CONFERENCE PROCEEDINGS

The Status of Mini-grids in Rural India

ROUNDTABLE DIALOGUE ON MINI-GRID IMPLEMENTATION IN JHARKHAND

May 6, 2022 | Ranchi, India | Lanvin Concessao and Dheeraj Kumar Gupta

OVERVIEW

On May 6, 2022, in Ranchi, WRI India and the Transform Rural India Foundation jointly organized the dialogue 'Mini-grid Implementation in Jharkhand'. The dialogue included discussions on the economic sustainability of mini-grids, the integration of productive-use-of-energy (PUE) applications for enhanced mini-grid utilization, policy support and financial requirements for scaling, and frameworks for measuring the ground-level impacts of mini-grids. The dialogue was attended by 38 experts from various backgrounds in the mini-grid sector who have implemented, financed and/or designed mini-grids for electricity access in rural and remote parts of Jharkhand and other Indian states (see list of participants).

During the discussions, experts highlighted the role of mini-grid implementation in delivering access to electrification in rural and remote parts of India, as well as its role in the country's ongoing energy transition. Equally important, the participants discussed the barriers to scaling mini-grid solutions in the present policy environment that has favored grid extension to all households. Participants emphasized the socioeconomic benefits of mini-grids for communities: providing access to a reliable and quality power source, improving productivity and generating income. They stressed the need for an enabling policy environment to create mini-grids that are sustainable and financially viable for unserved and underserved communities.

Participants offered the following recommendations:

- Promote community engagement and ownership for the inclusive growth and sustainability of mini-grids
- Map electricity access and development indicators across energy-poor states, especially where providing grid-connected power is not feasible

CONTENTS

The content of these conference proceedings reflects the views of the conference participants and does not necessarily reflect the views of the World Resources Institute or other conference partners. These proceedings aim to faithfully reflect the conversations and content generated at the conference but for ease of readability some wording has been edited.

- Establish coordination mechanisms between mini-grid developers and electricity distribution companies to provide reliable and affordable power in rural areas
- Create a conducive regulatory environment for tariff-setting and promotion of mini-grids
- Increase mini-grid capacity utilization by looking beyond household electrification and supporting uptake of PUE applications for livelihoods
- Integrate equity considerations into beneficiary selection and load management when adopting PUE appliances
- Develop impact frameworks to build evidence of mini-grid sustainability

INTRODUCTION

Access to electricity is a key driver and enabler of socioeconomic growth and improved livelihoods. In India, the Pradhan Mantri Sahaj Bijli Har Ghar Yojana ('Saubhagya') was launched in September 2017 to provide energy access to all by providing last-mile connectivity and electrifying all unelectrified households in the country. This target was achieved in March 2019, with the government declaring 100 percent electrification of all 'willing' households. This has been a commendable effort, with over 26.2 million rural households being connected to the national grid since 2017 (REC Limited 2022). This effort was aimed at extending the reach of grid electricity, but it did not specifically address the quality and reliability of electricity supply.

While the expansion of the main grid has significantly improved electricity access, mini-grids have played an important role in improving reliability of electricity services, particularly in rural areas which either have been unelectrified under previous rural electrification schemes or face continuous reliability problems like power outages and voltage fluctuations. This is one of the reasons why there were more than 14,000 mini-grid projects and over 2 million solar home systems deployed in India as of 2019 (SPI and ISEP 2019).

On May 6, 2022, the Transform Rural India Foundation (TRIF) and WRI India jointly organized a dialogue that brought together experts from civil society, financial institutions, government and the private sector to discuss the progress of mini-grid implementation in Jharkhand and other Indian states, and to reflect on the opportunities and barriers to scaling up mini-grid adoption. The dialogue was designed to collectively reflect on the lessons learned from mini-grid implementation across the country, in terms of system design, economic sustainability of mini-grids, integrating productive use applications, policy frameworks and financing for scaling up the use of mini-grids, as well as frameworks and metrics to measure mini-grids' impact.

The dialogue was aimed at addressing some of the critical questions and lessons learned from past implementation through conversations around the following themes:

- What measures are being taken to ensure the sustainability of mini-grids, in terms of both community engagement and operations and maintenance?
- What approaches have been used to set tariffs for mini-grids?
- How do consumers, implementing agencies and electricity distribution companies (DISCOMs) approach the issues involved in interconnecting mini-grids with the national grid?
- How do we create demand for PUE applications in mini-grids? How is load managed to ensure optimal utilization?
- How can the financing landscape for mini-grids be improved? How can measuring and monitoring impact frameworks support the scaling of mini-grids?

