog to Mini Grid Solutions: Karin Simondon (Roland Berger)
- Mini Grid Survey of Nepal, Cambodia, and Myanmar: Bryan Bonsuk Koo (World Bank)
- Lessons from Renewable Energy Development from Nigeria and Bangladesh: Mostaq Ahmed (Green Housing and Energy)
- Enabling Villages to Harness Community Power: Staffan Qvist (MPower Initiative)

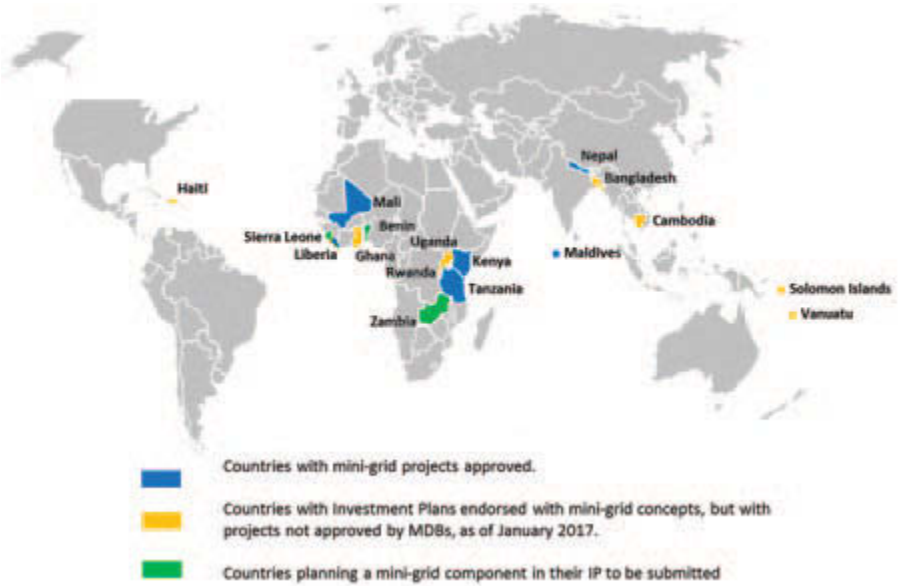
5 | SCALING-UP RENEWABLE ENERGY PROGRAM (SREP) ROUNDTABLE

The goal of the Scaling-Up Renewable Energy Program (SREP) is to support the demonstration and deployment of renewable energy projects in middle- and low-income countries. Mini grids are a significant part of the program's portfolio. It has allocated more than $140 million to mini grid projects in 15 of 19 SREP countries, endorsed another six investment plans, and expects to co-finance more than $850 million of investments in the sector (map 1).

The program achieves the goal through three pathways:

- providing concessional finance, technical assistance, and policy support for renewable energy investments
- leveraging significant additional financing from other sources for larger impacts
- providing experience and peer-to-peer learning in scaling up renewable energy.

Map 1 | Support to mini grids from the Scaling-Up Renewable Energy Program (SREP)



Representatives from 14 SREP countries met to share the status of their activities supporting mini grids. The roundtable provided an excellent opportunity to build on the peer-to-peer learning that began at the SREP mini grid workshop in Kenya in 2016.

Key Themes and Ideas

In the opening session, SREP representatives provided overviews of the specific challenges mini grid operators face in their countries (see appendix C). Common challenges raised included the following:

- the impact on investment of political uncertainty, particularly around election time
- the absence of a clear regulatory framework and technical standards

- the need for technical assistance to and capacity building of mini grid operators and SREP implementation teams
- the need to attract private financing and developers.

This section summarizes the main topics and challenges discussed in the sessions that followed.

Risks in Mini Grid Development

SREP country representatives identified several risks in mini grid development, including planning and investment risks, regulatory risks, and lack of local capacity.

Planning and Investment Risks

- Because initial investment costs are high, smaller mini grids are more expensive to construct per MW and find it more difficult to attract capital.
- There may be potential overlap between national grid electrification and mini grid initiatives in countries like Ghana, which is increasing the number of mini grids from 55 to about 200. The increase in the number of mini grids calls for better planning for interconnection with the grid.
- The solar hybrid mini grid project in Maldives will be used to better understand the impact of renewable energy penetration on system reliability and technologies to optimize the system.

Regulatory Risks

- Regulatory hurdles and licensing requirements can impede the development of large mini grids (e.g., larger than 30 kW in Rwanda).
- Overregulation can jeopardize the private mini grid sector during the early development of the market. It may frustrate mini grid investment or lead to suboptimal alternative solutions, such as solar home systems.
- Bureaucratic licensing procedures by the electricity regulatory authorities are a challenge in some countries, such as Uganda.
- Uniform tariff policies (such as in Ghana) mean that differences between tariff revenue and private sector costs must be covered by other sources (government subsidies, private sector loans, donor grants to buy down capital or operating costs) if the regulator does not incorporate private sector costs in the rate-setting mechanism.
- There is an increasing need for technical standards to address risks associated with extreme weather, particularly on islands.
- Island states in particular need equitable policies to address land ownership questions.

Lack of Local Capacity

- In Haiti the government is seeking ways to quickly build the capacity of teams that will be in charge of project implementation, including procurement, financial, and technical expertise.
- In Liberia the Rural Renewable Energy Agency is looking into increasing local capacity to manage and operate a hydro mini grid project. Having local firms carry out these activities could reduce costs significantly.
- Maldives is hoping to expand training for operators of hybrid systems that are being built across the islands, where physical accessibility is a problem.
- In Vanuatu capacities have to be strengthened at the Department of Energy to implement funded projects and at the Utilities Regulatory Authority to develop innovative strategies for setting tariffs that balance affordability with adequate revenues to build and operate mini grid systems.
- Capacity building will be more effective if current short-term training programs are replaced or supplemented with longer term training that is integrated into countries' high school and higher education programs.

Business Models: Transitioning from a Subsidy-Based to a Market-Driven Business Model

- Private sector involvement and investment require that the operation of the system generates adequate revenue to cover capital costs and operating expenses and yields a profit.
- There is an interest in replacing the current subsidy-based models with a market-driven business model in order to make mini grids sustainable in the long run.
- High subsidies (up to 70 percent of total capital expenditures in Rwanda) are not a guarantee of private sector investment: interest from private developers may still remain low, given other barriers to investment.
- Private sector developers in Zambia are not keen on operating isolated mini grid, because low income levels limit connections and revenue collected.
- Uniform tariffs may require subsidies indefinitely, but they can be scaled back as demand for productive and other uses grows. Uniform tariffs can also be increased over time to reduce the level for subsidies.

