SmartPowerIndia
Powered by The Rockefeller Foundation

EXPANDING OPPORTUNITIES FOR RENEWABLE ENERGY-BASED MINI-GRIDS IN RURAL INDIA

Early commercial performance of renewable-energy based mini-grids, with key insights and recommendations for continued growth

APRIL 2017

Mini-grid electricity can complement grid electricity program to improve quality energy access for rural populations

ACRONYMS

CAPEX	Capital Expenditure
DRE	Distributed Renewable Energy
ESCO	Energy Service Company
SIMS	SPRD Implementation Monitoring System
SPRD	Smart Power for Rural Development
OBC	Other Backward Class
SC	Scheduled Class
ST	Scheduled Tribe

KEY TERMS

Anchor-based mini-grid: Anchor-based mini-grids provide electricity to a community for lighting and productive uses as well as to one or more "anchor" customers, which consume a large proportion of the electricity generated. The anchor customer for all current SPRD mini-grids is a telecommunications tower.

BTS: A Base Transceiver Station (BTS) is an equipment that facilitates wireless communication between user equipment (UE) and a network. A telecommunications tower houses multiple BTSs which need power for their operations.

Commercial customer: Refers to mini-grid customers who operate a commercial enterprise such as a tailoring shop, printing shop, or flour mill and use the mini-grid electricity for commercial purposes.

DISCOMS: Electricity Distribution Companies.

Distributed renewable energy (DRE): Refers to energy produced from small-scale local or on-site power plants that produce energy from renewable sources such as solar, wind, hydroelectric, or biomass. DRE is a decentralized alternative to the government energy grid, although some types of DRE plants can be set up to sell power to the government grid.

Energy-or electricity-based microenterprise: Refers to small local enterprises which utilize energy/electricity to carry out their activities. E.g. a local printing enterprise uses electricity to power the printer.

Energy Services Company: An Energy Services Company (ESCO) is a business which provides electricity as a service to its customers.

Household customer: Refers to customers which utilize the mini-grid electricity for household uses.

Institutional customer: Refers to local institutions such as a rural bank or a school, which utilize the mini-grid electricity to run the institution.

Mini-grid: A renewable energy-based mini-grid is defined as a system that uses a renewable energy-based generator (with capacity of 10 kW or more) to supply electricity to a specific set of customers (e.g., households and/or commercial, industrial, and/or institutional organizations) through a public distribution network.

Non-anchor mini-grid: Non-anchor mini-grids supply power only to community-based customers.

Operating margin: Operating margin is a measure of profitability. It indicates how much of each dollar of revenues is left over after both costs of goods sold and operating expenses are considered.

Peak load: Refers to the maximum electricity demand at a single time.

Productive load: Refers to uses of electricity that lead to economic development. Examples include electricity-based microenterprises, such as tailoring shop, photocopy shop, flour mill, irrigation etc.

Public distribution network: A network of electricity cables for delivering electricity from suppliers to consumers.

Exchange rate used for calculations: 1 USD = 65 INR.

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Women are being trained to use electric sewing machines to help increase the speed of producing garments at an apparel manufacturing unit

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EXECUTIVE SUMMARY

1

Access to electricity can transform rural communities. Electricity not only helps alleviate poverty, but also amplifies the effect of other efforts to relieve issues of poverty. Lack of electricity in a community thus limits that community's income as well as every attempt to improve its socioeconomic development.

In 2015, an estimated 237 million Indians lacked access to reliable electricity. More than 90% of those who lacked electricity (ie., at least 210 million Indians[1]) live in rural India. The Indian government recognizes the criticality of the situation and has embarked on an ambitious rural electrification plan. Yet despite the government's best efforts, a significant gap still remains between electricity supply and demand in rural India. Industry sources estimate that over the next 20 years, India's government grid will be able to serve only 5% of the current number of under-electrified households.[2]

One way to bridge this gap is through commercially oriented distributed renewable energy (DRE)[3] solutions. These solutions can play a complementary role with the government's electrification programs by providing rural areas of India with access to reliable and high-quality electricity at a much faster pace.

The Smart Power for Rural Development (SPRD) program has analyzed various available DRE solutions that could meet some or all of the energy needs of rural India. Based on this analysis, mini-grids appear to be the most suitable solution to catalyze socioeconomic development: mini-grids can supply not just basic lighting but power livelihood generating activities like tailoring, printing and micro cold storages. In fact, mini-grids have the potential to become an integral part of India's rural electrification strategy by providing last-mile electrification to under-electrified and un-electrified Indian villages.

The SPRD program defines renewable energy based mini-grids as systems that use a renewable energy-based generator (with capacity of 10 kW or more) to supply electricity to a specific set of customers (eg., household residents and/or commercial, productive, and/or institutional organizations) through a public distribution network. Mini-grids can provide power for both lighting and productive uses[4] and have the potential to be integrated with the government grid. However, the Indian rural renewable energy-based mini-grid sector is in its infancy, with few companies engaged in building or supplying power through mini-grids. For this reason, there is also little evidence available to evaluate the potential for financial success and viability among mini-grid businesses.

The SPRD program is generating such evidence by working to build a favorable environment for viable[5] mini-grid businesses in rural India. SPRD currently has seven partner Energy Service Companies (ESCOs) that are leading efforts to provide electricity to rural communities. These ESCOs are now operating 106 mini-grids that have impacted the lives of approximately 40,142 people in rural Uttar Pradesh, Bihar, and Jharkhand. SPRD is now in a position to share early data that provides credible evidence on the commercial performance, as well as the challenges, of these rural mini-grid businesses.

The 106 SPRD mini-grids include two operating models: (1) Anchor-based mini-grids provide electricity to a community for lighting and productive uses, such as print shops, and irrigation, as well as to one or more larger “anchor” business customers, which consume a large proportion of the electricity generated. (2) Non-anchor mini-grids supply power only to community-based consumers for lighting and productive uses.

[1] International Energy Agency, World Energy Outlook (WEO) 2015 Electricity access database. Retrieved from http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/

[2] The Climate Group, 2015, The Business Case for Off-Grid Energy in India. Retrieved from https://www.theclimategroup.org/news/business-case-grid-energy-india

[3] Distributed renewable energy (DRE) refers to energy produced from small-scale local or on-site power plants that produce energy from renewable sources such as solar, wind, hydroelectric, or biomass. DRE is a decentralized alternative to the government energy grid, although some types of DRE plants can be set up to buy or sell power to the government grid. See the list of key terms.

[4] The term productive applications or productive uses refers to uses of electricity that lead to economic development. Examples include electricity-based microenterprises, such as computer shops, mobile repair shops, photo studios etc. and irrigation.

[5] A viable model helps power lighting and productive needs of a village while providing acceptable financial returns to an ESCO. Different ESCOs will have varied return expectations, but at the minimum, accepted financial returns for an ESCO may be termed as payback in eight to ten years and project IRR of 10% or more, over the asset's lifetime.

The rural villages now receiving electricity from SPRD mini-grids show early signs of social and economic impact, including increased economic productivity, improved perceptions of safety and security, and increased incomes among village entrepreneurs. These are encouraging findings.

Also encouraging are the results of SPRD's evaluation of the commercial performance of the mini-grids at the unit level (i.e., one village with one mini-grid plant, without considering corporate-level overhead expenses).[6] Analyzing 23 top-cohort plants from four partner ESCOs, reveal average unit-level profit margins of approximately 30% after the first year of mini-grid operation. As the ESCOs partnering with SPRD build on their early learning from operating these mini-grid plants, they will continue to find ways to increase revenue and make their technologies and business plans more efficient. We estimate that these mini-grid plants can attain regular operating profit margins of up to 60%.

Specifically, we expect that as the ESCOs mature, they will focus on ensuring that their mini-grids are the right size to meet local electricity needs, planning the most efficient use of the diesel fuel used for backup power, and reducing power losses. To increase revenue, building demand for electricity will also be necessary. This will be done by actively supporting the development of new electricity-based microenterprises in rural communities.

