RURAL ELECTRIFICATION IN INDIA

CUSTOMER BEHAVIOUR AND DEMAND

FEBRUARY 2019

The ROCKEFELLER FOUNDATION

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ISEP

ABOUT US

Smart Power India

Smart Power India (SPI) is the key agency implementing the Rockefeller Foundation's Smart Power initiative. SPI extends power to those without sufficient access, with the goal of ending energy poverty and transforming the livelihoods of the underserved. To this end, SPI works to build and nurture ecosystems which promote sustainable and scalable models for delivering electricity access.

Initiative for Sustainable Energy Policy

The Initiative for Sustainable Energy (ISEP) is an interdisciplinary research program at the John Hopkins University School of Advanced International Studies. ISEP uses cutting-edge social and behavioural science to design, test, and implement better energy policies in emerging economies.

The aim of ISEP is to identify opportunities for policy reforms that allow emerging economies to pursue human development at minimal economic and environmental cost. The initiative explores such opportunities both pro-actively, with continuous policy innovation and bold ideas, and by responding to policymakers' demands and needs in sustained engagement and dialogue.

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We also acknowledge the leadership and core team of Smart Power India (SPI) and Initiative for Sustainable Energy Policy (ISEP) who directed this study.

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FOREWORD

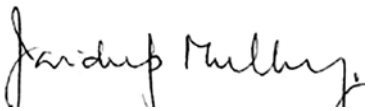
Led by the Government's outstanding efforts towards electrification, India has witnessed a massive transformation over the last decade with the grid now present everywhere. Enhancing these efforts with actions that can enable supply of quality electricity to the last mile is an ongoing task.

Smart Power India (SPI) was established by the Rockefeller Foundation to advance the Smart Power program, and complement the Government of India's efforts in realizing the goals of rural electricity access. Based on SPI's work, we have observed that the delivery models which evolve from customers' needs and demand patterns are sustainable. However, there are gaps in our understanding of crucial issues, including the quantification of baseline demand in rural areas, and the evaluation of factors which can improve consumption levels and payment behavior. Bridging these gaps is critical to devise viable electricity delivery solutions for under-served rural populations.

SPI commissioned this study to dive deeper into the aspects of demand and customer behavior in rural areas. Perhaps for the first time ever, a study has been able to provide an estimate of village electricity demand. Another important insight is that wide gaps in access are still present in the case of rural micro-enterprises. These are paying customers and often the ones with higher consumption. Only 65% of the rural enterprises surveyed reported grid-connections and many reported reliance on diesel.

Customer satisfaction, an important barometer of sustained use, is another area that requires attention. Presently, almost 40% of grid-electricity users do not express satisfaction with grid-electricity services. Dissatisfaction stems from attributes of reliability and adequacy. With regards to affordability, the impact of poor metering and irregular billing and collections contributes to negative perceptions.

These findings and frameworks are relevant not only to India, but to many countries that are reforming their electricity sectors, as well as to those advancing national electrification programs. We hope that SPI's pursuit to bring these learnings forward, supported by strong evidence, will inspire efforts to deliver quality service to customers – service that will underpin viable models of electrification and bring well-being to rural communities.



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FOREWORD

India is leading the global progress in electricity access. The country is on track to achieve the target of universal access to electricity much before the 2030 target date. Within this fast-changing electrification context lies the genesis of this study.

This study set out to answer fundamental questions. Does everyone in the villages now have access to quality electric power? Is improved access delivering electricity to rural micro-enterprises? Do the electrified villages receive the quality and quantum of electricity that is required to see improvements in their lives? And if we looked at the citizens as recipients of electricity as a service, what are their expectations and levels of satisfaction? Smart Power India and ISEP commissioned this large-scale study across four Indian states.

A few overarching findings stand out. First, the level of electricity access, if measured by infrastructural availability of the electric grid, stands high across villages in the surveyed states. This is true even for the lagging states like Bihar and Uttar Pradesh. However, the adoption of an electric connection has not improved everywhere and across different customer segments. Second, rural microenterprises largely remain unconnected from the electric grid and rely upon diesel generators amongst many other sources. Third, having an electric connection doesn't guarantee the energy's reliable supply and service redress from the supplier. This leads to disenchanted customers and a persistent perception of poor value. An outcome of all these is that the overall village electricity consumption in these villages, after stacking multiple sources of electricity, is only about half of the national average for residential consumption.

The study recommends that servicing rural areas with a larger quantum of energy, which goes beyond basic household lighting is crucial. With electricity available, there will be greater opportunities for rural micro-enterprises to build upon existing ventures as well as embark upon new enterprises that were hitherto unviable because of the dearth of electricity. This will not only fuel rural economic growth but will also catalyse a cycle, making the markets attractive for the suppliers.

Second, as natural monopolies, state electric utilities have a set market and the customer paradigm is not natural, because of which they see the customers as ratepayers. There is a need to build a strong understanding of customer segments and their requirements. There are learnings emerging from within the surveyed states. In Odisha, better service indicators among rural customers have not just led to a higher share of satisfied customers, but also higher consumption. Similarly, experiences of customers being serviced by private solar mini-grids show that a high-quality, reliable, and customized electricity service improves customer satisfaction.

Companies and industries make some of their best decisions when they take time to understand and engage customers. Electric utilities are not exceptions. Competitive industries understand the value of the customer in the equation. A bigger lesson to learn is that the provision of adequate electricity access must go hand-in-hand with an understanding of the demand behaviour of the customers. Adoption, experience and usage are all important pieces of the value chain. As a first step, it requires giving the rural electricity customer a seat at the table.

Sidhartha Vermani, Senior Director,
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Dr. Johannes Urpelainen

Prince Sultan bin Abdulaziz Professor and Director of Energy, Resources and Environment
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FOREWORD

Energy in rural India is undergoing a rapid transformation. The Government of India's *Saubhagya* scheme has brought electricity to 25 million households, but many states continue to struggle with poor quality of electricity service. Load shedding, outages, and voltage fluctuation prevent rural communities from realizing the full potential of electric power. Distributed renewable energy resources such as solar mini-grids offer a new solution to the problem of reliable power.

A collaboration between Smart Power India (SPI) and the Initiative for Sustainable Energy Policy (ISEP), this report explores the nature of India's rural electricity demand. The report draws on a survey of 10,000 households and 2,000 rural enterprises in 200 villages across four states: Bihar, Uttar Pradesh, Odisha, and Rajasthan.

The study offers new insights into baseline electricity demand in a diverse set of rural communities. Our survey data allows us to estimate total electricity demand from different sources, ranging from the electric grid to solar home systems and diesel generators. An important and original feature of the survey methodology is a robust validation of the results with daily energy audits to a random sample of rural communities.

The primary insight from the survey is that the use of electric power remains underwhelming in rural India. Most households and rural enterprises use minimal amounts of electricity. Productive loads to power the rural economy are rare exceptions. To put it bluntly, large swaths of rural India have missed the opportunity to exploit electric power for economic growth.

These results call for vigorous and sustained efforts to empower the rural economy. Policymakers in India must solve two intertwined problems. The first is the lack of economic opportunity. Without stronger agricultural and industrial supply chains, rural communities cannot sustain the kinds of anchor consumers that would make high-quality rural electricity service financially sustainable. The second is the lack of adequate and reliable power that would enable productive activities, such as foodstuff processing or light industry.

To solve the problem of stagnant rural power demand, the first step is to describe and diagnose the problem. We have taken this step in our collaboration, and the next step is to develop actionable, evidence-based policy solutions. It is our hope that a robust understanding of the baseline electricity demand in rural India serves both as an alarm and a planning tool for policymakers.

Johannes Urpelainen
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Executive Summary

India is at the cusp of energy transformation, leading the global progress in electricity access. Between 2000 and 2016, half a billion people gained access to electricity in India, increasing the share of grid-electrified households from 43% to 82%. Since then, several new efforts are underway at central and state levels, with the goal of achieving universal household electrification by March 2019.

While enabling access to electricity is a crucial first step, the goal of extending the electric grid to India's villages has eclipsed the need to provide quality access and service to the rural customers.

Studies have pointed out that demand-side issues appear more significant in explaining the current gaps in electricity access. There is a need to better understand the factors that influence customer attitudes and decisions about electricity adoption and use. Even more important is to assess whether the current levels of electricity access are satisfactory, as many customers with electricity continue to face power outages and poor-quality supply. These are concerns that need to be addressed to realize the United Nations Sustainable Development Goal 7: Affordable and Clean Energy to ensure access to affordable, reliable and modern energy for all.

About the Study

This report is a collaboration between Smart Power India (SPI), a subsidiary of the Rockefeller Foundation and the Initiative for Sustainable Energy Policy (ISEP), at the Johns Hopkins School of Advanced International Studies. The report distils learnings on electricity access and customer demand. One of the unique contributions of this report is the insight on baseline electricity demand at a village level, including the use of electricity for productive purposes.

The findings in this report are based on primary data collected from customer surveys of over 10,000 rural households and 2,000 rural enterprises across four Indian states – Bihar, Uttar Pradesh, Odisha and Rajasthan. This report also provides insights into customer experiences under different electricity delivery models – public sector distribution companies (DISCOMs), solar mini-grids, and private distribution franchises.

Key Findings

Electricity Sources Used by Rural Customers

- Grid-electrification coverage and adoption is high among rural households with the electric grid emerging as the primary source of electricity and lighting for many.

- However, gaps are prevalent with the rural micro-enterprises. In the study area, only 65% of enterprises had grid-electricity connections. While the share of connected rural enterprises is over 90% in Odisha and Rajasthan, it is lower than 60% in Uttar Pradesh and Bihar.

- Non-grid sources such as solar home systems, rechargeable batteries, mini-grids, and diesel generators form an important part of the rural electricity mix. Sixteen percent of households and 40% of enterprises use non-grid sources.

Barriers to Electricity Adoption

- Most households without grid-electricity cite affordability as a key barrier. While households are economically disadvantaged, concerns about affordability are a manifestation of the gaps in electricity meter coverage and billing efficiency, because of which customers have to bear inflated electricity bills.

- With the rural enterprises, affordability concerns are associated with high connection costs and the availability of alternatives that give customers the flexibility to get reliable electricity.

- An uncertain power supply and the long duration of power cuts can also deter potential customers from adopting electric grid-connections. One in two grid-users faces a power cut of at least 8 hours daily. Besides the inconvenience, an unreliable electricity supply forces a customer to bear additional expenses on power back-ups.

Drivers of Customer Satisfaction

- Only 60% of electric grid-users are satisfied with the DISCOMs' services. Such high levels of dissatisfaction should be a cause for concern as it links them to negative perceptions of electricity service. An inter-state comparison confirms that states, such as Odisha—with better service parameters like longer supply hours, better meter coverage and regular billing—have a higher share of satisfied customers.

- Service reliability and adequacy drive customer satisfaction more than the perception of affordability.

- Insights from the experiences of mini-grid customers suggest that a high-quality, reliable, and customized electricity service can help improve customer satisfaction. Over 80% of mini-grid users display satisfaction with their connections, despite citing affordability challenges.

Rural Electricity Demand and its Drivers

- Average electricity demand of surveyed rural households is 39 kWh per month, which is half of the national average for residential consumption. This demand is being serviced by different sources of electricity with customers often stacking multiple sources. The electricity demand of electric grid-users is higher at 51 kWh per month.

- Average electricity demand of rural enterprises is also low at 39.5 kWh per month. Enterprise electricity demand varies with commercial activity as well as the scale of operation. Several enterprises with high electricity demand use diesel generators, reflecting the latent demand for electricity.

- An average village has a total electricity demand of 1,826 kWh per day, with about 52% contributed by households, 7% by enterprises, and the remainder by agriculture. Various sources of electricity, including diesel generators, serve this electricity demand.

- Low consumption in rural areas is due to fewer appliances in use. Most of the electrified rural households use electricity for lighting and air circulation, but less than half use it for entertainment and less than a fifth use it for medium to high-power appliances such as a refrigerators, irons, and mixer-grinders.

- Apart from socioeconomic characteristics, a key predictor of rural electricity demand is hours of supply. Access to reliable and longer hours of electricity supply is correlated to higher adoption of grid-electricity.

Implications and Actions

- DISCOMs should expand the focus of their electrification efforts beyond households, to include rural enterprises engaged in non-farm activities. These are the potential paying customers with a steady demand for quality electricity supply. Some of these enterprises with high electricity demand use expensive sources, such as diesel generators and that is revenue lost for electricity utilities.

- To make grid-electricity attractive for rural customers, electric utilities need to ensure universal meter coverage and timely billing and payment collection. This can ease concerns about the affordability of grid-electricity and ensure sustained electricity use for customers with limited needs and capacity to pay.

