

IMPACT REPORT

Understanding the Impact of Rural
Electrification in Uttar Pradesh and Bihar, India:
Evidence from The Rockefeller Foundation's
Smart Power for Rural Development Initiative

May 2017

About Sambodhi

Sambodhi Research and Communications creates high-impact knowledge and catalyses accountability in the public domain through its research, project management, and monitoring and evaluation solutions. Sambodhi offers objective, evidence-based insights to implementers, government agencies, donors, and corporations, and has pioneered development of cutting-edge methodologies for the evaluation of large scale development interventions. Sambodhi's staff of 100 professionals works across Asia and Africa on issues concerning public health, HIV/AIDS, nutrition, water and sanitation, environment, and renewable energy, and has made valuable contributions to measurement, learning, and evaluation (MLE) programs – influencing development policies and improving implementation efficiency. Sambodhi's work has continually provided evidence to affect policy decisions and has been used in leading state policy-making documents such as the economic survey of India.

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For more than 100 years, The Rockefeller Foundation's mission has been to promote the well-being of humanity throughout the world. Today, The Rockefeller Foundation pursues this mission through dual goals: advancing inclusive economies that expand opportunities for more broadly shared prosperity, and building resilience by helping people, communities, and institutions prepare for, withstand, and emerge stronger from acute shocks and chronic stresses.

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Committed to supporting learning, accountability, and performance improvements, the Foundation's Monitoring and Evaluation team works with staff, grantees, and partners to monitor and evaluate the Foundation's pathways to impact in the short- and long-term, and to capture lessons about what works and what doesn't across the Foundation's diverse portfolio.

Cover photo:

Reliable electricity from a mini-grid has enabled local entrepreneurs to open their stores 1-2 hours longer.

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Supported by



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A 30 Kw solar mini-grid.

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Acronyms

CO ₂	Carbon dioxide
DESI	Decentralized Energy Systems India Pvt. Ltd
DHS	Demographic and Health Survey
EEC	Experimental Economics Center
ESCO	Energy service companies
GDP	Gross domestic product
LED	Light emitting diode
M&E	Monitoring and evaluation
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
OBC	Other Backward Classes
OMC	Omnigrid Micropower Company
ORGI	Office of Registrar General & Census Commissioner, India
SC	Scheduled Caste
SES	Socio-economic status
SPI	Smart Power India
ST	Scheduled Tribes
SPRD	Smart Power for Rural Development

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Finally, we are very grateful to our respondents – more than 1,000 households and 300 enterprises – for their time and support.

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Two young women are learning to use a computer at a training center powered by a mini-grid.

Preface

Globally, over 1 billion people still live without electricity. Roughly 237 million of these people are in India. This Impact Report provides insights to the progress, achievements, and challenges of The Rockefeller Foundation's Smart Power for Rural Development (SPRD), a \$75 million initiative aimed at accelerating development in India's least electrified states, starting in Bihar and Uttar Pradesh.

Through the deployment of decentralized renewable energy mini-grids, SPRD works to accelerate the growth of rural economies, while at the same time improving the lives and livelihoods of poor and marginalized families and communities. At the time this report was published, SPRD had reached over 40,000 people.

To ensure that the Foundation evaluates the impact of SPRD and tests our assumptions about whether, how, and at what pace change happens, an independent monitoring, learning and evaluation partner, Sambodhi, regularly monitors and evaluates SPRD's progress and impact in villages in Bihar and Uttar Pradesh.

This report represents an important learning milestone in the SPRD journey. It has generated significant insights on how SPRD is having impact on the lives of villagers in Bihar and Uttar Pradesh, and what more is needed to sustain, grow, and scale these gains.

We are grateful to the team at Sambodhi for its ongoing diligence, independence, and rigorous impact evaluation in providing these insights. They push us to question our assumptions, reflect on the impact evaluation data, and their feedback grounds us in the realities of the lives of men, women, households and businesses in rural villages in Bihar and Uttar Pradesh.

Through learning what works, we are hopeful that the positive gains we are seeing in this Impact Report will be sustained and scaled. We are pleased to share this Impact Report with you, and with other stakeholders in the rural electrification field.

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The establishment of mini-grids has allowed micro-enterprises to purchase mechanical equipment, thus improving their productivity and revenue.

Executive Summary

Launched in 2015, Smart Power for Rural Development (SPRD) is a \$75 million Rockefeller Foundation initiative aimed at accelerating development in India's least electrified states. Through the deployment of decentralized, renewable energy mini-grids, SPRD has supported the Foundation's vision of speeding the growth of rural economies, while at the same time improving the lives and livelihoods of poor and marginalized families and communities.

At the core of SPRD's theory of change is a belief that if energy service companies (ESCOs) and local governments see the business case for providing renewable energy to poor communities, rural electrification can be achieved at scale. With access to energy, individuals, households, and communities can then generate economic opportunities and enhance their quality of life.

Since its launch in 2015, SPRD has made progress toward its goal of transforming the energy landscape of rural India. As of October 2016, SPRD was serving approximately 6,000 households and 3,000 small businesses, providing lighting as well as productive loads. At the time, there were 95 operational SPRD mini-grids owned and operated by 7 ESCOs, serving more than 11,000 residential and commercial customers in Uttar Pradesh and Bihar.

A monitoring and evaluation (M&E) grantee, Sambodhi, was funded to work alongside implementing partners to measure and document the changes that the initiative is having in people's lives. Sambodhi also collected data to inform decision making and support course correction throughout the initiative's implementation.

This report summarizes M&E data collected in late 2016, covering the period March 2016–August 2016. The sample for this report is 39 sites across Uttar Pradesh and Bihar, consisting of 1,000 households and 320 micro-enterprises. Together, these constitute nearly 10 percent of SPRD customers. Another 328 non-customer households were consulted to provide a comparative perspective.

Overview of key findings

SPRD's reach

Most SPRD customers are from low or middle income populations, reflecting the demographic profile of Bihar and Uttar Pradesh. Similarly, SPRD is reaching under-served local businesses reflecting the profile of commercial activity in both states.

Over 80 percent of SPRD customers have low or medium socio-economic status and belong to what are called "low or middle wealth groups." Only a small percentage are considered better-off, belonging to "higher wealth groups." More than 33 percent of households connected to SPRD rely on seasonal or vulnerable livelihood sources such as labor jobs and small businesses. Another 36 percent work in the agriculture sector.

Impact on rural economies and households

SPRD households and business customers are moving up the energy ladder, with households moving at a greater pace than businesses.