The ESCOs expect to increase the number of customers purchasing electricity from mini-grids over time, as well as the amount of electricity used per person. In addition, the ESCOs are likely to enhance revenue by introducing innovative pricing packages such as time-of-day pricing, and promoting their customers' use of energy-efficient electric-powered devices.

While the ESCOs work to strengthen their on-the-ground performance, it is also important to address the key external challenges to the viability of renewable energy-based mini-grids. The most notable external challenges include the lack of long-term commercial financing; the lack of security in investing in mini-grids within the context of the government's larger rural electrification initiatives; uncertainty about the relevant government taxes and Central Financial Assistance (CFA); the lack of electricity-based livelihood activities in rural India and the need for new technologies to lower the cost of building new mini-grids. The key enablers of mini-grid financing, government support, and technology investments need to fall in place for ESCOs to be able to realize the full potential of the mini-grid opportunity.

Successfully addressing the key challenges outlined in this report will allow the existing ESCOs to grow and innovate and attract new businesses to the field-thus delivering reliable electricity to under-electrified villages and heralding an era of renewable energy-led socioeconomic development in rural India. The SPRD Program and Smart Power India's role is to support nascent ESCO partners as well as create and enable the necessary conditions for mini-grid businesses to be commercially viable in rural India.

Shopkeepers are reducing their reliance on diesel generators and opting for mini-grid electricity

[6]For the purposes of this report, a mini-grid unit was defined as one village with one renewable energy–based mini-grid plant. The unit-level profit and loss calculations took into account only the unit-level expenses, such as unit-level labor expenses, and operating expenses. The corporate overhead costs of an ESCO are not considered in the unit-level analysis.

RURAL INDIA'S ELECTRICITY SHORTAGE: THE NEED FOR ALTERNATIVE SOLUTIONS AND PRIVATE SECTOR PARTICIPATION

2

It is estimated that 237 million Indians lack access to reliable electricity, and more than 90%[7] of these individuals live in rural India. While India generates sufficient electricity and has the necessary capacity to meet current national demand, it struggles to distribute this electricity efficiently and effectively to rural areas. Distribution of electricity depends partly on the performance of utilities and the infrastructure through which electricity flows. In many places, utilities underperform and the infrastructure is inadequate, while in other places the infrastructure does not even exist. Consequently, there is significant disparity in access to electricity across rural India: Many villages have constant access to electricity, others have intermittent access, and some-because they are not connected to the grid-simply do not have any access.

In recognition of this unmet need for electricity in rural India, and the challenge of providing power to rural villages, the Indian government is prioritizing power-grid expansion, strengthening decentralized distributed generation, and undertaking utility reforms through various initiatives.[8]

In April 2015, the government identified 18,452[9] inhabited villages without access to electric power (un-electrified villages) and targeted them for electrification. Significant progress has been made in the last 24 months, and 13,224 of these 18,452 un-electrified villages have now been electrified. However, there remains a large disparity in access to electricity, and only 1,049 (8%) of these newly electrified[10] villages have achieved complete electrification (ie., 100% of households connected to the government grid). The gap between demand and supply in rural India thus remains large, and appears larger still when one considers the following:

- Villages that were deemed electrified before April 2015 still have a large number of un-electrified households.
- Smaller un-electrified hamlets are not counted in the census of "un-electrified villages."[11]
- The reliability (hours of supply) and quality (voltage) of electricity in many electrified villages remains poor.
- Electricity is not always available for productive and economic uses, such as for local microenterprises.

Despite the government's ongoing efforts, a clear, critical gap remains between electricity supply and demand. Eliminating this gap will require alternative delivery models. This presents a significant opportunity for the private sector: by creating viable[13] models for delivering electricity, the private sector can complement government efforts, address the electricity gap and drive socioeconomic development in rural India.

Improved lighting helps fruit and vegetable shops in Atrauli, U.P. to stay open till late

[7]International Energy Agency, World Energy Outlook (WEO) 2015 Electricity access database. Retrieved from http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/

[8]Active government initiatives include DeendayalUpadhaya Gram JyotiYojana (DDUGJY), National Solar Mission, 24x7 Power for All, and Ujwal DISCOM Assurance Yojana (UDAY), among others.

[9]REC India, 2016, GARV Dashboard: Rural Electrification, as of 12th April 2017. Retrieved from http://www.garv.gov.in/dashboard

[10]The official definition of electrification is "The number of households electrified should be at least 10% of the total number of households in the village." Available at http://www.ddugjy.gov.in/mis/portal/definition_electrified_village.html

[11]A village is recognized as the basic area of habitation and may consist of many smaller hamlets.

[12]A viable model helps power lighting and productive needs of a village while providing acceptable financial returns to an ESCO. Different ESCOs will have different return expectations but, at the minimum, accepted financial returns for an ESCO may be termed as financial payback in eight to ten years and project returns of 10% or more over its lifetime.

THE SUITABILITY OF MINI-GRID PLANTS FOR RURAL ELECTRICITY NEEDS

3

The SPRD program in India has examined various DRE solutions that could meet some or all of the energy needs of rural India, and a renewable energy-based mini-grid has emerged as the most suitable solution to drive socioeconomic development.

While multiple DRE solutions are available to meet rural energy needs, each has specific applications and limitations. Table 1 compares the traditional and renewable energy solutions reviewed during SPRD's analysis. A renewable energy-based mini-grid emerges as the most suitable DRE solution for driving socio-economic development in rural India. This is due to the mini-grid's ability to serve both lighting and productive needs and to provide high-quality reliable electricity at lower or equivalent cost when compared to existing alternatives.

However, renewable energy based mini-grids are CAPEX intensive and require a minimum threshold power demand of 40kWp or more to break-even and obtain commercially viability. Consequently, they can only be implemented as market-based models in villages which offer this threshold power demand. Such villages will typically have an existing commercial marketplace with productive activities - such as print shops, photo studio, sweet shops et al - and/or the presence of a significant anchor load - like a telecom tower or a petrol pump - subscribing to mini-grid electricity.

The renewable energy-based mini-grid can become an integral part of India's rural electrification strategy, providing last-mile electrification to the hitherto under-electrified and un-electrified Indian villages.

	TRADITIONAL SOLUTIONS		RENEWABLE ALTERNATIVES				
	KEROSENE	DIESEL GENERATOR	DEVICES (e.g. solar lanterns)	SOLAR HOME SYSTEMS	PICO GRIDS	MINI-GRIDS	
USES	LIGHTING	LIGHTING ENTERPRISES AGRICULTURE	LIGHTING	LIGHTING	LIGHTING	LIGHTING ENTERPRISES AGRICULTURE	PROMOTES ECONOMIC DEVELOPMENT
HOUSEHOLDS (HH) COVERED[1]	1 HH	1 TO 20 HHs	1 HH	1 HH	<40 HHs	> 200 HHs	SERVES KEY REGIONS IN A VILLAGE
POTENTIAL TO INTEGRATE WITH GRID	NO	NO	NO	NO	NO	YES	PROVIDES LAST MILE SUPPORT TO NATIONAL POWER SYSTEM
PRICE RELATIVE TO EXISTING ALTERNATIVES[2]	HIGHER	HIGHER	LOWER	LOWER	LOWER	LOWER	SIGNIFICANT COST REDUCTION
HEALTH AND ENVIRONMENT IMPACT	NEGATIVE	NEGATIVE	POSITIVE	POSITIVE	POSITIVE	POSITIVE	POSITIVE IMPACT ON HEALTH AND ENVIRONMENT