- Electricity service providers need to adopt a customer-first approach and work toward improving customer satisfaction levels. Towards this end, electricity service providers need to improve the reliability and quality of their supply.

- Given the role of non-grid solutions in facilitating electricity access, there is a parallel need for continued policy support for such solutions. They could supplement as well as complement the efforts for the electric grid-based rural electrification.

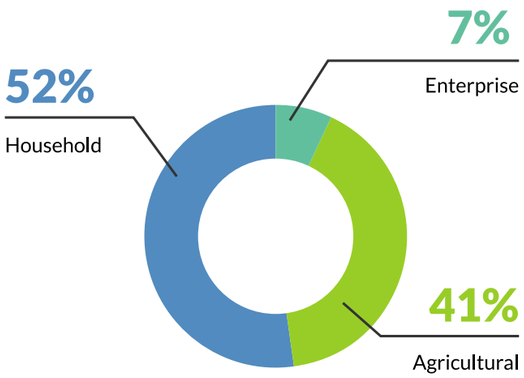
- Electricity demand in villages might increase with reliable supply and enabling of new productive use activities. Policies need to support adoption of medium to high-power appliances in rural areas, which could help to stimulate demand.

Concluding Remarks

It is hoped that this study will provide a fresh insight into the dynamic and fast-changing rural electricity market in India. A better understanding of rural customers is critical to identify diverse customer needs and devise customized solutions and strategies to reach under-served and un-served rural populations.

BASELINE ELECTRICITY DEMAND OF A VILLAGE

VILLAGE DEMAND
1,826 kWh/day



VILLAGE PROFILE
Based on average values of 200 villages

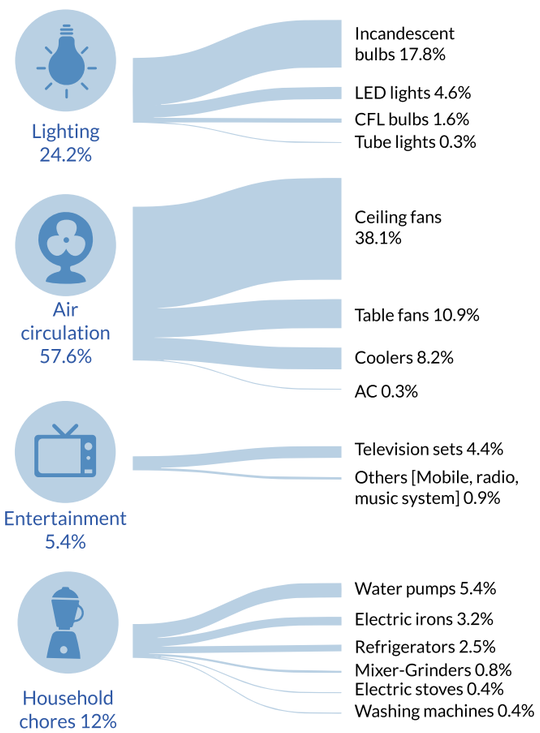
4650
Population

860
Households

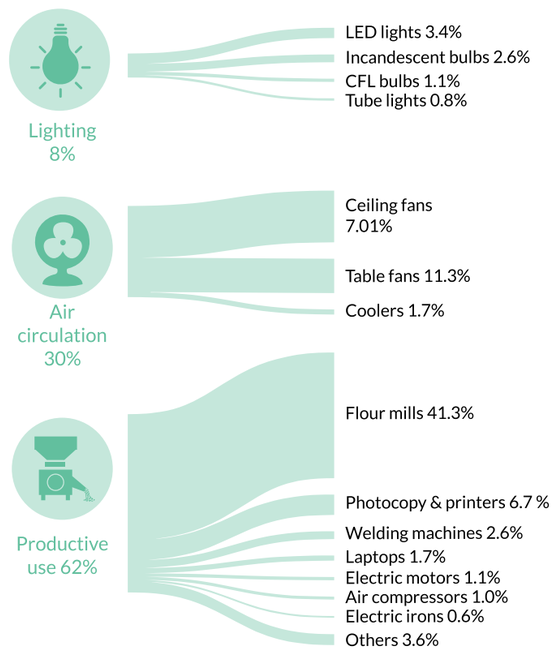
100
Enterprises

300
Households using irrigation pumps

Composition of Household Electricity Demand
For a consumption of 100 kWh per month



Composition of Enterprises Electricity Demand
For a consumption of 100 kWh per month



1. The Power of Putting the Customer First

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Driving across rural India, it is easy to observe just how far electricity has penetrated the hinterland. In Bihar, for example, a state that was recently declared as 100% electrified, utility poles stretch across fields of green, evidence of the reach of the electric grid. The Government of India's *Saubhagya* (Pradhan Mantri Sahaj Bijli Har Ghar Yojana) scheme has done much to provide these connections—exempt of initial connection fee—to homes across rural India, and the numbers tell a remarkable story.

The pace of electrification has rapidly increased, with 40 million people coming on-grid each year since 2011.

Between 2000 and 2016, half a billion people gained access to electricity in India, increasing the share of grid-electrified households from 43% to 82%.[i] The pace of electrification also rapidly increased, with 40 million people coming on-grid each year since 2011.

Paradoxically, studies consistently reflect that evidence of this wider electricity coverage in rural India does not automatically equate to higher rates of adoption and consistent use. India is still far from realizing the United Nation's Sustainable Development Goal 7: "Ensuring access to affordable, reliable and modern energy for all."

When the Saubhagya scheme was launched in September 2017, an estimated 30 million households in India lacked access to grid-electricity, with a majority of those identified as *poor rural* households.[ii] The challenge isn't necessarily coverage; among those that do have access to power, there is a significant share of electrified households and commercial establishments facing several supply-side challenges, including unscheduled power cuts, and poor quality supply with frequent interruptions, and low voltages.

In a bid to address these issues themselves, many rural customers often stack different sources of electricity. Patterns vary by household and commercial establishment, based on need. Witness the real-life example of a chemist on one side of a village street who uses just solar power at his store. He has selected a customized package with pricing that meets his needs. Across the road, his competitor uses a combination of sources: the electric grid, a solar mini-grid, and a diesel generator.

This Smart Power India (SPI) study is based on one of the largest customer surveys of the Indian electricity sector. It is a review of rural electricity markets, customer segments, and customer preferences; findings could be used to design interventions and recommend measures for improving access and adoption of electricity in rural areas. The survey covered more than 10,000 rural households and 2,000 rural enterprises across four Indian states—Uttar Pradesh, Bihar, Odisha, and Rajasthan—in a bid to better understand rural customers and their demand.

This report's four key objectives, with related actionable items for both the government and the private sector, are:

- Map the availability and use of sources of electricity in rural areas across different geographies.
- Identify key barriers hindering the adoption and use of electricity by rural customers.
- Establish a baseline of electricity consumption by rural households and enterprises, and identify the key drivers of electricity demand and customer satisfaction.
- Identify replicable learnings from alternative delivery models.

Providing Access to Electricity

Rural electricity access is provided by state-owned utilities with distribution companies (DISCOMs) playing a key role. In providing access to the electric grid, utilities bear high infrastructure costs, transmission losses, power theft, and operational difficulties.[iii] That is in addition to the acknowledged challenges of last-mile electricity delivery.

Several electricity delivery models have emerged to meet that gap, including various public-private partnership-based constructs like the *distribution franchise model*. DISCOMs, under the distribution franchise model, outsource their electricity distribution activities to private players in order to reduce Aggregate Technical & Commercial (AT&C) losses, improve operational efficiency, and ensure improved customer service.

Odisha, for example, has the largest number of electricity divisions licensed to three private companies; they cater to both urban and rural customers. These companies have implemented several initiatives to improve customer experience, such as spot billing machines and 24x7 customer-care centers. Despite this approach, and its implementation across many states in India,[iv] experiences with this model remain mixed.

Then, there are a large number of private and not-for-profit players providing distributed renewable energy (DRE)–based solutions. More than 14,000 micro- and mini-grids[v] and over two million solar home systems have been deployed in India. DRE mini-grids are commonly small solar power plants with a peak-load capacity between 10 and 100 kW. They are used to supply electricity in a specific area through a dedicated distribution network. While a large share of mini-grids have been installed under the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) scheme, others are operated by private players, often supported by philanthropic organizations.

These centralized and decentralized interventions offer opportunities to accelerate ongoing efforts toward universal electricity access. However, the extent to which such interventions facilitate access and meet customer expectations is less understood.

Understanding Electricity Customers and Demand

It's a fair question: If there are many electricity service providers in the Indian market, why are there gaps in access?

The answers perhaps lie in policies and programs that approach the subject of electricity access from a supply-side perspective. In August 2015, the Indian government launched the DDUGJY in order to achieve 100% village electrification within 1000 days. That target was met in April 2018, when the government declared every village in India as electrified—but this only means that at least 10% of households in every village were connected to the electric grid.

Moving beyond this limited definition of village electrification, the government's next target, under the *Saubhagya* scheme, was set at 100% household electrification by March 2019.

Both government initiatives are commendable, and reflect policy focus on the issue of electricity access. They also indicate the supply-side approach inherent in

rural electrification drives. However, as some studies have pointed out, demand-side issues appear more significant in explaining current gaps in electricity access. These issues include, among others: significant barriers to adoption, low electricity demand due to lack of appliances, and poor satisfaction with the level and quality of service.[vi]

Previous studies of gaps in electricity access in India have also pointed to factors such as low affordability, lack of clarity about procedures, and an unreliable supply.[vii,viii] Even as these broadly indicate areas of concern, there remains an insufficient in-depth understanding of how and why these factors influence customer attitudes and decisions about adoption and use. For instance, claims of customers citing affordability as a barrier to adoption are intriguing, given that domestic electricity connections are heavily subsidized in India.[ix]

There also appears to be an inadequate understanding of electricity demand, and its drivers, in rural areas.[x] This is on account of limited information available in public domain. Few studies of the electricity landscape in India have delved into issues of electricity demand and its drivers; they largely focus on urban customers and rely on general household surveys, which often lack comprehensive data on energy use.[xi, xii]

Adding to the unknown, electrification drives such as the Indian Government's *Saubhagya* scheme have largely focused on households as potential customers, while overlooking rural commercial enterprises. Such gaps are symptomatic of a disconnect between electricity suppliers and their customers, and an inadequate understanding of customers' electricity needs and attitudes toward different sources.

This holds true for both grid-electricity services and DRE providers. Despite the physical availability of grid-infrastructure today, many rural customers fail to utilize electricity connections. DRE providers, in turn, face difficulties in identifying the right customer segments, marketing strategies, and billing mechanisms. For the industry at large, a closer look at demand patterns and customer perceptions of—and experiences with—electricity services, is likely to provide a richer understanding of barriers to electricity use, and drivers of customer satisfaction.

Introducing the Study

This study collected primary data for rural households, enterprises, and communities spread across four states in India: Bihar, Odisha, Rajasthan, and Uttar Pradesh, which together account for 70% of all un-electrified households in India. These states have also seen diverse interventions and delivery models, while providing electricity access and better customer service.

Given multiple research objectives, and the complex nature of the issue, the study employed a mix of data collection strategies, including social surveys complemented by qualitative interviews. The findings are based on social surveys of 10,049 households and 2,019 enterprises spread across 200 villages in the states of Bihar, Odisha, Rajasthan, and Uttar Pradesh.

Villages surveyed were selected through purposive sampling, which covered villages with different types of electricity interventions—grid-electricity managed by public DISCOMs, grid-electricity managed by private distribution franchises, and private solar mini-grids.