SPRD has enabled incremental movement of household customers up the “energy consumption ladder.” Among lower income clients, close to 55 percent have acquired LED lightbulbs for the first time. Middle and higher wealth groups have also quickly moved beyond household lighting to acquire electrical appliances such as fans and refrigerators.

SPRD has enhanced monetary gains and business growth in rural economies by increasing the quantity, type, efficiency, and scale of micro-enterprises, and contributed to social, economic capital with modest gains in village GDP. Off-farm micro-enterprises connected to mini-grids have experienced a 13 percent average increase in their monthly revenues.

SPRD has expanded the quantity and types of village micro-enterprises, enhanced the comfort and efficiency of the operating environment for small businesses, and increased the monetary gains of villagers. The 13 percent average increase in monthly revenue that SPRD’s micro-enterprise customers have seen since early 2015 represents a 14 percent increase for SPRD lighting load customers and a 12 percent increase for productive load micro-enterprise customers.

Data from 2016 indicate that SPRD villages experienced an \$18.50 per capita increase in GDP+. Of this, \$3.00 is from an increase in per capita GDP and \$15 is based on a valuation of social benefits, including additional leisure time and personal development activities.

The establishment of mini-grids has led to mechanization, expansion, and creation of new businesses. Almost 11 percent of connected micro-enterprises and shops have expanded their businesses by adding newer appliances, and about 7 percent of connected micro-enterprises are new – established as a result of gaining access to energy. Of these, half are micro-enterprises that consume SPRD electricity for productive purposes such as incense stick-making units, snack-making units, and a reverse-osmosis water filtration plant.

The types of micro-enterprises within SPRD-connected villages have also expanded. Early on, many micro-enterprise SPRD customers were small, sole-proprietor businesses, such as tailoring and carpentry shops. By 2016, the program had seen the emergence of businesses with a larger social reach, such as training centers for tailoring and computer skills. These have the potential to expand the human capital and skills of the villagers significantly and, in turn, help create an employable population.

Mini-grids have yielded many benefits to micro-enterprises. Access to reliable lighting has allowed businesses to stay open after daylight hours, something that was previously difficult. Connectivity has also enabled micro-enterprises to invest in fans and improved lighting, all of which enhance the convenience and comfort of doing business.

SPRD services have led to improved health conditions, study time, safety, and increased mobility at the household and community levels, significantly improving villagers’ access to public institutions such as health centers, educational institutions, market places, and streets.

Parents report that better lighting improves the quality and length of their children's study hours. SPRD light is reportedly much easier on children's eyes than light from kerosene lanterns or other sources, and children complain less about eye irritation.

At the community level, in addition to enabling the establishment of new training centers, electricity supply has improved the accessibility of public facilities such as health centers and markets by providing them with reliable lighting.

The street lighting enabled by SPRD has helped create a greater sense of security within communities, especially for women. Villagers report that the combination of improved household and street lights has improved their mobility – within and outside their homes. Close to 87 percent of women feel that their mobility has vastly improved after dark, due to reduced apprehensions about safety. This is even more meaningful considering that Bihar and Uttar Pradesh have among the highest rates of violence against women in India.

More and better lighting has led to greater comfort and efficiency for households and businesses.

This is particularly true for women, with around 90 percent highly appreciating the increased ease of daily chores. In addition to making their daily lives easier, SPRD clean lighting has contributed to reducing indoor air pollution.

While SPRD has improved the quality of life for women, including improved ease of chores, improved safety, health, and mobility, and acquisition of new skills, it has not adequately involved women in the decision making related to the acquisition of electricity.

More and better lighting also leads to greater comfort and efficiency for women, with around 90 percent highly appreciating the increased ease of daily chores. In addition to making women's daily lives easier, SPRD clean lighting has also contributed to reducing indoor air pollution. More than 75 percent of women report a reduction in respiratory ailments since lessening their heavy dependency on kerosene.



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An entrepreneur purchased electricity from a mini-grid to power electrical tools and appliances in his welding shop.

Introduction

The Smart Power for Rural Development initiative

Launched in 2015, Smart Power for Rural Development (SPRD) is a \$75 million Rockefeller Foundation initiative aimed at accelerating development in India's least electrified states. Through the deployment of decentralized, renewable energy mini-grids, SPRD has supported the Foundation's vision of accelerating the growth of rural economies, while at the same time improving the lives and livelihoods of the poor and marginalized.

At the core of SPRD's theory of change is a belief that if ESCOs and local authorities see the business case for providing renewable energy to poor communities, rural electrification can be achieved at scale. With access to energy, individuals, households, and communities can engage in economic opportunities and enhance their quality of life. The aim of SPRD is to enable 1,000 villages in India to gain efficient access to reliable and affordable electricity, in turn leading to expanded livelihood opportunities and improved social and environmental conditions.

SPRD's approach is anchored in the deployment of mini-grids: standalone installations that utilize

renewable energy to generate electric power to residential, enterprise, and anchor-load customers such as cell-towers. The initiative was designed to address key gaps in the mini-grid market, including lack of appropriate financing for private ESCOs, untested business models, uncertain policy frameworks regarding the arrival of the national grid, and the weak understanding that ESCOs and potential investors have of the rural demand for electricity.

The Rockefeller Foundation provides patient capital, usually in the form of debt, to private ESCOs. This allows the Foundation to enter and drive the expansion of the mini-grid market. To support its work, in 2015, the Foundation created Smart Power India (SPI), a unique new entity to provide project development support to ESCOs in areas such as site selection, business modeling, community marketing, micro-enterprise promotion, technology and innovation partnerships, performance analysis, and policy support.

As of October 2016, there were 95 operational SPRD mini-grids owned and operated by 7 ESCOs, serving more than 11,000 residential and commercial customers in Uttar Pradesh, Bihar, and Jharkhand.

Monitoring and evaluation of SPRD

To support the attainment of SPRD's ambitious goals, The Rockefeller Foundation funded a monitoring and evaluation (M&E) grantee, Sambodhi, to:

- **assess the impact of the initiative on villagers' lives** through a staggered baseline and endline study of a sample of intervention sites to determine the extent of the initiative's impact on people, families, and communities
- **conduct ongoing monitoring, data collection, and analysis** to enable course correction and continuous improvement through its analysis of the effectiveness and efficiency of program operations, implementation, and service delivery at the community level.

Tracking of key output and outcome indicators for SPRD is an ongoing process that provides regular feedback to the Foundation and its partners to inform decision making and fine-tune the intervention. Since June 2015, data collection has taken place biannually at intervention sites that have been operational for at least six months.

