

\_\_\_\_\_ REEEP®

# SCALE AND SUSTAINABILITY

\_\_\_\_\_ TOWARD A PUBLIC-PRIVATE  
PARADIGM IN POWERING INDIA

December 2017





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## ABOUT THIS DOCUMENT



This report is easier to describe for what it is not, rather than for what it is. It is not an academic study; it is not a promotional brochure; it is not fully comprehensive in scope, nor final in its conclusions. It is intended not to conclude a discussion on rural electrification in India, but to spark a new one.

REEEP - the Renewable Energy and Energy Efficiency Partnership - is an international multilateral partnership with a mandate to leverage the private sector in pursuing climate-friendly energy for all. In doing so, we focus on so-called “market-based” solutions to energy challenges in developing countries, an approach that pursues economic, in addition to environmental, sustainability. In our work, we look for technologies and business models on the cusp of profitability, but also for challenges such as lack of market information, imperfect risk perceptions among key actors and inefficient market distortions. Our role, as we see it, is to tackle those hurdles, while supporting inherently solid market approaches to clean energy.

Basic access to modern energy is one of the most fundamental issues facing developing and emerging economies - including India. To accelerate the expansion of access, REEEP has supported market-based Decentralised Renewable Energy (or DRE) solutions. The sector is inherently thorny for market actors for many reasons, most of which can be traced back to the fact that almost nobody, anywhere, pays the true market price for the power they consume. In reality, most governments consider power to be a public good. As such, they spend billions of dollars in subsidies every year toward building and maintaining the infrastructure for generating, transmitting and distributing power through the main utility grid.

DRE, as this report argues, has the potential to rapidly bring power to people who are without it, in a way that is faster and more cost-effective than extending the main grid. It also has the potential to do so in an economically and environmentally sustainable manner, and in the process achieve significant

impact in mitigating climate change, enabling livelihoods and improving quality of life. This potential will go unmet, however, for as long as the playing field between traditional grid power and DRE remains uneven.

This document assesses the DRE market - looking at the supply, demand and framework conditions for the sector - and articulates potential approaches to levelling the playing field. These approaches are meant primarily for the consideration of actors in the international development cooperation and financing space - such as development agencies, development financing institutions (DFIs), multilateral development banks (MDBs), philanthropic foundations and impact investors - as well as relevant Indian Government stakeholders at central and state levels.

In assessing the sector, REEEP spoke with dozens of representatives from MDBs and other DFIs, impact investors and commercial financial institutions, as well as policymakers, regulators and commercial actors. REEEP also interviewed a number of DRE enterprises participating in the Rockefeller Foundation’s Smart Power for Rural Development (SPRD) initiative (see page 30). Furthermore, the authors assessed individual site data and project economics for several indicative deployments across the Indian states of Uttar Pradesh and Bihar.

This paper does not delve into specific technologies or business models in any great detail (although it does touch on a few), but rather focuses on the overall long-term political economy of electrification, and on potential approaches and mechanisms that international impact-connected financing and national government stakeholders could employ to de-risk the sector immediately by building predictability and security for investment.

This report represents the views of REEEP, and not necessarily those of the Rockefeller Foundation, Smart Power India, the Government of India, or any other institution or individuals. □



**DRE, as this report argues, has the potential to rapidly bring power to people who are without it, in a way that is faster and more cost-effective than extending the main grid.”**



# ACRONYMS AND KEY TERMS

AC	alternating current
CEA	Central Electricity Authority (India)
CO <sub>2</sub> e	carbon dioxide equivalent
DC	direct current
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DESCO	distributed energy service company
DFI	development financing institution
DRE	decentralised renewable energy
GoI	Government of India
GW	gigawatt
IFC	International Finance Corporation
IPP	independent power producer
LCOE	levelised cost of electricity
LED	light-emitting diode
MDB	multilateral development bank
MoP	Ministry of Power (India)
MNRE	Ministry of New and Renewable Energy (India)
MW	megawatt
PPA	power-purchase agreement
PV	photovoltaic
RBF	results-based financing
REC	Rural Electrification Corporation Limited
REEEP	Renewable Energy and Energy Efficiency Partnership
RESP	rural energy service provider
RF	Rockefeller Foundation
SHS	solar home system
SPD	small power distributor
SPRD	Smart Power for Rural Development
SPV	special-purpose vehicle
TANESCO	Tanzania Electricity Supply Company Limited (India)
UDAY	Ujwal DISCOM Assurance Yojana
UP	Uttar Pradesh
UPERC	Uttar Pradesh Electricity Regulatory Commission
UPNEDA	Uttar Pradesh New and Renewable Energy Development Agency

# ACKNOWLEDGEMENTS

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**Up to 300 million people in India have no electricity – a building block of a prosperous modern society. Many more lack reliable access to electric power.**

# EXECUTIVE SUMMARY

Current plans to provide “Power for All” in India via the country’s utility or distribution companies (known as discoms), through main-grid extension and utility-scale generation projects, are largely polluting, slow to build, and expensive. The central utility grid is 70% coal-powered, and the proportion of fossil fuels is still expected to be greater than 50% of the energy mix in 2040, despite high targets for renewable-energy generation capacity and heavy investment in it.

Grid power projects and extension, such as laying high-voltage transmission lines, take years from conception to completion, incurring enormous time-linked opportunity costs for underserved communities, in addition to the already extremely high capital costs of such infrastructure. However, the weakest link in the power value chain is distribution. This challenge is ultimately political and economic in nature, since with few exceptions discoms are chronic loss-makers and perpetually stressed financially. Providing power for all under the existing paradigm will therefore be a drawn-out and hugely expensive enterprise, despite the successes of existing government electrification programmes.

Mini-grids powered by decentralised renewable energy (DRE), and operated by distributed energy service companies (DESCOs), which provide a utility-like service on a for-profit basis, can offer a long-term, solution for the underserved, which can expand rapidly and easily along with demand. DRE-powered mini-grids are quickly deployed and reasonably priced. Furthermore, if done in the right way, such mini-grids can be integrated with the main grid at a later date. Equally significant, DRE power is environmentally cleaner than coal - or diesel-generated alternatives.

Mini-grids and DESCO business models, particularly those based on solar photovoltaic (PV) cells with battery storage, have largely met with success in field tests, providing both reliable and significantly cleaner power than the hundreds of thousands of diesel generators that provide electricity across many rural villages. DESCOs give households a “grid experience” unmatched by localised solar home systems (SHS), in addition to providing household and commercial customers with economic opportunities for energy-intensive appliance upgrades.

DESCO-operated mini-grids are not yet viable on a purely commercial basis, due to high up-front capital expenditures, low levels of initial effective demand, and high levels of uncertainty among investors as to the sector’s long-term

viability. Chief among the risks for mini-grid operators and investors in India is the arrival of the central utility grid to a mini-grid-serviced area - often via low-voltage distribution lines, at high cost and incurring significant network losses. Given the extremely low discom tariffs, these grid extensions - even though they often provide unpredictable and insufficient power - are highly disruptive to DESCO project economics, despite clear customer preferences for more reliable services.

Investors see other risks in the mini-grid model, sometimes erroneously. REEEP’s investigations revealed significant concerns connected to customer behaviour, particularly theft and non-payment, but these issues have largely been overcome by operators.

Electrical power is a political issue in India, as it is in most countries. Power is subsidised, and likely will be for a great many years to come. There have been encouraging signs in 2016 and 2017 of government interest in DRE mini-grids, both at state level, with the ground-breaking release of the first state mini-grid policy in Uttar Pradesh, and at the central government level, with movement towards a national mini-grid policy. Indeed, just prior to publication of this report the Modi Government announced a plan to electrify

every household in India by 2019. The \$2.5b plan, known as Saubhagya, is both ambitious and risky, dependent as it is upon a blend of public and private financing, but relying largely on public or quasi-public institutions to deploy and maintain. It will also likely test the limits of the government in overcoming structural economic and physical barriers, as this report will show. But current incentive schemes are sub-optimal, the procedures for securing them are unclear and lack transparency, and it is unknown whether they will be available at the scale required for mini-grids to make a significant impact on the “Power for All” challenge.

Ultimately, the sector will require long-term cooperation between the public and private sectors in order to render DESCO-model mini-grid deployments viable at scale and attract sufficient amounts of domestic and international investment. Such cooperation is sensible and to be expected, given the characteristics of the rural electrification space.

An important consideration for securing funding is that international development cooperation agencies, development financing institutions (DFIs) and multilateral development banks (MDBs) have expressed interest in supporting climate-smart energy access in India. DRE mini-grids offer precisely this kind of power. DFIs and MDBs could contribute actively and effectively to the development of a collaborative public-private approach via targeted investments in projects and financial instruments.

Such investments could include pilot projects on protocols for grid arrival and interactivity; innovative financial instruments to nationally standardise and securitise infrastructure-class distribution assets; targeted support for off-take and end-users; and insurance mechanisms to cover asset transfers, and improved feed-in tariffs and service fees to ensure long-term revenue security, depending on the model.

The importance of such investments in India is immense, given the role of energy access in economic development and well-being. The value for the climate would also be considerable: by REEEP estimates, a long-term (15-year) electrification of 15,500 “mini-grid ready” villages in the states of Bihar and Uttar Pradesh alone would meet the electricity needs of 36.5 million people and mitigate over 122 million tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions, while reducing local particulate-matter pollution from diesel and kerosene combustion. This has important implications for climate-linked DFIs as a potential source of funding for DRE mini-grids. □



**A long-term (15-year) electrification of 15,500 “mini-grid ready” villages in the states of Bihar and Uttar Pradesh could meet the electricity needs of 36.5 million people and mitigate up to 122 million tonnes of CO<sub>2</sub>e.”**





The focus on generation obscures the power sector’s principal bottlenecks, which lie in transmission and distribution.

# THE BACKDROP TO POWER AND ELECTRIFICATION IN INDIA

INDIA’S CURRENT CAPACITY:

329 GW

DEMAND (INCLUDING UNSERVED- AND UNDERSERVED POPULATION):

440 GW

AVERAGE TIME TO PREPARE TYPICAL GRID EXTENSION PROJECTS:

9 years from conception to commissioning

Energy is a fundamental building block of a modern, prosperous society. Yet worldwide, around 1.2 billion people have no access to electricity, and as many as 2 billion do not have sufficient electricity to meet their needs. More of these energy-poor people live in India than in any other country. With around 590,000 out of 597,000 villages designated as “electrified,” India’s official electrification rate is 98.8% (Rural Electrification Corporation Limited, 2017). Yet around 300 million Indians - or 23% of the population - have little to no electricity access (NITI Aayog, 2017). This dichotomy underscores both the complexity of energy access as a concept, and the uniqueness of the “Power for All” challenge in India, a country in many ways as modern as any other in the world, but where significant swathes of the country clearly have not yet caught up with the 21st century have not yet gained access to modern services and conveniences. Access to electricity in India faces hurdles of generation, transmission and distribution, but also of policy, regulation, economics and reform.

GENERATION

India has largely pursued an accelerated version of the traditional electrification paradigm, typified by utility-scale generation projects and extension of the central utility grid (Comello et al, 2017). The country’s energy mix relies heavily on coal, which accounts for around 70% of total generation and results in India having one of the most carbon-intensive electricity grids in the world (Brander et al, 2011). In 2015 the International Energy Agency still touted India as the next global coal centre after the decline in demand in China, predicting that India would account for half of the coal-fired generation capacity installed worldwide until 2040. However, in December 2016 India’s Central Electricity Authority (CEA) released a National Electricity Plan which states that apart from plants already under construction, no new coal-based capacity will be required in the next decade (Central Electricity Authority, 2016). The anticipated growth in demand for electricity and thermal energy to fuel the country’s economic growth is certainly significant - nearly 900 gigawatts (GW) of new generation capacity will be needed by 2040. Nevertheless, a focus on generation obscures the power sector’s principal bottlenecks, which lie in transmission and distribution. —>

Below: The main road in Gopalganj, Bihar. Credit: James Smith for REEEP





COST OF GRID EXTENSION (\$/KM)\*

Source: Fuso Nerini et al., 2016

5,000

LOW VOLTAGE LINE (0.2 KV)

9,000

MEDIUM VOLTAGE LINE (33 KV)

28,000

HIGH VOLTAGE LINE (69 KV)

53,000

HIGH VOLTAGE LINE (108 KV)

\*This excludes costs for transformers, household connections etc.