STUDY SAMPLE

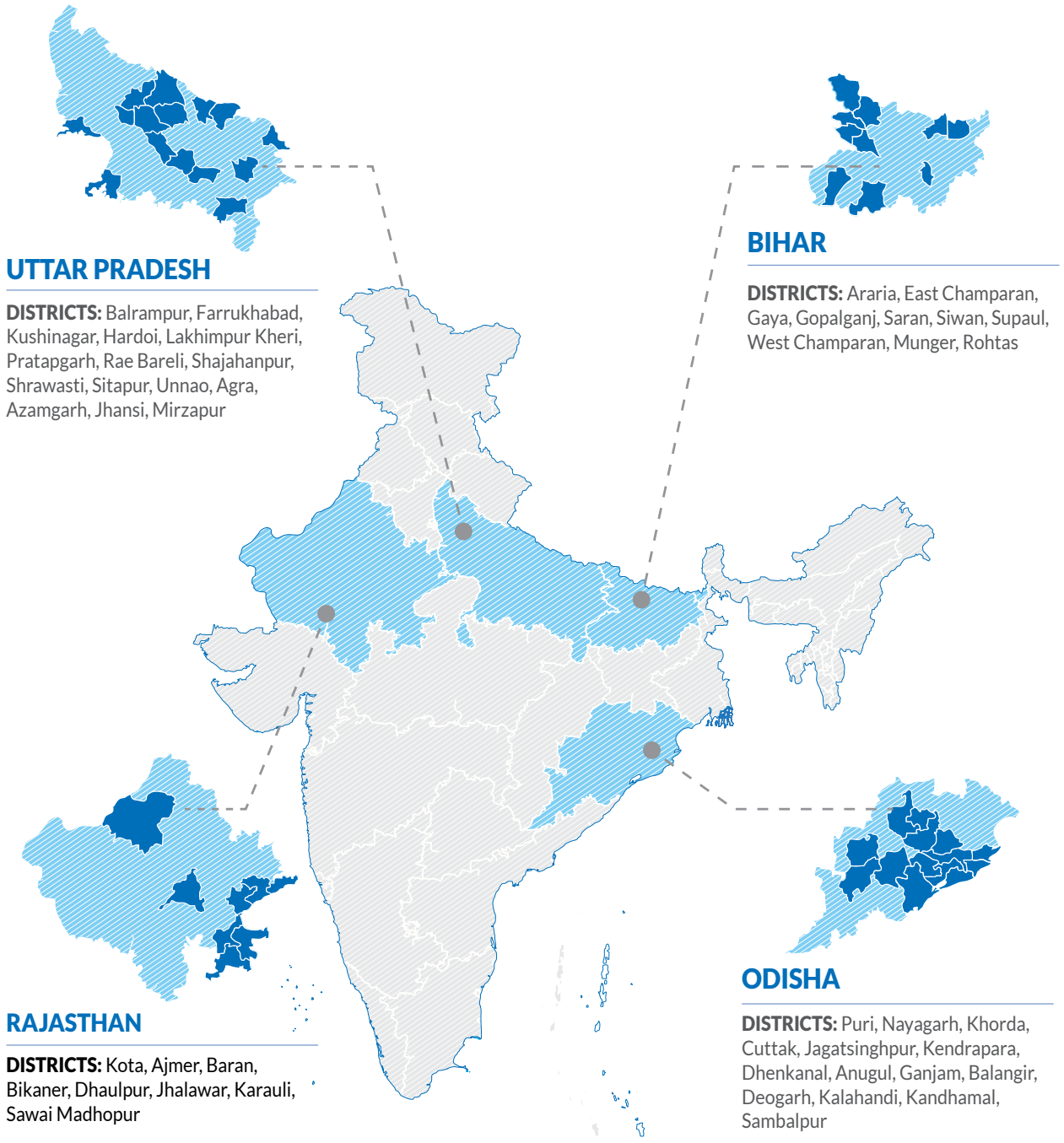
10,049
HOUSEHOLDS
(50 in each village)

2,019
ENTERPRISES
(10 in each village)

200
VILLAGES

47
DISTRICTS

4
STATES



UTTAR PRADESH

DISTRICTS: Balrampur, Farrukhabad, Kushinagar, Hardoi, Lakhimpur Kheri, Pratapgarh, Rae Bareli, Shajahanpur, Shrawasti, Sitapur, Unnao, Agra, Azamgarh, Jhansi, Mirzapur

BIHAR

DISTRICTS: Araria, East Champaran, Gaya, Gopalganj, Saran, Siwan, Supaul, West Champaran, Munger, Rohtas

RAJASTHAN

DISTRICTS: Kota, Ajmer, Baran, Bikaner, Dhaulpur, Jhalawar, Karauli, Sawai Madhopur

ODISHA

DISTRICTS: Puri, Nayagarh, Khorda, Cuttak, Jagatsinghpur, Kendrapara, Dhenkanal, Anugul, Ganjam, Balangir, Deogarh, Kalahandi, Kandhamal, Sambalpur

Overall, the study covered 50 villages with solar mini-grids (referred to as MG villages), 50 villages with electricity distribution franchises (referred to as DF villages), and 100 villages without mini-grid or distribution franchises, but similar to the MG villages and DF villages in terms of population and distance from the nearest town. This approach enabled measurement and comparison of attitudes, perceptions, and satisfaction of electricity users and non-users with access to different types of electricity services. Within each village, 50 households and 10 enterprises were sampled in a random manner.[1] Additional details on the research design and methodology employed are available in Annex 1.

Using this Study

SPI believes this study will provide fresh insights into the dynamic and fast-changing rural electricity market in India. A better understanding of rural customers is instrumental in identifying diverse needs and constraints in electricity access. It's an understanding that, in turn, could help devise customized solutions and drive consumption among both underserved and unserved rural populations across the country. SPI also trusts that its work on the role of alternative electricity delivery models will inspire approaches that complement government efforts—and the 24x7 Power for All program[2]—in providing quality electricity in a reliable and timely manner.

This report includes the following:

- Annexes, which present details of the methodology adopted.
- A glossary, which captures definitions of key words and phrases in the report; italicized words indicate terms defined in the glossary.
- End notes that provide references to external data sources

1. Only villages with a minimum of 20 rural enterprises were included in this study.

2. The program is a joint initiative between the central and state governments in India, with the objective to ensure 24x7 affordable and quality power supply to all customers by March 2019.

2. Personifying the Rural Electricity Customer

Rural Household Customers 15

Rural Enterprise Customers 18

Rural audiences, like any other group of customers, display diversity in their social and economic statuses, with differences observed among both households and rural enterprises. These differences influence not just demand for electricity, but also customer attitudes and preferences toward various sources.

This chapter makes the case that understanding this socioeconomic diversity facilitates a better understanding of electricity needs and choices in rural India. It first reviews households and then rural enterprises.

Rural Household Customers

This study assess the stated and observed ownership of durable assets, housing characteristics, and the availability of certain amenities, such as toilets and LPG connections to segment customers.

To facilitate a deeper understanding of usage patterns in rural households, this study assesses the stated and observed ownership of durable assets, housing characteristics, and the availability of certain amenities, such as toilets and Liquified Petroleum Gas (LPG) connections for cooking.[3] This information assists in the identification and development of four household profiles, as indicated below.

Each category also exhibits distinct levels of education, primary occupation, and income which, as seen going forward, are also drivers of electricity demand.

The Four Rural Household Customer Profiles

A.Rural Poor:

Where most households have *kutcha*[4] houses with one room. A majority own bicycles, and a few houses are connected to the grid.

B.Rural Lower:

Where most households have semi-pucca or pucca[5] houses, with two to three rooms. Some houses have toilets and are equipped with LPG connections. A majority own agricultural land, have grid-electricity connections, and own bicycles and electric fans.

C.Rural Middle:

Where most households have pucca houses, with two to four rooms and toilets on the premises. A vast majority own agricultural land, have LPG connections, are on the grid, and own electric fans, television sets, and motorcycles.

D.Rural Affluent:

Where all households have pucca houses with at least four rooms, toilets, and an LPG connection in the house. All of them own agricultural land with grid-electricity connections, electric fans, bicycles, and motorized two-wheelers. A vast majority own television sets, while every second household has a motorized four-wheeler.

Levels of education vary by profile; decision makers in *rural affluent* households are typically educated beyond the high school, potentially increasing household living standards. Those in *rural poor* households are typically illiterate, with some having school education. A majority of those in *rural lower* and *rural middle* households have school education, with some educated beyond the 10th class (Table 2.1).

3. For details on methodology, see Annex 2.1.

4. Houses made from mud, thatch, or other low-quality materials.

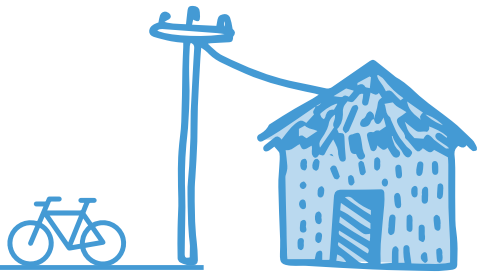
5. Houses made with high-quality materials throughout, including the floor, roof, and exterior walls.

CUSTOMER PROFILES RURAL HOUSEHOLD

Study categorises households into four groups, based on : household ownership of durable assets, housing characteristics, and availability of certain public amenities.

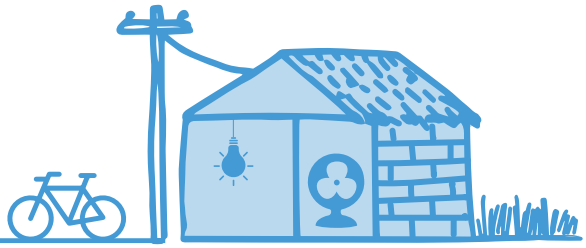
Rural Poor Households

*Where most households have roughly constructed (kuccha) houses with **one room.** A majority **own bicycles,** and a few houses are also **connected to the grid.***



Rural Lower Households

*Where most households have semi-finished (semi-pucca) or fully constructed (pucca) houses, with **two to three rooms**. Some houses have **toilets** and are equipped with **LPG connections**. A majority of them **own agricultural land**, **bicycles**, have **grid-electricity connections**, and **electric fans.***



Rural Middle Households

*Where most households have pucca houses, with **two to four rooms** and **toilets** in the premises. A vast majority **own agricultural land**, have **LPG connections**, are **on the grid**, and own **electric fans**, **television sets**, and **motorcycles**.*

Rural Affluent Households

*Where all households have pucca houses with at **least four rooms**, **toilets**, and an **LPG connection** in the house. All of them **own agricultural land** with **grid-electricity connection**, **electric fans**, **bicycles**, and **motorised two-wheelers**. A vast majority own **television sets**, while every second household has a **motorised four-wheeler**.*

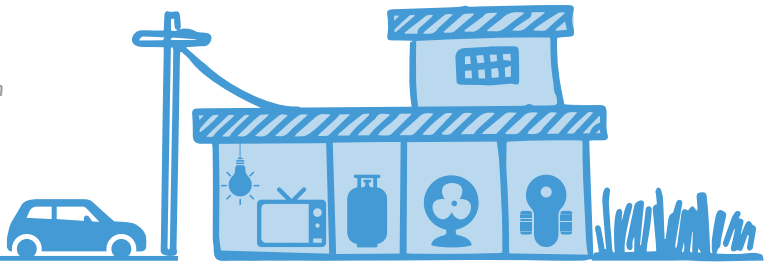


Table 2.1 : Demographic profile of rural households, by economic status

Household Characteristics	Household's Economic Status			
	Rural Poor	Rural Lower	Rural Middle	Rural Affluent
Highest education level of household head:				
No formal education	56%	40%	23%	13%
Up to class 9	37%	44%	45%	36%
Class 10 and above	7%	16%	31%	51%
Primary source of household income:				
Labor (agriculture or non-agriculture)	73%	56%	35%	10%
Agriculture and allied activities	12%	27%	31%	46%
Salaried job or business	15%	17%	34%	44%
Income and expenditure statistics:				
Annual Income (INR)	58,700	78,000	1,14,000	1,87,000
Monthly expenses (INR)	3900	5000	7200	10,500

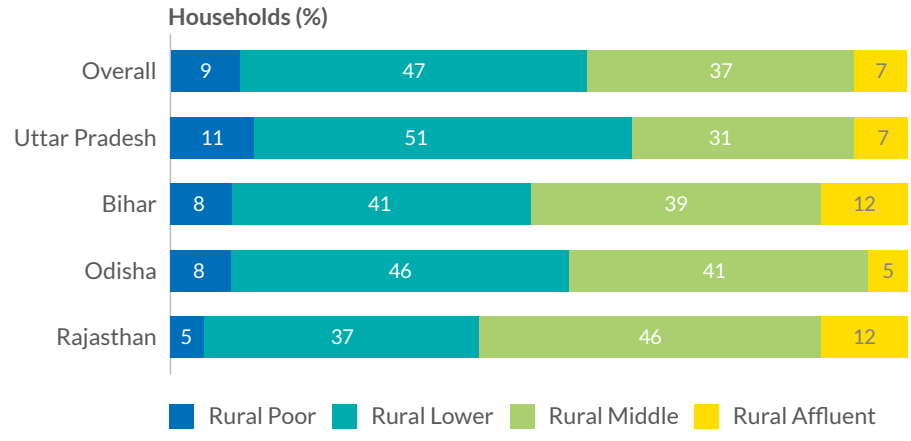
Low High

Acronym: INR, Indian Rupee.