[1] Each household represents 5 people
[2] Kerosene and diesel

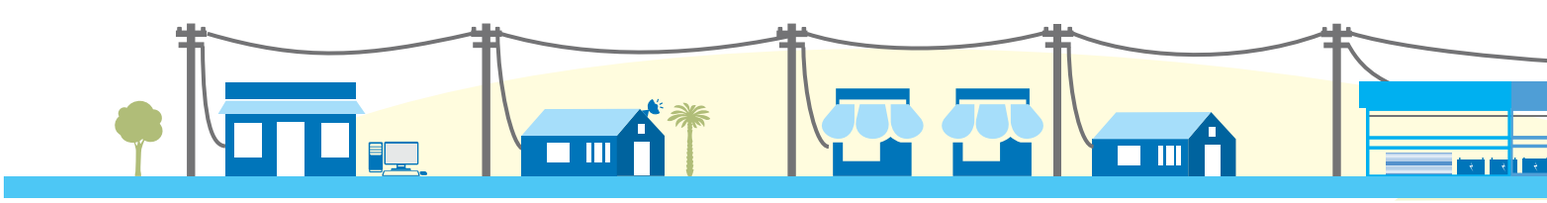
Table 1: Analysis of distributed renewable energy solutions for rural India

THE SMART POWER FOR RURAL DEVELOPMENT PROGRAM

4

Purpose of the Smart Power for Rural Development Program

Despite several obvious advantages to renewable energy mini-grids, key market constraints have prevented the private sector from taking these mini-grids to scale. Mini-grids require significant capital expenditure, however obtaining commercial financing can be difficult due to the mini-grid's yet unproven business model. In addition, rural India can be a challenging operating environment, and companies are often unfamiliar with operating in these settings. The SPRD program was established to address these challenges and promote private sector participation in the rural mini-grid market. From offering long-term financing to advocating for favorable policies (see Table 2), the SPRD program is working closely with companies and other key stakeholders to create the necessary conditions for private companies to run commercially successful renewable energy–based mini-grid businesses in rural India.



AREAS	KEY MINI-GRID MARKET CHALLENGES	SPRD INTERVENTIONS
FINANCE	⊖ Limited availability of finance	⊕ Offer long-term, concessional debt financing to ESCOs ⊕ Develop alliance with other capital providers to enable access to additional financing
POLICY	⊖ Uncertainity in government's grid expansion plan ⊖ Lack of clarity around integration of mini-grids with government grid	⊕ Advocate for policies that encourage the Indian mini-grid market
OPERATIONS	**Supply:** ⊖ High capital expenditure incurred by ESCOs that build plants ⊖ Challenging rural operating environment	⊕ Invest in technology and innovation to reduce capital expenditure and deliver operations efficiencies ⊕ Provide insights into mini-grid operating processes and market behaviour
	Demand: ⊖ Lack of assured demand ⊖ Lack of relationships with rural consumers	⊕ Support site selection ⊕ Support load acquisition and rural marketing ⊕ Promote micro-enterprises
MONITORING	⊖ Lack of systems to monitor plant performance	⊕ Enable data monitoring through the SPRD Implementation Monitoring System (SIMS)

Table 2: Key challenges to the mini-grid market, and SPRD interventions

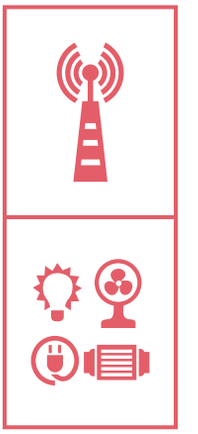
SPRD's Renewable Energy-Based Mini-Grid Plants

SPRD currently supports seven partner Energy Service Companies (ESCOs). These businesses operate a total of 106 renewable energy-based mini-grid[13] plants impacting approximately 40,142[14] lives across the Indian States of Uttar Pradesh, Bihar and Jharkhand.

The SPRD program's partner ESCOs are either independent private companies or social impact organizations. These ESCOs believe that renewable energy-based mini-grids are a viable solution to rural electrification: They can bring electricity the last mile to reach rural consumers, leading to a win-win in both commercial and social outcomes.

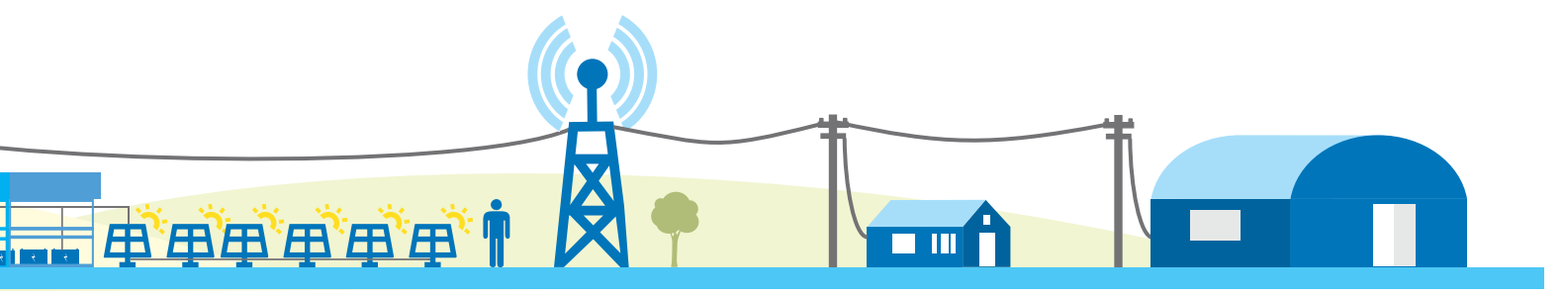
The SPRD mini-grids currently range in capacity from 30 kWp (kilowatt peak power) to 60 kWp, and they consist of one of the following two models:

Anchor-based mini-grid provide electricity to a community for lighting and productive uses as well as to one or more "anchor" customers, which consume a large proportion of the electricity generated. The anchor customer for all current SPRD mini-grids is a telecommunications tower.



Non-anchor plants supply power only to community-based customers.

The SPRD ESCOs operate in Uttar Pradesh, Bihar, and Jharkhand. These three states have the lowest electrification rates in India. Approximately 40,142 people are impacted by the SPRD electricity via the customers outlined in Figure 1.



106 MINI-GRIDS

7,221 HOUSEHOLDS

3,202 SHOPS

568 COMMERCIAL ENTERPRISES

97 TELECOMMUNICATIONS TOWER

17 INSTITUTIONS

Figure 1: Impact (in numbers) of currently operating SPRD mini-grids

[13] *A renewable energy-basedmini-grid is defined as a system that has a renewable energy–based electricity generator (with capacity of 10 kilowatts and above) and that supplies electricity to a target set of consumers (eg., residents for household usage and commercial, productive, industrial, and institutional uses) through a public distribution network.*

[14] *Impact was calculated based on direct users of SPRD electricity, counted as follows: Household lighting = 5 users; shop lighting = 1 user; commercial enterprise = 1 user; institution = 10 users.*

Social and Economic Impact of SPRD Mini-Grid Plants

A rapid assessment[15] of over 1,000 household customers and 320 microenterprises across 39 SPRD sites shows early indicators of social and economic impact, as outlined in Figure 2.