Right: Irrigation service. Credit: Mlinda Jharkhand

TRANSMISSION

As of September 2017 India has 329GW in installed capacity serving around 160GW of demand. Yet the country has still suffers regular peak power shortages (for instance, nearly 2 GW across all states in June of 2017) (Central Electricity Authority, 2017), leading to considerable losses for the economy (losses due to peak power shortage were estimated at \$68 billion in 2013) (Federation of Indian Chambers of Commerce & Industry, 2013). While India has presided over significant growth in generation in a short amount of time, it remains comparatively slow at building high-voltage transmission lines. An average transmission line project, once conceptualised, takes 9 years just to commission (Federation of Indian Chambers of Commerce & Industry, 2013). Once commissioned, projects often face unanticipated delays and budget overruns, usually associated with land-use and clearance issues. Today, only around 5% of India’s electricity network consists of high-voltage transmission lines (the remainder being low-voltage distribution lines). This contributes to some of the highest network losses in the world (22.7%, compared with 6-7% in China and 2.5% in the European Union) (Central Electricity Authority, 2017; International Energy Agency, 2015), and leads to severe inefficiencies in managing loads. The result is significant deficiencies in power availability and quality even for “electrified” households in most areas of the country outside urban centres.

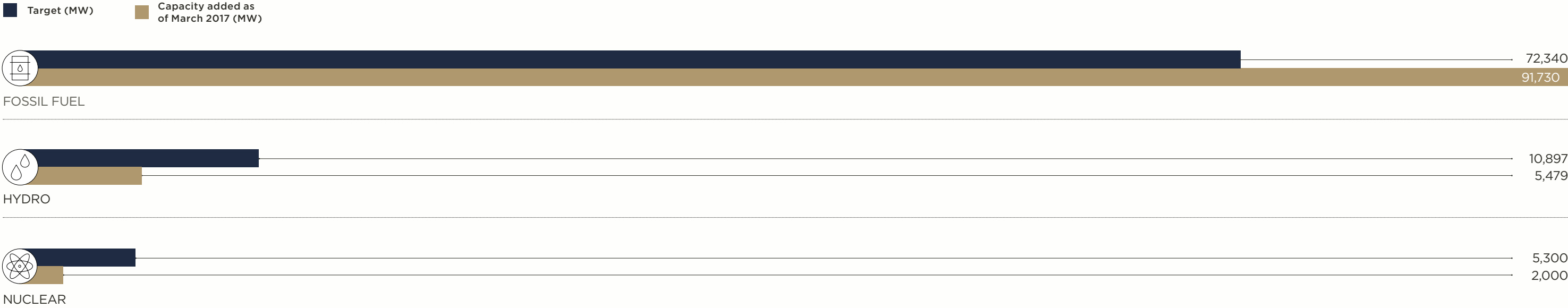
DISTRIBUTION

As critical as the transmission bottleneck is, power distribution presents perhaps a greater hurdle to bringing power to India’s rural areas under the existing paradigm - indeed, the government has acknowledged that distribution is the “weakest link in the value chain” of power (Press Information Bureau - Government of India, 2015). Major technical and practical obstacles are the sheer number of (often geographically →

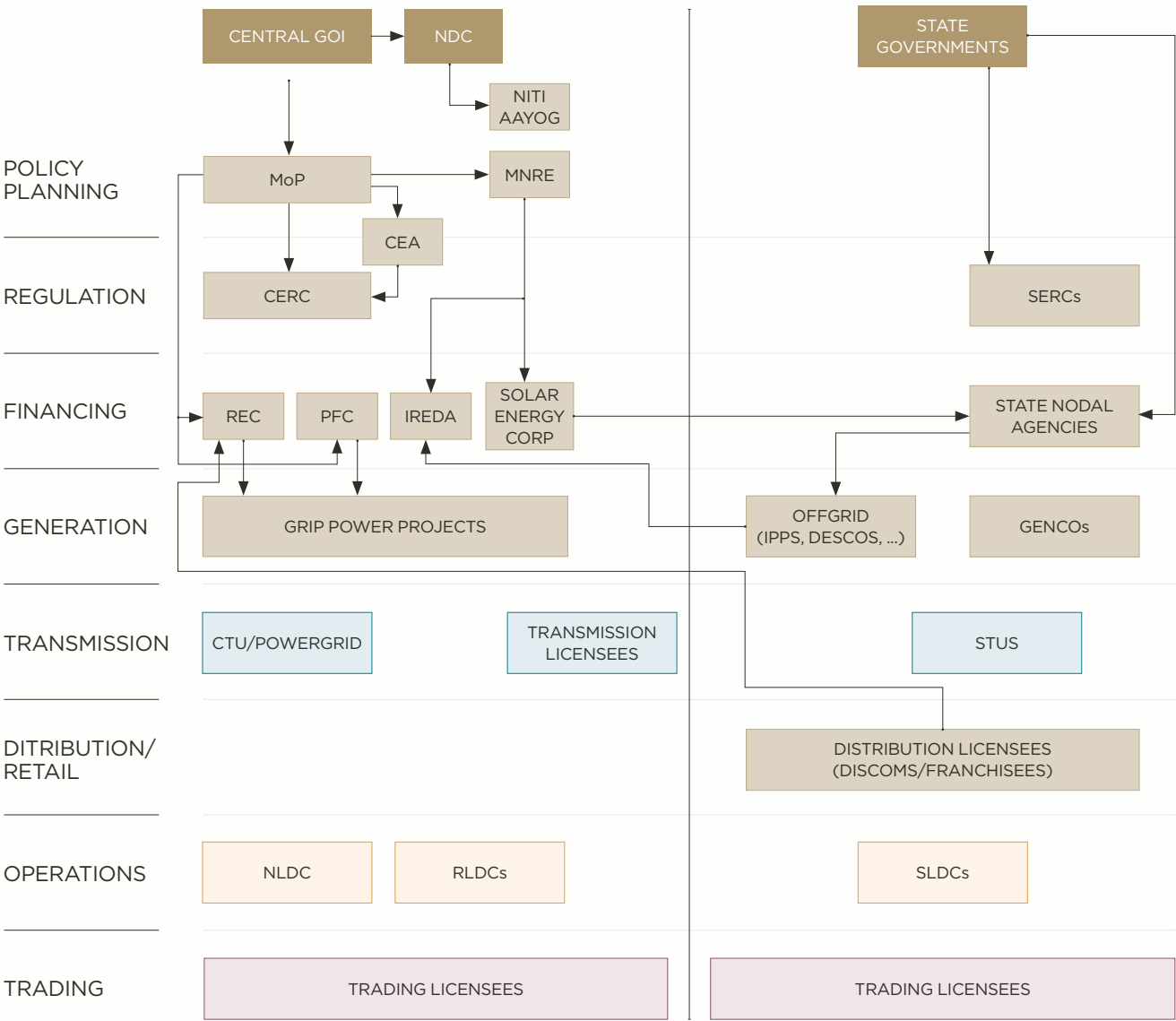


INDIA IS MEETING ITS POWER PRODUCTION TARGETS, BUT RELYING LARGELY UPON NEW COAL-FIRED CAPACITY TO DO SO:

Source: Central Electricity Authority, 2017



INDIA POWER  
SECTOR LANDSCAPE



KEY:

- |  |   |   |
|--|---|---|
| <b>GOI:</b> Central Government of India                      | <b>REC:</b> Rural Electrification Corporation Ltd               | <b>CTU:</b> Central Transmission Utility (POWERGRID)                            |
| <b>NDC:</b> National Development Council                     | <b>PFC:</b> Power Finance Corporation Ltd                       | <b>STUs:</b> State Transmission Utilities                                       |
| <b>NITI AAYOG:</b> National Institute for Transforming India | <b>IREDA:</b> Indian Renewable Energy Development Agency Ltd    | <b>DISCOMs:</b> Distribution Companies/ Licencees                               |
| <b>MNRE:</b> Ministry of New and Renewable Energy            | <b>Solar Energy Corp:</b> Solar Energy Corporation of India Ltd | <b>NLDC/RLDCs:</b> National Load Despatch Centre/Regional Load Despatch Centres |
| <b>CEA:</b> Central Electricity Authority                    | <b>SERCs:</b> State Electricity Regulatory Commissions          | <b>SLDCs:</b> State Load Despatch Centres                                       |
| <b>CERC:</b> Central Electricity Regulatory Committee        | <b>GENCOs:</b> Generation Companies                             | <b>MoP:</b> Ministry of Power   |

remote) unconnected households in the country, insufficient last-mile supply because of limitations in transmission infrastructure, widespread theft, and other transactional losses. Ultimately, however, the challenge is a political and economic one, due to the importance of distribution operations in financing the power value chain (i.e. revenue collection from customers).

POLICY AND REGULATION

Power provision is a politicised issue in most countries; it is no different in India. Of note is the inclusion of electricity in the Concurrent List of the Indian Constitution, which means it is the purview of both the central Government of India (GoI) and state governments. The constellation of ministries and agencies responsible for electrification is complex (see the figure on the opposite page), with the central Ministry of Power (MoP) holding core responsibility. The MoP is advised in strategic planning by the CEA, and in policy-making, tariff-setting and regulatory issues by the Central Electricity Regulatory Commission. The government-owned Rural Electrification Corporation Limited (REC), under the purview of the MoP, is responsible for infrastructure financing for rural electrification projects of all types. State-level regulation is handled by State Electricity Regulatory Commissions, transmission by a state-government-designated State Transmission Utility (to ensure neutrality in transmission networks), and distribution by one to three public or private power-distribution companies, or discoms.

ECONOMICS

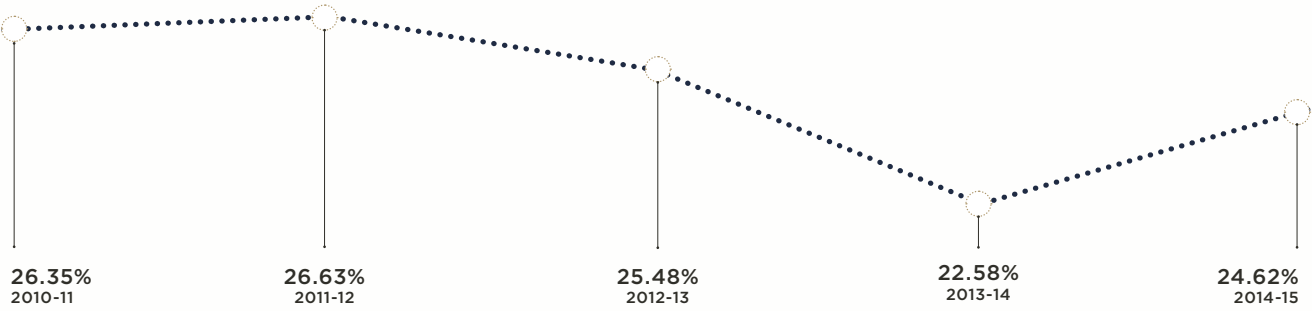
With a few exceptions, the country's discoms are chronic loss-makers and perpetually stressed financially. In 2015 discoms had sector-wide losses totalling over \$60bn and outstanding debt of around \$70bn (Press Information Bureau - Government of India, 2015). The technical and commercial losses in distribution of around 25% mean that discoms are still losing almost a quarter of the revenue they should be collecting (Pargal & Ghosh Banerjee, 2014; Central Electricity Authority, 2017). Aside from technical losses and theft - in 2011, five states lost more than 100% of distribution revenues - the sector is hamstrung by below-cost recovery tariff levels. The discrepancies between costs and revenues of electricity provision generally increase toward the physical boundaries of the network. This means that in purely financial terms the extension of the utility grid to serve households and shops is an economically disastrous investment for discoms. In 2011 utilities made a loss of \$0.06-\$0.08 for each kWh of power sold to rural consumers (Press Information Bureau - Government of India, 2015). The subsidies to discoms for grid extension, managed by REC, have not matched expectations, and are often not enough to cover operating costs of new distribution infrastructure that the REC has built out via direct procurements. →

Below: A mini-grid run by TARA Urja in the Gopalganj district in Bihar. Credit: James Smith for REEEP



AGGREGATE TECHNICAL AND COMMERCIAL LOSSES

Source: Central Electricity Authority, 2017





ENERGY MIX IN GW  
(IEA, 2015; CEA, 2017)

Fossil Fuels  
Nuclear  
Renewables



Source: IEA, 2015; CEA, 2017

“

India’s aggregate technical and commercial network losses (ATC) are some of the highest worldwide at nearly 23%, leading to severe inefficiencies in managing load and maintaining sustainable economics.”