DIALOGUE OUTCOMES

Promote community engagement and ownership for the inclusive growth and sustainability of mini-grids

Communities play multiple roles in the mini-grid ecosystem: as beneficiaries, as owners and as customers of mini-grids, depending on the model of implementation and financing.

Experts argued that community involvement can increase the sustainability of mini-grid systems if communities are empowered to operate, manage and take ownership of their systems. Given that these are high-investment infrastructure, community buy-in right from the planning phase is essential to ensure that the systems are deployed in locations where they do not quickly become obsolete—due to either lack of utilization or inadequate management and servicing of the system. The community's energy needs must be properly mapped with aspirational loads (see Figure 1) while designing and sizing of mini-grids.

FIGURE 1 | Focus Group Discussion with mini-grid customers at Kurdeg Block, Simdega District, Jharkhand

Source: Compiled by WRI India

At the planning stage, community involvement informs developers about communities' energy needs, aspirations, socioeconomic conditions, crop production patterns, challenges, opportunities for storage and processing within the village and willingness and propensity to pay for services. Experts noted that formalized institutions formed within community, such as self-help groups, farmer producer organizations and Panchayati Raj institutions, play an important role in ensuring the inclusion of all communities in infrastructure planning for villages. These governance structures can ensure that no one is excluded from the benefits of infrastructure, regardless of caste, gender, age or religion.

Where formalized structures do not exist, robust community institutions, such as village energy committees (VECs), are created to oversee the management of mini-grids in villages. These VECs have decision-making authority on matters across the spectrum of mini-grid operations—including planning, installation, tariff determination and payment collection, operations and maintenance.

Entry Points for Action

It is important that community institutions be strengthened and encouraged to take up ownership of the mini-grids. Mini-grid developers should actively involve community and grassroots organizations to help build the capacity of VECs. Representation within these committees must consider gender balance and

adequate participation from all sections of society, especially the most marginalized groups. The committees also play a role in creating equitable ownership of PUE appliances by creating checks and balances to ensure that the financially well-off aren't the only ones in the community who can benefit from (and possibly exploit) mini-grids.

Map electricity access and development indicators across energy-poor states, especially where providing grid-connected power is not feasible

With the expansion of the main grid-based electrification, future mini-grid deployment will require methodical selection of unserved and underserved areas. Participants found that bringing electricity access to communities left behind in socioeconomic development should be prioritized for mini-grid deployment. One example shared was that of particularly vulnerable tribal groups in Jharkhand.

In 2022, Jharkhand released a new solar policy to reach a cumulative target of 110 megawatts for mini- and micro-grids, in the form of solar villages, by 2027 (JREDA 2022). Geospatial analysis can help government stakeholders map the right locations for implementation of solar villages. Geospatial tools like the Energy Access Explorer (EAE), developed by World Resources Institute, can provide location-specific information on resource availability such as solar irradiation, as well as data on infrastructure like road network, and transmission and distribution networks, to show the current energy supply situation. Mini-grid developers can also use the EAE to assess the level of available service, customer location, concentration of demand and available resources such as water bodies. This can also help government and development finance institutions direct the flow of capital into the right regions and communities to support electrification efforts.

Entry Points for Action

As the Jharkhand State Solar Policy and similar renewable energy policies state, implementation of solar energy projects in rural India will need better identification and mapping of suitable government and private land banks. Open-source geospatial platforms like the EAE can help different stakeholders identify and prioritize areas for energy access interventions with mini-grids as the supply source. Geospatial tools can help governments map the villages where main grid extension is expensive for DISCOMs. Such tools can allow users to aggregate supply and demand data from multiple databases and can be tailored to accommodate state specific data needs, based on the availability of datasets.

Establish coordination mechanisms between mini-grid developers and electricity distribution companies to provide reliable and affordable power in rural areas

Experts at the dialogue articulated diverse views on the integration of centralized and decentralized grids. Several mini-grid developers felt that DISCOMS do not fully recognize the presence and importance of mini-grids, and often see them as competitors. Lack of publicly laid out plans and timelines from the utilities for grid expansion has led to lack of awareness among mini-grid developers and consumers. This has further led to duplication of infrastructure in several areas, with varying implications for investments and for electricity supply to consumers. In some cases, once the grid was extended to an area, the mini-grids stopped being used and became stranded assets. In other regions with an unreliable main grid, new mini-grids have been deployed and are working well, as long as the main grid remains unreliable.