Opportunities and Recommendations

- A mini grid has to generate adequate income to be sustainable. Productive uses of electricity in rural areas must be encouraged and promoted, as they have in Rwanda. Government has a role to play in identifying productive uses. If businesses receive the proper support, they will be able to pay for increasing amounts of electricity as they grow.
- Where communities lack the resources needed to expand the system, increased tariffs or subsidies could generate additional income to invest in productive uses that would provide the needed revenue for expansion.
- Costs can be reduced in various ways:
  - cross-subsidizing households with revenues from productive-use customers
  - increasing the customer base or the volume of sales by creating more anchor loads
  - reducing the fixed price per customer through subsidies
  - installing modular units, which reduce up-front costs and training needs
  - creating local or regional supply chains to reduce shipping costs.
- Renewable energy (typically in a hybrid generation system that uses batteries and backup diesel) is often less expensive than existing generation alternatives. In the Solomon Islands, for example, reliance on imported diesel led to the highest electricity tariffs in the South Pacific, making renewable energy very competitive. Maldives' hybrid mini grids are expected to be viable and profitable after five years because of the reduction in fossil fuel costs.
- The public sector should set up research and development (R&D) centers in mini grids, possibly partnering with established R&D institutes, as proposed by Zambia.
- Nepal's Alternative Energy Promotion Centre (AEPC) envisions testing a model for partnership with the private sector to support more economically viable businesses oriented to off-grid system development.
- Governments should develop technical requirements for integration of mini grids into the main grid, as Ghana has done.
- Geospatial mapping is useful for identifying more potential areas for establishment of mini grids (as in Kenya) and to avoid potential overlap of mini grid initiatives and national grid electrification (as in Ghana).

6 | MINI GRID TECHNICAL CONFERENCE

In opening remarks, U Khant Zaw, the Director General of the Department of Rural Development (DRD), provided an overview of what the government of Myanmar is doing to advance both mini grid and other approaches to universal access. He spoke about the development of DRD, several initiatives under it, and the importance of private sector participation.

Mi Mi Khaing, the Director General of the Electricity Supply Enterprise, noted that mini grids provide about 0.6 percent of total generation in Myanmar. Abdoulaye Seck, the World Bank's Country Manager for Myanmar, spoke about the importance of mini grids in achieving universal access. He described Bank support and stressed the importance of collaboration by partners, including ESMAP, the Climate Investment Fund, governments, and the private sector.

Each topic at the technical conference was introduced by an expert, who facilitated the discussion that followed. Each break-out group was charged with identifying one or two challenges and suggesting solutions. Where possible, each group was asked to identify specific steps that government, private sector, and development partners can take to implement each solution.

This section summarizes the introductory presentations and the takeaways from the 10 break-out sessions. All the presentations can be found at http://www.esmap.org/node/57666.

1. Five Key Policy and Regulatory Decisions: Bernard Tenenbaum (World Bank Consultant)

Five main regulatory and policy decisions should be discussed before setting up mini grids:

- tariff setting
- what happens when the grid arrives in a mini grid village
- licensing and permits
- quality of service
- preference for top-down versus bottom-up regulatory framework or both.

Issue #1: Should there be a national uniform tariff accompanied by subsidies for mini grids? If so, how should the tariff structure for mini grids be determined?

A national uniform tariff means that mini grid owners must charge the same tariff as the grid. Will the government be willing and able to subsidize the private sector or national utility at the same level as the national grid? If there is not a uniform tariff policy, every mini grid has the flexibility to charge tariffs that are aligned with their costs or the avoided cost of energy.

Proposed solution #1: Regulators should allow for mini grid tariffs to reflect the cost and value of service. The mini grid tariff need not be the same as the national utility tariff unless the government can make a strong commitment to subsidize the higher cost of the mini grid.

> **Proposed solution #1.1:** Countries without a regulatory authority should create template contracts, which are signed by the developer, the village, and the local DRD office. The templates should cover different situations (e.g., new mini grids, existing mini grids, and different technologies and sizes).
>
> **Proposed solution #1.2:** The tariffs and contracts used by private developers and village electrification committees (VECs) should differ. Templates for each could be developed at the national level, covering tariffs, quality of service, hours of service, and other features.

- **What can the government do?** The government can establish advisory committees of stakeholders to give advice.
- **What can the private sector do?** The private sector can participate actively in the development of regulatory contracts that meet their needs for financing.

Issue #2: Should licenses for mini grids be exclusive (a legal monopoly) or nonexclusive, and how long should they last?

Proposed solution #1: Mini grid operators below a certain size should be exempt from licensing. But they should be given the opportunity to register their existence with the national government, which may help them secure financing.

If mini grid developers have signed and received approval for a tripartite or bilateral agreement with the community (and, if trilateral, a government entity), they should automatically be granted a license.

Proposed solution #2: Licenses could be granted for two years. To obtain a longer term license (desirable for developers/investors), the operator would need to demonstrate that the system had improved its quality, to ensure that it is ready for the grid. This requirement would provide an incentive to improve the quality of service.

Proposed solution #3: Mini grids that have built a distribution system that meets the standards of the national utility and provided several different business options for when the main grid arrives, as part of their licensing.

- **What can the government do?** The government can request input from stakeholders.
- **What can the private sector do?** The private sector can give advice on the content of the licenses they need to seriously consider investments.

2. Subsidies and Tariffs: Subodh Mathur (World Bank Consultant)

Two main principles govern subsidies and tariffs: (a) ensuring that the financial package of subsidies, equity, and debt is enough to finance the capital costs of a mini grid and (b) ensuring that the subsidy takes account of the financial capabilities and funds of investors, government, partners, and consumers.

Issue #1: What is the appropriate subsidy level for mini grids owned and operated by the private sector? What type of model is more appropriate? Should it be linked to the volume of electricity generated, capital costs, technology, location, number of customers, and their income levels?

Proposed solution: The subsidy design could be based on all of these parameters. It will differ in each project.

- **What can the government do?** The government can focus on providing viability gap funding, crafting a subsidy policy, providing technical assistance, and creating a platform for different stakeholders to provide input.
- **What can the private sector do?** The private sector can bid in government solicitations, competing on price and reliability. It can solicit commercial banking sector involvement.

- **What can development partners do?** Development partners can provide expertise in designing subsidy schemes, support market studies, and provide funding support, if needed.