The upshot of the power sector’s political economy is that communities living on the edge of, or just beyond, the grid remain trapped in power limbo. In the near term, it is almost certain that some type of basic grid connection – undertaken at high cost and at low efficiency, and providing low-quality and low-availability power – will arrive at a village. However, the deployment of last-mile distribution infrastructure to connect households and other off-takers within rural and peri-urban villages (sometimes called “intensification”) is a monumental and time-intensive undertaking, and thus a highly uninviting investment for discoms looking to improve their financial performance.<sup>1</sup>

REFORM

Since the late 1990s the government has made a number of efforts to bring the situation under control. Under the most recent initiative, the Ujwal DISCOM Assurance Yojana (UDAY) introduced in November 2015, states are permitted to transfer 75% of participating discoms’ debts onto their own balance sheets, issuing new bonds to cover the amounts, and convert the remainder into more manageable commercial products. This will have the effect of immediately lowering interest rates to around 8% from the 13%-15% that discoms currently pay to service debt. Discoms will also receive enhanced access to grants under several incentive schemes, including the country’s rural electrification scheme, Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY). In return, the discoms must implement a range of reforms designed to improve operational and financial efficiency, and meet milestones over the programme’s lifespan. As of this writing, around 90% of discoms’ total debt load has been shifted to state balance sheets or to restructured commercial loans and bonds. The long-term impact of UDAY is not yet clear, and in the absence of serious reform of tariff structures it is not known to what degree states will be able to soak up discom losses over longer periods of time. The other unknown will be Saubhagya, the Government of India’s recently-announced initiative, backed up by \$2.5b, to electrify every household in the country by 2019. The plan is short on details, but clearly relies on a blend of financing between the central (60%), state (10%) and banks (30%). Without addressing key underlying issues, however, it is far too early to comment on whether the plan can overcome the structural economic, financial and physical challenges laid out in this report. □

<sup>1</sup>The unattractiveness of this activity is exacerbated when – as is typically the case – those villages are largely agricultural, as agricultural users of electricity are further subsidised, both through cross-subsidies within the distribution network (generally from industrial users) as well as through separate direct subsidies from other branches of government.

Right: A cell tower, anchor load for renewable energy provided by DESI Power, in Araria District, Bihar, India. Credit: Robin Wyatt for the Rockefeller Foundation







**Left:** A man shows his solar lantern in Kasina village, Saran district, Bihar. Credit: James Smith for REEEP



In the long term, DRE can spur economic growth, reduce the opportunity cost of providing power to underserved communities, and build resilience into the central utility grid.

# DECENTRALISED RENEWABLE ENERGY, MINI-GRIDS AND THE UTILITY MODEL

The lack of access to electricity in rural areas, and the poor prospects for rapid, reliable electrification in the short term, have opened the door for private commercial providers of decentralised (distributed) electricity services to rural communities in some parts of India (see box left). They have begun to uncap the suppressed demand for power, and are in most cases able to make a (usually modest) return on investment in the process. These actors offer a unique opportunity to relieve stress on the country’s discoms and accelerate rural and peri-urban electrification in the near term. In the longer term, they could spur economic growth, reduce the opportunity cost of providing power to underserved communities and build resilience into the central utility grid through “interactivity”, i.e., by supplying some or all of the power they produce to the central grid. **Grid interactivity entails a technical and procedural integration between parts of, or the entirety of, production, storage and distribution infrastructure of the distributed energy service provider and that of the central grid. One of the promising models of provision of decentralised electricity services is through mini-grids powered by renewable energy sources.**

Decentralised (or distributed) renewable energy (DRE) refers to any system that uses renewable energy to generate, store (in some cases) and distribute power in a localised way. These systems fall into three categories: small solar or biomass-powered devices, such as solar lanterns and advanced biomass cooking stoves; integrated solar-powered home systems (SHS), which power multiple devices or appliances for a single household; and “small” generation and storage resources (typically somewhere between 1kW and 10MW)<sup>2</sup> connected to isolated distribution networks. Systems in this third category, usually called mini-grids or micro-grids (this report refers to them as mini-grids), are powered by solar, biomass, wind or hydro, or a combination of two of these sources. They use battery banks for stabilisation and storage and are often backed up by diesel/petrol generators.

Several models of mini-grid operation have emerged in underserved areas worldwide in which the system is run as a “mini utility”. In such cases, a privately-run distributed energy service company (DESCO) has the role of building, owning, operating and maintaining the entire mini-grid system, although the degree of responsibility in one or more of these areas can vary, even within the so-called BOOM (build-own-operate-maintain) model.<sup>2</sup> DESCO business models - like those of large utilities - require a broad spectrum of expertise to undertake a range of activities, from designing the technical specifications of complex power systems to acquiring and serving a large number of customers, all while navigating often-labyrinthine regulatory and licensing regimes. Unlike utilities, however, DESCOS typically pursue - at least as an objective - commercial returns, although they are also usually supported by some form of non-market financing, such as grant funding or concessional debt. →

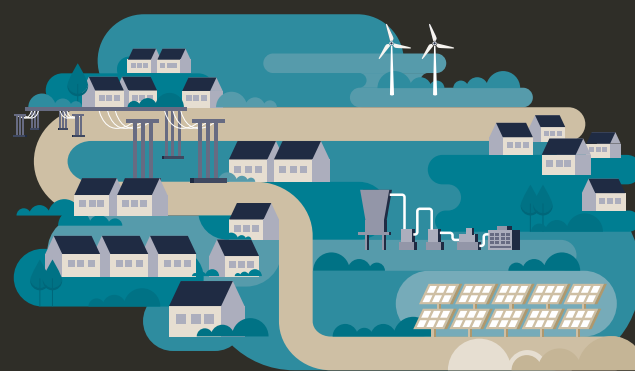


# COMPARING MINI-GRIDS TO SOLAR HOME SYSTEMS



## SOLAR HOME SYSTEMS

- Tech lifetime 3 - 5 years
- Typical capacity 10-100W
- Potential to serve a wide and large customer base with basic energy services quicker than with mini-grids
- Viable also in lower density areas (in comparison to mini-grids) and in hilly or mountainous areas
- Market growth to date driven by private sector actors (supported by grant funding and impact finance)
- Lower market barrier to entry for businesses in comparison to mini-grids, which require high degree of planning and technical know-how
- End-user focused businesses focused on enabling access to energy services rather than kWh
- Business models more mature than DESCOs
- Appliance efficiency improvements and decreasing tech costs increasing value proposition, but ceilings in load exist
- PAYG technologies relatively advanced and enable flexible pricing and (1 - 3 year) payment models to match customer cash flow
- Technology enables remote system shut down reducing risk of revenue collection
- Technology enables customer data collection improving understanding of sector risk, business models, energy needs and predictability for businesses improving the attractiveness of the sector for investment over time



## MINI-GRIDS

- Tech lifetime 15 - 20 years
- Enable customers to gradually increase level of energy service (improve level of energy access across tiers) with higher or effectively no load ceilings
- Able to serve a mix of customers (households, productive and institutional customers) and higher levels of energy needs/demand beyond the basic energy needs
- Greater diversity in income-generating loads (i.e. refrigerators, larger televisions, computers, pressing irons, sewing machines, power tools, agricultural machinery, etc.)
- Viable in relatively high density areas with little geographic variation (i.e. generally flat), minimum and maximum population sizes depending on business models, and often with anchor clients offering high and/or stable and predictable energy demand codified in power purchase agreements (PPAs)
- Current market growth mainly donor-driven with few if any purely commercial DESCO models globally
- Require clear legal and regulatory framework conditions for long-term sustainability
- Relatively complex technical and operational aspects together with relatively high CAPEX for mini-grids increase barrier to entry for businesses
- Usually implemented with a variety of BOOM (build-own-operate-maintain) models
- Typically 7-10 year project payback period
- Smart metering, monitoring and consumer financing solutions as well as advances in battery technologies improve the prospects and shape the mini-grid business models in the future

The DESCO mini-grid sector is still very young, but it has developed rapidly in the past few years, thanks to some key technological and other advances. These include remote smart monitoring and metering, mobile billing and payment, and consumer financing models. Advances in storage (battery) technologies are crucial to the sector's growth and sustainability, but high prices and a focus on industrialised-country applications have slowed the impact of improved batteries on DESCO mini-grid installations. Only recently, for instance, have lithium-ion battery banks appeared in mini-grid systems, despite their longer lifespan and superior performance in remote settings and in warm climates. This recent progress is the result on the one hand of improved economics thanks to massive growth in battery production for other applications, such as Tesla in the United States and a host of suppliers in China. But it is also helped by targeted support for research and development of developing country-specific applications. One example of this is The Rockefeller Foundation's support for the Institute of Transformative Technologies, which is testing and assessing new battery technology for mini-grid appropriateness in the lab before they are deployed to the field.

Other progress relevant to the DRE sector more generally includes advances in ultra high-efficiency devices and appliances, since these lower the load required to service households and small businesses and thus make mini-grids more viable. Examples include LED lamps and high-efficiency televisions, and in lower-cost brushless direct-current (DC) motors that can power items such as fans, refrigerators and water pumps. Indeed, because solar PV natively produces DC power, there has been an increasing emphasis on the potential of fully DC mini-grids. But while the efficiency and cost advantages of fully DC systems make them especially appropriate for very remote areas (i.e., those with no electricity access and to which grid extension is prohibitively expensive), they are not technically compatible with the three-phase alternating current (AC) of the central utility grid. Technical compatibility is the basis of mini-grid-to-grid interactivity, which is a crucial element of any sustainable public-private approach for leveraging market-based DRE towards rural electrification (see page 34).

One drawback to the rapid pace of advances in the DRE mini-grid sector is that there is often a lack of communication among major stakeholders involved in electrification, particularly when it comes to understanding the risks and opportunities of current technologies and business models. There is considerable uncertainty, even among major players with significant financial exposure to the sector, regarding the "bankability" prospects of DESCO projects, the capacity of private DESCOs to maintain a sustainable presence as well as to build and operate at scale, the commitment of central and state governments to maintain subsidy regimes, and even the basic demographics of target areas in a time of rapid urbanisation. Several categories of investor see investments in rural Indian villages with payback periods greater than 3-4 years as untenably risky, leaving DESCO projects - whose payback periods are often 7-10 years or more - out of the picture. At the same time, many public-sector stakeholders are unaware that DESCOs have largely solved long-standing challenges such as asset theft and non-payment. The scepticism towards DESCOs among many in the public sector seems partially based on past experiences with decentralised mini-grid deployments (although those were not commercial models).

There remain a number of knowledge and credibility gaps with regard to the long-term potential of DESCOs to reach scale, provide customers with sufficient quality and service and survive without concessional financial support. These gaps relate primarily to the DESCO business models themselves (technologies, revenue models and financing instruments), as well as to other key elements of the marketplace: adequate and suitable demand for DESCO services, and the framework conditions (the political, regulatory and legal circumstances) that will allow that demand to be fully expressed and capitalised upon. The following section of this report attempts to provide information to fill these gaps. □

<sup>2</sup> Other models include "build-own-outsource", "build-own-lease" and "build-sell".





Although the central grid offers the lowest per-kWh tariffs, these do not reflect the lifecycle costs of providing power through the central grid, or the per-km costs of extending the grid (including transmission).

# THE DRE MINI-GRID MARKET OUTLOOK

## SUPPLY: THE BUSINESS MODELS

The publication in January 2017 of the International Finance Corporation’s (IFC report) Operational and Financial Performance of Mini-grid DESCOS represented the sector’s first real quantitative analysis of the operational and financial performance of DESCO business models in several geographic areas, including India. Despite the early developmental stage of the sector and the difficulty of extrapolating lessons from small and varied sample sizes, the IFC report is an important first step towards helping investors and decision-makers understand the complex ecosystems of DESCO deployment and operation, and the key barriers to growth.