Distribution of Household Customers by state

This study finds that the distribution of various household profiles is broadly similar across all four states studied (Figure 2.1). Across states, an average of 9% fall under the *rural poor* category. However, a higher share of households in Uttar Pradesh belong to the *rural poor* and *rural lower* category. Odisha and Rajasthan have high shares of *rural middle* households.[6]

Figure 2.1: Percentage distribution of rural households across states, by customer socioeconomic profile



6. Due to the research design, this distribution is representative only for the districts covered in this study and not representative at the state level.

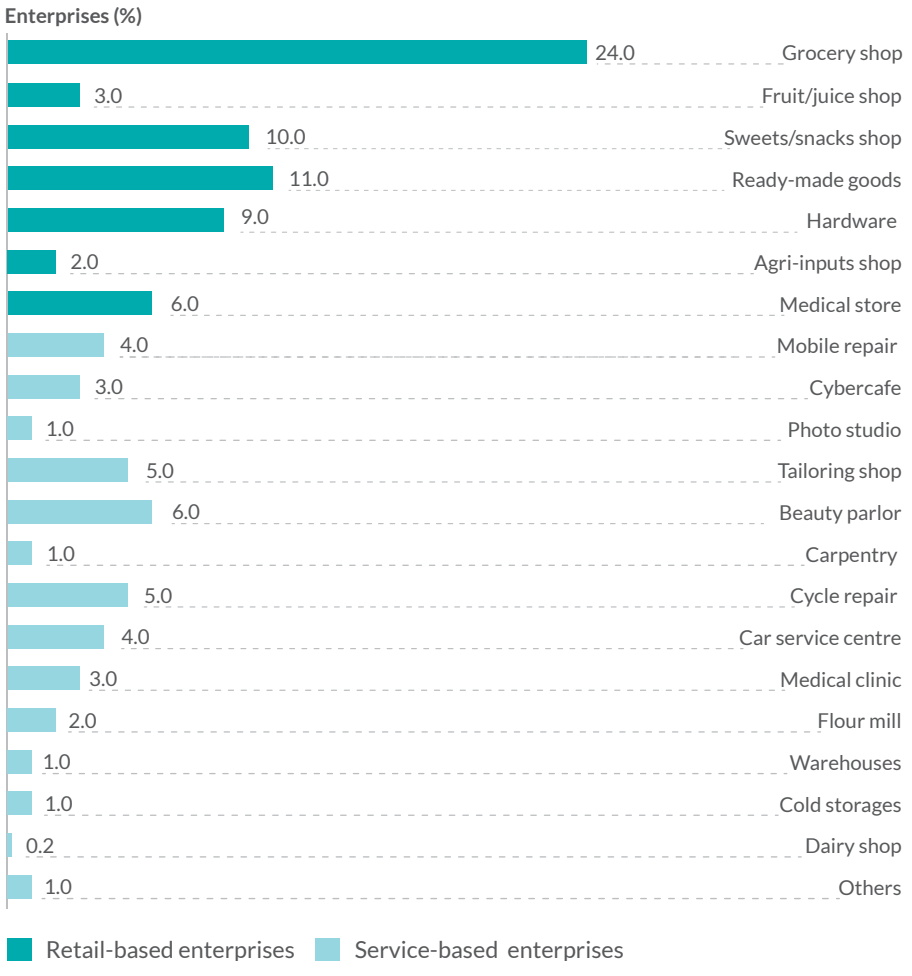
Rural Enterprise Customers

Enterprises in rural India are heterogeneous, with a diversity of commercial activities and scale of operation.

Two-thirds of rural enterprises engage in retail trade, with the remaining one-third providing a wide range of services (Figure 2.2). Among the more common enterprises are grocery shops, followed by shops selling fast-moving consumer goods such as ready-made items, hardware, sweets, and snacks. Also familiar to every marketplace are service-based enterprises such as tailors and personal care services, such as beauty parlors. *For a definition of these enterprise activities, please refer to the Glossary at the end of this report.*

A limited number of enterprises engage in agricultural services, such as flour mills, dairy, warehouses, and cold storage, because such enterprises are generally located near farms or within households. The survey, however, sampled enterprises located within a larger marketplace.

Figure 2.2: Distribution of rural enterprises, by commercial activity



7. For details on methodology, see Annex 2.2.

Rural enterprise profiles are based on enterprise building characteristics, the number of employees, and inventory value.[7] As a result, this study identifies three profiles of the rural enterprise.

The Three Rural Enterprise Customer Profiles

A.Rural small enterprises:

Where most enterprises operate from rented spaces with *kutcha* or semi-*pucca* structures with a small shop area of less than 100 square feet (sq.ft). These are predominantly owner-managed shops, with very few enterprises having employees. A majority have inventory stock with a value less than INR 30,000 at a given point in time, reflecting their small scale of operation.

B.Rural mid enterprises:

Where most of these shops have fully constructed (*pucca)* structures that are small to medium in size, and two-thirds of businesses own their shops.

While a majority are owner-managed shops, a third have employees assisting the owner. A majority have inventory stock with a value between INR 30,000 to INR 1,50,000 at a given point in time.

24% of enterprises surveyed are rural small, a majority (58%) are rural mid, with the remaining 18% belonging to the rural large profile .

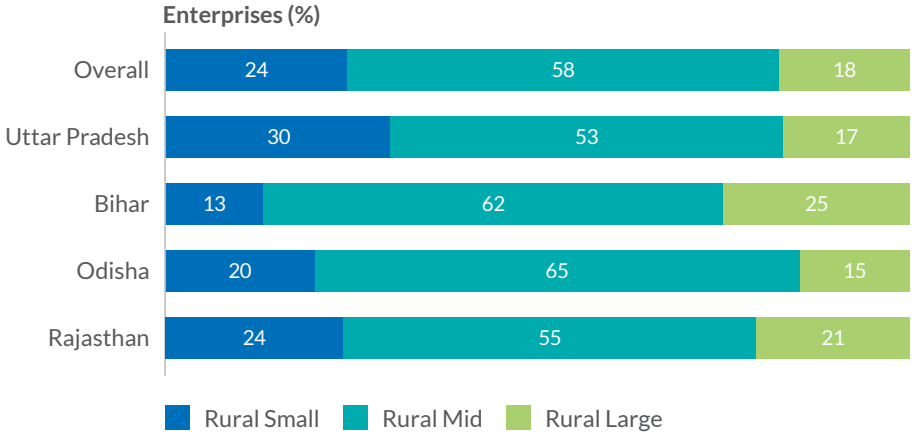
C.Rural large enterprises:

Almost all these shops have *pucca* structures; a medium to large area, which could be greater than 250 sq.ft; with most entrepreneurs owning their shops. A majority of these shops have employees, and an inventory value greater than INR 1,50,000 at a given point in time.

Distribution of Enterprise Customers by state

Based on the above classification, 24% of enterprises surveyed are *rural small*, a majority (58%) are *rural mid*, with the remaining 18% belonging to the *rural large* profile (Figure 2.3). The distribution of rural enterprises is broadly similar across the four states, with Bihar having a relatively higher share of *rural large* enterprises.

Figure 2.3: Distribution of rural enterprises across states, by scale of operation



Most enterprise activities in rural India are carried out at different scales of operation; the study analyzed that scale for each of the retail- and service-based categories.

CUSTOMER PROFILES RURAL ENTERPRISE

Study categorises enterprises into three groups based on: enterprise building characteristics, the number of employees and inventory value .

Rural Small Enterprise

*Where most enterprises operate from **rented spaces with kutcha or semi-pucca structures** with a small shop area of less than **100 square feet**.*

*These are predominantly owner-managed shops, with very **few enterprises having employees**. A majority have inventory stock with **value less than INR 30,000** reflecting their small scale of operation.*

Rented spaces
Less than 100 sq.ft area
Inventory stock values less than INR 30,000

Rural Mid Enterprise

*Where most of these shops have fully constructed **(pucca) structures that are small to medium in size**, and **two-thirds of businesses own their shops.***

*While a majority are **owner-managed shops**, a third have **employees assisting the owner**. A majority have inventory stock with **value between INR 30,000 to INR 1,50,000** reflecting their medium scale of operation.*

Two third business own their shops and owner managed shops
Between 100 and 250 sq.ft area
Inventory stock with value between INR 30,000 to INR 1,50,000

Rural Large Enterprise

*Almost all these shops have **pucca structures**, a medium to large area, which could be greater than **250 sq.ft**, with **most entrepreneurs owning their shops**.*

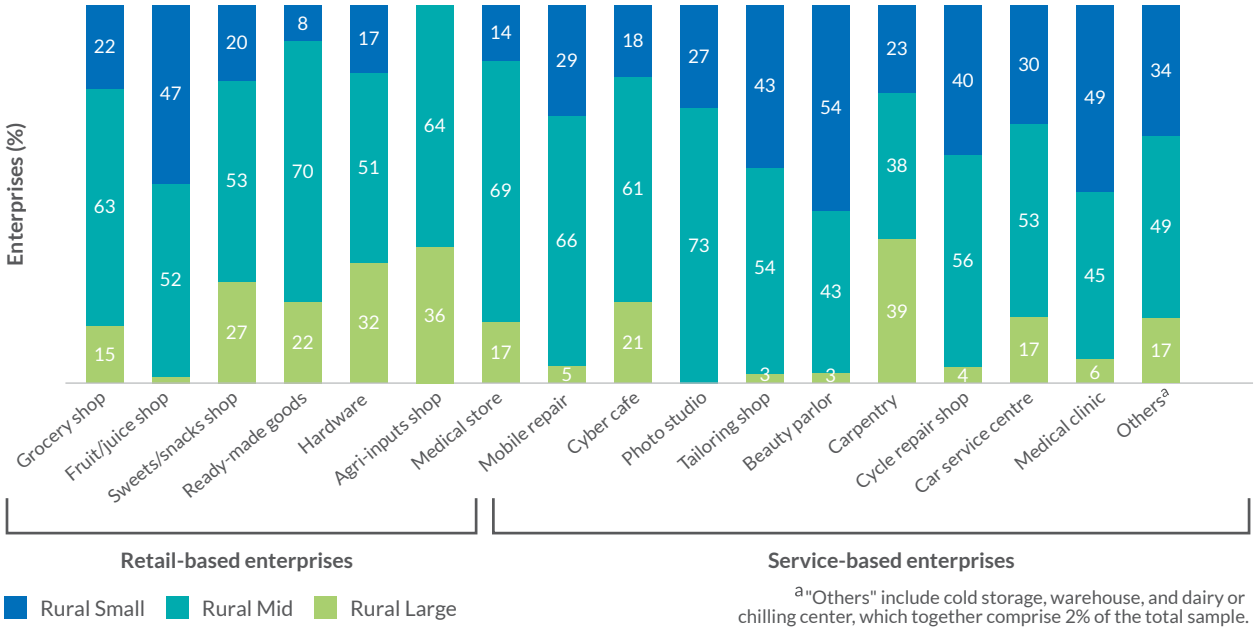
***A majority of these shops have employees**, and an inventory **value greater than INR 1,50,000** reflecting their larger scale of operation.*

Most own their shops
Greater than 250 sq.ft area
Inventory stock with value greater than INR 1,50,000

With the exception of fruit and juice shops, most enterprises engaging in retail trade belong to the rural mid scale and rural large scale categories. Service-based enterprises, such as flour mills, operate only at a *rural mid* scale or *rural large* scale. Enterprises such as cybercafes, photo studios, mobile repair, etc., are also predominantly *rural mid* and *rural large* enterprises. Any remaining service-based enterprises belong to either the *rural small* or *rural mid* categories.

Even though these findings are specific to the areas covered in this study, it confirms that commercial activities pursued by rural enterprises are at varied scales (Figure 2.4)

Figure 2.4: Scale of rural enterprises, by commercial activity



[a] "Others" include cold storage, warehouse, and dairy or chilling center, which together comprise 2% of the total sample.

The next chapter sheds light on different types of electricity sources used by rural enterprises, and how this type of adoption is interlinked with their socioeconomic characteristics.

3. Sources of Electricity

Rural Households 23

Rural Enterprises 27

Marketplaces and households in Indian villages are anything but stereotypical; even in rural settings, customers more often than not have the option of choosing between multiple products, based on needs, tastes, and price-points.

Stores that line the main shopping area, for example, include providers of Internet services, school supplies, vegetable vendors, and small restaurants that serve both food and community news. Adding to that variety are the choices that each business owner makes when it comes to electricity. Whether choosing electric grid, solar mini-grids, diesel generators, or other options, they are guided by habit, differing business strategies, past experiences, and current economic realities.

Information on—and perceptions of—sources of electricity in rural India isn't as clearly defined. While existing literature talks of the diversity of energy sources used by households for lighting and cooking, few studies look at the diversity of electricity sources used by rural households; even fewer focus on rural enterprises.[xiii,xiv]

This is an important distinction, one with direct bearing on policy and financial decisions made by governments, and business decisions made by the private sector to further develop rural India.