Issue #2: What should the parameters be for determining the level of subsidy, and how can it be made sustainable for the government?

Proposed solution: A mechanism should be adopted that allows reasonable tariffs.

- **What can the government do?** The government should set tariffs on a case-by-case basis.
- **What can the private sector do?** The private sector should conduct a market study to determine the suitable level of subsidy.
- **What can development partners do?** Development partners can estimate the broader economic benefit to the area, which should be taken into account in setting the subsidy.

Issue #3: How can parity be achieved between mini grid rates and the subsidized national tariff while also ensuring affordability?

Proposed solution: The subsidy should not be heavily regulated.

- **What can the government do?** The government should avoid heavy-handed regulation. Information on the level of the national grid subsidy should be made available to increase transparency.
- **What can the private sector do?** The private sector can help prepare a realistic business plan to help inform tariff setting.
- **What can development partners do?** Development partners can help build capacity.

Staff from various ministries in Myanmar, as well as participants from other developing and partner countries attended the HOMER Software training facilitated by ESMAP.

3. Three Standardized Solar Hybrid Mini Grid Packages: Peter Lilienthal (Homer)

Solar mini grid systems can be designed at three different sizes: small (10 kW), medium (80 kW), and large (1 MW). Criteria for selecting the size should include:

- population density
- distance from the grid
- load diversity
- cost of diesel fuel and cost of diesel generator
- installed cost of a solar system
- tariff structure.

Issue #1: How can demand be estimated?

Proposed solution: Demand can be estimated through surveys, studies, and promotion of productive-use anchor loads.

- **What can government do?** The government can design appliance efficiency standards, conduct surveys, and project future load in line with the project lifetime. It can clearly define electricity access in national policies based on the Multitier Framework to clarify at what tier (Tier 0–Tier 5) of access is electricity considered.
- **What can the private sector do?** The private sector can develop modular systems that can easily be adapted to growing demand. It can make data on the cost of components public.
- **What can development partners do?** Development partners can conduct surveys and other studies.

Issue #2: How can the quality of distribution systems be ensured?

Proposed solution: The quality of distribution systems can be ensured by developing quality standards, procuring good quality components, and building capacity.

- **What can government do?** The government can implement and enforce quality standards and build capacity for designing and building systems that meet standards.
- **What can the private sector do?** The private sector can ensure the quality of its products and equipment, factoring in quality procedures and procurement and using certified equipment and demand warranties from equipment manufacturers.
- **What can development partners do?** Development partners can sample standards and respect and appreciate the cost/quality trade-offs. Criteria in requests should not outweigh price; they should also focus on quality. Development partners should also focus on capacity building.

Issue #3: How can capacity building be made part of the process?

Proposed solution: Consumer education drives, dedicated project management training, and continuous training can help improve capacity.

- **What can government do?** Government can provide project management training (knowledge of bidding procedures, permits, clearances, tariffs) and help educate consumers. It can partner with local universities to build local capacity and include capacity building as an integral part of its institutional framework.
- **What can the private sector do?** The private sector can focus on consumer education and system design training.

- **What can development partners do?** Development partners can arrange for a continuous training program for local suppliers and manufacturers on installation and manufacturing. They can help establish incentives to retain trained manpower. They can increase consumer awareness/education on operations and maintenance and support technical training.

4. Standardizing Process for Productive Uses and Integrating Gender Considerations: Svati Bhogle (TIDE [member of Energia]) and Sebastian Rodriguez (Infrastructure for Sustainable Development)

The design of mini grids usually focuses on a technical solution that is often misaligned with the outcomes stakeholders desire. Women are generally underrepresented at all levels in the energy sector. As mini grids are deployed in areas where women's participation is strong, new opportunities for capacity building are required for both men and women. Participation of women throughout the value chain, especially at decision-making positions, offers opportunities and long-term benefits.

Issue #1: Women's perceptions and participation during the design process are frequently not considered because of lack of adequate communication channels and materials and technology-centric approaches. How can this be fixed?

Proposed solution: Women's participation should be accounted for throughout the project cycle, including in project planning and load management. The focus should not be limited to productive uses. Activities around productive uses should include activities women perform, such as grinding and agricultural activities.

Issue #2: How can the impact of mini grid development on women become more of a focus?

Proposed solution: An outcomes framework is different for men and women. Gender implications should be considered in consultations, planning, construction, operation, and the development of productive uses.

5. Digital Platforms for Community Engagement: Avinash Kumar (Director, Quicksand Design Studio, India)

Other sectors have engaged communities. Engagement with end-users could be undertaken through storytelling and infographics/comics.

Issue #1: How can perceptions of energy solutions be changed?

Proposed solution: Proper terminology needs to be used to connect with consumers. For instance, hydropower is referred to as "water mills" in Myanmar. The roles of village chiefs and perceptions at the village level should be noted and gender roles understood. Engagement is not only a technological discourse, it is also a social discourse.

- **What can government do?** The government can survey target and marginalized groups to see how they use electricity for productive uses and livelihoods. It could determine from surveys how power changes people's daily lives and communicate that information through films.
- **What can the private sector do?** The private sector can communicate directly with target groups as part of system design and determine how to communicate tariffs to communities.

- **What can development partners do?** Development partners need to conduct gender consultations as part of their funding commitment and contribute funds specifically for this activity.

Issue #2: How can developers determine how potential end-users use energy, in order to design systems that meet their needs?

Proposed solution:

- **What can government do?** The government can consult with women during the preparation phases to customize solutions to their needs. It can promote mini grid development as a service that enables the kinds of uses households need rather than purely in terms of the number of kilowatt hours available.
- **What can the private sector do?** The private sector can ensure that costs can be covered by the tariffs. It can develop new processes and devices based on hybrid power consumption for specific livelihoods (e.g., irrigation for growing rice, bananas, and tubers).
- **What can development partners do?** Development partners can create financing and communication programs to facilitate the recommendations made above and inform the government and private sector engagements.