While not all mini-grids provide 24-7 power supply to communities, two things differentiate the mini-grids installed in rural and remote regions from the conventional grid: the predictability of electricity supply (reliability) and the improved quality of power supply for larger loads (i.e., three-phase connection). For this reason, some customers have continued to use mini-grid power in locations where grid power-supply quality and reliability issues persist, and they have been willing to pay higher mini-grid tariffs (Rockefeller Foundation et al. 2017).

Moreover, meaningful integration of mini-grids with the main grid is plagued with technological challenges, including unsafe interconnection with the grid at the correct frequency and phase, inconsistent frequency and voltage regulation for both mini-grids and utilities, grid instability due to intermittent power production on the mini-grids and the need for specialized hybrid inverters that can both export power to the grid and run without using the grid as a reference (Greacen et al. 2013).

> *Complementing mini-grids with the conventional grid has been brought up in many policy dialogues, and mini-grid operators have been provided with several options for access to national grids in rural areas. Specifically, mini-grids can:*
> *- Run in parallel to the conventional grid with separate distribution networks;*
> *- Sell electricity to the conventional grid at a tariff approved by the regulators;*
> *- Operate as an energy service company for the conventional grid in regions where the conventional grid is deemed unfeasible; and*
> *- Exit and transfer the assets to a DISCOM at a cost agreed to by the mini-grid operator and the DISCOM (Energy Department, Government of Bihar 2017; OERC 2019; UPNEDA 2016; JREDA 2022).*

Entry Points for Action

Integrating the mini-grids with the main grid would significantly improve the reach to unserved and underserved areas and build a holistic environment for electricity services. Initiatives that can avoid stranded mini-grid assets and enable greater coexistence (rather than competition) of solutions, while also providing the most economical way for communities to access reliable electricity, need to be identified. Coordination and regulatory mechanisms need to be set up to help bridge the gap between the perspectives of DISCOMs and those of mini-grid developers.

Create a conducive regulatory environment for tariff-setting and promotion of mini-grids

Section 14 of the Electricity Act of 2003 exempts a person who intends to generate and distribute electricity in a rural area (as notified by the state government) from obtaining a license. Therefore, mini-grids are mostly unregulated (except for safety and supply norms as imposed by the regulator under Section 53 of the Electricity Act of 2003), and tariffs are often decided by developers. Some developers consult the community in determining the tariff to be charged, while others do not. Tariff structures are designed based on the prevailing conditions of electricity access in the village and may vary from site to site. For example, the domestic tariff for a completely unelectrified village will differ from that of a partially electrified village.

This also extends to tariffs for productive use of energy (PUE) applications such as irrigation, where existing operating costs (such as current pump capacity, time taken to irrigate a plot of land, costs for fuel and for pump maintenance) are evaluated and tariffs are set to keep the operational costs lower than a diesel-based pump equivalent. With the energy consumption per hour for commercial appliances being higher than tariffs for domestic use, PUE consumer groups are charged higher, thereby cross-subsidizing household consumers.

Some mini-grids financed through grants or corporate social responsibility funding operate as a social good. In these cases, customers are charged a nominal per unit cost (around 10 rupees [INR] per kilowatt-hour [kWh]), irrespective of the type of load. This makes PUE appliances very cost-competitive compared to existing diesel-based applications.

Currently, mini-grid developers charge relatively higher tariffs to sustain and expand their operations For example, the energy charges per kWh charged by Jharkhand Bijli Vitran Nigam Limited (JBVNL) for domestic rural connection is around INR 5.75/kWh, excluding fixed costs (JSERC 2020). In comparison, dialogue participants estimated that mini-grid tariffs can range from INR 10/kWh to INR 45/kWh, depending on time of use. For solar mini-grids, day-time power is charged less, and customers are

encouraged to shift most PUE loads to the daytime. Users are charged a higher tariff during evening and night hours, since during these times solar mini-grids will run on batteries.

Entry Points for Action

Given that these tariffs range from two to six times the tariff of a grid electricity connection in rural areas, the use case for these mini-grids may be limited to places where reliable grid-connected power does not exist. Mini-grids built on zero- or low-cost capital with no or limited expectations of return may be hard to sustain in the long run, especially if funding arrangements are not in place for continued operations and maintenance of the system. The need for regulatory oversight needs to be explored in order to: support tariff determination, balance the long-term interests of various stakeholders and settle disputes. State government support for the mini-grid sector, through subsidies and investments, will strengthen the rationale for regulatory oversight.

Increase mini-grid capacity utilization by looking beyond household electrification and supporting uptake of PUE applications for livelihoods

Experts at the dialogue highlighted that while the focus of early mini-grid projects was on meeting the basic lighting and mobile phone charging needs of households, the expansion of the Saubhagya scheme to electrify households has also resulted in a shift towards deployment of mini-grid-enabled productive loads and microenterprises.