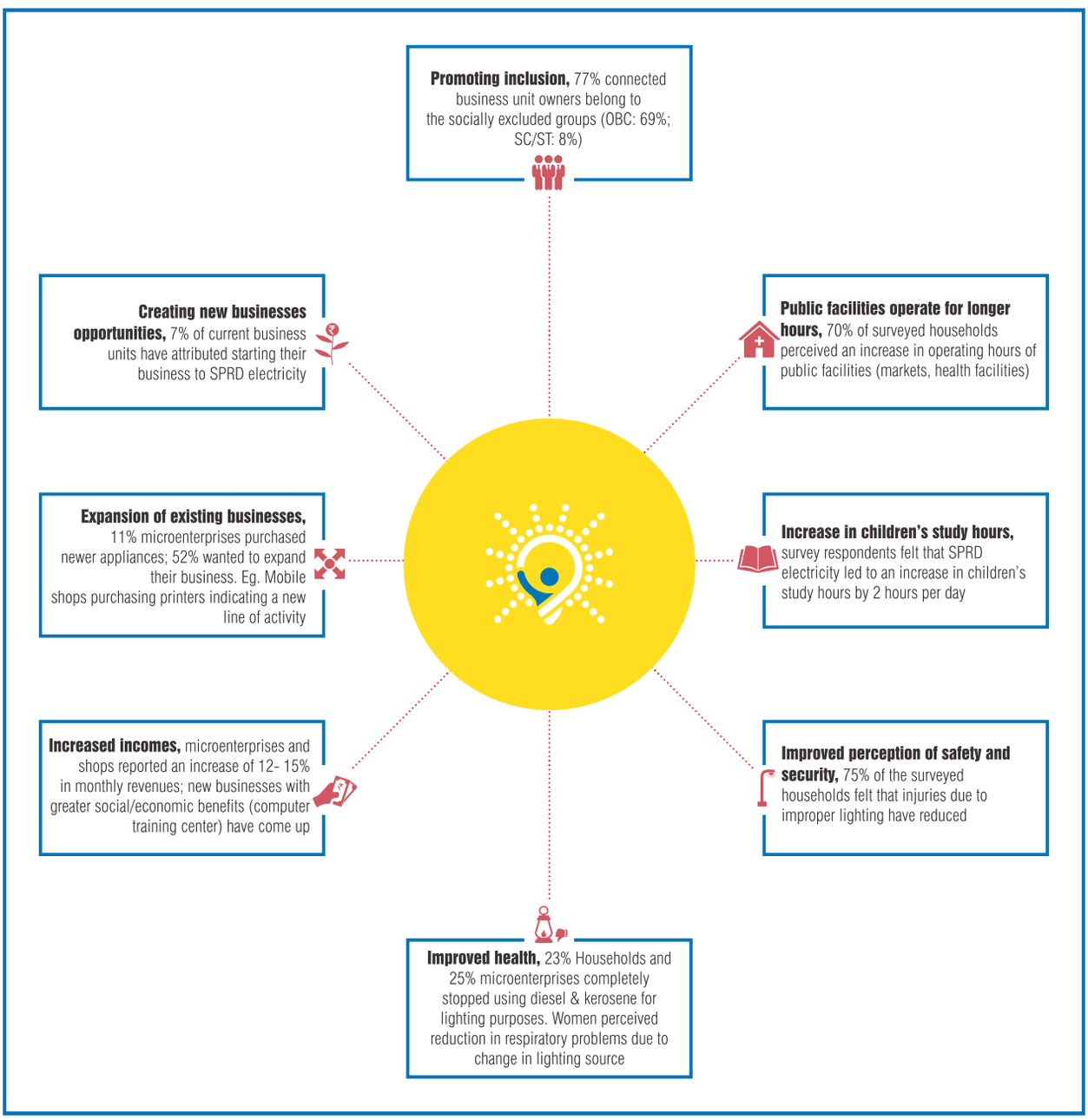


Figure 2: Early indicators of the socioeconomic impact of SPRD mini-grids

[15] *The rapid assessment was conducted by an independent monitoring and evaluation organization.*

Riyaz, a rural entrepreneur now runs an apparel manufacturing unit where electric sewing machines have helped increase his unit's productivity and output quality

GROWING BUSINESS

THE SPRD PROGRAM HAS HELPED TRANSFORM THE LIVES OF MANY MICRO ENTREPRENEURS IN THE STATES OF UTTAR PRADESH, BIHAR, AND JHARKHAND.

Siya Ram Pandey's carpentry business: Growing by leaps and bounds

Siya Ram Pandey lives in Bheldi village in Bihar.

He has run a carpentry business for the last nine years. Motivated by the availability of reliable electricity from an SPRD-supported ESCO, he recently installed a electric machine. This machine performs multiple functions, such as drilling, grinding, and shaping. It has helped him save time and offer quicker delivery of products: he is now able to complete five orders a day, compared to his previous rate of three orders a day. With this equipment as well as two additional workers, his business revenue increased by 22% in a span of three months, and his profit has increased by 20%.

Affordable and high-quality electricity, as and when a business needs it, is critical to unlocking the true potential of existing businesses.

A BRIGHTER FUTURE

SPRD ELECTRICITY HAS EMPOWERED WOMEN IN THE RURAL VILLAGES OF UTTAR PRADESH, BIHAR, AND JHARKHAND, HELPING THEM TAKE A LEAP TOWARD A BRIGHTER FUTURE.

Sandhya: Tailoring a brighter future

Sandhya is a resident of Shivpura village in Uttar Pradesh.

Supported by an SPRD ESCO, Sandhya participated in a tailoring training program and eventually started her own tailoring business. She successfully runs her business with two electric sewing machines. She also conducts training sessions for young women who are interested in acquiring tailoring skills. Approximately 10 women from nearby villages come to her center to learn - providing her with an additional source of income.

In addition to using electricity for her business, she also has an electricity connection for household use, which helps her children study at night.

THE COMMERCIAL PERFORMANCE OF THE SPRD-SUPPORTED MINI-GRID PLANTS

5

SPRD studied the commercial performance of a sample of 23 top-cohort plants of its partner ESCOs' mini-grids[16] to obtain a picture of the key elements that drive performance, as well as key insights and challenges.

Scenarios were then developed to estimate the performance of an SPRD renewable energy mini-grid plant at villages with different numbers and types of customers.

Average unit-level profit and loss

SPRD's analysis of average unit-level profit and loss[17] of the sample mini-grid plants found that the anchor-based plants had a higher absolute monthly operating margin, or profit.[18] The average operating margin for anchor-based plants was US$510 per month, compared to the non-anchor plants' average operating margin of US$200 per month (see Table 3).

For the anchor-based plants, the largest expense, is diesel - which is critical as fuel to provide backup energy to the anchor telecommunications towers and meet their stringent uptime service requirements. Labor costs are the other key contributor to the operating expenses of both anchor-based and non-anchor plants. Other expenses include land leases, maintenance, and insurance.

	ANCHOR-BASED PLANTS		NON-ANCHOR PLANTS	
	Current (year 1)		Current (year 1)	
Unit P&L Statement (Monthly Average)	**(USD '000)**	**% of Rev**	**(USD '000)**	**% of Rev**
Revenue	**1.71**		**0.72**	
Households	0.15	9%	0.15	21%
Shops	0.11	6%	0.21	29%
Commercial Microenterprises	0.09	5%	0.36	50%
Telecom Tower	1.37	80%	-	-
Operating Expenses	**1.20**		**0.51**	
Diesel Expense	0.62	36%	0.01	2%
Manpower Expense	0.49	29%	0.46	64%
Other Expenses (e.g. Land, Maintenance)	0.09	5%	0.04	5%
Operating Margin	**0.51**	**30%**	**0.20**	**29%**

Table 3: Average monthly profit and loss statement of anchor-based and non-anchor plants

[16] *A sample of 23 top cohort plants run by four ESCOs and distributed across the states of Uttar Pradesh and Bihar was analyzed, using 6 months of operations data from each of the sample plants. Eighteen plants were anchor-based and five were non-anchor plants; age of the plants varied from 8 to 19 months; and plant capacity ranged from 27 to 60 kWp for anchor-based plants, at an average capacity use of more than 95%, and from 30 to 37 kWp for non-anchor plants, at an average capacity use of approximately 64%.*

[17] *Unit-level profit and loss was created by excluding corporate and cluster-level costs; please refer to the list of key terms for definition of unit as used in this report*

[18] *The operating margin is a measure of profit, and is calculated by subtracting all operating expenses from the total revenue.*