6. Three Asian Case Studies on the Arrival of the Main Grid: Chris Greacen (World Bank Consultant)

There are examples of isolated village mini grids connecting to the main grid, but they are rare. The cost of interconnection depends on the business model (wholesale small power producer, small power distributor, or coexisting retail power producer and distributor). Case studies from Cambodia, Sri Lanka, and Indonesia indicate (see figure 1)

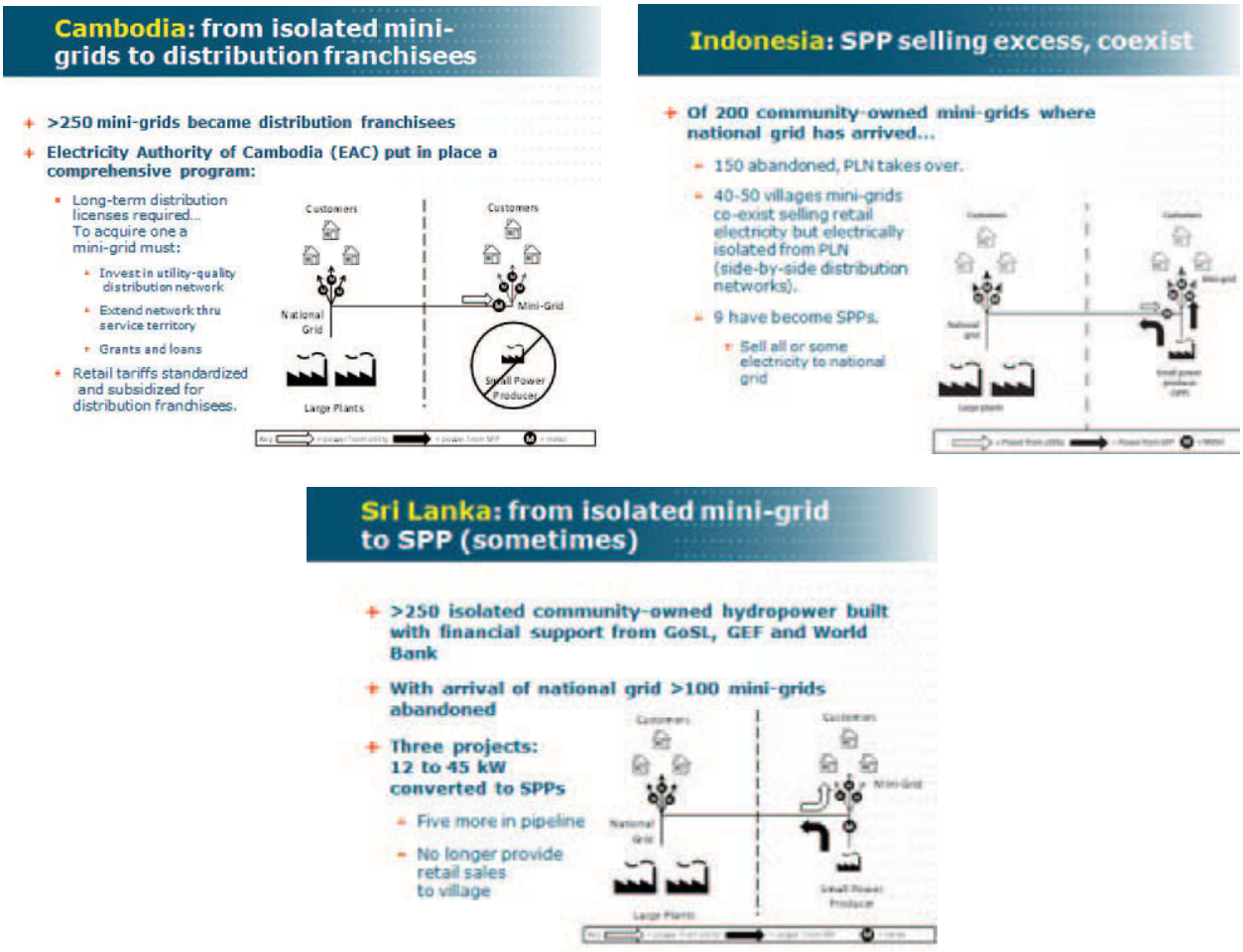
- Long-term distribution licenses required
- Invest in utility quality distribution network
- Extend network through service area
- Standardize and subsidize retail tariff for distribution franchisees

Issue #1: How can the risks associated with the arrival of the national grid be reduced?

Proposed solution:

- **What can government do?** The government can help make available on the web a geospatial masterplan with a more nuanced understanding of mini grid versus grid extension costs to serve specific villages. It can provide assurance that if a mini grid is built in an area that is 10 years away from main grid extension, the government will provide compensation if the grid arrives sooner than planned. The regulator can allow small power producers to interconnect and agree to purchase electricity from mini grid generators at the feed-in tariff. It can allow mini grids to become small power distributors and provide a special low wholesale tariff.
- **What can the private sector do?** Mini grid players can exercise caution in selection locations that are at least X miles/Y years from the national grid. They can build grid-ready distribution networks where appropriate and adopt business models that anticipate arrival of the grid.

Figure 1 | What happens when the national grid arrives? Case studies from Cambodia, Sri Lanka, and Indonesia.



7. Interconnection and Technical Specifications: Payomsarit Sripattananon (Thailand Provincial Electricity Authority [VSPP])

Issue #1: What happens to the ownership and operation of the distribution system when the grid arrives?

Proposed solution: Either the national utility or the mini grid developer owns the distribution system. Maintenance is easier and the regulatory burden lighter if the utility owns it. But mini grid developers would like to stay in business and keep serving customers.

Issue #2: Is it desirable for mini grid owners to build to grid code, or should "skinny grids" be built that are replaced when the main grid arrives?

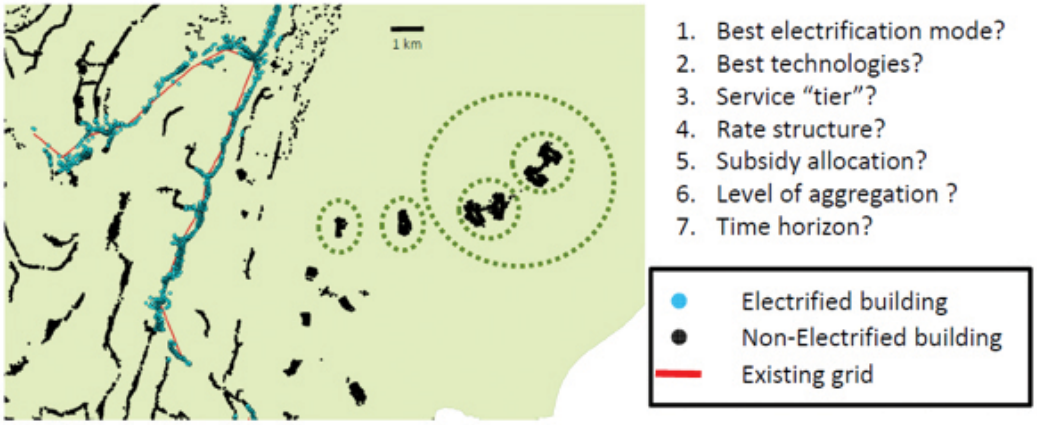
Proposed solution: The solution depends on these factors:

- the cost of a "skinny grid" versus a utility-compatible grid
- how much electricity customers will use
- when (or whether) the main grid arrives
- whether the utility will purchase mini grid assets (and at what price) or allow small power distributors.