Within these parameters, 39 sites were selected for the third round of implementation progress monitoring which concluded in October 2016. The exercise was conducted with a representative sample of 1,000 household customers and 320 micro-enterprises, which represented some 10 percent of SPRD's current¹ customer base.

¹ October 2016

Customer profiles and consumption patterns

Understanding household customer and non-customer base

SPRD's household customers

Most SPRD customers are from low or medium income populations, reflecting the demographic profile of Bihar and Uttar Pradesh. Over 80 percent of SPRD customers have a low or medium socio-economic status and belong to what are called “low or middle wealth groups.” Only a small percentage are considered financially better-off, belonging to “higher wealth groups.”

Most SPRD customers come from socially excluded groups (Jacobson, 2016), with 58 percent belonging to what the government of India refers to as Other Backward Classes (OBCs), and 22 percent to Scheduled Castes (SCs) (see box). This distribution mirrors the demographics of the villages and the states where SPRD is active (ORGI, 2016). Similarly, the economic profile of SPRD customers is consistent with local figures, with almost 90 percent of customer households belonging to low wealth groups (see Figure 1).

In terms of livelihoods, more than 33 percent of households connected to SPRD rely on seasonal or vulnerable livelihood sources, such as labor jobs and small businesses. Another 36 percent work in the agriculture sector. Yet, while agriculture is the primary

Other Backward Classes and Scheduled Castes

Other Backward Classes (OBCs) is a collective term the Government of India uses to classify castes which are socially and educationally disadvantaged. The Backward Classes Division of the Ministry of Social Justice and Empowerment looks after the policy, planning and implementation of programs relating to social and economic empowerment of OBCs, and matters relating to two institutions set up for the welfare of OBCs, the National Backward Classes Finance and Development Corporation and the National Commission for Backward Classes.

Scheduled Castes (SCs) and Scheduled Tribes (STs) are official designations given to various groups of historically disadvantaged indigenous people in India. The terms are recognized in the Constitution of India and the various groups are placed in one or another of the categories.

Calculation of wealth categories

Wealth categories are based on household asset ownership, a method adopted from the Demographic and Health Survey (DHS). The wealth index, a composite measure of a household's cumulative living standard, is calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles, materials used for housing construction, and types of water access and sanitation facilities. Generated with a statistical procedure known as principal components analysis, the wealth index places individual households on a continuous scale of relative wealth. The DHS separates all interviewed households into wealth quintiles.

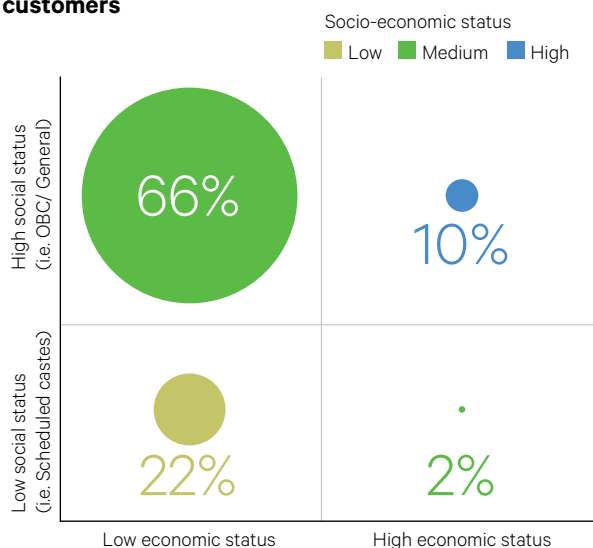
occupation for 36 percent of SPRD customers, some 33 percent of SPRD customers do not have access to agricultural land. Approximately 10 percent of the SPRD-connected households run small businesses and shops as their key source of livelihood.

SPRD's micro-enterprise customers
SPRD is reaching under-served local businesses, reflecting the profile of commercial activity in Uttar Pradesh and Bihar. Nearly 80 percent of connected businesses have monthly revenues of \$448 or less.² Similar to household customers, 69 percent of micro-enterprise owners belong to Other Backward Classes, reflecting the broader commercial profile in Uttar Pradesh and Bihar.

Since 2015, SPRD has continued to expand its micro-enterprise customer base. At the time of this assessment, 80 percent of businesses connected to SPRD used electricity for lighting purposes. Over time, the initiative has placed a greater emphasis on the importance of engaging productive load customers – those that use

² Micro-enterprises, under SPRD, have been classified into three categories: i) revenue less than \$149 per month (38 percent); ii) revenue between \$149 and \$448 per month (42 percent); and iii) revenue greater than \$448 per month (20 percent).

FIGURE 1: Socio-economic profile of SPRD household customers



68 percent of SPRD's household customers fall in the medium socio-economic status category (represented by upper left and lower right quadrants). Of these, 66 percent are households with high social status and low economic status, and 2 percent are households with low social status and high economic status. Around 22 percent of household customers belong to the low socio-economic status group, which consists of households that rank low on social as well as economic parameters.

energy to increase productivity, expand their business, or establish a new business. SPRD has continued to engage a wide variety of productive load businesses (Figure 2) such as fuel stations, grain mills, and irrigation pumps, which constitute the typical high-load micro-enterprise customers. These types of units, which account for 7 percent of all micro-enterprises connected to SPRD, have the potential for positive socio-economic impact³ by creating new employment opportunities within villages. Computer centers, photo-copy units, photo studios, and pharmacies, which are typical medium-load customers and account for close to 13 percent of the customer base, also have high potential for positive socio-economic impact (Figure 3).

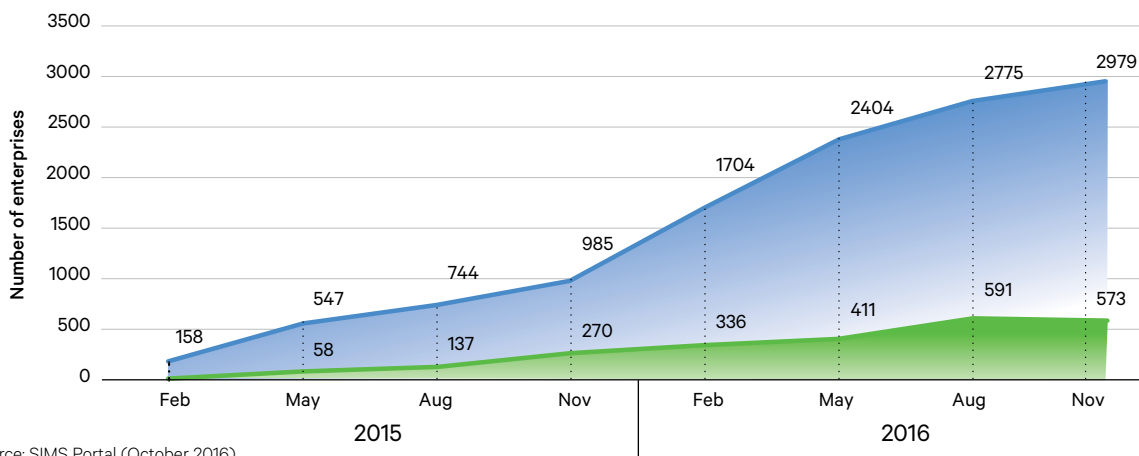
ESCOs acquire micro-enterprise customers through conversion or creation.