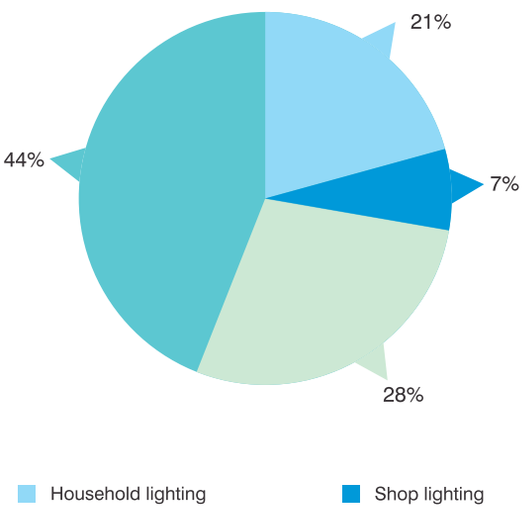
Anchor-based plant archetypes based on customer mix

While Table 4 provides an 'average profit and loss statement' across sample plants, a deeper dive into the anchor-based plants of the SPRD- supported ESCOs reveals two archetypes of customer mix:

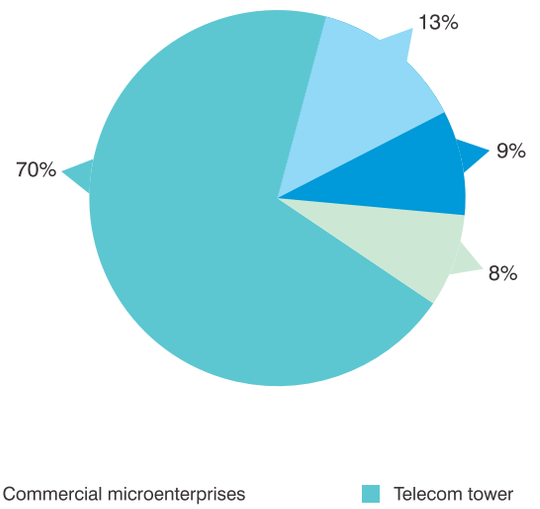
'Type A' anchor-based plants have higher revenue contribution from the community than from the anchor load (the telecommunications tower). These plants have either been operating for a longer period and have acquired community customers over time or been established at sites with large existing power demand from the community.

'Type B' anchor-based plants have a higher revenue contribution from the anchor load (the telecommunications tower) than the community. These plants are either newly established and will gradually acquire community customers over time, or they are serving smaller villages which have a low overall power requirement.

TYPE A ANCHOR-BASED PLANT: REVENUE MIX



TYPE B ANCHOR-BASED PLANT: REVENUE MIX



TYPE A

	MONTHLY REVENUE (USD '000)	% OF REVENUE
Household lighting	$0.37	21%
Shop lighting	$0.13	7%
Commercial microenterprises	$0.48	28%
Telecom towers	$0.75	44%
	$1.73	

TYPE B

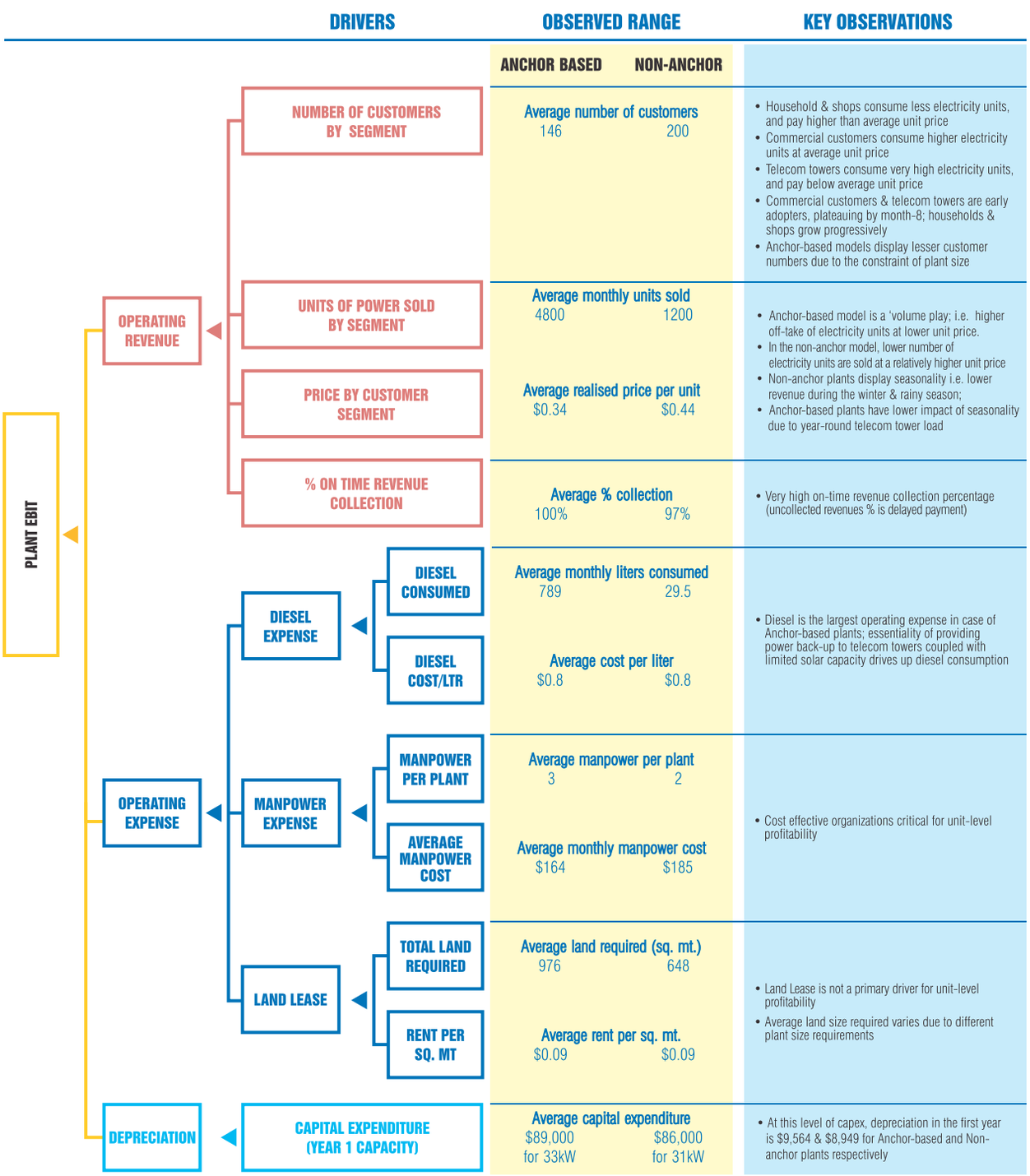
	MONTHLY REVENUE (USD '000)	% OF REVENUE
Household lighting	$0.14	13%
Shop lighting	$0.03	9%
Commercial microenterprises	$0.08	8%
Telecom towers	$0.76	70%
	$1.01	

Table 4: Revenue profile of a sample Type A, Type B Anchor-based plant

Elements Driving Mini-Grid Profit

The key elements that affect a mini-grid plant's operating margin-or profit-are illustrated in Table 5. Identifying these drivers allows for a deeper understanding of how to enhance plant performance.

All four elements that drive operating revenue-number of customers by customer type, units of power sold by customer type, price by customer type, and on-time revenue collection-need to be actively managed. A focus on achieving an optimal customer mix will maximize overall plant revenue. Meanwhile, among the operating expenses, diesel is the largest expense in anchor-based mini-grid plants. Labor is the highest expense in non-anchor plants and is second only to diesel expense in anchor-based plants. Land lease and maintenance costs are a small proportion of total costs and are therefore not key drivers of operating expenses.



**HH = Households

Table 5: Elements that drive the unit-level (operating profit margin) of a mini-grid business

Potential for Plant Performance across Different Scenarios

Renewable energy-based mini-grid plants are expected to display varying levels of performance. The level of performance and commercial viability depend upon the operating model of the plant and the potential customers in the village.