8. Geospatial Planning: Claudio Vergara (MIT)

Geospatial planning is an integral part of designing any energy access intervention (figure 2).

Figure 2 | Using a geospatial plan to make decisions about mini grids



Issue #1: How useful are master plans?

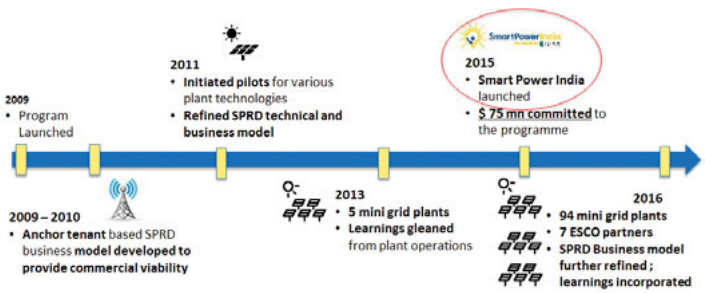
Proposed solution: Master plans are helpful, but they need to be publicly available and easy to update, ideally along with a web-based interface.

- **What can the government do?** The government can facilitate the process by providing information for the location of buildings and census data. It can also ensure open accessibility by creating a transparent database updated by a government or external agency.
- **What can the private sector do?** The private sector can focus on the technology aspects of the mini grid components.
- **What can development partners do?** Development partners can provide survey data, such as the multitier framework with the consideration of gathering information related to geospatial planning.

9. Facilitating New and Established Mini Grid Companies: Pariphan Uawithya (Rockefeller Foundation)

Smart Power India (SPI) was established with initial support from the Rockefeller Foundation (figure 3). It is operating in the states of Uttar Pradesh, Bihar, and Jharkhand.

Figure 3 | Timeline of Rockefeller Foundation's venture in mini grids in India



Issue #1: Lack of financing and financial intermediaries

Issue #2: How can the lack of support services for existing and new developers be addressed?

Proposed solution: A facility can be created that coordinates end-to-end implementation support services to private developers.

- **What can government do?** Government can support a facility to coordinate end-to-end implementation support services to private developers.
- **What can the private sector do?** The private sector (developers/financiers) can engage in mini grid operations.
- **What can development partners do?** Development partners can fund the facility, using concessionary financing (debt) and grants.

10. Guarantees and Financial Products: Kapila Subasinghe—Vice President (Corporate Banking) at DFCC Bank

Issue #1: What can be done to encourage banks to finance private or community-owned mini grid systems?

Proposed solution: Several types of actions can help overcome banks' reluctance to lend in the sector:

- Provide access to long-term funds through commercial loan. Loans should be available at commercial terms.
- Mainstream credit delivery, including by making it a viable business with opportunities to cross-sell other financial products.
- Start with a few financial institutions that express willingness and expand to others through loan syndications.
- Encourage established banks to finance microfinance institutions on the strength of their balance sheets for off-grid renewable energy financing.
- Provide training and capacity building to financial institutions, developers, and beneficiaries.
- Create Standard Power Purchase Agreements (SPPAs).
- Assess grid expansion plans to understand when the grid might arrive.
- Secure commitments from provincial councils for off-grid electrification through grants.
- Collateral
    - Secure cash flows through escrow accounts
    - Mortgage of project assets and shares
    - Custody of SPPA, project documents, licenses, and rights
    - Cross guarantees
- **What can government do?** Government can design and provide credit guarantee schemes.
- **What can the private sector do?** The private sector can form associations to aggregate projects, leverage technology to mitigate operational risks, and develop shared insurance schemes.
- **What can development partners do?** Donors can provide access to long-term funding, access to concessionary loans, and/or grant support.

7 | CLOSING REMARKS

Rohit Khanna, the Manager of the Energy Sector Management Assistance Program (ESMAP), and Jon Exel, the Program Lead for the Global Mini Grids Facility at ESMAP, provided closing remarks.

Closing Remarks by Rohit Khanna (ESMAP)

The good attendance at this event reflects increased global interest in mini grids. Down the road, everyone will look back and realize the essential role of the critical mass of projects and community of support.

Integrating mini grids as part of rural electrification is challenging. The issues—subsidies, universal tariffs, planning for the arrival of the grid—are the same around the world, but the solutions are not. They must reflect local circumstances. Continued dialogue with all stakeholders is therefore critical. Particularly important is the private sector, which can identify the appetite for risk, constraints, and information gaps.

The development community has an important role to play in promoting mini grids. The World Bank/ESMAP, together with DFID and Danida, is continuing to implement the Global Facility on Mini Grids. To play its facilitating role, the development community needs to acquire a deep understanding of the status quo and what the goals of the mini grid community are. ESMAP global mini grid events support knowledge exchange. The Climate Investment Fund and ESMAP will continue to support learning on the operationalization of mini grids. Each event will build on the experience of previous learning events.

Next steps include the following:

- Improve donor coordination. Governments and mini grid developers can become overwhelmed by too many experts flying in and giving contradictory advice.
- Continue to provide opportunities for joint learning, capacity building, generation of knowledge and tools, and collaboration.
- Understand the flexibility needed to create a vibrant space for private sector investment.
- Find creative ways to foster productive uses; integrate women at all levels of mini grid development processes; and engage and educate consumers and communities about the benefits of energy, particularly mini grids.

Closing Remarks by Jon Exel (ESMAP)

Jon Exel, the Program Lead for the Global Mini Grids Facility at ESMAP, discussed what is needed to provide a value proposition to the end-user. Drawing parallels to the solar home system industry, which was nascent until a few years ago, he observed that most of the issues around solar home systems have been resolved. Similar progress will take place in the mini grid sector, driven largely by cost reductions already seen in the marketplace and by innovations through smart technologies. These drivers will bring solutions and provide value for people in the field.