³ Perceived impact potential of a micro-enterprise is defined as the ability of the unit to create socio-economic impact with regard to people served, quality of life created, and the contextual importance of product or service provided.

Conversion refers to replacing diesel-generated electricity with electricity from mini-grids. Almost 11 percent of conversion clients expanded their businesses by adding newer appliances. For example, a fruit shop in Hardoi District, Uttar Pradesh, added an electric juicer to sell freshly-squeezed fruit juice. Similarly, many snack shops installed refrigerators to sell cold drinks.

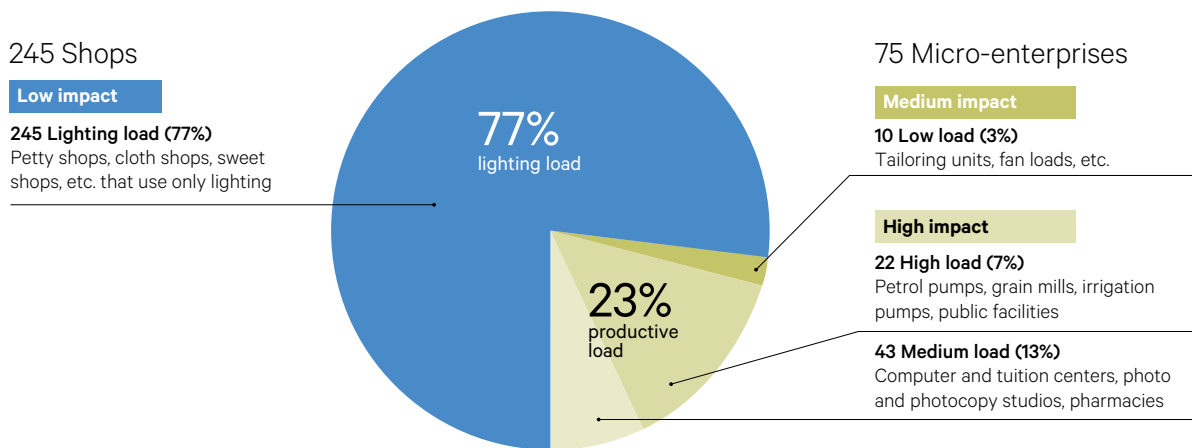
Creation refers to new businesses started as a result of access to electricity from mini-grids. Approximately 7 percent of connected micro-enterprises have been created, due to SPRD electricity supply. Of these, nearly half are micro-enterprises that consume SPRD electricity for productive purposes, such as incense stick-making units, snacks-making units, and a reverse-osmosis water filtration plant.

FIGURE 2: Proportion of lighting and productive loads



Source: SIMS Portal (October 2016)

FIGURE 3: Types of micro-enterprises connected to SPRD



Shifts in energy consumption patterns of customers

One of the most notable successes of the initiative has been SPRD's ability to transition households and businesses away from potentially harmful and polluting sources of lighting such as kerosene and diesel. Most SPRD-connected households (86 percent) use power purchased from mini-grids as their key lighting source, and 23 percent have completely stopped using kerosene for lighting purposes. Consumption of government grid electricity increased over the course of SPRD's implementation – from 26 percent to 35 percent – owing to improved supply by the government. Micro-enterprises have also started moving to cleaner sources of lighting fuel – 82 percent now primarily use electricity from mini-grids and almost 25 percent have completely stopped using kerosene and diesel for lighting.

Impact of SPRD on energy consumption

SPRD household customers are incrementally moving up the energy consumption ladder. More than half of SPRD's household customers from lower wealth groups are buying LED bulbs for the first time. Customers from middle and higher wealth groups are

beginning to purchase and use electrical appliances beyond basic lighting devices.

Micro-enterprises are moving up the energy ladder by acquiring appliances that improve the comfort and efficiency of their businesses and enable diversification. The concept of the energy ladder can also be applied to micro-enterprises. In the context of micro-enterprises, the basic premise of this concept is that, once connected, enterprises will acquire new appliances and thus be able to move to higher levels of productive economic activity. This assumption is being played out among SPRD micro-enterprise clients. One-third of micro-enterprises purchased mobile phones after getting connected to SPRD, while 18 percent have purchased fans. This has proven an improvement in shops' ambience, benefitting owners as well as customers, with 60 percent of owners reporting improved lighting conditions and ease in business operations.

Garment shop owner from Laliya

“People come from nearby villages, and if my shop is not comfortable enough, they will not come back. I have installed an electric fan for them. It is important to keep your customers satisfied. If the SPRD connection remains this smooth, I will get an LED television for my shop. It sometimes gets quiet when there are no customers.”

3

Impact of SPRD on micro-enterprises

SPRD's impact on micro-enterprise operations

The types and extent of impact on micro-enterprises vary greatly by business and load type. For shops using an SPRD lighting load, the impact has largely been enabling longer operational hours and making the store more attractive to customers by providing electric fans and phone charging. Around 60 percent of micro-enterprise customers reported that SPRD has contributed to improved ease in doing business – particularly for productive load customers. Close to 11 percent of owners reported investing in a new appliance.

Larger as well as smaller scale enterprises have benefited considerably from mechanization. For example, individual, small-scale tailoring units have shifted from manual to motor-run stitching machines, which has increased their productivity by at least 50 percent. Likewise, carpenters have shifted from manual tools to machinery, making it easier for them to deliver high quality work and expand their services.

Together, improved operations and higher productivity have contributed to a range of positive outcomes for micro-enterprises. This is further explored in the next section.