This study considers three dimensions that facilitate a better understanding of electricity sources across diverse geographies and contexts: the adoption of grid-electricity; the role of different non-grid solutions in facilitating electricity access; and specific lighting solutions used by the un-electrified population.

Rural Households

Recent years have seen the pace of electrification intensify across India, with the government reporting 100% electrification of villages in April 2018. That growth comes with a tacit acknowledgment that additional work is required, work that will move services beyond the physical infrastructure.

Adoption of Grid-Electricity

Seventy-five percent of households within the study area reported the use of grid-electricity. Gaps in access to grid-electricity were analyzed using metrics defined in Table 3.1.[xv] As per the survey data, 90% of rural households have an electric pole within 50 meters of their house.[xvi] The remaining 10% have electric poles located further away, a visible reflection of gaps in the penetration of electric grid's infrastructure. For such households, the absence of grid connections can be mainly attributed to lack of infrastructure, or a supply-side gap.

However, the presence and awareness of grid-electricity does not always equate to a 100% rate of adoption. Fifteen percent of households in the study area do not have grid connections despite the availability of an electric pole near their home. The gap between availability and adoption reflects lack of demand for grid-electricity, the reasons for which are discussed later in Chapter 4.

Table 3.1: Metrics to measure the supply-side and demand-side gaps in grid-electricity access

Metric	Construction	Findings
Availability rate	(Households that have electricity connection or electric pole within 50 meter distance) / (Total households)	**90%**
Hook-up rate	(Households that have electricity connection) / (Households for which infrastructure is available within 50 meter distance)	**84%**
Access rate	(Households that use electricity) / (Total households)	**75%**
Unserved population	(100%) – (Access rate)	**25%**
Demand-side gap	(Availability rate) – (Access rate)	**15%**
Supply-side gap	(Unserved population) – (Demand-side gap)	**10%**

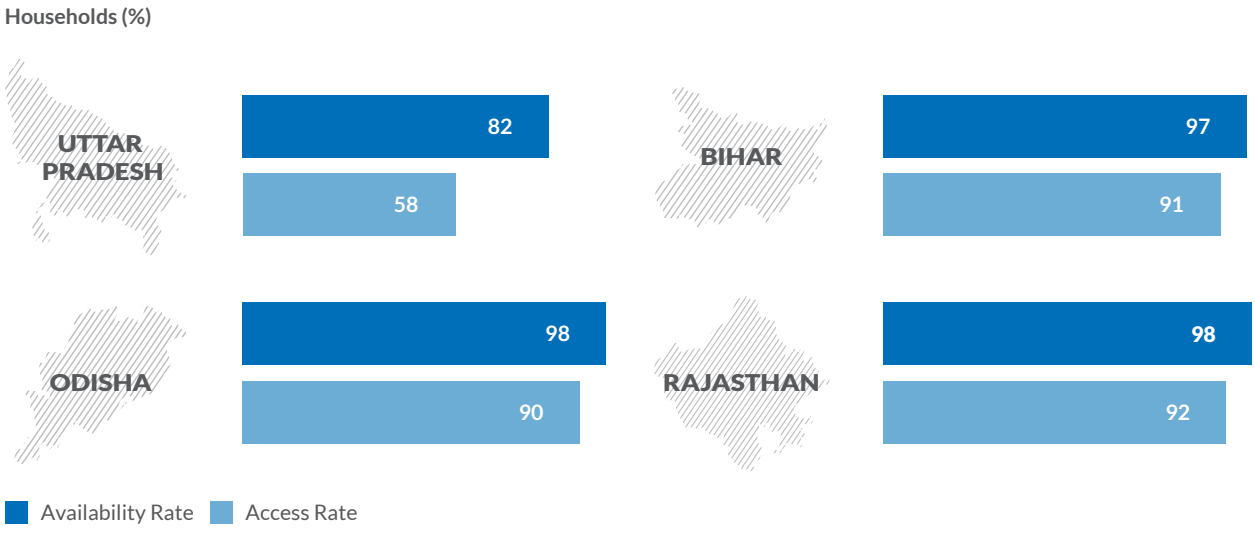
Note: *Adapted from the World Bank's 2014 study titled Power for all: Electricity access challenge in India.*

Findings on the adoption of grid-electricity become more relevant when we look at statistics for households, grouped by states. While the availability of the electric grid is high across all four states studied, the share of grid-users is more than 90% in villages located in Bihar and Odisha but lower than 60% in Uttar Pradesh.

The task of household electrification is going to be challenging in Uttar Pradesh, where efforts are needed to ensure adequate provisioning of grid-infrastructure, as well as addressing of demand-side challenges.

In Rajasthan, Bihar, and Odisha, however, gaps in access to grid-electricity are primarily due to lack of demand from customers.

Figure 3.1: Gap between availability and adoption of grid-electricity for rural households, by state



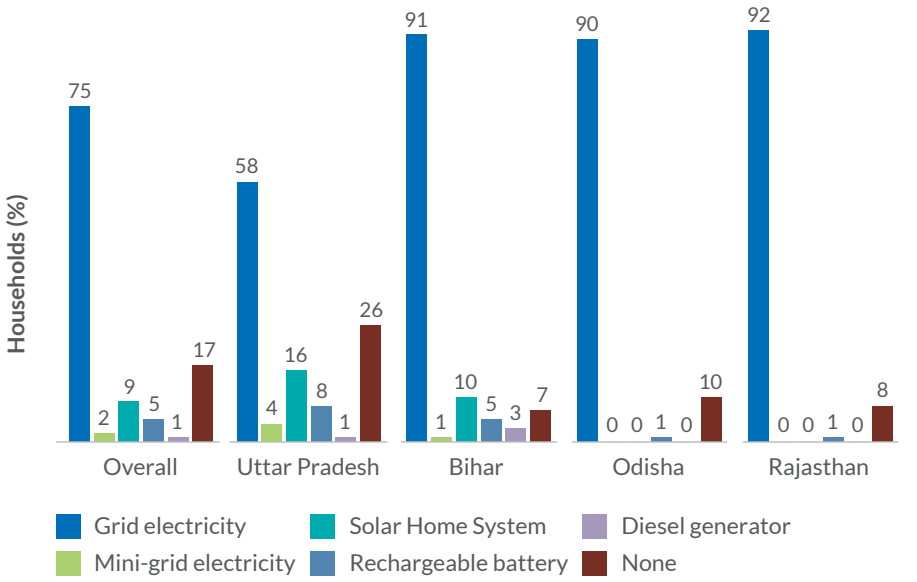
Non-Grid-Electricity Use

Despite the increasing footprint of grid-electricity, this study finds that several non-grid sources[8] are in use; these include, primarily, solar home systems, followed by rechargeable batteries, mini-grid electricity, and diesel generators (Figure 3.2).

Overall 16% of households use non-grid-electricity sources, half of which also have grid connections. This is an important finding, as there is an assumption that non-grid sources are popular only among un-electrified households. In addition, past studies on the state of electricity access do not report such high levels of penetration of non-grid solutions in rural India.[xvii]

The number illustrates the role played by non-grid sources—both in enhancing the quality and reliability of access for those who are grid connected, and in facilitating electricity access for households lacking electric grid connections.

Figure 3.2: Electricity sources used by households across states



Geographically, more than 95% of non-grid users in the study area are concentrated in Bihar and Uttar Pradesh. Annex 3.1 contains a list of electricity sources used by households belonging to villages with alternative electricity interventions.

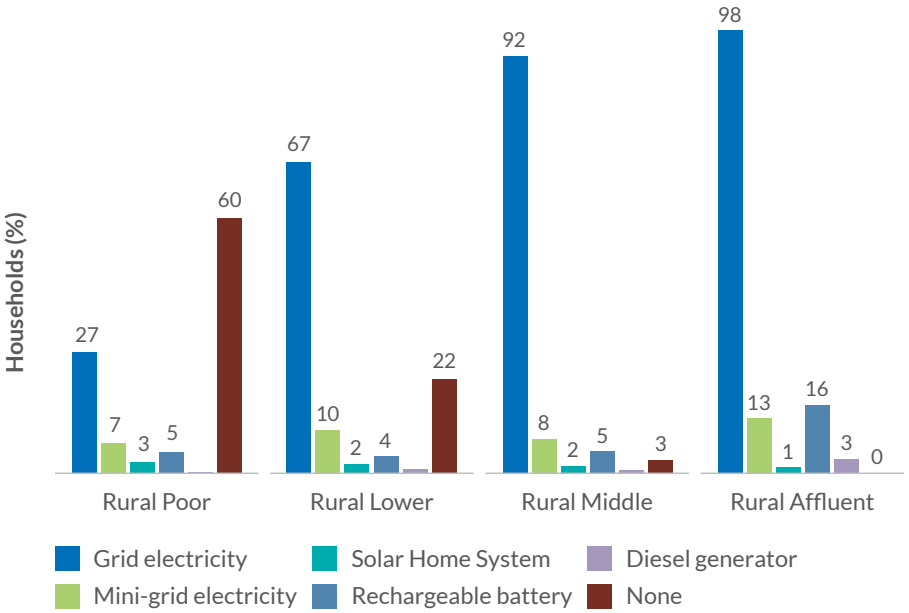
Usage Across Customer Segments

This report previously examined four profiles of rural households. Perhaps unsurprisingly, less than a third of *rural poor* households use grid-electricity, with only two-thirds of *rural lower* households accessing the electric grid. A significant share of households in these two socio-economic categories use non-grid sources to meet their electricity needs, relying particularly on mini-grid, solar home systems, and batteries.

Grid-electricity is the most popular source among *rural middle* and *rural affluent* households, with non-grid sources used mainly for backup purposes. It's a reminder that the use of grid-electricity consistently increases with the parallel growth of a household's socioeconomic status (Figure 3.3).

8. All electricity sources other than grid-electricity are referred to as non-grid-electricity sources.

Figure 3.3: Electricity sources used, by customer profile

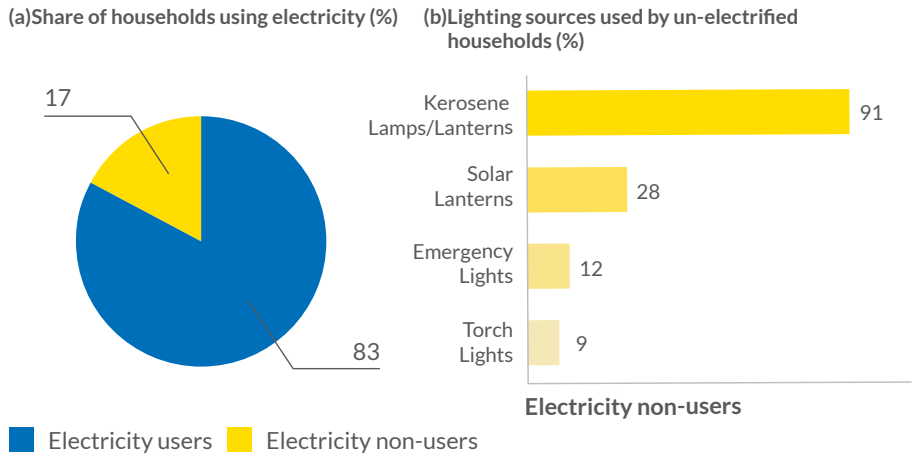


Rural Households That Do Not Use Electricity

The decision not to use electricity is a function of availability as well as affordability. A significant number of un-electrified homes (17%) remain, and a majority of these are rural poor and rural lower households. This is despite ongoing electrification drives and the availability of multiple alternative sources. Geographically, a majority (73%) of such households are in the eastern districts of Uttar Pradesh, which points to, and raises concerns about, the presence of systematic barriers hindering electricity access.

Un-electrified households meet their lighting needs mostly with the use of kerosene lamps and lanterns, with a few using modern lighting sources such as solar lanterns, emergency lights, and torch lights (Figure 3.4 (a) and (b)).