Successful development of the sector requires the following:

- a focus on productive uses of mini grids
- the involvement of small, medium, and large companies
- regulation that is cautiously designed and practical

- resolution of grid expansion issues through smart regulations and negotiated contracts
- resolution of grid expansion through agreement.

Almost 300 people from 52 countries participated in the event, providing cross-fertilization of ideas and knowledge. For instance, the Renewable Energy Association of Myanmar (REAM) has expressed keen interest in learning more about pilot solar-diesel hybrids based on what it learned this week about the Rockefeller Foundation's description of the work it has done in India.

In Myanmar, ESMAP's Global Facility on Mini Grids, in partnership with SREP and the Climate Investment Fund, will continue to support the preparation and implementation of mini grid operations as part of the basket of solutions—grid extension, mini grids, individual home systems—countries are using to achieve universal access. These projects should be viewed as learning by doing as countries move toward upscaling.

The next steps could include implementation of a component on mini grids in projects. This effort could start with a small number of mini grids, focusing on productive uses that have helped in the development process. A framework could be built to select and support mini grids. It should be flexible enough to allow funds from other agencies to flow through it.

ESMAP will continue to provide just-in-time support to its clients in preparing and implementing projects. The World Bank has a roster of experts in place, including experts on mini grid and off-grid solutions. Many of the experts that have been leading sessions today will continue to be available to assist operational teams and clients in resolving problems in a timely fashion.

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APPENDIX A | DESCRIPTION OF MINI GRIDS VISITED

The learning event included field visits to two villages in central Myanmar that are served by mini grids, one powered by diesel and one by solar PV. The mini grids in both villages are owned and operated by the local village electrification committee (VEC).

Myin Chi Naing

Myin Chi Naing village, in Kyaukse Township, Mandalay District, has three identical 3.6 kW solar PV mini grids. They are providing electricity to 200 households, a monastery, and a library. Villagers are delighted that their houses—and their streets—are no longer dark at night.

The system powers two five-watt LED lights, a USB charging port, and a 230-volt electrical outlet in each household. Many households also use the electricity to charge cell phones and watch TV.

Households purchase electricity using a prepay metering system that uses magnetic cards. All customers are signed up for the basic package, which provides up to 100 Wh of electricity a day and a maximum of 50 W at any time. Each consumer can consume up to 3 kWh a month. Tariffs are K 1,500 (about $1.10) a month. As demand increases, SolarRiseSys may increase capacity and provide additional tariff levels.

The mini grids were built by the Yangon-based SolaRiseSys Co., Ltd., as part of an Asian Development Bank (ADB) pilot program that installed solar PV–based mini grids in 12 villages in the Mandalay, Magway, and Saiging regions. A grant from the ADB covered 80 percent of the capital costs to put the infrastructure, including power poles, solar panels, batteries, and meters, in place. The project is owned and operated by the local VEC, with technical support from SolaRiseSys.

SolaRiseSys is ready to replicate and expand its efforts, even without subsidies. What it needs are enabling mini grid policies and regulations by the government.

The system was built to be “grid-ready” in two ways. First, electricity is distributed on grid-ready concrete poles. Second, the inverter has the ability to connect with the grid, using grid power to charge batteries and providing the mini grid with a supplemental source of power. The inverter could be swapped out for an inverter with the capability for bidirectional power flows, injecting solar electricity into the grid when batteries are charged and the solar panels are providing a surplus.

This 3.6 kW solar PV mini grid is one of three such mini grids in the village of Myin Chi Naing.

Execution Agency: Department of Rural Development (DRD), under the Ministry of Agriculture, Livestock and Irrigation (MALI)

Development Partner: Asian Development Bank, with funding from the Japan Fund for Poverty Reduction (JFPR)

Technical Consultant: Nexant Asia

Project cost: $98,580, of which 20 percent was paid by the village (10 percent during the delivery of equipment and 10 percent one year after commissioning, upon verification of acceptable performance of the system)

Ton Lon

Ton Lon is located three miles from the grid; main grid electricity is expected to be installed in 2017. The village's 100 residents are too poor to afford the up-front connection fee, however.

About a third of its residents connect to the mini grid. Users who pay K 2,500 ($1.84) a month can turn on a single 26 W compact fluorescent lamp (CFL) bulb. For K 4,000 a month ($2.94), they can power a CFL and a television. Payment of the monthly fee also entitles the household to use the water from a tank located next to the generator. Local leaders are interested in finding a way to bring electricity to the majority of households in the village, who cannot afford the monthly fees.

The generator is owned and managed by the VEC, which comprises 14 people. The VEC is split into seven groups of two. Each pair starts and stops the generator one day a week. The generator operates from 6 P.M. to 9 P.M., at the same time that water is pumped.

Ton Lon's genset is a 24 horsepower, 1-cylinder diesel agricultural engine manufactured by Changzhou machinery, coupled with a universal joint made of strips of an old tire to a 10 kW single-phase alternator (Chinese-made, brand unknown). In 2016 the DRD gave the generator to the village to power a submersible pump (which it also provided) that draws water from a 200-foot well. The installation was one of many similar installations by the DRD in the area. The installation company won a regional tender for installation of these combination diesel generators/well pumps. The village later added a distribution system comprising a mixture of interior-grade romex-type wire and galvanized steel baling wire wrapped around tree branches or crude wooden poles. Voltage losses are assumed to be huge, especially in rainy weather (wet trees conduct electricity to ground).

Lon is typical of the village-operated mini grids found in much of rural Myanmar that were not built as part of any government program. In building the distribution system, the village did not seek technical help but built it themselves.

Diesel costs K 3,400 ($2.50) a gallon; the generator burns about 1 gallon during the three hours it is operated. The occasional breakdown of the generator results in no service for three to four days until a repairman can be sent to the village.

Project cost: DRD provided the diesel generator to the village at no cost.

APPENDIX B | THE GLOBAL FACILITY ON MINI GRIDS

Lack of knowledge and exposure to proven practices continues to create regulatory, commercial, and implementation barriers that hold back the expansion of sustainable mini grids. In response, the Energy Sector Management Assistance Program (ESMAP) initiated a Global Facility on Mini Grids to accelerate the pace of electrification by scaling up least-cost mini grids into World Bank Group operations and developing the knowledge to do so.

Focusing on Sub-Saharan Africa, South Asia, East Asia, and Small Island Developing States, the facility has two pillars:

- **Operational upscaling.** Under this pillar, the facility supports activities to mainstream least-cost mini grids into World Bank Group operations. Where possible, these mini grids will be powered by renewable energy.
- **Global knowledge development and learning.** Under this pillar, the facility supports activities to develop the required knowledge to assist in achieving the first objective. This development will look at the experience of mini grid projects worldwide and disseminate proven practices through partnerships, including the Clean Energy Mini Grids High Impact Opportunity of the SE4ALL initiative.