Carpenter from Mahalgaon

“Before connecting to SPRD, I usually took three or four days just to smooth and even out wooden planks, often leading to a delay in delivering products. I always felt the need for a mechanized device for smoothing, but there was no electricity in the village and my diesel generator was unreliable. With the SPRD mini-grid plant in place and assurance of a continuous supply of electricity, I purchased a polishing device that can run, uninterrupted, for seven hours. This has enhanced productivity, but also the quality of my products, and I can cater to a larger number of customers. The work which used to take three to four days now can be finished in one, and my work is much easier and less tiring.”

SPRD's impact on micro-enterprise revenue

SPRD enhances business growth in rural economies by increasing the quantity, type, and scale of micro-enterprises. The types of micro-enterprises within SPRD-connected villages have expanded. Early on, many micro-enterprise SPRD customers were small, sole-proprietor businesses, such as tailoring

and carpentry shops. In 2016, the program saw the emergence of businesses with a larger social reach such as training centers for tailoring and computer skills. These have the potential to expand the human capital and skills of the villagers significantly, and to help create an employable population. The last year of the program also saw the growth of socially responsible enterprises, such as reverse-osmosis water filtration units in areas with limited clean water supply, and ultra-sonography units and health centers that provide doorstep delivery of health services to remote villages.

Some micro-enterprise owners have diversified their businesses. For example, owners of sweet shops have bought refrigerators and started selling chilled drinks during the summer. Mobile repair shop owners have invested in computer systems and printers. Fruit stall owners report buying electric juicers to increase efficiency and serve more customers. While these findings are still preliminary, they are indicative of the potential effects that access to energy can have for micro-enterprises – including both improved efficiency and greater opportunities for revenue generation.

Micro-enterprises connected to mini-grids have experienced a 13 percent⁴ average increase in their monthly revenues. Shops with lighting loads have shown a 14 percent monthly increase, equal to \$41, while productive units have had a 12 percent average increase, equal to \$49.

Currently, SPRD's impact is most visible in off-farm enterprises. Off-farm enterprises account for almost 97 percent of all micro-enterprises connected to the initiative's mini-grids. The few exceptions include irrigation pumps⁵ being used for dry season cultivation,

or grain processing units. The benefits for off-farm enterprises are often in the form of increased revenue, while benefits of on-farm enterprises are often seen in decreasing costs. For example, SPRD-connected irrigation pumps reduce the cost of irrigation by around 70 percent, creating a substantial savings.

Enhancing economic activities with SPRD

Aiming directly at creating economic opportunities within villages, SPRD has placed an increased emphasis on moving beyond lighting load customers towards increased numbers of productive load customers.

Monitoring feedback has highlighted the ongoing need for a more enabling business environment. Lack of access to credit and finance has been a commonly cited challenge and barrier for those looking to expand or create new opportunities. Of the connected micro-enterprises, 75 percent of owners must depend on their own savings to set up their ventures. At the same time, 38 percent of interested entrepreneurs are reluctant to start something new.

In response to the needs of micro-enterprises, ESCOs have supported them to access credit. However, finance alone is insufficient to ensure sustainability of the enterprises. For example, the ESCO TARA Urja has helped many entrepreneurs receive low-interest credit, either by linking them with financial institutions or providing them with loans against a utility contract. Understanding that finance alone is not sufficient and that technical skills are also needed to operate productive units, TARA Urja has also provided training in vocational skills such as mobile repairing, or operating spice grinders and confectionery machines. TARA Urja hosts a diverse portfolio of productive units such as barber shops, mobile repairing units, juice centers, ultra-sonography centers, water filtration units, welding machines, and irrigation pumps as well as training centers for tailoring and computer skills.

⁴ This difference does not account for other factors such as general improvements in economic conditions that might benefit all enterprises – including those not participating in SPRD. Hence the difference indicates contribution and not attribution.

⁵ In context of SPRD, irrigation pumps are considered an enterprise as they generate productive load for SPRD while also contributing as an economic activity.

4

SPRD's contribution to village economic welfare

GDP+ as an indicator of economic welfare

Research suggests that reliable electricity supply has the potential to transform lives and drive economic growth.⁶ The benefits of access to electricity for rural communities are manifold, including increased evening hours of study for children, improved access to information and mass media, increased safety and security at night, and substantial health and quality of life benefits, particularly for women. However, little is known about how the above economic, environmental, and social benefits of electrification translate into the improved economic welfare of a community.

Measuring GDP+

With its focus on inclusive economies and resilience, The Rockefeller Foundation supported Sambodhi in developing the GDP+ tool to capture and quantify

the key social, economic, and environmental changes generated through rural electrification.

Recognizing the limitations of measuring only the monetary value of GDP to reflect the true value of SPRD to communities, the GDP+ tool includes measures of gross domestic product (GDP) as well as social change. In this case:

- social change is monetized by analyzing the change in time allocation across economically productive or leisure activities with respect to the existing wage rates
- environmental change is monetized by measuring the reduced carbon footprint with the existing carbon credit prices in the global market.

By using this method in eight intervention villages on a bi-annual basis, SPRD was able to illustrate that it created a positive change in economic welfare in its intervention villages by a per capita amount of \$18.50. It is interesting to note, as shown in Table 6, that more than 80 percent of this change was due to social benefits, thus underscoring the importance of social and human capital in achieving impact.

⁶ Source: see reference list for UN, 2016; Barnes, 2014; Independent Evaluation Group, 2008; UNDP, 2009; Barnes, *et al.*, 1997; UNDP-World Bank, 2004.

TABLE 1: GDP+ measurement

Aspect	Indicator	Difference attributable to SPRD	Difference attributable to SPRD (monetized)	% Contribution to GDP+
Economic	GDP per capita (\$)	3.0	\$3.00	16%
Environmental	Carbon footprint per capita (tons CO ₂ e)	0.08	\$0.50	3%
Social	Increase in time for leisure/productive activities per capita (hrs)	0.5	\$15.00	81%
	Reduction in domestic chores per capita (hrs)	0.0		
Net change in GDP+			\$18.50	

Application of the GDP+ method

Economic growth

The expenditure approach⁷ has been adopted for calculating village-level GDP as a measure of economic growth (EEC, 2015). GDP is primarily measured by computing household-level expenditures under the following heads:

- consumption expenditures – on foods, such as grains, vegetables, spices, and condiments; on non-food items such as rent, healthcare, and education; and on energy expenses
- investments – purchase of assets
- investments – savings
- exports – sale of goods and services to households or enterprises located outside the village

⁷ This approach considers the final value of goods and services produced as the total expenditure incurred by the economy to avail them within the reference period. Components of expenditure approach include personal consumption expenditures (C); gross private investment (I); government expenditure on services such as roads, market and health facilities; and net exports (difference between the values of goods and services produced within the economy and exported, and goods and services produced outside the economy but used within it). Thus, the GDP is calculated using the following formula: $GDP=C+I+G+(X-M)$.