### HOW DOES THE DESCO MODEL SQUARE UP AGAINST THE ALTERNATIVES?

On paper - i.e. looking at complete, unsubsidized lifecycle costs - the DESCO model is competitive with other forms of electrification at project level, such as grid extension, diesel generation and SHS. Comello et al. (2017) compared the levelised cost of electricity (LCOE) in retail tariff terms between mini-grid technologies (solar/battery and solar/diesel “hybrid” systems), kerosene, localised diesel-powered pico-grids (of which there are “hundreds of thousands” in India, according to informed guesses), and the central utility grid (see figure on opposite page).

Although the central grid clearly offers the lowest per-kWh tariffs, these do not accurately reflect the cost of generation, much less the total lifecycle costs incurred in providing power through the central grid, or the per-km costs of extending the grid (including transmission). The other aspect of grid extension is time: grid projects typically take around nine years from conception to completion (and transmission projects can take considerably longer) (Power for All, 2016).

In comparisons between mini-grids and SHS, energy access projects are often rated on a cost per connection basis, with this figure typically representing a subsidy or grant from a donor made within a results-based financing (RBF) framework. In such programmes SHS typically have a considerable advantage over mini-grids, given significantly lower CAPEX costs and risk profiles, particularly given the advances in consumer financing (pay-as-you-go or PAYG) and technologies that allow the remote lockout of units in case of late or non-payment. In a recent countrywide RBF programme in Zambia, per-connection bids from DESCOS operating mini-grids were typically between \$80-120 higher than those of SHS providers/distributors.

However, this comparison cannot be made in a vacuum. Even very low loads can be more economically served by mini-grids, given the right proximity and density within a mini-grid catchment area, combined with an appropriate customer mix (i.e., including productive and/or institutional loads) and load distribution and management approaches. Furthermore, such comparisons do not adequately reflect the service lifetimes of the technologies, which are typically 3-5 years for SHS and upwards of 15-20 years for mini-grid systems. Nor do they evaluate the flexibility and quality of an electricity connection via mini-grid compared with that of SHS. Mini-grid connections typically allow greater opportunity to move “up the energy ladder”, or across energy service tiers, than do SHS (see the SE4All Multi-Tier Framework for Energy Access for more about energy “tiers”). This flexibility can be drastically enhanced in the event of grid interactivity (see Section 4), which - if executed efficiently - improves capacity and lowers tariffs for end users. →

**\$0.06**  
RETAIL TARIFF,  
MADHYA GUJARAT  
VIJ COMPANY LTD.

**\$0.38**  
SOLAR- AND  
BATTERY-BASED  
MINI-GRID

**\$0.54**  
SOLAR AND  
DIESEL-BASED  
MINI-GRID

**\$0.57**  
DIESEL MINI-GRID

**\$0.94**  
PETROMAX KEROSENE  
LANTERN

**\$0.95**  
POOLED HOUSEHOLD-  
LEVEL DIESEL POWER  
GENERATION

## LCOE COMPARISON

Cost or retail tariff (\$/kWh)

Source: Comello, Reichelstein, Sahoo & Schmidt, 2017

1

2

3

4

6

5



MEETING THE CHALLENGES OF SCALE

DESCOs operating mini-grids face a number of challenges in scaling up that are peculiar to the sector. The IFC’s report pinpoints several key elements, many of which dovetail closely with those REEEP has identified in its work with mini-grid operators in Africa, India and Southeast Asia:

- **Site identification and selection:** Given the high capital expenditure and the typically high cost of relocating deployed mini-grid assets, it is crucial that DESCOs analyse and understand their “micro-markets” at village level – this includes aspects such as geography, demography, population density, income, client mix (among household, productive and institutional clients) and the presence of a so-called “anchor” client (such as a mobile telecom tower/base station).
- **Customer engagement:** Engaging with, acquiring and retaining paying customers is often a challenge for DESCOs, yet quickly reaching and maintaining very high customer penetration within a catchment area is critical to the project economics of most grids at site level, and its importance is multiplied at a portfolio level.
- **Metering and payment:** Although theft and non-payment are chronic issues for Indian discoms, DESCOs have essentially solved both issues with technological and operational aids. With metered and integrated distribution (or reticulation) systems, theft of current has all but disappeared from modern mini-grids. Meanwhile, sophisticated pre-payment systems have resulted in predictable revenues from the vast majority of clients (benchmarking for REEEP sites in Tanzania and Smart Power for Rural Development (SPRD) sites in India is around 90%). REEEP has also observed some DESCOs making significant progress in regulating the load to cope with daily peaks and troughs in demand. This is leading to improved efficiency and increased revenue.

THE FINANCIAL ECOSYSTEM

Financing for rural electrification in India is improving, with considerable volumes of financing inflows either in progress or expected in the near to medium term. This figure is approaching \$300m, even excluding the possible further commitment from a major donor-country development bank of \$200-\$250m, which brings potential foreign concessional investment in energy access to some half a billion dollars over the next 5-7 years (Source: Interviews with investors and representatives). □



**Above:** Mohammad Irshad at his wheat mill in Bara, Araria District, Bihar. Credit: Robin Wyatt for the Rockefeller Foundation

Modular Is Better

REEEP has supported a number of DESCOs seeking to expand energy access via DRE mini-grids, primarily in Southeast Asia and sub-Saharan Africa. Two of the most promising commercial models we have worked with are being pursued by relative newcomers to the space: Redavia and Standard Microgrid Inc., both of which have addressed traditional weaknesses, from an investor risk perspective, by relying upon highly standardised, modular solar generation systems. This modularity allows a staggered build-out of a system to meet demand as it grows, and also lowers the risk of generation and storage assets being stranded in a remote location should a project fail to meet targets. Modularity in physical assets could further improve the economics for mini-grid deployments in India, where up to now more permanent systems have been preferred.

**Below:** Bindheswan Kumar and Sudama Rai at the site of the new OORJagram Rural Enterprise Zone, which is being strategically constructed at the intersection of two roads in Diara Rasulpur, Saran District, Bihar. Credit: Robin Wyatt for the Rockefeller Foundation



**Left:** A furniture maker in Katsa, Saran district, Bihar. Though some processes are still done by hand, this furniture shop also uses power tools powered by the village mini-grid, resulting in increased production. Credit: James Smith for REEEP

THE EFFICIENT PUBLIC-PRIVATE POWER ECOSYSTEM

A resilient, efficient power ecosystem in India will be one which utilises and incentivises technologies and models appropriate to location, application and demand - and which can adapt as these develop over time.

The power ecosystems of rural and peri-urban areas in much of the world, including in India, are characterised by inefficiency. When electricity is present, it is often brought by the central utility grid, at great expense economically and ecologically, only to suffer from shortages and load shedding. What good is a flood of electrons to your village if they are not being used, or are lost in heat?

Most households and businesses do not need six hours of power at low-cost (or indeed below-cost) during the day, but rather require baseline lighting at night and as-needed power to charge mobile phones, portable torches, radios and televisions. Some users – typically in concentrated commercial areas – will require more power during the day to power refrigerators, tools, computers, and other appliances.

There is no silver bullet technology or approach to the energy access challenge. For rural areas and hamlets with highly dispersed populaces and/or geographies

with very low loads, solar home systems (SHS) are typically the most economic and efficient solution for electrification. For market villages or large hamlets with commercial activities, relatively flat geographies and households in close proximity, solar or biogas-powered mini-grids are typically the most economic and efficient options. Even agricultural villages can often be most economically served by a mini-grid if a high-load client (such as an agricultural processing centre or mobile telecommunications tower) is nearby. For industrial applications and centralized, urban areas, the main utility grid is typically the most economic option.

All of these solutions are effective and efficient in providing value for consumers only in the presence of conducive political, regulatory and financial conditions. This means creating a level playing field between them – not on a per-kWh basis, but on the basis of which technology and model is most economical and effective in meeting the needs of customers. →





- 1 Grid-interactive solar-powered mini-grid
- 2 Hydroelectric power station
- 3 Rice-husk gasifier and powerplant connected to mini-grid
- 4 Solar Home System (SHS)
- 5 Urban industrialized zone
- 6 Isolated solar-powered mini-grid
- 7 Wind farm





Left: Installation of the final module of the first solar panel at the OORJAgram Rural Enterprise Zone in Diara Rasulpur, Saran District, Bihar. Credit: Robin Wyatt for the Rockefeller Foundation

of deployment, given their relative sophistication in terms of understanding and monetising the value of electricity, and they can be a source of predictable, upgradeable off-takers throughout implementation. Such villages also typically meet the minimum requirements for load density that will make mini-grids economically competitive with SHS, even in connection-based comparisons.

In addition to the presence of a marketplace, we looked for those villages with fewer than 10 hours per day of summertime electricity access, on the assumption that more than 10 hours is indicative of intensive power provision, which would make it difficult for a DESCO to acquire enough load revenue to compete with the local discom (at \$0.06/kWh tariffs). It is worth noting that many thousands of more or less roughly constructed “mini-grids” based on a diesel generator, operated by a local entrepreneur and serving anywhere from several to scores of local shops and businesses, are the incumbent electricity provider in such villages. (Source: Interviews).

We also included a village size threshold, but while retaining cKinetic’s 1,000-household maximum (a village with more than 1,000 households was assessed to be either too large a catchment area or, if dense enough, to be too high-priority for discoms in the near future, increasing the risk of a quick grid intensification), we lowered the minimum from 300 to 150 households to reflect advances and efficiencies in modular systems with smaller entry points (e.g. at around 10-15kW).

These indicators and thresholds are not hard and fast, and our relatively cursory analysis of village-level conditions cannot substitute for a robust site-selection process. However, REEEP’s analysis should provide a more accurate picture than previously available of the existing opportunity for utility-model mini-grids, and can serve as a yardstick of the financial absorption capacity of the sector for DFIs and other potential investors. →

DEMAND:  
THE SITES

From a demand standpoint, there is a degree of uncertainty among stakeholders about how to segment the market. Mini-grids are inherently village-level enterprises, yet most estimates of the market for energy are based not on village-level analysis, but rather on broader statistics relating to electricity access at the individual level (i.e., based on numbers of underserved people, without consideration of their relative locations).