To better understand the different possibilities for financial performance, the SPRD program has modeled various performance scenarios for varying village potentials and plant operating models (see Table 6). This analysis is based on the specific business and operating models currently seen in the sample SPRD plants.

A small, medium and large potential village is defined based on the range of village population size currently served by the SPRD program ESCOs. A mini-grid in a small village is likely to have 170 connected community customers, a medium village 320 connected community customers and a large village 500 or more connected customers. The capital expenditure (CAPEX) necessary for a typical 30 kWp mini-grid is estimated at approximately US$86,000 and is considered for payback calculations.

	KEY SCENARIO PARAMETERS AND ASSUMPTIONS					ESTIMATED UNIT-LEVEL PARAMETERS			
VILLAGE TYPE	PLANT MODEL	ESTIMATED POTENTIAL CUSTOMERS	COMMUNITY CUSTOMER CONVERSION	ESTIMATED CONNECTED CONSUMERS	RECOMMENDED PLANT CAPACITY	MONTHLY REVENUE	MONTHLY OPERATING MARGIN	PAYBACK PERIOD	
Small Village	Non-Anchor	280 community customers	60%	170 community customers	10kWp	$500	($510)	(Negative operating margin)	Only an Anchor-based model may be viable in a small potential village
	Anchor-based	280 community customers + 3 BTS telecom tower		170 community customers + 3 BTS telecom tower	51kWp	$1,793	$861	9 years	
Medium Village	Non-Anchor	530 community customers		320 community customers	18kWp	$831	$357	13 years	Only an Anchor-based model may be viable in a medium potential village; unless the ESCO is willing to accept a longer payback of 13 years
	Anchor-based	530 community customers + 3 BTS telecom tower		320 community customers + 3 BTS telecom tower	58kWp	$2,104	$1,157	8 years	
Large Village	Non-Anchor	830 community customers		500 community customers	50kWp	$1,580	$964	9 years	Both a Non-Anchor and an Anchor-based models may be viable in a large potential village
	Anchor-based	830 community customers + 3 BTS telecom tower		500 community customers + 3 BTS telecom tower	80kWp	$2,851	$1,796	7 years	

Table 6: Comparison of estimated financials of mini-grids serving small, medium, and large villages

Table 6 highlights that only anchor-based mini-grid plants in small and medium villages are likely to be commercially viable[19] (i.e. financial payback of under 10 years at the unit-level). This is because the revenue garnered from the community customer is not sufficient to offset operating expenses. In such villages, a sizeable revenue from the anchor customer allows the mini-grid to function viably. In large villages, the revenue from community customers allows both non-anchor and anchor-based mini grid models to be commercially viable. In essence, mini-grids can be commercially viable only above a certain threshold of power demand. This threshold is estimated to be 40kWp. Villages lacking in this threshold community load can be served in a commercially viably manner by a mini-grid if an anchor load such as a telecom tower subscribes to the mini-grid electricity.

[19] *The project's financial returns are calculated taking into account a government Central Financial Assistance*

KEY OBSERVATIONS AND LESSONS LEARNED

6

KEY OBSERVATIONS

Site Selection

Selecting sites that are most appropriate for mini-grid operations is critical to ensuring commercial success.

Mini-grids require a certain threshold of power demand to be commercially viable (typically a minimum of 40 kWp; however, this can vary depending on the business model and customer mix). Therefore, not all un-electrified or under-electrified villages are suitable. Based on its experience supporting its partner ESCOs, the SPRD program has developed tools to help select appropriate villages as well as to estimate the financial returns of a mini-grid project. While a detailed energy survey must be done to assess a village's load demand as well as feasibility, in general the SPRD program recommends sites that meet the following conditions:

- Include at least 800 to 1,000 households along with a market and commercial enterprises
- Have the potential to cluster with similar villages nearby
- Include or be geographically nearby an anchor load such as a telecommunications tower

Plant Operations

A strong focus on execution is essential to overcome operational challenges.

The early SPRD supported mini-grid plants faced a number of operations-related challenges, which included the following:

- High diesel consumption in anchor-based plants due to greater demand than the existing solar capacity could supply
- High in-plant power losses (an average of 23% across the sample) attributable to inefficient plant equipment, as well as to transmission and distribution losses
- Unplanned shutdowns due to adverse natural events such as storms, floods, and earthquakes

In addition to the routine operational challenges mentioned above, ESCOs with a telecommunications tower as an anchor load have to cater to the stringent uptime requirements of the telecommunications companies.

To operate mini-grids at high operational efficiency levels, ESCOs need to focus on the following:

- Constant collection and analysis of all power plant data, including data related to production, consumption, outages, and losses
- Periodic optimization of the power plant's renewable energy capacity based on demand analysis. This will also help minimize diesel usage and thus reduce operations costs

Demand Generation

To be financially successful, ESCOs need to focus not only on acquiring a village's existing power demand, but also on building additional demand for power by supporting the development of electricity-based local enterprises.

This is a win–win for both the ESCO and the community, as the growth in local enterprise translates into increased economic development for the community and increased demand for electricity for the ESCO. SPRD Program is testing early approaches towards developing such microenterprises and supporting the ESCOs.

Box 1: Debunking Misperceptions

Perception: Rural consumers will not be able to pay electricity bills on time, which will lead to revenue risk for ESCO.
Reality: Average on-time revenue collection was 97% to 100% across customer segments in the sample analyzed by SPRD. This can be attributed to the value that customers see in electricity.

Marketing and Customer Segmentation

A focused 'rural marketing' approach is necessary to drive success.

The key customers of mini-grids are households, shops that need lighting, local commercial enterprises, and an anchor customer (in an anchor-based model) such as a telecommunications tower.

Attracting the optimal mix of customers is crucial for driving profitability. Contrary to popular perceptions, there is a willingness to pay for mini-grid electricity in rural India (see Boxes 1 and 2). However, tapping into this demand requires a coherent marketing and sales strategy that is based on a strong understanding of the customers. The SPRD program's initial customer analysis has revealed (see Figure 3) that households tend to be late adopters of the mini-grid and tend to use electricity in evenings or early mornings. In contrast, commercial enterprises tend to be the early adopters of mini-grid electricity.