- imports – purchase of goods and services from households or enterprises located outside the village.

Sambodhi examined the current per capita GDP of sampled villages, their growth over the previous six months, and the factors that drove the growth. Analysis found the per capita GDP in the intervention areas had grown 6 percent, from \$414 to \$439. While the growth in GDP was in line with the economic growth of the country, the factors contributing to GDP shifted (*Trading Economics*, 2016). Among SPRD villages, investments in both assets and savings increased, while the contribution of food and non-food expenses remained constant. There was also a marked reduction in energy expenses as a proportion of GDP, mainly due to reduction in consumption of diesel. These findings are preliminary and will continue to be validated in subsequent rounds of data collection. Likewise, diesel consumption for agricultural purposes is seasonal, and hence it may be too early to attribute the change in energy expenditures to SPRD.

The contribution of different components varies across communities and households. For households

FIGURE 4: Contribution of different components to GDP

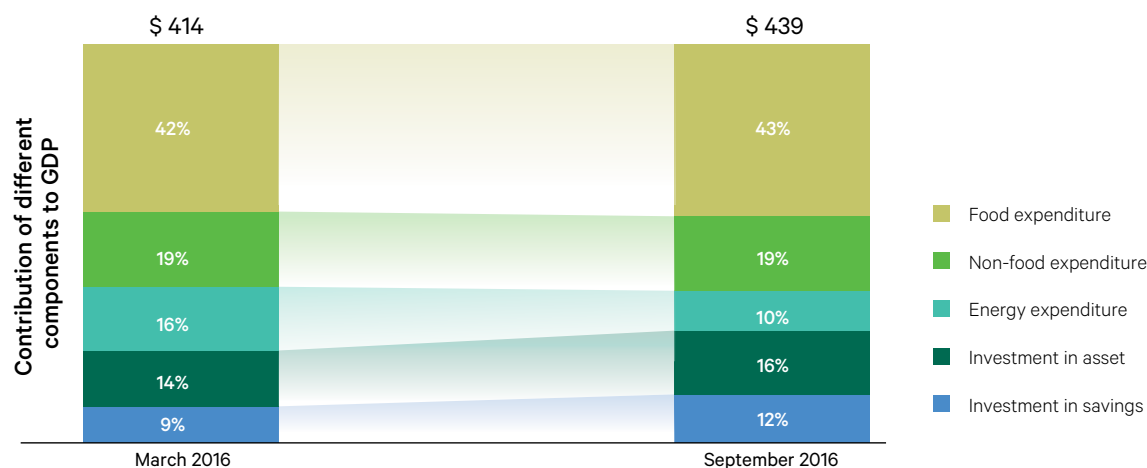
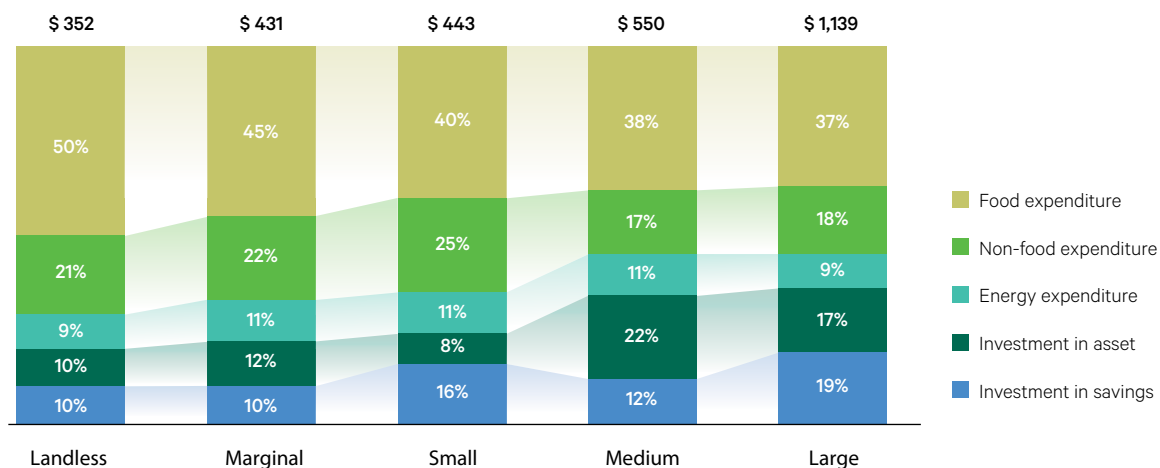


FIGURE 5: Contribution of different components of GDP across different land-holding categories



with very small landholdings, consumption expenditures make the greatest contribution to GDP. There seems to be a direct inverse correlation between landholding size and consumption expenditure as a contributor to GDP. For households with larger landholdings, the contribution of investments is proportionately larger than that of small or marginal households.

While contribution to GDP varies with socio-economic parameters, at an aggregate level it is critical to estimate SPRD's contribution to an overall increase in GDP.

Per capita GDP in the SPRD areas increased by 6 percent (\$25), compared with an increase of 5 percent (\$22) in the non-SPRD areas. This reflected a difference of \$3.00 between SPRD and non-SPRD areas.

TABLE 2: Change in GDP attributable to SPRD (USD)

Type of village	Per capita GDP March 2016	Per capita GDP Sept 2016	Per capita GDP growth	Change in GDP attributable to SPRD
SPRD	\$414	\$439	25 (6%)	\$3.00
Non-SPRD	\$411	\$433	22 (5%)	

Social change

With mini-grid connections, daily chores can be performed with increased efficiency, including greater flexibility after sundown. This is particularly important for women, who often bear the sole or primary responsibility for domestic duties. Less time spent on chores and more flexible hours can, in turn, translate into increased opportunity to engage in economically productive work, and personal development or leisure activities. Improved safety and security conditions after sundown also enable women to socialize after dark.

Homemaker from Katliya

“We used to go to sleep after all the household work was done, because using the kerosene lamp for other activities did not make much sense. After all, only a limited quantity is available under the subsidy! But now we have the SPRD light till midnight. I do a bit of knitting after dinner instead of just going off to sleep.”

Recognizing these causal relationships, the GDP+ tool applies a time reallocation scale to identify the social change triggered by SPRD. Any increase in daily time spent on income-generating or leisure activities is considered a positive change, while an increase in the time spent on daily domestic chores is considered a negative change.