Figure 3.4 (a&b): Lighting sources used by un-electrified households

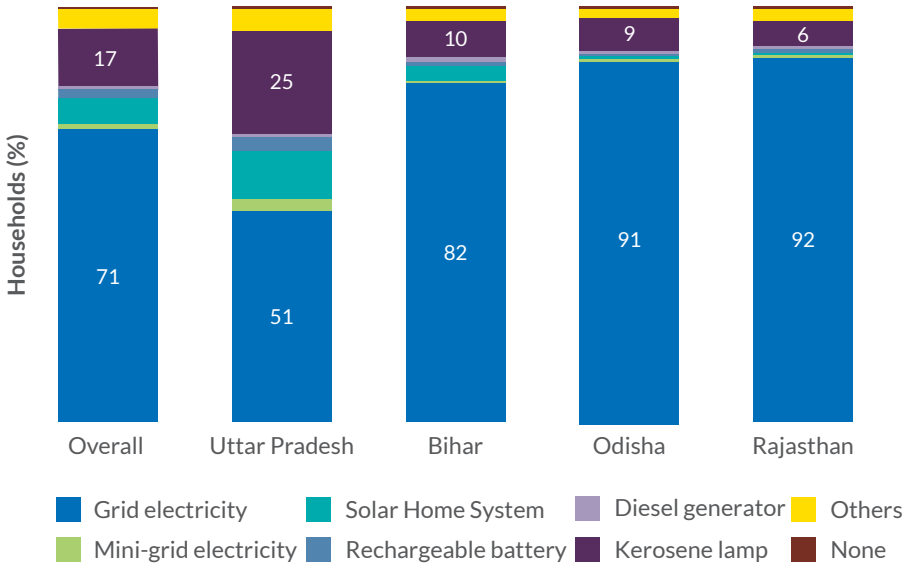


Sources of Lighting

Rural households use various sources of electricity and lighting, with several households stacking multiple options. This then raises a question about the primary source of lighting in use.

Data from households surveyed show that grid-electricity is the primary source for a majority of the surveyed population. Kerosene is the next most used source of lighting (Figure 3.5). In Uttar Pradesh, one in four households continues to rely on kerosene lamps and lanterns. In contrast, in states with a higher adoption of grid-electricity—such as Odisha—the reliance on kerosene for lighting is significantly lower.

Figure 3.5: Primary source of lighting for rural households, by state



Others include solar lanterns, emergency lights, candles and torch lights

Rural Enterprises

One hundred percent electrification of villages is an impressive achievement by any measure and so is the work done under *Saubhagya*, the government's ongoing electrification initiative. The program largely focuses on household electrification, perhaps unintentionally prioritizing "*Ghar*" over "*Dukaan.*" The results are predictable: only 65% of enterprises connect to the electric grid.

Enterprises that have better access to reliable electricity rely less on diesel, can offer better services and stay open longer—increasing income for that entrepreneur, and creating prosperity within communities. They are, in effect, engines for growth within the rural economy.

Nearly every small business invariably operates on a simple precept: *I work to earn enough money that will feed my family, educate my children, and provide for my parents. I work to perhaps leave something for my family.* The definition of "*enough money*" varies, depending on the strength of a business owner's vision.

Policies and schemes don't necessarily consider the voice of the rural enterprise customer; one-size-fits-all electricity is just one example. Given constraints in supply and pricing, usage varies by the nature of the enterprise, with owners often using several sources of electricity to meet their needs.

Commercial enterprises in rural India are, and should remain, an integral part of plans to increase rural prosperity and growth. Yet their overall adoption of grid-electricity lags behind that of rural households, making it increasingly critical to focus on consistency and quality delivery of electricity to this segment.

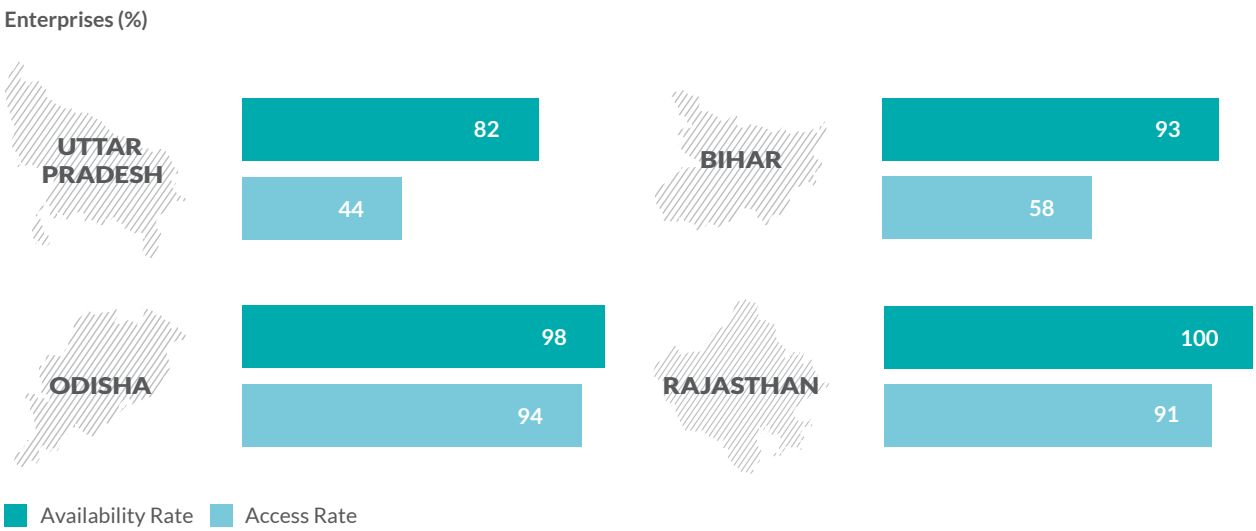
This study finds that electricity usage is highest among enterprises engaging in skill-based services, or those which are capital intensive, including mobile repairs, cybercafes, photo studios, medical stores, and hardware shops.

Adoption of Grid-Electricity

In the survey of rural enterprises across four states, the study found that only 65% had grid-electricity connections. This percentage is lower than that of households in the area, with particularly low adoption rates in Bihar (58%) and Uttar Pradesh (43%). There are two primary reasons behind these low rates of adoption: (i) grid-electricity for enterprises is not subsidized as domestic electricity connections, and (ii) ongoing schemes for rural electrification largely focus on households.

As with households, gaps in electricity access among rural enterprises is mainly a reflection of demand-side concerns. Approximately 90% of enterprises have an electric pole within a 50-meter distance, but only 65% have taken a grid connection. This leaves 25% of enterprises lacking grid-electricity, despite the physical proximity and availability of grid-infrastructure. The gap between availability and access is particularly high in the states of Bihar and Uttar Pradesh (Figure 3.6). Factors explaining these gaps are discussed in subsequent chapters.

Figure 3.6: Gap between availability and adoption of grid-electricity for enterprises, by state



Non-Grid Sources of Electricity

In the absence of a concerted effort targeting rural enterprises, 40% of rural enterprises use non-grid-electricity sources to meet their lighting and other service needs. Rechargeable batteries, solar home systems, solar mini-grids and diesel generators are common non-grid sources; their popularity varies across states (Figure 3.7).

40% of rural enterprises use non-grid-electricity sources. Some service-based enterprises like flour mills and carpentry shops use expensive non-grid sources like diesel to power high wattage motor loads.

In Bihar and Uttar Pradesh, one in two rural enterprises use non-grid-electricity sources, while the share is 16% for enterprises in Odisha and Rajasthan. For details on electricity sources used by enterprises in different village categories surveyed, see Annex 3.2.

Electricity Sources by Commercial Activity

The choice of electricity source for a rural enterprise varies with the type of commercial activity and the scale of operation. The use of grid as well as non-grid-electricity sources is highest among enterprises engaged in services such as mobile repair, photo studios, and cybercafes. These enterprises largely stack several sources of electricity, driven by a higher need for reliable electricity access.

The study finds that a majority (60 to 70%) of enterprises engaged in retail trade, use grid-electricity; some also use non-grid sources. Some service-based enterprises like flour mills and carpentry shops use expensive non-grid sources like diesel to power high wattage motor loads.

A significant share of enterprises engaged in activities such as repair services and tailoring do not use any electricity at all. This may be partly attributed to economic constraints, as a significant share of these enterprises operate at a very small scale (Figure 3.8).

Figure 3.7: Electricity sources used by rural enterprises, by state

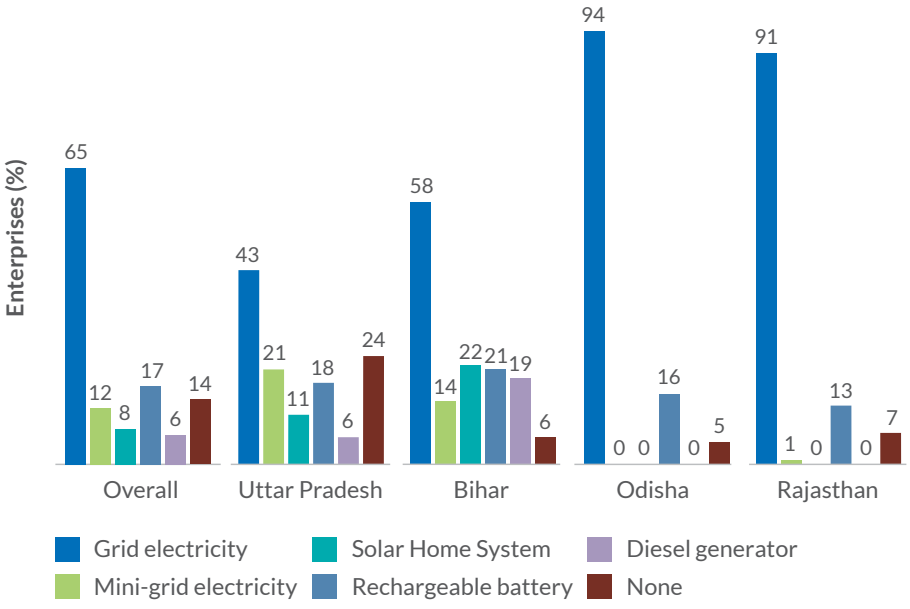
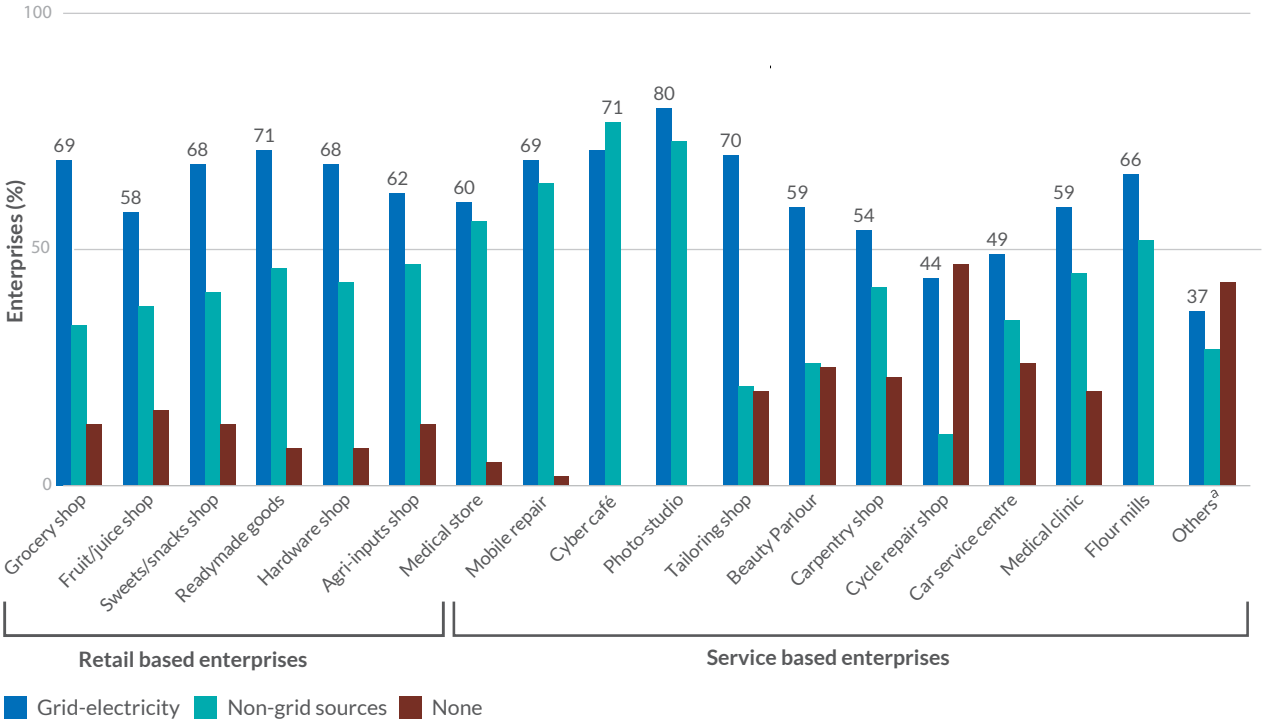
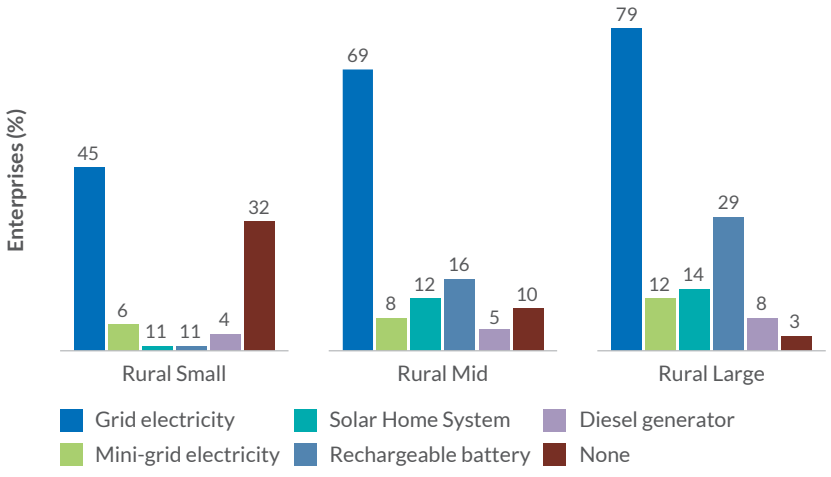


Figure 3.8: Electricity sources used by rural enterprise



Unsurprisingly, the use of grid-electricity increases with the scale of operation of an enterprise; those with more assets and inventory are more likely to use this as a source, potentially due to higher capacity and the willingness to pay for access (Figure 3.9). The scale of operation also determines the increasing use of non-grid sources, as enterprises stack their sources to meet their needs; this is a cyclical process that would need to be addressed to ensure true growth for rural enterprises. Enterprises lacking electricity access generally belong to the *rural small* and sometimes *rural mid* customer profiles.