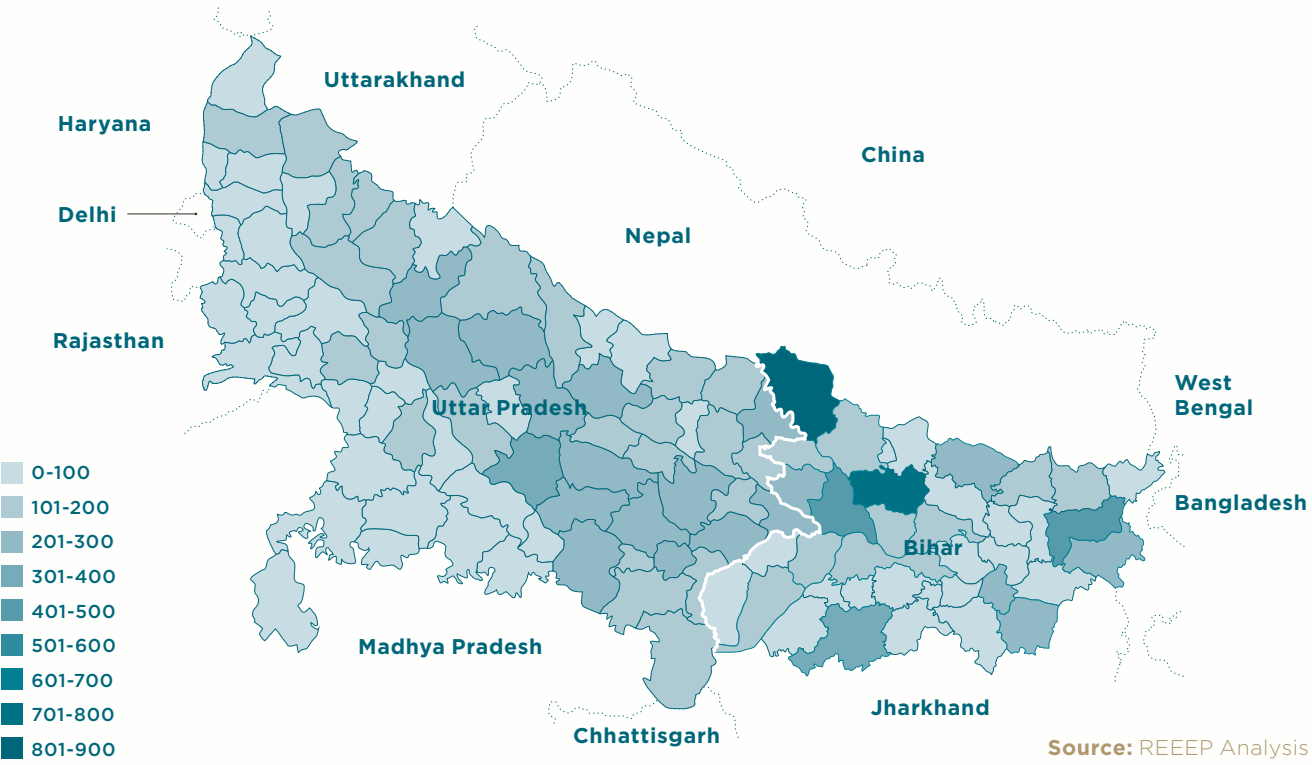
A number of organisations have approached the demand question from the village-level or site perspective, notably cKinetics, which estimated the market size in India based on a survey of villages containing between 300 and 1,000 households (cKinetics, 2013). REEEP has taken this approach further, using an analysis of site economics in the SPRD portfolio, available GoI data on village-level demographics, and stakeholder interviews and qualitative reports from SPRD mini-grid deployments, to arrive at three proxy indicators for mini-grid uptake “readiness” at village level. This assessment is not intended to encompass overall demand for energy services across India, but rather to

demonstrate the potential near-term viable demand for mini-grids operating under a DESCO model.

We estimate that in Bihar and Uttar Pradesh alone (the two states in most acute need of energy access) there are around 15,500 villages that meet our threshold criteria (described below) for mini-grid uptake readiness. This translates to nearly 6.3 million households - and 36.5 million individuals - that could economically be served by DESCOs operating DRE mini-grids.

REEEP’s analysis found that in the absence of detailed site surveys and assessments, the most relevant single proxy indicator of viability for a mini-grid deployment is the presence of a regular market with multiple shops and small enterprises. The Census of India defines such a market, or *mandi*, as “a cluster of shops with or without fixed premises which are open on at least six days a week and opens at least from morning hours to dusk” (Office of the Registrar General & Census Commissioner, India, 2011, p. 6). Such commercial clients make up the foundational customer base for a DESCO during the early stages

VILLAGE-LEVEL MINI-GRID READINESS IN UTTAR PRADESH AND BIHAR



Source: REEEP Analysis

FRAMEWORK CONDITIONS

2016-2017 has been an especially dynamic and potentially game-changing period in India, in terms of both policy and regulatory changes and the financial firepower flowing into energy access (albeit not necessarily dedicated specifically to mini-grid deployment). 2016 began with an amendment to the National Tariff Policy (Ministry of Power, 2016) which for the first time made explicit mention of mini-grids, and specifically the necessity of protecting and incentivising private investment in them by putting into place “an appropriate regulatory framework to mandate compulsory purchase of power into the grid” upon grid arrival – an integral part of interactivity.

In February 2016 the Government of Uttar Pradesh (UP) became the first Indian state to publish a dedicated Mini-Grid Policy (UPNEDA, 2016). The policy is the first to explicitly address DRE mini-grids and to mainstream some of the key priority areas, such as providing single-window clearance (through the Uttar Pradesh New and Renewable Energy Development Agency or UPNEDA); extending benefits related to land use, environment and stamp duty for sanctioned projects under the State Industrial Policy; offering an exclusive state subsidy (viability-gap funding assistance of up to 30%); and proposing explicit operating (i.e., exit) frameworks upon “grid arrival” (either sale of power to the grid at a predetermined and approved tariff, or an indexed asset buyout by the incoming discom, in this case through UPNEDA).

The regulatory framework of the Uttar Pradesh Electricity Regulatory Commission (UPERC) goes a step further by providing a set of interactivity options. It also allows DESCOs to migrate within these options: DESCOs may operate standalone despite the existence of the grid; they may sell surplus power to the grid at a tariff determined by the regulator; or they may sell all power to the grid, again at a tariff determined by the regulator.

REEEP sees the UP policy and UPERC’s regulatory framework as important and positive steps for the state and the sector. Discussion on how to implement the policy continues. At the same time, both the policy and framework lack clarity on a number of issues, such as the nature of downstream infrastructure subsidies and precise financial frameworks for implementation. Furthermore, the multiplicity of options in the event of grid arrival may actually be less effective due to a lack of clarity and transparency in decision-making and tariff levels. A draft national policy on mini-grids has been under consultation within the MoP since June



...it is clear that moving the needle on investment in, and deployment of, mini-grids by DESCOs at scale will require a greater degree of coordination both between the public and private sectors, as well as between ministries and agencies of the Indian Government”

2016, but its progress and prospects remain unclear at the time of writing, particularly given the political economy of electrification discussed earlier.

Ultimately the mandate for power provision and extension - rural and otherwise - lies with the MoP, whereas the primary driving force behind the market-based DESCO approach, in terms of subsidies and incentive programmes as well as the mini-grid policy, has been the Ministry of New and Renewable Energy (MNRE), which is responsible for promoting and deploying renewable energy. Although they share a minister, it is unclear to what degree so far the two ministries have been operationally integrated and cohesive in linking the market-based approaches of the MNRE and the public service-driven approaches of the MoP.

Regardless of the operational relationships between ministries, it is clear that moving the needle on investment in, and deployment of, mini-grids by DESCOs at scale will require a greater degree of coordination and involvement with those entities involved in rural electrification through grid expansion, with an eye towards optimising roles and responsibilities where needed, and leveraging the advantages of the private sector to reach electrification objectives. Fundamentally this means using private companies such as DESCOs to serve individual customers, and using public finances to fill the funding gap generated by below-market tariff levels and to compensate private companies for providing a public good (i.e., expanding energy access). □

DESCO POLICY FRAMEWORKS:  
GLOBAL PERSPECTIVES

India is not the only country in the process of adjusting its policy framework to encourage rural electrification through mini-grids and DRE approaches. Regulatory challenges are not solved overnight, but the following examples point the way to answers to some of the different issues:

Tanzania

Globally, Tanzania ranks very low in terms of electrified households. In 2012, the share of the rural population with access to electricity was 3.6%, compared with a global average of 12.2% for all low-income countries (World Bank, 2016). Although in the 1990s the state-owned utility company, TANESCO, made limited efforts to electrify rural areas by central grid extension and mainly diesel-based off-grid solutions, the government announced its determination to tackle the problem with the introduction of the National Energy Policy in 2003, followed by the Rural Energy Act in 2005 (Nganga, Wohler, & Woods, 2013). The policy promoted renewable energy by providing public funding, while the new law prioritised improved access to modern energy in rural areas through technical assistance and finance. The Electricity Act of 2008 allowed independent power producers (IPPs) to supply power directly to customers, and since 2009 the Small Producers Programme has provided standardised power-purchase agreements (PPAs) with TANESCO for small-scale and off-grid producers (Ahlborg & Hammar, 2014; African Development Bank, 2015). Now IPPs can easily set up mini-grids in rural areas, charge their customers a cost-based price and, upon grid extension to their area, feed the electricity into the main grid at a fixed tariff. However, despite the favourable policy landscape, the diffusion of DRE mini-grids in Tanzania so far has been limited. Reasons include constricted access to local finance, corruption, and the repeated insolvency of TANESCO, which often fails to disburse monies to IPPs (Ahlborg & Hammar, 2014; African Development Bank, 2015). Tanzania’s experience suggests that even when positive policies are in place, governance issues can affect the viability of public-private DRE mini-grid initiatives.

Cambodia

Cambodia has seen the successful integration with the main grid of 250+ mini-grids that originally operated independently (ESMAP, 2017). Although the majority of these were diesel-powered rather than renewable energy, they demonstrate a number of factors contributing to a comprehensive programme to connect private mini-grids as the national grid expanded in the early 2000s. Rather than the national utility Electricité du Cambodge (EdC) building out totally new last-mile distribution networks, these mini-grids have become small power distributors (SPDs), mainly purchasing electricity at wholesale either from EdC or from neighbouring countries, and reselling to consumers. A small number in isolated areas still operate independently, but according to regulations established by the Energy Authority of Cambodia (EAC).

Initially, the EAC issued two-year licences covering a specific geographical area, based on providing a service to that entire area. The licences were to be extended provided that the operator improved infrastructure sufficiently to meet new standards. A series of financial incentives was put in place, including loan guarantees, zero-interest loans and some grants to support improvements. By 2014, all licensees had licences with a term of five years or more.

Retail tariffs are regulated by the EAC, based on a detailed standardised calculation of full-cost recovery that would generate an IRR of 10% in a well-managed company. The calculation is completed for each project and takes into account full depreciated asset base calculations, projected electricity sales, sales amounts to different customer classes (who have different tariffs) and electricity (or fuel) purchase costs. Isolated mini-grids are then able to charge the full-cost recovery tariff. Customers of SPDs connected to the main grid pay a standardised tariff, and the gap between the standardised tariff and the calculated full-cost recovery tariff is subsidised through the country’s Rural Electrification Fund administered by EdC.



**Below:** Mohammad Naushad operates a lathe powered by energy derived from biomass by DESI Power, in Gayari, Araria District, Bihar. Credit: Robin Wyatt for the Rockefeller Foundation



To realise the opportunity of market-based DRE in accelerating electrification and strengthening resiliency in power systems, the sector will require increased of coordination between and among public and private actors and national and multinational stakeholders.

# TOWARDS A PUBLIC-PRIVATE PARTNERSHIP PARADIGM

There has been tangible progress in improving the performance of DESCO business models and services in India and worldwide, as well as the policy and regulatory environments for DESCO models. But it is unclear whether these improvements will be sufficient to support the scale of near-term investment that the DRE mini-grid sector needs to fully realise the long-term benefits, i.e., the provision of high-quality, high-intensity power to previously under-served communities, and the strengthening and stabilising of the central grid through interactivity with mini-grids.

To realise this opportunity, the sector will require some degree of coordination between public and private actors and national and multinational stakeholders, in terms of electrification strategy, policy and regulation, financing and investment models and implementation. This coordination should yield a predictable and robust public-private approach to creating a decentralised infrastructure for power generation, storage and distribution. This would be intended for connection to the central utility grid, according to a predictable schedule for installing high-voltage transmission lines.

The GoI is showing signs of taking the long view of decentralised mini-grids, seeing them as a way to help accelerate electrification of off-grid communities now, while improving power resiliency and efficiency for on-grid communities both now and in the future. This approach shifts the discussion of electrification away from an “on- or off-grid” paradigm to a smarter, “beyond grid” model that can accommodate the projected skyrocketing of demand in India.<sup>3</sup>

But this new paradigm is unlikely to come about organically, nor will it be sustainable without systematic and robust mechanisms to govern the public-private interactions and financial transactions that are inherent in such a system. In the absence of any such public-private partnership approach, REEEP sees the outlook for commercial providers of DRE and their customers in India as at best highly uncertain. →

<sup>3</sup> India's demand growth, which averages 4.9% annually, puts all other major countries and regions in the shade: to meet this, India needs to build more than 880GW of new power generation capacity by 2040; by comparison, the installed capacity of the European Union is currently around 1,000GW (International Energy Agency, 2015).