As highlighted in Table 3, SPRD has increased the involvement of women in personal development activities by 0.5 hours per day. Monetizing this change – using the hourly wage rate (MGNREGA, 2016) for 100 productive days in a year (MRD, 2016) – found that the contribution of social change to economic welfare in the six months covered by the impact assessment was \$15. With no observable change in the daily time use for men and women in the non-SPRD regions, this change of \$15 can be associated with SPRD.

Environmental change

As Chapters 3 and 4 illustrate, SPRD has been able to replace or reduce use of kerosene and diesel in

TABLE 3: Daily time use for women

Daily activities	Avg. daily time invested (hrs) March 2016	Avg. daily time invested (hrs) Sept 2016	Change (hrs)
Agriculture on own farm	6.0	6.0	0.0
Agriculture on other farms	1.0	1.0	0.0
Non-agricultural labor	3.0	3.0	0.0
Personal development (training/ knitting/sewing)	0.0	0.5	0.5
Leisure	3.0	3.0	0.0
Domestic chores	6.0	6.0	0.0

TABLE 4: Monetizing social benefits

Net positive change (hours)	0.5
Hourly wage rate (USD)	0.3
No. of productive days in a year	100
Annual contribution of social benefits to change in GDP+ (USD per capita)	15.0

households and in micro-enterprises. While replacing fossil fuel has positive effects on the indoor ambience, it also has a significant bearing on environmental stress. The GDP+ measurement factors in this environmental contribution by measuring the reduction in fossil

fuel usage, which can then be monetized using the carbon dioxide equivalent factor and the existing global carbon exchange rates. Table 4 highlights the six-month change in carbon emissions at the household level.

The per capita environmental footprint of SPRD villages was reduced by 0.085 tons of CO₂ equivalent. This translates into a contribution of \$0.50 to the overall change in GDP+.

Reduction in diesel and kerosene usage contributes the most towards reducing the environmental footprint.

TABLE 5: Change in carbon emissions

Energy source	Carbon dioxide equivalent ¹ (tons CO ₂ equivalent)	March 2016		October 2016		Change (ton CO ₂ e/unit)
		Average annual consumption per capita	Total CO ₂ emissions (tons CO ₂ e/unit)	Average annual consumption per capita	Total CO ₂ emissions (tons CO ₂ e/unit)	
Firewood (kg)	0.10	213	0.021	162	0.016	-0.005
Kerosene (liter)	2.50	6	0.015	6	0.015	0.000
LPG (liter)	1.70	10	0.018	11	0.019	0.001
Petrol (liter)	2.40	7	0.017	6	0.014	-0.003
Diesel (liter)	2.60	68	0.176	33	0.085	-0.091
Govt. grid electricity (kWh)	0.53	2	0.001	27	0.014	0.013
Total	0.248		0.163		-0.085	

Source: UNEP, 2016.

TABLE 6: Monetizing environmental benefits

CO₂e reduced per capita per year (ton)	0.085
Carbon credit price, 2 March 2016 (\$)*	5.54
Contribution of environmental benefits to change in GDP+(\$)	0.5

*Source: Investing.com, 2016.



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Monitoring data since June 2015 indicate that children's after-sunset study hours increased an average of 30 minutes – from 1.5 hours to 2 hours.

Impact of SPRD on households

SPRD contributes to improved and sustained engagement in education

Close to 97 percent of school-age children in rural India are enrolled in public or private schools (Pratham, 2015) including 94 percent of children in Bihar (*Times of India*, 2015) and 96 percent in Uttar Pradesh (CMS, 2013). However, as the 2015 Annual Status of Education Report (ASER)⁸ pointed out, a high rate of enrollment doesn't ensure better learning outcomes (Pratham, 2015); poor study conditions at home is one of the key barriers. Inside Primary School—A Study of Teaching and Learning in Rural India, a 2011 report by ASER (Bhattacharjea, 2011), indicated a correlation between access to electricity at home and learning outcomes of school children. While it is too early to attribute education outcomes to SPRD, this is an important correlation for the Foundation and stakeholders to be cognizant of as the initiative moves forward.

Enabling longer and improved study conditions has been one of SPRD's most important results to date.

⁸ ASER is an annual survey that aims to provide reliable annual estimates of children's schooling status and basic learning levels for each state and rural district in India. ASER has been conducted every year since 2005 in almost all rural districts of India.

Monitoring data since June 2015 indicate children's after-sunset study hours increased an average of 30 minutes – from 1.5 hours to 2 hours. While increase in study duration is considered a very important change, parents of school children consider the quality of the lighting itself – including its consistency and illumination level – to be even more impactful.

Some 67 percent of parents cite the fixed timing of ESCO household power supply (usually the six hours between 6pm and midnight) as helping their children plan their study time better. They also cite the benefits

Parent of school children from Supaul District, Bihar

“You can't expect a child to study for more than two hours after school. But it is important that whatever time he or she studies is effective. Earlier, it was very difficult to make the kids study in the evening under the kerosene lamp. They would complain of eye irritation. The boys would even start fighting with each other for space, since the lamp covered very little area. Now, I can actually see them study properly under the bulb, even if it is for the same duration as earlier.”

of higher quality SPRD light, which flickers less, covers a larger area than kerosene wick lamps and grid electricity, and reduces eye irritations.

Impact on women

While SPRD has improved the quality of life for women, including ease of daily chores, increased safety, health, and mobility, and acquisition of new skills, it has not involved women adequately in the decision-making process related to the acquisition of power. Women who live in rural Bihar and Uttar Pradesh often spend several hours each day working in their family's agricultural field, a couple of hours at the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) site,⁹ and another eight hours taking care of children and in-laws, cooking family meals, and feeding poultry. This is representative of the 144 million women (ORGI, 2016) in these states who spend most of their time on domestic chores. With improper lighting, chores become more difficult, injuries due to darkness increase, and continuous use of kerosene wick lamps while cooking increases vulnerability to respiratory ailments. More than 75 percent of women report reduced respiratory ailments when they using SPRD lighting rather than kerosene- or diesel-based lamps.

With improved SPRD lighting and access to a reliable power supply, 90 percent of women experience increased ease in carrying out daily chores. In addition, 88 percent of women report that light enables them to spend more time in social activities, because participation is more difficult and less safe in the dark. Women have also shared many ways in which they can now enjoy free time, including apprenticeships in basic skill trainings and watching movies on mobile phones.