Choosing the right PUE application requires knowledge of the existing village environment and available resources like land, water, forest produce, crops and small industries. In addition, any new PUE will depend on new resources being made available to the users. For example, improved access to energy would allow farmers to use electric pumps to irrigate their fields and cultivate new crops (e.g., growing mustard in rabi season). This creates a new demand for processing of mustard seeds to produce oil, in addition to the existing practice of bartering crops in exchange for mustard oil, which is a staple in many households in Jharkhand.

Developers should assess the economic viability of these PUE applications. Often community members struggle to pay the full upfront cost of buying PUE appliances. The right last-mile financing options for communities need to be created. These could take the form of government subsidies, low-interest loans to procure appliances, innovative servicing models facilitated by mini-grid developers (e.g., pay-as-you-use) or rental models.

For traditional loans for productive-use appliances, financiers will have to comply with Reserve Bank of India regulations and will need to gauge the repayment capacity of the end-user community. VECs are often not registered as legal entities, unlike farmer producer organizations or cooperatives. This makes lending to VECs and the community members a challenge for financial institutions.

Creating market opportunities and linkages must be investigated once financing for PUE applications is available. Communities should be supported in building market ecosystems that include good road networks, transportation, storage and access to urban markets. The creation of these value chains should ensure that maximum benefits are garnered by the community—the mini-grid's primary beneficiary.

Entry Points for Action

Establishing community-led formal entities registered with the government can create more avenues for financing different livelihood activities under mini-grids. The Solar Pump Irrigators' Cooperative Enterprise (SPICE) in Dhundi is one example of a cooperative model that has solarized its irrigation system, replacing diesel-based pumps in the village. Their formal legal status helped finance institutions reduce the risk of lending funds to them and allowed for transformation of the irrigation systems.

Integrate equity considerations into beneficiary selection and load management when adopting PUE appliances

With greater utilization, equity considerations play a role in the selection of beneficiaries within the threshold of a mini-grid's capacity. Project developers must assess the village's power dynamics with respect to economic status, spatial spread, religion and caste, among others. There are three primary types of loads: domestic, social and productive. Domestic and social loads (e.g., health care centres and schools) can be managed relatively easily due to the predictability of energy demand, but more attention needs to be given while connecting productive loads.

In most cases, project developers can leverage the presence of local grassroots organizations, development institutions and community member groups to promote awareness, outreach and mobilization in the community and among consumers. In the planning stages it is important to identify the 'early adopter' beneficiaries. The early adopters are usually those who are experienced in running similar PUE applications on a different energy source (such as using rice hullers powered by diesel engines). These early adopters could be more open to innovation and taking risk, as they could be more familiar with the raw materials and business economics of running such applications. Some of these early adopter entrepreneurs can emerge as changemakers within the village and motivate others to build microenterprises with similar interventions. This happens primarily when entrepreneurs begin to see the positive impact of mini-grid-powered PUE applications in terms of reduced operation costs (fuel costs), greater processing efficiency, ease of operation and maintenance and therefore higher income generation. In addition to among 'early adopters', PUE applications need to be made feasible for socially and economically weaker households in the village.

Load management, critical for any mini-grid, is the joint responsibility of the developer, mini-grid operator and consumer. Dialogue participants shared examples of mini-grids in Jharkhand's Simdega district, where irrigation pumps, rice hullers and pulverizers are scheduled to operate at different hours. Experts have noticed that PUE applications, currently being powered by diesel generators, are usually oversized—due either to limited market options at the time of procurement or lack of awareness as to the appliance capacity. Moreover, the seasonality of produce makes the PUE utilization intermittent—where year-round mini-grid utilization varies. This may discourage investment, as income generation for new customers is viewed as a seasonal activity at times. Experts highlighted that recent years have seen an uptake of 'combo machines' which can process multiple products, such as the rice mill with pulverizer combination machine (as shown in Figure 2). This allows the same PUE to be used across multiple seasons for commodities grown at different times of the year. Participants recognized, however, that standardization is currently lacking in the PUE appliance sector.

FIGURE 2 | Individual entrepreneur-run solar-powered rice mill with pulveriser combo machine in Nalbari district, Assam

Source: Compiled by WRI India

Entry Points for Action

Projection of demand and supply, along with capacity building and training on load management, is important for mini-grid operators and VECs. When accompanied by behavioral changes and scheduling practices, mini-grids can become more sustainable with less chances of breakdown. Mini-grid planners and donors need to explore expansion of mini-grids through modular systems, once they reach maximum utilization. Research and development of energy-efficient and multipurpose PUE applications should be supported to provide greater throughput and minimize the seasonality effect.