# A SUSTAINABLE STRATEGY FOR DRE MINI-GRIDS

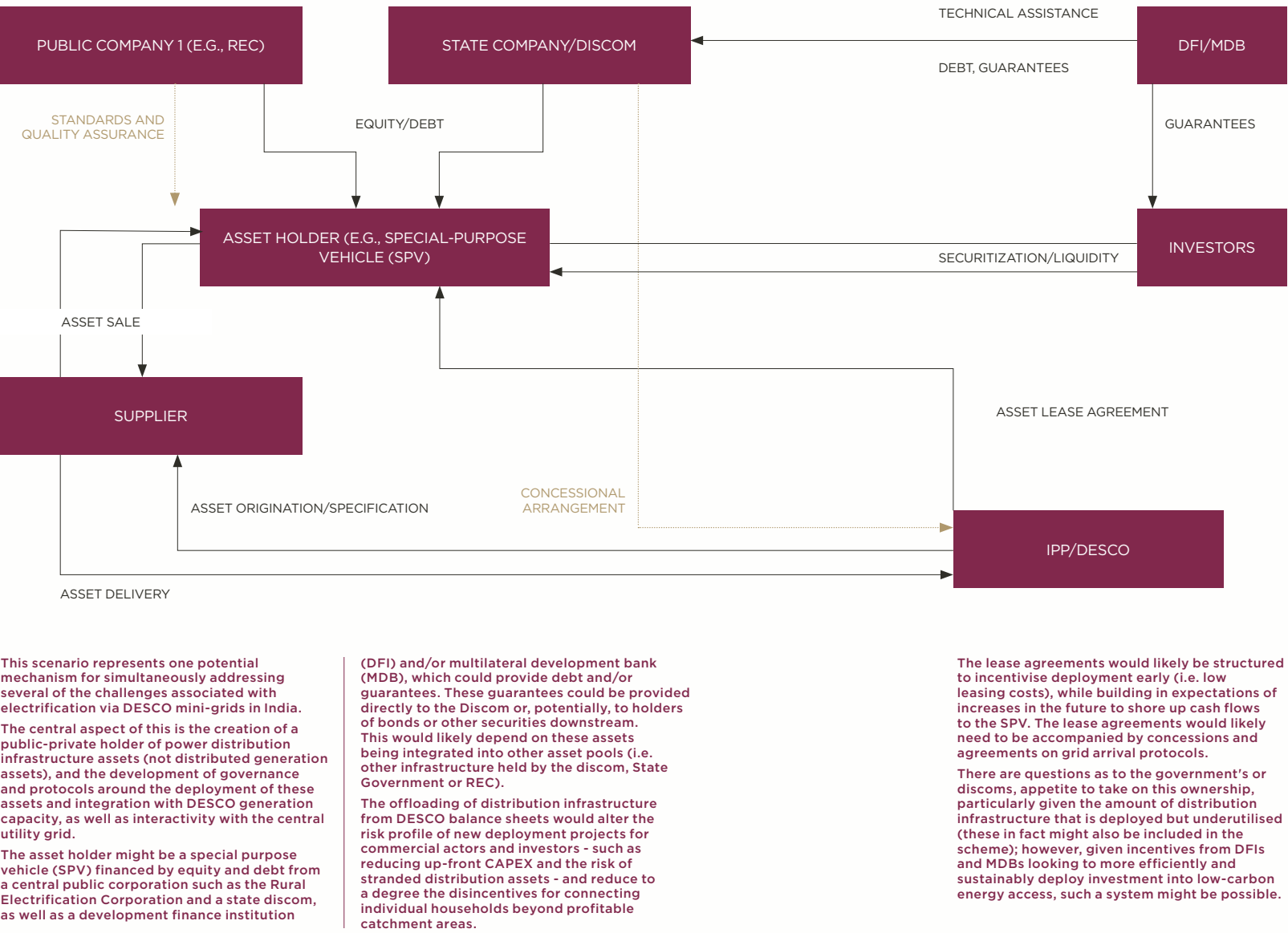
A sustainable long-term electrification strategy designed to leverage DESCOs operating DRE mini-grids must, by necessity, be flexible in design and execution. It should include a number of interventions introduced in stages to guide the sector gradually towards a long-term public-private partnership approach. The strategy should take as its starting point grid intensification, i.e., the build-out and servicing of last-mile distribution infrastructure within villages and hamlets. This represents the most acute risk for operators of mini-utilities applying some version of the DESCO model, as well as the most daunting operational and financial challenge for the MoP, the REC and discoms.

## WHEN INFRASTRUCTURE ISN'T INFRASTRUCTURE

It is a truism in the mini-grid sector that, because mini-grid systems deploy infrastructure over what is at least anticipated to be a long period of time, they should be treated as infrastructure-class assets by investors. This is true inasmuch as power generation, transmission and distribution at grid scale are considered infrastructure, providing essential energy-supply services to societies. In addition, many of the assets deployed by mini-grid systems might be indistinguishable from those deployed by a utility company, such as inverters, power lines and cables, poles, underground reticulation, switches and sockets, and they typically have very long lifespans (20+ years).

However, DESCOs do not enjoy the competitive, regulatory and political protections that make grid-power infrastructure a secure long-term investment from the point of view of liability protection and diversification. Given their exposure to alternative forms of competition, and their reliance on patronage in the near to medium term, under current circumstances few investors would consider DESCO mini-grids to be infrastructure-class assets.

## POTENTIAL SCENARIO FOR MORE EFFICIENT FINANCING OF MINI-GRID DISTRIBUTION INFRASTRUCTURE VIA PUBLIC-PRIVATE INVESTMENT VEHICLE(S) AND GOVERNANCE STRUCTURE



Yet, the power distribution/reticulation assets<sup>4</sup> of DESCO-operated mini-grids could, if standardised and bundled across multiple projects, meet these criteria. The development of a solution for achieving this represents potentially low-hanging fruit for the GoI in terms of lowering the financing costs for mini-grid deployment - and thus for rapid expansion of energy access to high-need areas.

## STANDARDS

From a technical standpoint, standardisation would require, at the outset, 3-phase AC distribution infrastructure. The specific equipment and installation - i.e., cables, poles, trenches, sockets, fuses, breakers etc. - would also be subject to standards in order to maintain a minimum quality and service across large deployment areas.

## BUNDLING

The concept of “bundling” distribution assets across multiple mini-grid sites, or projects, in this case broadly refers to the development of portfolios of standard distribution assets to be taken over by a state or parastatal entity (such as the REC or a discom) and securitized for resale to capital markets (see diagram left for more about how such a vehicle could be structured). The DESCOs would thus be operators of the mini-grid itself, but not owners of the (typically irretrievable) power distribution assets they have deployed to end-users, reducing CAPEX and overall financial risk exposure. At the same time, the GoI would secure the private sector-led intensification of villages with robust, long-term power reticulation at minimal financing cost.

## CONCESSIONS

From a political and regulatory standpoint such an approach would likely require concessions on deployment that would, in effect, restrict discom intensification for a period of time and/or require discoms to take over the assets at the end of this period as central-grid power arrives.

## PROTOCOLS AND PREDICTABILITY

The procedures and compensation for grid arrival must be articulated and codified so as to make the financial impact predictable and manageable for DESCO operators. Compensation should take into account the true cost of providing electricity to certain areas, rather than existing discom tariff structures. This approach also requires suitable financial instruments and sufficient backstopping (i.e., guarantees or other risk-sharing instruments) to reassure investors that expectations will be fulfilled according to the predicted calculations and procedures.

## POWER AS A PUBLIC GOOD

As an essential service, power has always been subsidised, and possibly always will be. However, the specific strategies and instruments of those subsidies have a considerable impact on the financial stability and sustainability of the companies and sectors involved. Besides requiring a shift in thinking away from the either/or mentality of market-based vs government service and on-grid vs off-grid, a sustainable strategy will also need a shift in the way state and other support for electrification is described and implemented, away from large but unpredictable capital expenditure subsidies and below-market working capital as a blanket solution, and towards a systematic and predictable system that enables and incentivises DESCOs to innovate and perform in providing energy services to customers, while providing the long-term investment security typical of high-social-value, low-profit enterprises. →

<sup>4</sup> Stabilisation battery storage might also qualify, depending on technical specifications.



# HOW TO GET THERE: RECOMMENDATIONS FOR INVESTMENT TO SCALE UP THE DRE SECTOR

Rural and peri-urban electrification in India is a sector characterised by high risk, high up-front capital requirements, long-term exposure and relatively low profitability, but with very high social and environmental impact and other benefits. Existing public efforts could benefit significantly from additional financial and operational resources to meet demand, and the sector should be making use of public-private partnerships to maximise the overall impact as well as value for money of public outlays (as opposed to, for instance, public procurements for complete DRE mini-grid systems).

## DRE MINI-GRIDS: AN INCENTIVE FOR CLIMATE-AWARE INVESTORS

Despite solar PV representing by far the most commonly used technology in power generation of DESCO-operated mini-grids, there is surprisingly little emphasis on the climate benefits of PV and hybrid mini-grids in India. Generally, little if any financing is directly linked to mitigation (although this may change with a planned guarantee programme by the Global Green Growth Institute and Green Climate Fund). And DRE mini-grids - or for that matter off-grid energy in any form - aren't to be found anywhere in India's Nationally Determined Contribution to the Paris Agreement under the United Nations Framework Convention on Climate Change. Yet given the emissions intensity of India's central grid, and the widespread use of diesel-powered generator sets and kerosene, there is clearly a significant carbon inventory in India's rural areas despite the lack of grid electricity. →

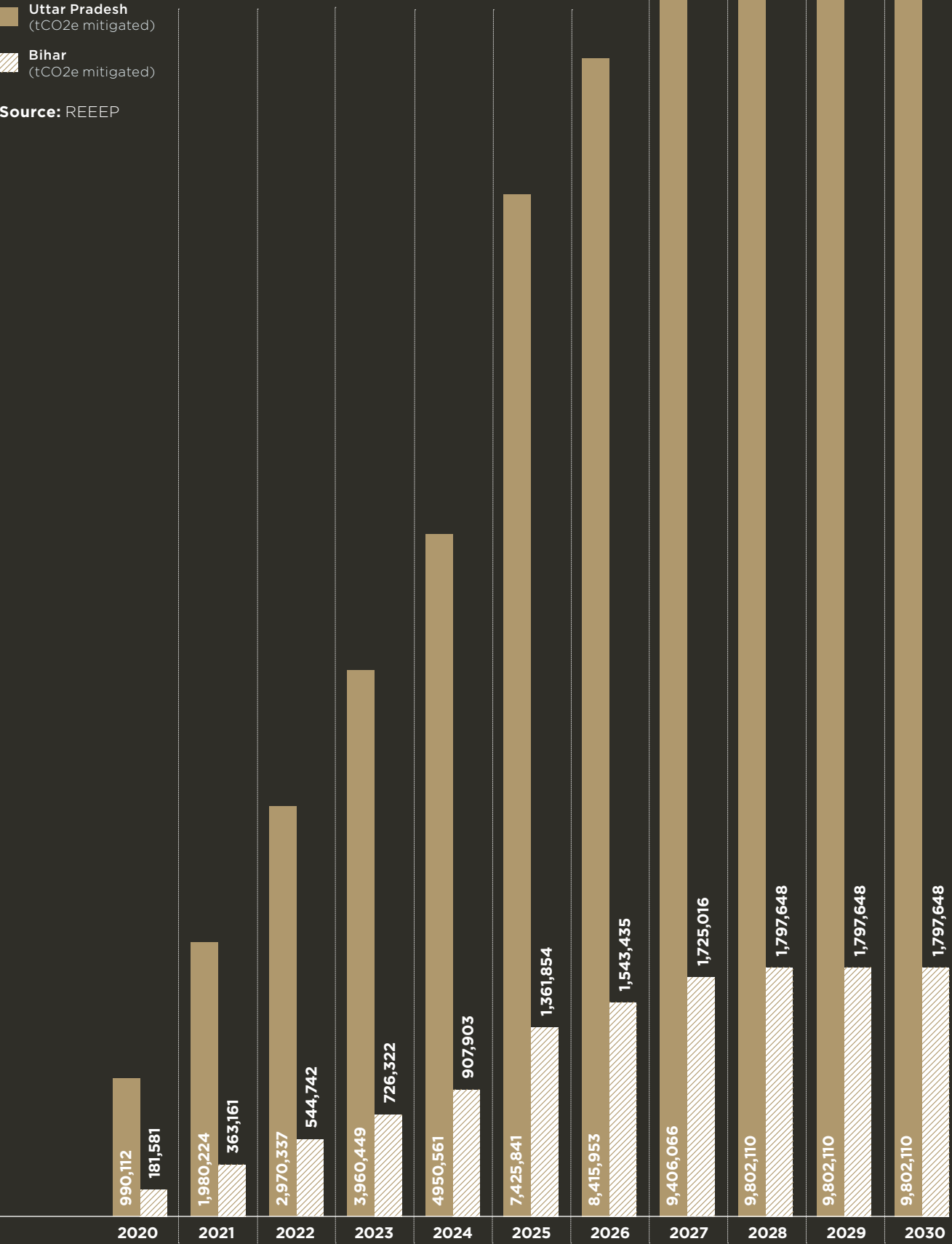
## CO<sub>2</sub> Impact and Value to Climate Finance

As an example, rather than the REC procuring a village distribution system for connection to the grid (or a distributed mini-grid system to be operated by a discom), as currently happens under DDGJUY, it could provide an off-taker subsidy by "procuring" connections, or energy service subscriptions, directly from DESCOs, who would then be responsible for leveraging whichever technologies and business models deliver efficiently. This approach is currently being utilised in Zambia by the Swedish International Development Agency and REEEP, which

have set up the Power Africa: Beyond the Grid Fund for Zambia to directly procure energy-service subscriptions for Zambians from providers, including DESCOs. This approach uses market forces to improve the value for money to the taxpayer and support the sustainable growth of the market, while employing robust due diligence and monitoring, reporting and verification mechanisms to lower risk (for more about the Power Africa: Beyond the Grid Fund for Zambia please visit [www.reeep.org/bgfz](http://www.reeep.org/bgfz)).