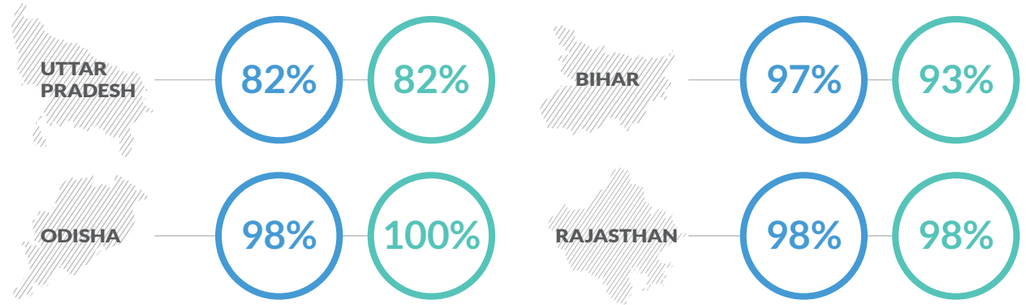
Figure 3.9: Electricity sources used by rural enterprises, by scale



LANDSCAPE OF ELECTRICITY ACCESS ACROSS STATES

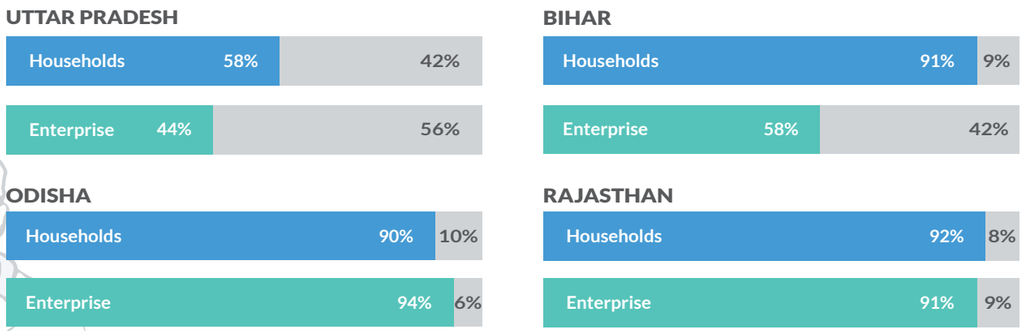
DEMAND METRICS

Customers with grid-electricity available* to them

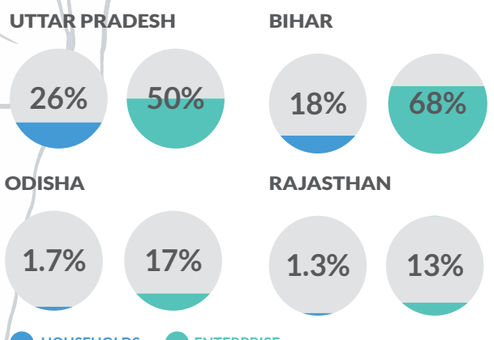


* Measured as the availability of an electric pole within 50 meter distance

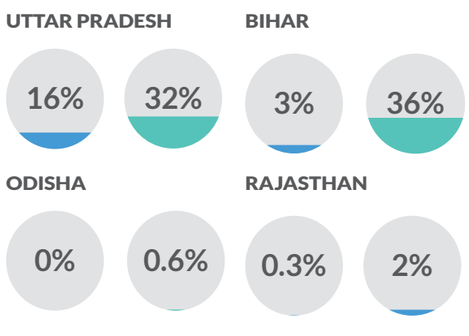
Customers who use grid-electricity



Customers who use non - grid sources

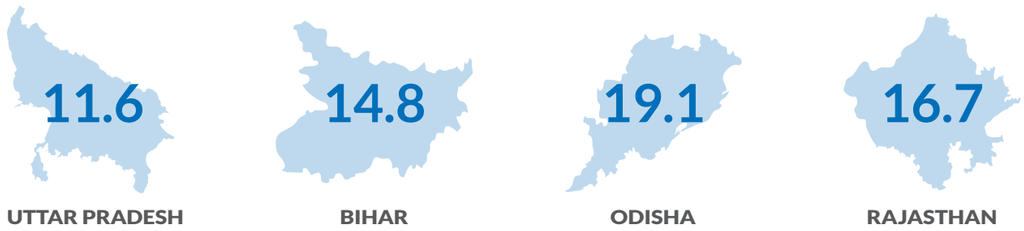


Customers who use only non - grid sources



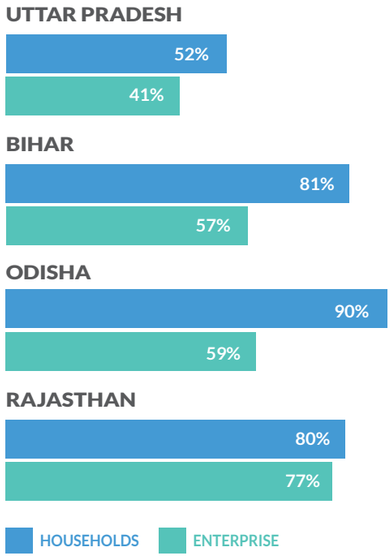
SUPPLY METRICS

Average hours of grid-electricity supply per day

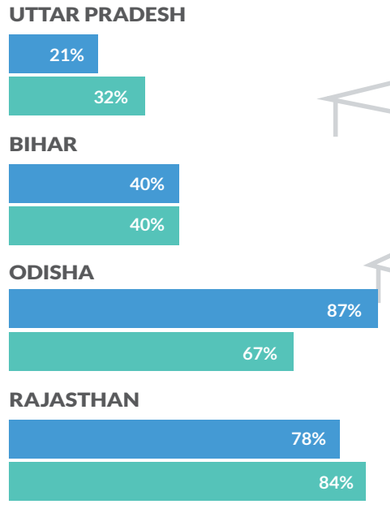


Hours of grid-electricity supply between 6pm and 12 am

Share of grid users having metered connections



Share of grid users receiving electricity bills on time



Enterprises That Do Not Use Electricity

This study also reveals an interesting statistic about rural enterprises: 14% do not use any kind of formal electricity source at all. A third of these unelectrified enterprises rely on diverse and often multiple lighting sources, ranging from kerosene and candles to solar lanterns and emergency lights (Figure 3.10 (a) and (b)).

However, a majority of un-electrified businesses (65%) do not use any lighting source, and they largely operate in villages in Uttar Pradesh. The number seems plausible, as these enterprises mainly operate during daylight hours and rely on sunlight for their lighting needs.

Sources of Lighting

Enterprises stack multiple electricity sources, and those who do not have any formal source of electricity use alternatives for lighting purposes. Overall, among enterprises, grid-electricity is the most popular primary source of lighting for rural enterprises across all states. This is followed by alternatives: mostly solar home systems, rechargeable batteries, and mini-grids (Figure 3.11). In Uttar Pradesh, specifically, alternatives are the primary source of lighting for more than 65% of rural enterprises.

This stands in contrast to observations made about rural households, where kerosene lamps remain the second most popular source—in large part because of ready, and exclusive, access to subsidized kerosene for poor households. The data also indicates that with no access to this subsidized kerosene, rural enterprises have moved toward cleaner electricity and lighting sources.

Figure 3.10 (a&b): Lighting sources used by un-electrified enterprises

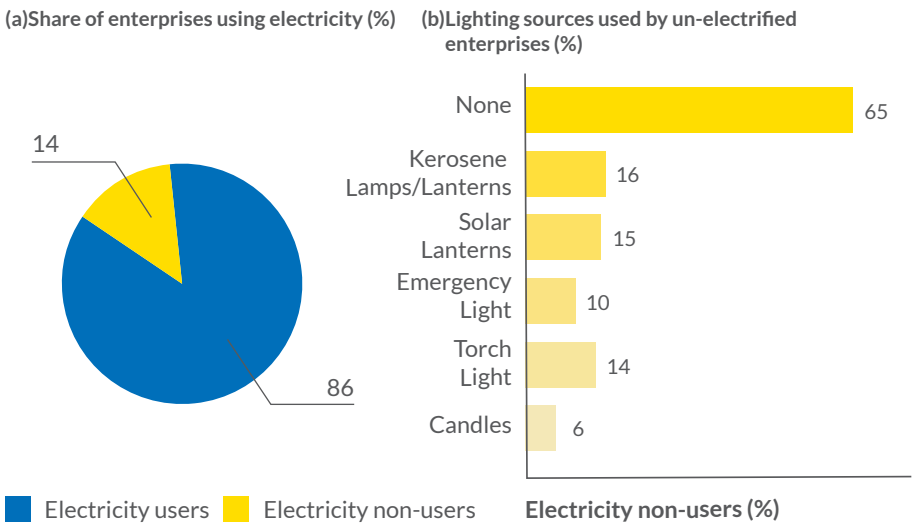
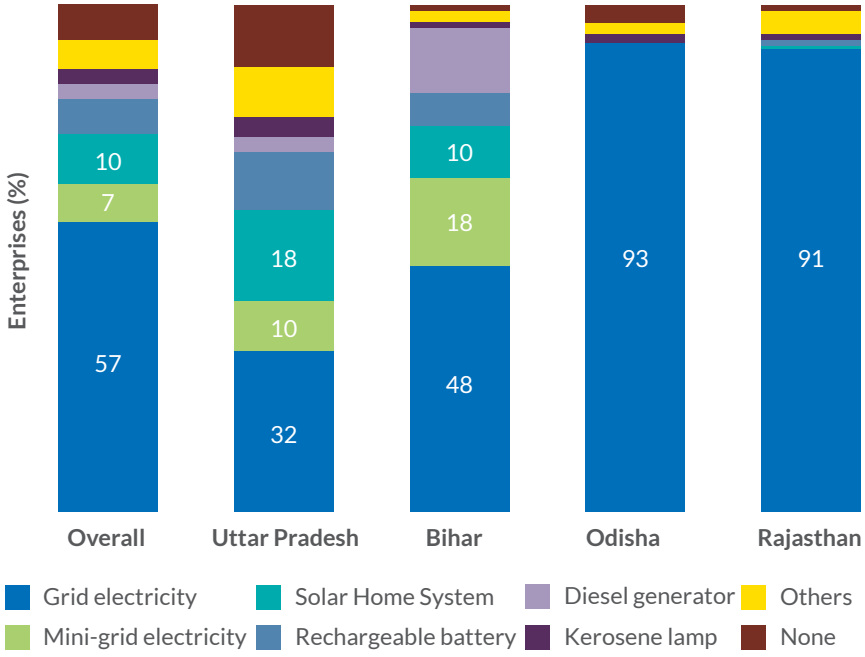


Figure 3.11: Primary sources of lighting for rural enterprises, by state



Others include solar lanterns, emergency lights, candles and torch lights

Key Takeaways

- Grid-electrification coverage and adoption is high across states with the electric grid emerging as the primary source of electricity and lighting for many.

- Non-grid sources such as solar home systems, rechargeable batteries, and mini-grid electricity form an important part of the rural electricity mix. Despite the physical availability of grid-electricity, almost a third of rural enterprises in Bihar and Uttar Pradesh rely exclusively on various non-grid sources. The choice of these sources of electricity varies by geography and economic status for households. For enterprises, these choices vary by type of commercial activity.