The Global Facility is designed to complement a range of programs by other development agencies. It constitutes the knowledge management component of the Green Mini Grid Market Development Programme supported by the Department or International Development (DFID) in Africa and by other implementing partners, including the African Development Bank and the rural energy agencies of Kenya and Tanzania.

Knowledge outputs (research studies, case studies, guidance notes) produced under the facility will directly benefit client governments by informing their policies and programs to attract private sector investment for clean energy mini grids. World Bank operational teams and partners will use them, and the Bank will disseminate them widely through events organized by the Facility and SE4ALL's Clean Energy Mini Grids High Impact Opportunity.

APPENDIX C | STATUS AND PROGRESS OF SCALING-UP RENEWABLE ENERGY PROGRAM (SREP) PROJECTS

Table C.1a | Status and progress of Scaling-Up Renewable Energy Program (SREP) projects

COUNTRY	POPULATION AND ACCESS TO ELECTRICITY	PROJECT DESCRIPTION	STATUS	ISSUES AND WAY FORWARD
Benin	Population (2013): 10 million Share of population with access to electricity: 27 percent (about 55 percent in urban areas and 7 percent in rural areas)	Project 1: Deployment of renewable energies. Project includes construction of decentralized mini grids with electricity generating units from renewable energies in 50 localities and support for realization of PV solar power stations connected to the grid. Project 2: Support of government and private developers selected under the "Production of Electricity" component of the Millennium Challenge Account Benin II Program.	• Under formulation • Investment plan to be submitted	Issues are largely political. Formulation period of first project document coincided with electoral period in Benin. After new regime took office, new focal point appointed. Agreement needed on projects to be prioritized in the IP.
Ghana	Population: 26.9 million Share of population with access to electricity: 83 percent national (2016)	Project 1: Construction of renewable energy mini grids and stand-alone solar PV systems Project 2: Installation of solar PV–based net metering Project 3: Generation of utility-scale solar PV/wind power	• Cabinet approval obtained • Letters of agreements signed • Mini grid policy approved and operationalized	• Clarity needed on whether uniform tariff option means that cost difference will be paid for (through cross-subsidy, levy, etc.) or incorporated into Public Utilities Regulatory Commission rate-setting approval mechanism. • National grid electrification and mini grids initiatives have potential overlaps. • Technical requirements for mini grid development and future integration into main grid are needed. • Setting up the Project Cordination Unit and Project Implementation Unit at the Ministry of PowerP and EC.

(continued)

Table C.1a | Continued

COUNTRY	POPULATION AND ACCESS TO ELECTRICITY	PROJECT DESCRIPTION	STATUS	ISSUES AND WAY FORWARD
				• Two public sector investment projects are being developed into full (bankable) projects for consideration by the SREP subcommittee. • Full implementation of public sector-led SREP projects launched.
Haiti	Population: 10.9 million Share of population with access to electricity: 30 percent (5 percent in rural areas)	Project: Expansion and improvement of electricity services for households, businesses, and institutions. Project includes three components: • grid-connected variable renewable energy • off-grid electricity for productive, social, and household uses • creation of an enabling environment, capacities, and skills for renewable energy scale-up	• Project Concept Note finalized and endorsed • Project Document (PAD) for each component under preparation and close to being finalized • Financial and economic analysis • Environmental and social	• Need to assess impact of financial situation of the public utility—and sole off-taker—on project design (modification in design to mitigate risk). • Regulatory framework for grid-connected and off-grid renewables is absent. • Potential technical and financial risks are inherent to pioneering projects. • Need to identify complementary financing opportunities for on-grid renewable energy investment under the project and beyond. • Need to find approaches and methodologies to quickly build capacity of team in charge of SREP project implementation and determine how to scale up this capacity along with renewable energy market development. • Need to remove barriers to implementation of SREP project. • Need to ensure constant support from high-level decision makers.

Kenya	Population: 48.5 million Share of population with access to electricity: 54 percent national	Mini grid project under the Kenya Electricity Modernization Project (KEMP), to be implemented at cost of $10 million, financed by SREP ($7.5 million) and IDA ($ 2.5 million)	• Project financing agreements for IDA financing and SREP grant signed by IDA and the government of Kenya • Subsidiary agreements under IDA funds and SREP funds signed • Project implementation unit established in Rural Energy Authority • Land allocated by county governments for all potential sites	• How to enhance inclusion of private sector in mini grids—through a regulatory framework or a business model? • What should technical standards be? • What form should financial compensation take (subsidies?)? • World Bank is supporting Kenya in using geospatial mapping to identify more potential areas for establishment of mini grids. • Electrification in these areas will be through renewable energy mini grids and stand-alone renewable energy systems. • Electrification strategy is being undertaken. Issues include who will operate and manage mini grids.
Liberia	Population: 4.4 million (2014) Share of population with access to electricity: Less than 10 percent	SREP Liberia is currently $50 million. The Climate Investment Fund grant is split equally between the World Bank and the African Development Bank. Liberia Renewable Energy Access Project (LIRENAP) includes components: • construction of a hybrid mini-hydro and diesel generation plant • provision of technical assistance to strengthen rural electrification institutions and regulations • market development of stand-alone solar systems: fostering the growth of a market for solar energy lighting devices	• Project approved • Environmental and social management framework and resettlement policy framework developed • Detailed feasibility study of hydropower site and diesel plant conducted • Procurement ongoing for ESIA for diesel power plant and transmission lines; Resettlement Action Plan scheduled	• Local capacity is limited or lacking. • Foreign firms are discouraged from participating in the market, because their participation would raise costs significantly.