Well-lit households usually means well-lit surroundings. Close to 87 percent of women feel that their mobility and safety after dark has vastly improved. This is even

more meaningful considering that Bihar and Uttar Pradesh have among the highest rates of violence against women in India. Women's safety is a major issue in rural areas, where male family members have often migrated to distant towns and cities in search of work, leaving women at home. Without electrical connections, women have to venture out alone at night to charge mobile batteries at local mobile shops. This risk has been somewhat alleviated with residential customers who are connected to mini-grids and benefit from light and the ability to charge mobile phones.

Monitoring findings to date indicate that SPRD's customer acquisition activities are largely centered on men. Women report that it is usually the men who interact with ESCO representatives and, hence, men are more aware of SPRD offerings. They also suggest that if they were better engaged by service providers, they would have a stronger and informed, if not an equal, say in purchase decisions.

Impact on access to public facilities

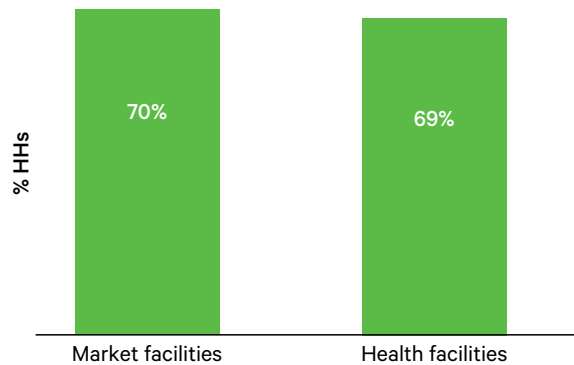
Lighting provided by SPRD has significantly improved villagers' access to public institutions such as health centers, educational institutions, market places, and streets. Close to 70 percent of the household customers (Figure 6) report that electricity from mini-grids has helped markets and health facilities expand their working hours, improved the quality of lighting, and substantially reduced noise pollution caused by diesel generators, which were previously relied upon for generating electricity.

Healthcare patient from Bahaich

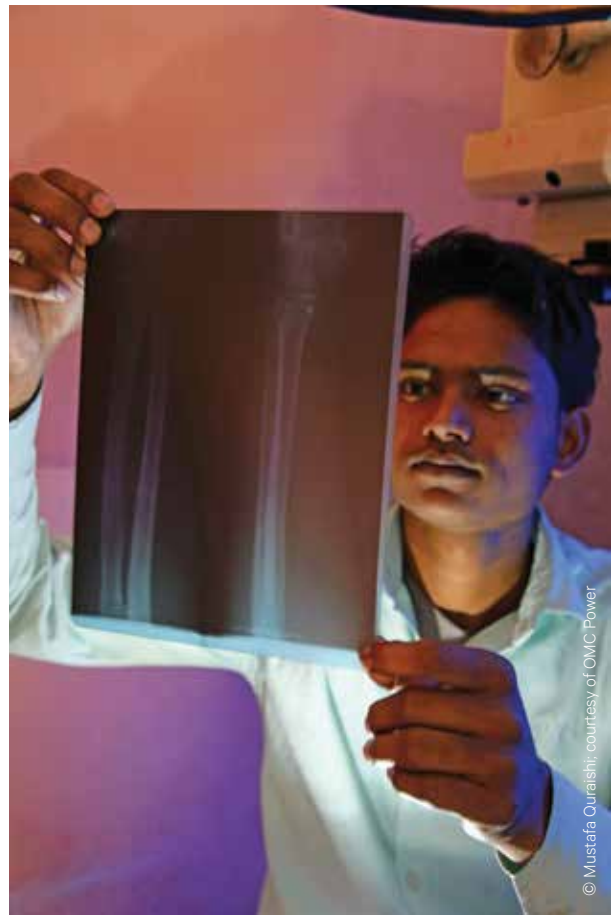
“Since the mini-grid electricity started being supplied in the village, the local private dispensary is open longer. Now we can visit the doctor even late in the evening.”

⁹ MGNREGA ensures 100 days of employment a year to rural poor.

FIGURE 6: Households perceiving increase in operations of public facilities



Adequate electricity supply is of utmost importance to health centers, especially in a rural context. Working refrigerators are required for proper maintenance of vaccines and medications. Likewise, a poorly lit clinic can delay or compromise medical treatment (USAID, 2015). In rural Uttar Pradesh and Bihar, in addition to public facilities, there are many private clinics run by informal health care providers. While historically they have relied on government grids that are sometimes supplemented by diesel generators, electricity from mini-grids has given them a more reliable solution. Reliable electricity supply has helped support the running of medicine shops and diagnostic centers, such as those for ultra-sonography. For instance, when the village of Shivpura in Uttar Pradesh took advantage of having its reliable electricity supply from the ESCO TARA Urja to set up an ultra-sonography unit, it meant people no longer had to make a 40 km bumpy ride to Balrampur, the nearest town, for the procedure.



A man is able to review x-ray results because of a light powered by a mini-grid. Electricity from mini-grids has enabled healthcare facilities to remain open for more hours.



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Eighteen percent of micro-enterprises have purchased fans after getting connected to a mini-grid. This has helped improve shops' ambience, benefitting owners and customers alike.

6

Implications of findings for SPRD

The findings and data presented in this impact report are informing discussions with The Rockefeller Foundation, Smart Power India, and SPRD grantees and partners on ways to strengthen the SPRD strategy and approach to implementation, particularly in relation to the following.

- **Moving households and businesses up the energy ladder at a greater pace.** While SPRD has enabled incremental movement of residential and commercial customers up the energy consumption ladder, the initiative will work with Smart Power India and partners to increase the depth and speed of consumption via introduction of energy efficient devices and appliances.
- **Increasing efforts to identify and reach excluded populations.** SPRD is reaching the status quo profile of socio-economic populations and underserved businesses. However, it will also support ESCOs in further identifying potential customers and implementing customer acquisition plans to reach an increased number of low- and medium-income people and underserved businesses that are not connected to mini-grids or grids. This will include a greater focus on women in customer outreach, decision making and engagement.
- **Scaling up micro-enterprise development support.** While there has been a modest increase in GDP per capita and livelihood options in rural areas due to SPRD, this monetary gain comes largely from lighting customers. To see greater economic development, SPRD will scale up micro-enterprise development support to enable the expansion and creation of new businesses that use electricity for productive purposes, such as garment centers, cold storage units, rice hullers, water purification enterprises, and honey processing units.

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A woman scans her finger prints in order to attain a government-issued identification card designed to link individuals to public welfare and social services. The scanning device is powered by a mini-grid in Uttar Pradesh.

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