## CLIMATE IMPACT SCENARIOS 2020-2030

Estimated carbon impact of rapid mini-grid deployment in Uttar Pradesh and Bihar



For this report REEEP worked with Perspectives Climate Change to develop a simple carbon-impact scenario model to better understand and demonstrate the long-term carbon impact of electrification via DRE mini-grid, focusing on the characteristics of first-order prioritised villages as outlined in on page 30-31. The tool uses a methodology from the Gold Standard carbon-certification organisation to estimate suppressed demand from micro-scale electrification, and several

assumptions about business-as-usual characteristics (i.e., the share of demand to be met by diesel combustion, grid connectivity and kerosene).

According to REEEP estimates, the highest-potential 15,500 villages in Bihar and Uttar Pradesh alone represent an average of 8.15 million tonnes CO<sub>2</sub>e of mitigated emissions per year over a 15-year period from 2020-2035. This translates to over 122m tCO<sub>2</sub>e in aggregate over the period to 2035.

Although there is limited scope for certified products (such as voluntary credits or the next generation of the Clean Development Mechanism), there is certainly sufficient mitigation impact to contribute to the climate goals attached to many climate-linked impact funds or development financing schemes. There is significant intrinsic benefit to the climate from investments in DRE mini-grids, and the DESCOs that build and operate them.

There is also an appetite among international development cooperation agencies, DFIs, MDBs, foundations, impact investors and other actors for various degrees of concessional investment in energy access and climate mitigation in India. For a public-private partnership approach to take hold, all of these stakeholders will need to be involved.

Page 36-37 outlined a potential first step towards scaling up a public-private partnership approach by disentangling DESCO distribution assets (and potentially some storage and related assets) from the rest of the DESCO business model, and building a financing and regulatory ecosystem around last-mile distribution that would ensure the longevity of those assets and a partnership approach with the public agency or agencies mandated to expand electrification.

The removal of distribution assets from DESCO balance sheets would immediately have an effect on site-level economics, as these typically make up 10%-15% of capital expenditure, depending on the site (Source: aggregated analyses and interviews). However, the greater impact on project bankability and the sector at large would result from the regulatory procedures governing the ownership and/or transfer of those assets, and the political buy-in reflected in such a system. →



**Above:** Morning traffic leaving Patna in the direction of Muzaffarpur, Bihar. Credit: James Smith for REEEP

THE HIGHEST-POTENTIAL 15,500 VILLAGES IN BIHAR AND UTTAR PRADESH ALONE REPRESENT AN AVERAGE OF

**8.15 million tonnes CO<sub>2</sub>e of mitigated emissions per year over a 15-year period from 2020-2035**

## ESTIMATING CARBON IMPACTS OF DRE MINI GRID DEPLOYMENT IN BIHAR AND UTTAR PRADESH

REEEP estimated, for the purposes of this report, and to build the basis for an informed discussion also about possibilities for leveraging climate financing in scaling up the market for DESCO-provided power in India, the potential carbon impact of such a scale-up in the “initial wave” - i.e., by focusing on villages in which DRE is already a market viable solution. The scenarios are meant only to provide a rough estimate and understanding, built as they are upon underlying assumptions and figures that range in accuracy and reliability.

The first critical assumption is the number of villages REEEP identified as “mini-grid ready” - which already inherently possess at least the minimum characteristics required for a village to be economically viable for a DESCO business model. These characteristics, as we outlined on page 31, include the presence of a permanent market or *mandi* (a cluster of shops with or without fixed presence which are open at least six days a week and from morning to dusk), and presence of at least 150 households for which power supply for all uses is below 10 hours per day.

A village-level analysis of Bihar and Uttar Pradesh based on these criteria revealed approximately 15,500 villages as “mini-grid ready”.

The next step is understanding what the baseline energy scenario in these villages

looks like. REEEP and Perspectives developed two village archetypes. Two archetypes cannot of course cover the significant diversity of energy provision that can be seen across these two states; however, they provide a suitable baseline for a rough estimate scenario.

Baseline Village 1 derives approximately 50% of the total power demand from the central utility grid and 50% from diesel-powered generators running periodically at a load factor of between 15-35kW. The scenario used the combined margin grid emission factor for India of .975 (CEA, UNFCCC). Baseline Village 2 derives around 20% of total power from the grid, 30% from a mixture of diesel generators with varying outputs and emissions factors, and 50% from kerosene lighting.

In terms of demand being powered, REEEP utilised the Gold Standard's Suppressed Demand Methodology for Micro-Scale Electrification and Energization, which assumes that existing expressed (i.e. “real”) demand in underserved areas does not accurately reflect the demand that would exist in the event that demand could be served. The approach is based in defining so-called minimum service levels (MSLs) for various types of consumer groups that will draw power when power is available to them.

Using data from the 2011 Indian census, we calculated the average number of

households, schools, health centres, dispensaries, markets, etc. per village across our 15,500-village sample, to arrive at an average demand in kWh per village per year.

Although the suppressed demand methodology anticipates increased demand, we remained conservative in expectations of demand growth in terms of new schools, health centres, markets, etc., calculating zero absolute growth in those figures (i.e. the Uttar Pradesh sample of 0.03 health centres per village did not increase over time due to energization). We further estimated for this scenario that powering a mobile telecommunications tower would be possible for around 1/3 of villages (although in such instances, we assumed a high (50%) ongoing use of diesel to meet uptime requirements of towers).

Due in large part to the high carbon intensity of the Indian grid, diesel generation and kerosene combustion, the results show a significant and long-term impact on carbon emissions of these 15,500 villages, with around one million tCO<sub>2</sub>e per year in the first year and growing to over 10m/year in just over 6 years. In ten years in this scenario, mini-grid deployment in these villages will have mitigated over 80m tCO<sub>2</sub>e.

**For all sources and methodologies please contact the authors at [info@reeep.org](mailto:info@reeep.org)**

### DEFAULT MSL FOR ELECTRICITY CONSUMPTION (KWH) FOR EACH ELIGIBLE CONSUMER GROUP

DESCRIPTION OF PARAMETER FOR EACH ELIGIBLE CONSUMER GROUP	DEFAULT MSL ENERGY CONSUMPTION VALUE IN KWH FOR CONSUMER GROUP PER DAY
Energy consumption in kWh ( <i>ec</i> ) for a household ( <i>hh</i> ) in year ( <i>y</i> )	3.0 kWh/day
Energy consumption in kWh ( <i>ec</i> ) for a health center ( <i>hc</i> ) in year ( <i>y</i> )	8.6 kWh/day
Energy consumption in kWh ( <i>ec</i> ) for a dispensary ( <i>d</i> ) in year ( <i>y</i> )	4.1 kWh/day
Energy consumption in kWh ( <i>ec</i> ) for a school ( <i>s</i> ) in year ( <i>y</i> )	10.0 kWh/day
Energy consumption in kWh ( <i>ec</i> ) for a kindergarten ( <i>k</i> ) in year ( <i>y</i> )	4.4 kWh/day
Energy consumption in kWh ( <i>ec</i> ) for a public administration building ( <i>pa</i> ) in year ( <i>y</i> )	4.4 kWh/day
Energy consumption in kWh ( <i>ec</i> ) for a trading place ( <i>tp</i> ) in year ( <i>y</i> )	11.0 kWh/day



DRE-BASED MINI-GRID ACTIVITIES IN INDIA:  
PERSPECTIVES AND ADVANCEMENTS

The Shakti Sustainable Energy Foundation (“Shakti”), an independent not-for-profit organization working on mini-grids in India for last 5 years, is also of the view that interconnection of mini-grids with the discom grid network is the ultimate solution for long term sustainability.

In support of mini-grids in general, and specifically in sustenance with grid-interactivity, many interventions are taking place at the Central and State level. For example, the National Mini-Grid Policy (draft) acknowledges the role mini-grids can play and encourage inter-connectivity of mini-grids with the discom grid. In early 2016, revised National Tariff Policy (NTP) mandated all State Electricity Regulatory Commissions (SERCs) to adopt enabling regulations.

State of Bihar, Uttar Pradesh (UP), Jharkhand and Odisha are designing policies and regulatory frameworks in support of mini-grids and their interactivity with the discom grid. A key objective of these policies and regulations is to ensure sustainability of the mini-grids even upon the arrival of the discom grid and to enable smooth interconnection. However, to date, there are no successful examples in the country where a mini-grid and the discom grid are interconnected or interacting. This poses a significant risk that even while regulations permit such interconnectivity, the lack of practical examples may restrict mini-grid implementation.

To build a proof of concept and assess techno-economic feasibility of interconnecting the DRE-based mini-grids with the centralised grid, a number of pilot projects are being designed in the states of Uttar Pradesh (UP) and Bihar. These projects will aim to showcase techno-commercial archetype(s), grid interconnectivity protocols, and investment elements associated with options for interconnecting mini-grids with the centralised grid.

So far, in the state of UP, both mini-grid policy and regulations are in place. The regulations provide options for grid-interconnection between existing discom grid and mini-grids. Many DESCOs have deployed mini-grids in the state and there is a supportive framework for exploring DRE and the

mini-grid sector in terms of future market and opportunities. For the pilots, site and stakeholder assessments have been completed by Shakti. The existing mini-grid sites will be leveraged to demonstrate the feasibility of coexistence (and integration) of mini-grids with the discom grid leading to firm operational evidence.





Alongside, the state of Bihar has also announced its RE policy, which targets the deployment of 100MW equivalent mini-grids in the state in next five years. Demonstration sites for interactivity are also being explored in Bihar, wherein existing RE policy supports mini-grids and the regulations as well as an operational framework for interconnecting mini-grids with the discom grid are still in preparation.

The states of Jharkhand and Odisha have also initiated the process of drafting mini-grid regulations. There have been engagements with distribution companies, regulators and mini-grid operators to create an overall enabling environment for the establishment of mini-grids for providing reliable electricity at the last mile.

Public-Private Partnership (PPP)  
Interventions

In parallel, the Shakti team is exploring and developing possible Public-Private Partnership (PPP) construct for electricity access, including from DRE-based mini-grids. The prospective options for the convergence of public and private entities range from the simple option of discoms procuring excess power, to a more complex structure involving micro-utilities for providing reliable electricity services through a common distribution network under a formal contract with the discom. Some of these models might be explored through the on-going demonstration pilot projects in UP and Bihar while other opportunities will be explored beyond these pilots. Such PPPs can improve the reliability and quality of supply for the consumers and lead to a competitive and profitable market transformation. They will also prevent any parallel or stranded assets or projects.