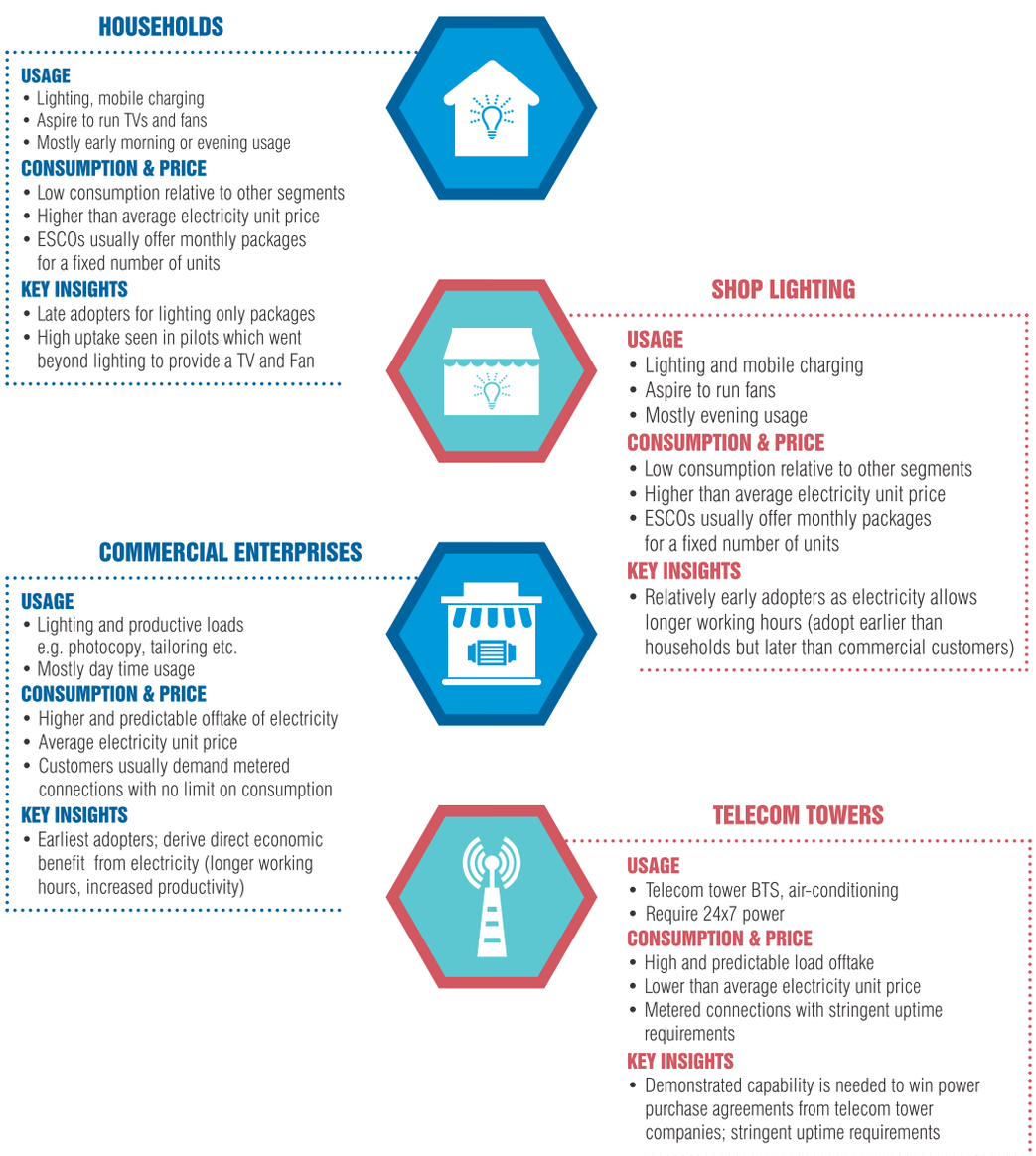


Figure 3: Types of customers that purchase power from the mini-grid power plants

Box 2: Debunking Misperceptions

Perception: Villages that receive some hours of government grid supply will not subscribe to mini-grid power.
Reality: Customers subscribe to SPRD electricity even when 8-10 hours of government grid supply is available. This can be attributed to the high quality and reliability of the SPRD supported mini-grid's electricity.

Necessary Elements for Success

Figure 4 summarizes the elements necessary for a financially successful renewable energy-based mini-grid plant.

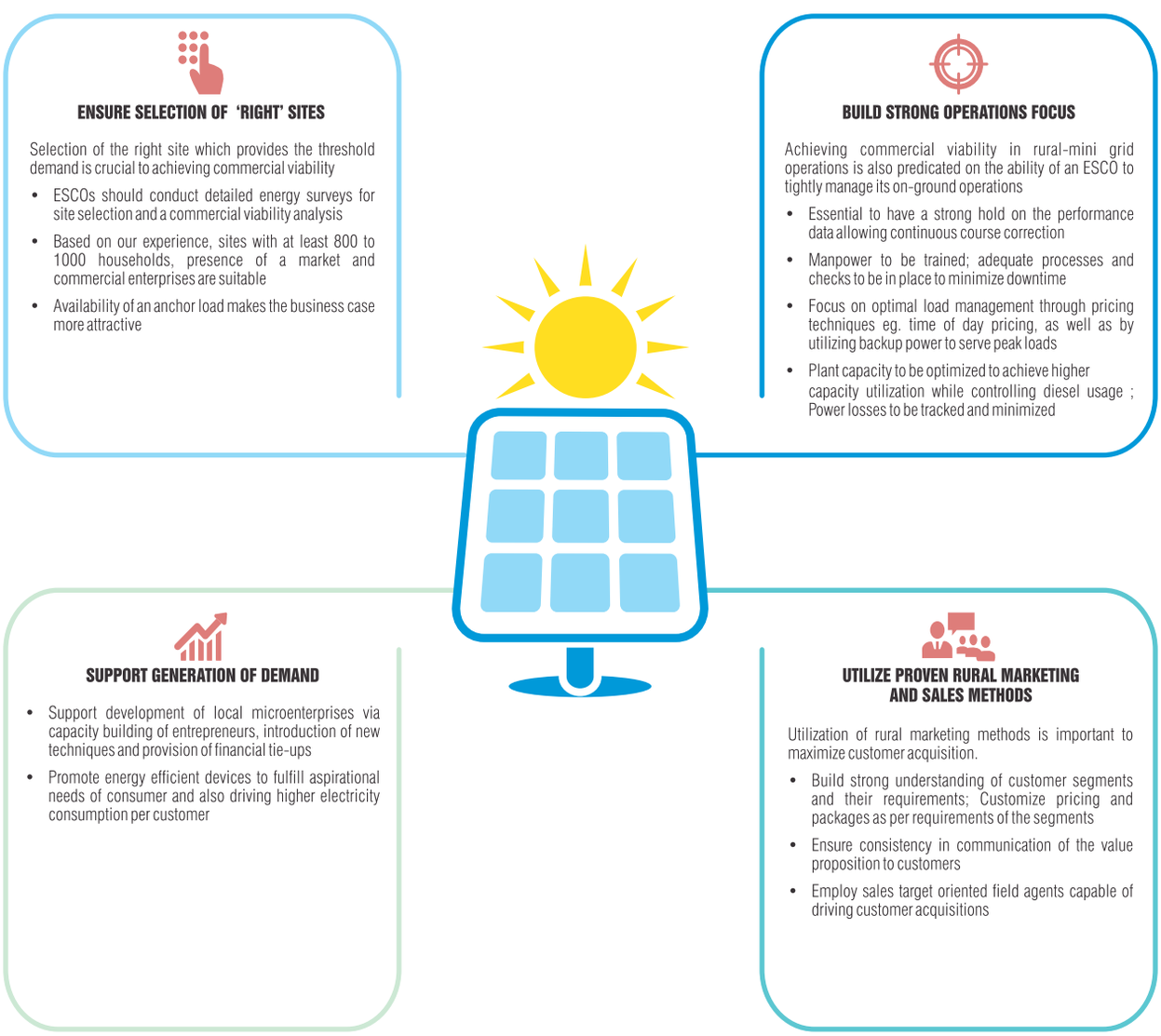


Figure 4: Elements necessary for the financial success of a mini-grid plant

RECOMMENDATIONS FOR DRIVING GROWTH IN THE COMMERCIAL MINI-GRID SECTOR

7

The SPRD program was launched in rural India with clear socioeconomic aims to drive development by providing reliable and high-quality electricity. Early evidence from the SPRD renewable energy-based mini-grid plants suggests that the mini-grids can create some social impact. But to truly drive development, this social impact has to be taken to scale. For this to happen, mini-grids need to be commercially viable so that they can be scaled up. Initial unit-level analyses suggest that several mini-grid plants are already generating profits - this allows us to be optimistic.

Part of the reason for this optimism is that these profits have been generated despite several external challenges. For instance, the huge up-front capital costs combined with ambiguities in governmental policy have to date discouraged companies from pursuing mini-grids as a potentially viable complementary solution to the government's electrification programs. Addressing these barriers will allow easier entry and the sector will flourish.

Below are a few key challenges faced by the sector and how best to address them.

Challenge 1: Lack of Availability of Commercial Finance

Recommendation 1: Provide long-term and low-cost financing.

To enter the renewable energy–based mini-grid sector, businesses need a long-term commitment and a heavy capital investment. For companies that might consider building and operating a mini-grid, an added disadvantage is the limited precedence and data availability of commercially run mini-grids and, in turn, limited understanding of the sector among investors. Long-term and low-cost finance is essential to success in this business. However, this sector has seemed to be in a quintessential "chicken-and-egg" situation. Investors are likely to show interest only if there is compelling evidence from a significant number of operating mini-grids. Yet the number of mini-grids required to deliver such convincing evidence will only be built via investments.