(continued)

Table C.1a | Continued

COUNTRY	POPULATION AND ACCESS TO ELECTRICITY	PROJECT DESCRIPTION	STATUS	ISSUES AND WAY FORWARD
Maldives	Population: 417,492 (2016) Share of population with access to electricity: 100 percent	POISED Renewable Energy for Outer Islands Small power station RE 2. RE readiness—power system rehabilitation 3. Outer Island solar/wind investments 4. Outer Island waste-to-energy investments	• Contracts awarded for five islands in October 2015. Other contracts • Complete and commission by February and March 2017	• Mini grid project will be one of biggest in the country. • Optimum level of renewable energy penetration has to be carefully assessed. • Private sector participation would be challenging. • Funding is not available to accomplish all projects government has planned. • Capacity should be developed.
Rwanda	Population: 11.7 million Share of population with access to electricity: 23 percent	$50 million SREP investment to enhance private sector investment in off-grid and mini grid solutions based on renewable energy. Implementation will be through a Renewable Energy Fund, to be created by the government.	Project approved by SREP in April 2017	• Mini grids are nascent subsector in Rwanda. Experience is limited to a few small (< 50 kW) systems. • Simplified licensing regulatory framework for mini grids has not been tested. • Tariff setting (cost-reflective, reasonable return). • Private developers perceive risk around grid expansion plans; need to develop options for private operators when the grid arrives. • Access to finance (viability gap financing, commercial debt). • Demand for mini grids is low in rural areas. • Hydro-resources are located far away from demand. • Technical and institutional capacity of private developers, government institutions, and commercial banks is weak.

		Some questions include: • How does one deal with competition between stand-alone systems and mini grids, given the cost reductions in solar systems? • Should people serviced by mini grids receive subsidies to level their tariff to the national tariff? • What are best practices for addressing concerns of private developers about what happens when the grid arrives? How do regulatory frameworks in other countries deal with this concern? How prescriptive should options for private developers be? How do private developers in other countries address their lower negotiating power vis-à-vis the national utility? • What are best practices for promoting productive uses of electricity in rural areas?

Table C.1b | Overview of the mini grid sector in selected countries

COUNTRY	POPULATION AND ACCESS TO ELECTRICITY	ISSUES	WAY FORWARD
Nepal	Population: 28 million Share of population with access to electricity: 76 percent	• Economic: Cost versus affordability of mini grid system (subsidy addresses the issue to some degree); lack of access to capital and credit; low penetration of productive use of energy • Policy and institutions: Policy for grid connection of mini grid systems to be finalized. Net-metering standard/guideline yet to be finalized. • Sociocultural and political: Most service centers and technicians are in urban regions. Fewer technicians are available in rural areas, where mini grid systems tend to be. • Market: Lack of competition and lack of robust supply chain leads to procurement challenges. • Technical: Condition of National Electricity Authority's electricity distribution system needs to be assessed for grid connection of mini grid system.	• Management of mini grid system: private or community model? Is private sector really interested in investing in energy service companies (ESCO)? • Scaling up in terms of capacity, geography, and penetration • Rural to urban transition to reduce burden on national grid and contribute in the greater energy mix • Subsidy-based mechanism
Solomon Islands	Population: 512,000 Share of population with grid-connected electricity: 12 percent	• Population is spread over many islands. • Land issues/consultation process • Network expansion—building in road reserve	• What comes first, economic growth or electricity infrastructure? • Economic growth and electricity go hand in hand • Solomon Power is taking the lead
Uganda	Population: 37.6 million Share of population with access to electricity: 20 percent	• Public financing to implement mini grids is lacking. • Licensing procedure by the Electricity Regulatory Authority is cumbersome. • Development of the off-grid master plan for the whole country has been delayed. • No policy has been established with respect to what happens to mini grids when the national grid extends to the area served by them. • There is political/public pressure to keep tariffs low. Doing so is difficult for mini grids.	With support from development partners, efforts are being made to subsidize up-front costs to ensure that tariff is affordable.

COUNTRY	POPULATION AND ACCESS TO ELECTRICITY	ISSUES	WAY FORWARD
Vanuatu	Population: 270,000 Share of population with access to electricity: 77 percent	Vanuatu's SREP Investment Plan includes: Hydropower project investments by the Asian Development Bank. • The World Bank Vanuatu Rural Electrification Project (VREP). VREP 1 supports "plug and play" solar systems to consumers in rural and remote areas; it is at the implementation stage. VREP II supports increased penetration of renewable energy and increased access to electricity services in off-grid areas of Vanuatu. Risks include the following: • Institutional capacity risks: Capacity of the Department of Energy (implementation of funded investments) and Utilities Regulatory Authority (manage competing demand for lower tariff) • Technological risks: Remoteness of islands is a challenge for systems (ongoing operations and durability to weather conditions) • Environmental risks: Potential for some clearing during construction of mini grids for some clearing of trees and crops • Social risks: Land ownership and managing disputes • Financial risks: Cost of systems and affordability by end-users	
Zambia	Population: 15.5 million Share of population with access to electricity: 31 percent (68 percent in urban areas, about 4 percent in rural areas)	• Initial investment costs of Mpanta solar mini grid (60 kWp) in Samfya, in the District of Luapula, are high. • Private sector is not keen on operating isolated grid mini grids because of low income levels, resulting in low fee revenues.	

Note: Table does not include SREP interventions that are at a very early stage, have not been approved, or have not been developed.

APPENDIX D | LINKS TO PRESENTATIONS BY SCALING-UP RENEWABLE ENERGY PROGRAM (SREP) COUNTRY

Benin

Ghana

Haiti

Kenya

Liberia

Maldives

Nepal

Rwanda

Solomon Islands

Uganda

Vanuatu

Zambia

Learning Event on Upscaling Mini Grids for Least Cost and Timely Access to Electricity Services | Nay Pyi Taw, Myanmar

Venue: Nay Pyi Taw, Myanmar

Event Brochure (agenda and bios)

Kick off Video (Jon Exel and Zhihong Zhang)

Presentations Day 1 | February 6, 2017

Presentations Day 2 | February 7, 2017

Photos Field Trip Day 3 | February 8, 2017

Presentations Day 4 | February 9, 2017

Media Advisory

Photo Story

Webstory

Blog

Interviews

"ESMAP is the Only Program that Combines Knowledge Exchange with Action on the Ground," says **Ms. Dipti Vaghela, Fulbright-Clinton Public Policy Fellowship, placed at the Renewable Energy Association of Myanmar, Hydro Empowerment Network**

Interview, Optimizing the Design of Mini Grids Training: **Dr. Peter Lilienthal, Creator of HOMER, Inc.**

Related Events

Upscaling Mini Grids for Least Cost and Timely Access to Electricity Services, Nairobi, Kenya

Learn more about the ESMAP **Energy Access** program and the ESMAP **Global Facility on Mini Grids.**

Questions or more information: **esmap@worldbank.org**

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Learn more about the ESMAP Energy Access program and the ESMAP Global Facility on Mini Grids: www.esmap.org/Energy_Access

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