TYPES OF FINANCIAL ECOSYSTEM SUPPORT FOR PPP MODEL

	PRE-FEASIBILITY/ EARLY STAGE	VENTURE/PILOT STAGE	DEPLOYMENT TO GROWTH	GROWTH TO MATURITY
 PROJECT/ ENTERPRISE RISK AND MATURITY LEVELS	Pre-feasibility studies, R&D projects with very high upfront costs and risks with low returns	Pilot projects and venture-stage enterprises with high-risk (and/or low-return) models and high transaction costs	Growing but still subject to high project risks and lower returns at commercial assessment	Mature but subject to sectoral risks, macroeconomic risks, reduced access to commercial markets
 ROLE OF PUBLIC FINANCING	Public financing can underwrite high upfront capital expenditures and exploratory activities, incentivize new market entrants and business model benchmarking	Public financing can reduce private investment risks by targeting viable businesses/models with working capital and low return expectations; taking junior positions; providing technical assistance	Public financing can strengthen positions of enterprises/projects by building balance sheet resiliency through subordinate debt/equity and enabling influx of commercial (market-rate) capital	Public financing can close-out investment positions and demonstrate commercial viability and sustainability of projects/enterprises
 FINANCING MECHANISMS	<ul style="list-style-type: none"><li>Grant funding</li><li>Concessional debt</li></ul>	<ul style="list-style-type: none"><li>Grant funding</li><li>Results-Based Financing</li><li>Junior equity</li><li>Concessional debt</li></ul>	<ul style="list-style-type: none"><li>Results-Based Financing</li><li>Equity</li><li>Concessional debt</li></ul>	<ul style="list-style-type: none"><li>Debt (non-concessional)</li><li>Equity</li></ul>
 OTHER SUPPORT MECHANISMS	<div>Technical Assistance</div> <div>Providing technical advisory services and capacity-building or capacity replacement to lean projects and enterprises (or local governments, where needed) to facilitate project/market efficiency and enabling environment</div> <div>Risk Underwriting and Other Incentives</div> <div>Developing financial instruments and mechanisms (such as dedicated credit lines, insurance schemes or other vehicles) for off-taking risk from investors and businesses, and improving long-term investment climate</div>			

Source:  
World Economic  
Forum, 2015

PROJECT/BUSINESS LIFECYCLE







**Left:** A water pump in operation in Hardiya, Gopalganj district, Bihar. Credit: James Smith for REEEP

**CAN GRID INTERACTIVITY WORK?**

For the model to be credible, there needs to be evidence that grid interactivity (also known as interconnectivity) can be practically managed and successful. For precedents we can look to other countries with DRE mini-grids that were originally designed as standalone systems and have later been successfully connected to the national grid. Examples are to be found in Sri Lanka and Indonesia, where nine hydropower mini-grids operate interactively with the national grid, the first of these interconnections dating back as far as 2003 (Energypedia, 2017). In Indonesia the systems range from 12 to 670 kW peak, and two different financial models have been applied, depending on whether the mini-grid operator agrees to act as an independent power producer (IPP) providing all generated electricity to the national grid, or only to sell excess energy not consumed locally. The excess-only model attracts a higher feed-in tariff intended to incentivise local consumption and reduce transmission costs and losses.

At the time of writing, hydropower mini-grids connected to the main grid are also beginning to come on-stream in India, with more in process. Close attention should be paid to these examples. Since hydropower provides a more stable source of power than PV, these mini-grids will not answer all the technical questions for all renewable-energy generation sources, but they can provide useful information on management issues and financial arrangements between operators and discoms.

**DEVELOPMENT CO-OPERATION**

We propose that Indian and international development co-operation agencies support a small number of DESCO-operated mini-grids for a pilot project on grid interactivity, in which the distribution assets are 100% subsidised, while generation assets and the operational capacity are borne by the DESCO. The distribution assets would be owned by a separate entity, which would receive a small usage fee.

For the pilot, it is likely that this entity would be an international organisation or research institution; however, when scaled up it would most likely be a discom, or another subordinate organ of the Ministry of Power (see page 15).

The trials could offer a transparent per-connection subsidy to consumers (indirectly) using a results-based procurement mechanism, which would allow power to be priced more competitively than alternatives. In such a scheme, minimum requirement criteria would be designed, following an energy access tier framework and adjusted to meet local circumstances, for defining an individual household (or other) energy connection. Companies would be reimbursed for each energy service connected to the grid, providing a predictable, transparent revenue flow. After a minimum of 12-24 months of operations, a discom would formally connect the mini-grid to the central grid.

Upon arrival of central-grid electricity, the pilot would test two or three options for takeover, with at least one representing a total transfer of assets and customers to the incoming discom (storage and generation assets would remain in place or be re-deployed, depending on site conditions), and one a “franchise” approach, with the DESCO remaining in place and serving customers at discom tariffs, and compensated for lost revenue at a predetermined “viability-gap” rate.

The pilot would closely monitor customer behaviour and usage, tariffs and various technical aspects of interactivity (such as whether and to what degree generation and storage assets can sensibly add value to the grid system for stabilisation, back-up or to power high non-coincidental productive loads during peak hours etc.). The pilot should gather real-world data about grid interactivity and attempt to clarify the optimal arrangements for securing private investment and serving communities. The pilot could also contribute positively towards the development of the complex standards and protocols required by such a scheme.

**DEVELOPMENT FINANCING**

Public financial support via direct subsidy has been essential to bringing the sector to where it is today, both in India and worldwide. However, such support provides neither the predictability nor reliability that DESCOs (and investors) need in order to scale up, nor does it always reward excellent and innovative business practices. Instead it often supports the well-connected darlings of this or that development agency, or firms that have built expertise in responding to complex government procurements, rather than those best placed to service thousands of rural customers using viable business models.

An example of a well-meaning - but fundamentally limited - approach is the MNRE’s Rural Energy Service Provider (RESP) scheme, which is designed to streamline subsidies for DESCOs contributing to the targets of the Jawaharlal Nehru National Solar Mission. The programme designates select DESCOs as RESPs within the mission’s Off-grid and Decentralised Applications Programme (Ministry of New and Renewable Energy, 2015). Empanelled RESPs are eligible for MNRE viability-gap funding of up to 30% of total capital expenditures for mini-grid deployment. While there are ostensibly six conditions for empanelment,<sup>5</sup> DESCOs are uncertain about how they are expected to prove that they fulfil these conditions. There is just as little transparency as to how many DESCOs are currently empanelled (the initial list included only four firms), how many sites can be →





**Above:** A sweets vendor in Hardiya, Gopalganj district, Bihar. Credit: James Smith for REEEP



**Above:** A woman using a sewing machine powered by a mini-grid. Credit: Smart Power India

**Right:** Carpenters in Belhdi, Bihar. Credit: Smart Power India



**Below:** Lathe owner Majaheed, one of DESI Power's customers, checks his meter to see how much electricity he has consumed, in Gayari, Araria District, Bihar. Credit: Robin Wyatt for the Rockefeller Foundation



covered in what time periods, or indeed the Gol's overall budgetary commitment to the programme. For subsidies to the power sector to be effective, they cannot be short-term or transitory, but rather must be long-term, predictable, and as non-distortionary as possible.

Given the high capital expenditure and long payback periods of mini-grid installations, in the medium term there will continue to be a requirement for concessional financing in various forms, such as below-market debt and impact equity, or first-loss guarantee programmes for local financing institutions. At the same time, there will be a near-term financing need to backstop any pilot public-private partnership mechanisms, given current levels of investor confidence in India's discoms.

In the medium term, it would be sensible for an Indian central government nodal agency - most likely the REC, for a number of reasons - to ring-fence any finance pools from which subsidies (i.e., distribution-infrastructure grants and associated incentives) would be given, as well as to set aside a fund to insure against unpaid feed-in tariffs or other asset-transfer compensation from discoms. This agency could perhaps develop a special-purpose vehicle with an MDB to underwrite both. This could dramatically improve investor confidence in the resiliency of cash-flow predictions beyond three or so years. In the short term it may make sense for an MDB to entirely manage such a fund with a view toward spinning it off as a special-purpose vehicle (SPV) after an assessment period and negotiation with the local partner.

The development of such an SPV or similar vehicle should take into account real-world data on the operational and financial performance of mini-grids, as well as the carbon impact.

Organizations like the Climate Policy Institute through its Global Innovation Lab for Climate Finance, are specialists in developing such for-purpose, scalable investment vehicles, and as such a logical partner for the design of an instrument leveraging the financial firepower of multilateral development banks and DFIs toward such a public-private financing solution. □

<sup>5</sup> 1) Entities must be registered as a public or private limited company or society;  
2) they must have implemented mini-grid projects or SHS in India;  
3) they must not be blacklisted by any organisation or have ever defaulted;  
4) they must demonstrate adequate capital deployment capability to invest in mini-grids;  
5) they may be recipients of funding from multilateral agencies in mobilising funds;  
6) they must have sufficient technical and human capacity.



CONCLUSION:  
FURTHER, FASTER, SMARTER

Somewhere between 240 and 300 million Indians are living without access to electricity, a fundamental condition for human well-being and prosperity growth in the 21st century. This is in stark contrast to the technical advances and financial resources available to much of the country. In rural areas there are widespread expectations of a rapid expansion of traditional power transmission and distribution infrastructure throughout the country.

However, despite impressive progress in rural electrification over the past decades, and ambitious commitments by the Government of India, such as Saubhagya (see pages 9 and 16), there remain substantial barriers to achieving India’s ambitious “Power for All” objectives. These challenges - incredible economic costs, convoluted political manoeuvring, and massive mobilisation of human and technological resources, among others - can be mitigated by leveraging the financial investment, process efficiency and technological advances of the private sector.

Market-based Decentralised Renewable Energy (DRE) - has progressed to a stage at which it is able to provide quality service to poor rural environments, including in India, and to handle many of the inherent operational risks. DRE mini-grids can be an efficient long-term solution to India’s electrification objectives, providing cleaner power more quickly and more efficiently than utility companies in the near term, with the ability to strengthen the resiliency of the central grid in the long term.

DESCO mini-grids at scale are not yet viable on a commercial basis, due to high up-front capital expenditures and high levels of uncertainty among investors as to the long-term viability of the sector. Chief among the risks for mini-grid

operators and investors in India is the arrival, often via low-voltage distribution lines at high cost and incurring significant network losses, of the central utility grid to a mini-grid-serviced area. Given extremely low discom tariffs and the unpredictable nature of grid power provision, these low-quality grid extensions are nevertheless highly disruptive to DESCO project economics and financing.

Ultimately, it will require long-term cooperation between the public and private sectors in order to render DESCO-model mini-grid deployments viable at scale, and attract sufficient amounts of domestic and international investment. This is sensible and to be expected given the characteristics of the rural electrification space.

At the same time, development cooperation agencies, DFIs and MDBs have expressed interest in supporting climate-smart energy access in India. These institutions could contribute to the development of a cooperative public-private approach via targeted investments in specific pilot projects and the development of specialised financial instruments.

Such investments should be in pilot grid arrival and interactivity protocol projects, innovative financing instruments for nationally standardising and securitising infrastructure-class distribution assets, targeted support for offtake and end-users, and insurance mechanisms for covering asset transfer and long-term revenue security through feed-in tariffs or other service fees, depending on the model.

The value of such investments for prosperity development in India is immense, given the role of energy access in economic development and well-

being. The value for the climate would also be considerable: by our calculations, a long-term (15-year) electrification of 15,500 “mini-grid ready” villages in Bihar and Uttar Pradesh alone would meet the electricity needs of 36.5 million people and mitigate over 122 million tonnes of CO<sub>2</sub>e, while reducing local particulate-matter pollution from diesel and kerosene combustion.

Every day that goes by without reliable access to energy - for a household, for a grocer, for a market, for a village - is a day on which inequality widens. In market-based DRE mini-grids, a solution is already available: one which can rapidly accelerate new access to energy to those without, which will stimulate economic development and new power, which will build resilience into the power grid when it arrives, and which will support India’s long-term energy demand and growth objectives. This solution requires an even playing field - politically, legally and financially - with other forms of power, including the grid. This can only be achieved with a public-private approach to electrification. The time to make it happen is now.

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