Since 2015, the SPRD program has taken initiative toward solving this conundrum in two ways: (a) by offering long-term concessional financing to partner ESCOs to set up rural mini-grid plants, and (b) by obtaining and analyzing early data to provide credible evidence on the commercial performance of rural mini-grid businesses. SPRD investments in this sector could be spurred by pooling and blending investments from multiple type of financiers[20] of varying risk appetites. The SPRD program aims to develop alliances with other capital providers to increase access to mini-grid financing.

Challenge 2: Need for Supportive Policies and Regulations

The policy issues relevant to the mini-grid sector relate to the conditions under which mini-grids are permitted to operate and to sell electricity, including conditions that may change if a village later receives the opportunity to purchase power from an expanded government grid. The lack of commercial financing for mini-grids has also been linked to uncertainties about government policy: ESCOs and their potential investors rightly recognize the government's grid extension, with its subsidized prices, as a credible risk to future mini-grid revenues. While an overly regulated policy environment for mini-grids could have the opposite of the desired effect, the absence of policy leads to unpredictability, and predictability is essential to attract private investments.

Throughout 2016, the mini-grid sector received noticeable government attention and support. The Cabinet approved an amendment to the National Tariff Policy that recognizes the need to provide appropriate options to secure private investments in renewable energy-based mini-grids, including the ability for mini-grids to feed power to the government grid. In addition, the state of Uttar Pradesh became the first Indian state to release a mini-grid policy, which includes draft regulations to operationalize the policy.

While the sector is garnering government interest and official recognition, more is required. Following are our recommendations:

[20] *Additional types of funding could be obtained from sources such as corporate social responsibility funds, patient capital, or commercial finance.*

Recommendation 1: Continue to offer Central Financial Assistance.

As noted earlier, the significant initial capital cost of setting up mini-grids is a big hurdle. The SPRD program's analysis also points to the fact that a capital subsidy is essential to ensure commercial viability of the mini-grids until a certain scale and maturity is achieved. The Ministry of New and Renewable Energy offers an attractive capital subsidy to private mini-grid developers in the form of Central Financial Assistance. Continuing to offer Central Financial Assistance for both current and new private developers of mini-grids will be necessary until a critical mass of mini-grids is built. Finally, simplifying the procedures for disbursing Central Financial Assistance funds will encourage potential ESCOs to use this fund.

Recommendation 2: Formally announce the National Mini/Micro Grid Policy.

The Ministry of New and Renewable Energy circulated the Draft National Policy on Renewable Energy–Based Mini/Micro Grids in June 2016 for input from stakeholders. The draft national policy and the Uttar Pradesh state policy are noteworthy developments that encourage the private sector to participate in mini-grid development. The formal announcement of the draft national policy, along with setting a national target for mini-grids, will provide momentum to the sector.

Recommendation 3: Support national policies with state-level policies and a clear implementation process.

National policies and regulations regarding the mini-grid sector are now emerging. The next step is to pay adequate attention to the process of implementing these policies. Specifically, at the state level, we recommend the following:

- Release state-level mini-grid policies. Uttar Pradesh is the first state to have released a mini-grid policy, and Bihar is in the process of realizing a mini-grid policy.
- Detail the implementation process for the envisaged policies, with the objective of promoting private investments.
- Provide clarity on plans for extending the government grid. This will allow ESCOs to make informed decisions on where to set up mini-grids.
- Ensure that regulatory frameworks provide options for protecting investments in the mini-grid sector from the risks associated with simultaneous expansion of the government grid.

Recommendation 4: Provide a conducive tax regime.

To encourage ESCOs to set up mini-grids, there will need to be a clear and conducive tax regime for the sector. Tax holidays, similar to those that benefit utility-scale solar projects, and exemptions from the service tax / GST should both be considered.

Petrol pumps running on mini-grid electricity are able to service more customers per day

Challenge 3: Lack of Suitable Technology Solutions

Recommendation 1: Standardize and consolidate the 'mini-grid' technology.

The technology currently being used by mini-grid businesses was borrowed from other applications and is not the optimal technology for mini-grid plants in rural India. This creates inefficiencies such as power losses and frequent breakdowns. Investment is required to develop a mini-grid model-with standardized components, metering, automated billing and collection, and inverter and charge control electronics-that is robust for rural operating conditions.

The sector is also faced with supply chain inefficiencies. ESCOs must currently order equipment from multiple suppliers, with the added challenge of delivery to remote rural locations. Consolidating a mini-grid solution that includes standardized components as well as delivery of materials would create significant value. The Rockefeller Foundation has partnered with the Institute for Transformative Technologies to find innovative ways to improve both cost and performance of the solar mini-grids in India.

Recommendation 2: Seek innovations to reduce the cost of capital expenditures.

It costs approximately US$86,000 to set up a typical 30 kWp mini-grid. This CAPEX, coupled with challenges in obtaining financing (see Challenge 1), make it difficult for many companies to enter this sector. Investment is needed to support technological innovations that can help reduce a mini-grid's CAPEX by at-least 15%. Reducing the CAPEX by this amount will open up possibilities for many more companies to enter the sector, and could unlock the true potential of the rural mini-grid market in India and other developing countries.

It is important to note here that the needed technological innovations are likely to provide a boost not only to the mini-grid market in developing countries but also to mainstream utilities. For example, cost-effective smart meters can be deployed not only by mini-grids, but also by mainstream electricity distribution companies (DISCOMS), thus opening up a much larger market for the innovators.

Successful solutions to the challenges outlined here will help attract private investment to the mini-grid sector, and thus allow it to achieve scale, innovate, and deliver reliable electricity to the under-electrified villages of India.

Several institutions, including banks, in rural U.P depend on mini-grid electricity to improve services

CONCLUSION

8

The SPRD program aims to catalyze a commercially sustainable, renewable energy–based mini-grid sector that can help bridge the large rural electrification gap in India. The ultimate goal is to accelerate the pace of socioeconomic development in India via access to reliable and high-quality electricity.

Given the right impetus, renewable energy–based mini-grids have the potential to become an integral part of India's rural electrification strategy, solving the challenge of providing reliable and high-quality electricity to the last mile—India's villages.

This analysis of the commercial performance of a sample of early SPRD mini-grids provides reasons for cautious optimism. Current unit-level operating margins range from US$200 to US$500 per month. As the plants mature, they may be able to achieve higher operating margins, depending upon the size of the local villages and the potential need for electricity.

Selecting the correct site for a mini-grid plant is necessary for commercial success. The SPRD program recommends mini-grids for sites that have at least 800 to 1,000 households as well as the presence of both a market and productive microenterprises. The presence of an anchor load makes the 'business case' for a mini-grid even stronger. In addition, ESCOs that operate mini-grids need to maintain close control of plant operations.

The ESCOs who partnered early with SPRD are deepening their learning and gaining understanding of the on-the-ground drivers of success. Yet their ability to scale up their businesses remains hindered by external challenges. The most prominent of these are lack of access to commercial finance, ambiguity around government policies, and lack of the right set of technologies to be sufficiently cost-effective and efficient. It is now critical for financiers, policy makers, and technology leaders to address these challenges. Doing so will enable a significant expansion of private businesses providing DRE-based electricity to rural consumers. This could be a much needed bridge to solving India's large rural-urban electrification gap.

Most Smart Power mini-grids use solar energy, while some use biomass or solar/biomass hybrid technology

Photo credits: Mustafa Quraishi
Additional photos: Husk Power Systems, Omnigrid Micropower Company Pvt Ltd

Street vendors are using mini-grid electricity for lighting to work longer hours

The ROCKEFELLER FOUNDATION