Develop impact frameworks to build evidence of mini-grid sustainability

From the perspective of simple payback periods, mini-grids do not appear to be a profitable venture. Participants in the dialogue underscored the need to look beyond traditional payback analysis in evaluating the viability of mini-grids and instead to ensure that the projects' social impacts are adequately considered. Therefore, it is important to set out the installation's objective and incorporate monitoring and evaluation (M&E) as an integral component, right from the design phase.

Participants agreed that mini-grid developers, the community and financial institutions all need to become stakeholders in the M&E of these interventions. This ensures that M&E is not limited to the short time frames that programs are designed for but becomes a mechanism that is regularly operationalized throughout a project's lifetime. Given the potential cross-cutting impact, the M&E plan should be designed to have distinct key performance indicators (KPIs) for the various stakeholders—implementers, end users (community), government and financial institutions. Currently, different mini-grid developers have different ways of measuring and reporting their impacts on the ground. This wide variety of approaches need to be streamlined for external audiences, such as the government or financial institutions.

Entry Points for Action

The concept of social return on investment is valuable to help quantify the social, environmental and economic value of these projects to financial institutions. The capacity of traditional banks and financial institutions should be built along similar lines to identify bankable projects with socioeconomic outcomes. For this, a standardized set of KPIs needs to be finalized in advance, in consultation with various mini-grid developers, donors and the community to regularly measure, monitor and report the economic, social, health and climate impacts of mini-grid interventions across the country. It is also imperative to build the capacity of communities to participate in the M&E process. Communication of the M&E findings at regular intervals allows for analysis of changes throughout the project, which in turn, creates space for learning, adaptation, and course correction, if needed. Figure 3 lists themes and indicative metrics that can be measured, as suggested by the participants.

NEXT STEPS

As the insights from this dialogue reveal, while there are several opportunities for providing reliable access to electricity in rural and remote regions through mini-grids there are several challenges in creating an integrated approach, which means coordinating among stakeholders across government agencies, electricity providers, mini-grid operators, communities and development organizations. Based on the feedback and reflections from the dialogue, WRI India and TRIF will work with stakeholders across the mini-grid ecosystem in pursuit of the following activities:

- Utilize geospatial mapping tools to aggregate electricity access and development indicators across states to prioritize regions where model villages powered by mini-grids
- Amplify the need for policy support to bridge the gap between the perspectives of distribution companies and those of the mini-grid ecosystem. Assess the need for government incentives and tariff regulation to achieve cost-parity by studying other countries' examples of integration with the utility grid.
- Explore financing instruments and innovate business models to scale farm- and non-farm-based PUE applications in rural India.
- Support enhancement of mini-grid capacity utilization through research and development for energy-efficient PUE applications, build community awareness regarding time-of-day usage and explore emerging solutions such as electrification (and charging) of rural transport vehicles like electric scooters.

FIGURE 3 | Themes and indicators that can be measured

Livelihoods	▫ Greater income generation within households ▫ Improved access to external markets to sell farm and non-farm produce
Health	▫ Improved health service delivery ▫ Change in health-seeking behaviour (e.g., number of institutional deliveries)
Education	▫ Greater access to online education and smart learning ▫ Improved school infrastructure
Climate Resilience	▫ Greater long-term sustainability, thanks to mini-grids' resilience to climate change impacts (extreme heat, floods, lightning, thunderstorms, etc.)
GHG Emissions	▫ Greater access to online education and smart learning ▫ Improved school infrastructure
Gender	▫ Reduced Drudgery ▫ Greater participation of women in mini-grid-powered livelihood activities
Quality of Life	▫ Improved quality of life patterns for all sections of society (safer streets, better learning outcomes from enhanced study hours, entertainment, etc)
Customer Retention	▫ Shorter resolution time for troubleshooting ▫ Customer satisfaction and perception of development post-electrification

Notes: GHG = greenhouse gas; RE = renewable energy.
Source: Compiled by WRI India

- When designing mini-grids, standardize field assessment guides to map current energy needs (i.e., those of households, productive-uses and social loads), as well as the community's aspirations in terms of electric appliances and microenterprise development.
- Foster dialogues among government, regulators, DISCOMs, mini-grid developers, academia and civil society to promote the sharing of knowledge and reflections on the creation of a collaborative ecosystem where different energy-supply options to target unserved and underserved regions can coexist.
- Design measurement, monitoring and evaluation frameworks to capture the socioeconomic impacts of mini-grid installations.

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ABOUT WRI INDIA

World Resources Institute India is a research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our approach

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.

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