- Multiple gaps in access to electricity remain, particularly in the state of Uttar Pradesh.

- Gaps are much more prevalent in the case of rural enterprises who currently use and pay for alternatives, including expensive options such as diesel. As a segment, they are not necessarily identified and served effectively by electricity providers.

The study's findings also give rise to several important questions. Why, for example, is the adoption of grid-electricity low despite being available? What barriers hinder the adoption of certain other sources, like mini grid electricity? And, what factors drive the sustained use of, and customer satisfaction with, electricity? Subsequent chapters attempt to answer these questions.

4. Drivers of Customer Satisfaction

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Factors influencing Customer Satisfaction 43
Learning from the Experiences of Mini-Grid Customers 50
Key Takeaways 53

The larger objectives of the universal electrification program in India go beyond achieving 100% connections to sustaining high standards of service to the satisfaction of the end customer. Achieving these objectives, therefore, requires an understanding of the factors that hinder the full adoption of electricity and those that drive customer satisfaction with electricity access.

This chapter explores why some customers do not use electricity despite its availability, and identifies measures to address the current gaps. Importantly, the study investigates factors that can lead to higher adoption of and improved customer satisfaction with electricity sources.

Factors hindering Electricity Adoption

Rural Households

This study's assessment of the realities on the ground, indicate that there exist several factors that both directly and indirectly influence the decisions of rural customers of electricity – decisions that result in 15% of rural households not adopting grid-electricity despite being in close proximity to the grid-infrastructure.

Based on customer responses, there are three key factors that explain the lack of adoption of grid-electricity:

1. An inability to afford grid-electricity,
2. Difficulty in getting a grid connection, and
3. Inadequate and unreliable power supply (Figure 4.1).

An Inability to Afford Grid-Electricity

Grid-electricity is viewed as expensive by a majority of households without grid connections. It is an intriguing claim by non-users, especially given the subsidized tariff made available.

Analysis of the economic status and monthly expenditures of these households shows that only a fourth of these users are *rural poor* households, with *kutcha* houses and hardly any durable assets. However, the remaining three-fourths who claim an inability to afford grid-electricity belong to the *rural lower* and *rural middle* categories, with monthly expenditures of more than INR 3000. For such households, the use of grid-electricity for lighting and other basic needs would imply a consumption of less than 30 units per month, or a monthly electricity expense of less than INR 200, depending on the State tariffs (as shown in Annex 4.1).

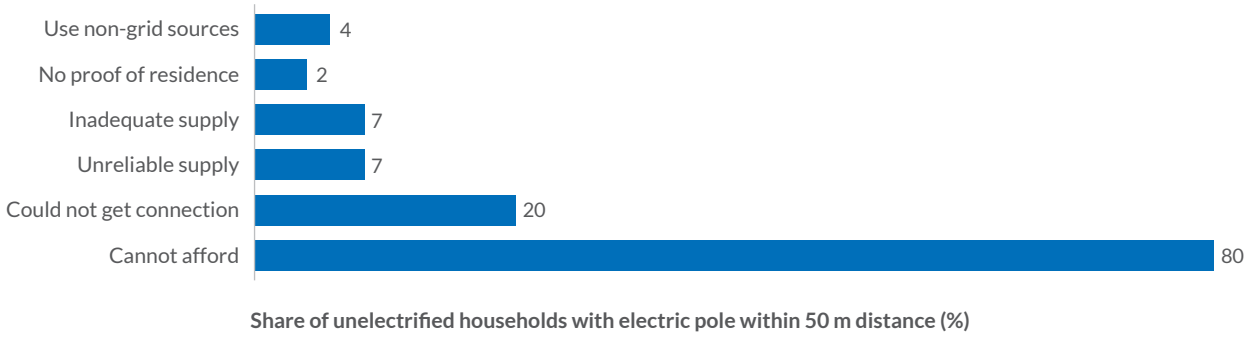
If these households were to use grid-electricity, their expense would be less than 6.7% of their monthly household expenditure. This is comparable with expenses incurred by current grid-users, who spend 6.4% of their household expenses on grid-electricity.

In other words, with the exception of a few households with limited resources, grid-electricity appears to be well within the purchasing capacity of a majority of non-users.

Why then do non-users perceive grid-electricity as unaffordable? Any issues with the high up-front cost of electricity connection, as pointed out by earlier studies, have been significantly addressed under the ongoing *Saubhagya* scheme.[9]

9. Under the scheme, un-electrified households with below poverty line (BPL) cards or meeting certain inclusion criteria can get free-electricity connections, while others can get the connection for INR 500 (to be recovered in 10 instalments.)

Figure 4.1: Household reasons for not connecting to electric grid



Note: *The total sum is greater than 100, as several households gave more than one reason.*

There appear to be other underlying reasons behind perceptions of unaffordability. More than 80% of non-users of grid-electricity citing these concerns are located in Uttar Pradesh, where there are two key issues.

i) A high share of unmetered connections.

Nearly half of the grid-connected households in Uttar Pradesh lack metered connections (Figure 4.2). They are charged a fixed monthly tariff of INR 400, a tariff that benefits wealthier households with high-load appliances. Poorer households, who need a fraction of the electricity for basic needs such as lighting and the charging of mobile phones, suddenly find themselves paying a much higher per-unit cost.

The numbers tell the story. A household using two 7-watt LED bulbs for 12 hours per day would consume only 5 units of electricity per month. With a metered connection, such a household in Uttar Pradesh will have to pay only INR 65 per month at current tariffs; with unmetered connections, the expenses rise to the aforementioned INR 400 per month, equivalent to INR 80 per unit.

ii) Irregularity in bill generation and collection.

In Uttar Pradesh, only 20% of grid-connected households receive an electricity bill on a regular basis, i.e., once in every one or two months. However, more than two-thirds of households surveyed have either never received any bill, or receive it at irregular intervals, ranging from once in six months to once in several years (Figure 4.3). The absence of regular bills increases the burden of arrears for late payment on households that can ill afford additional payments.

It also takes away the opportunity to plan household expenses—and limit electricity consumption-in the event of receiving any high bills. Some households also reported problems with disproportionately inflated electricity bills. This may happen due to erroneous meter readings by the electricity department personnel, or the practice of generating bills using average consumption levels recorded through meters installed at a feeder level.

Figure 4.2: Share of households with metered grid-electricity connections, by state

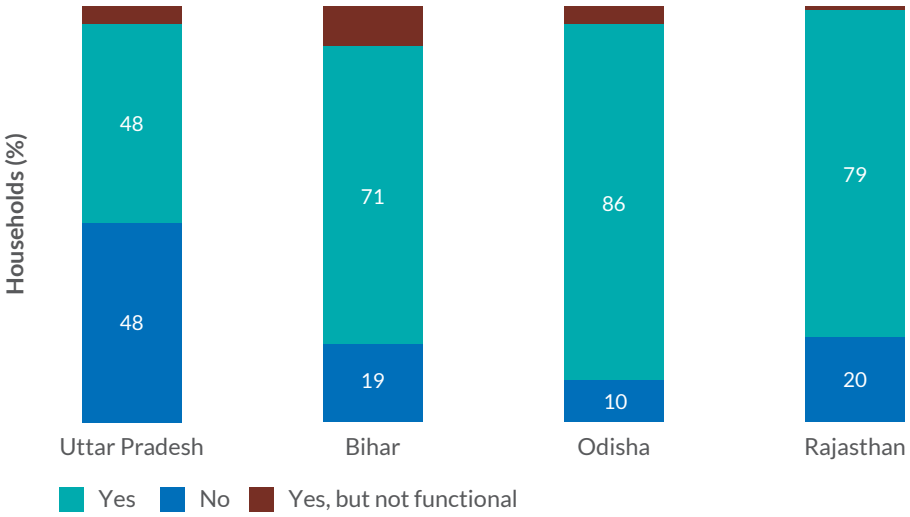
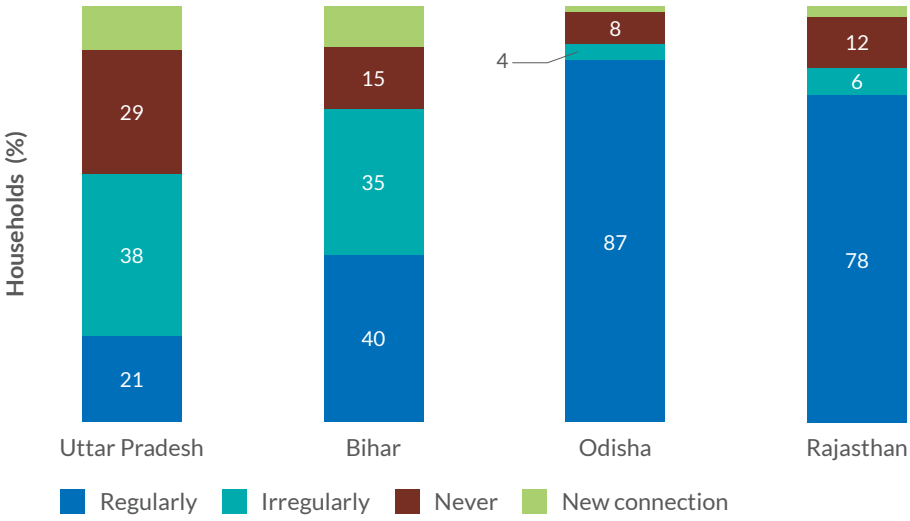


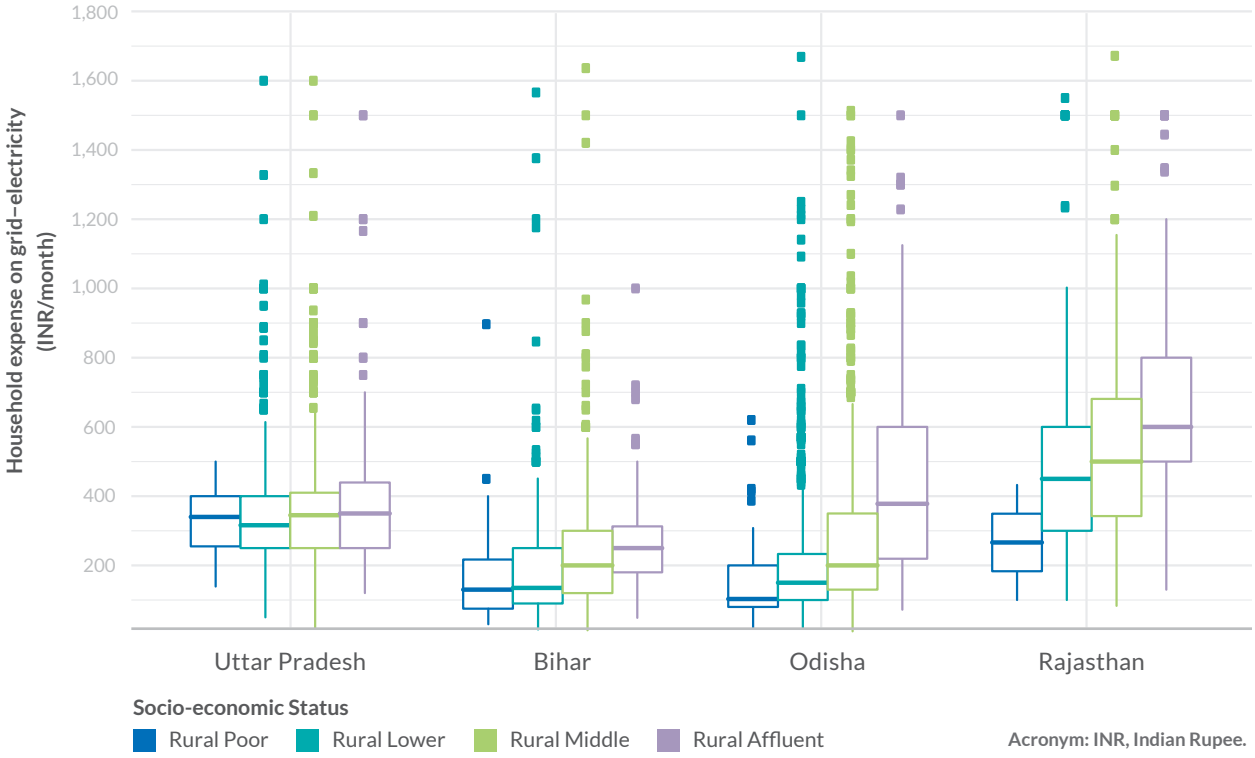
Figure 4.3: Frequency of receipt of grid-electricity bill by households, by state



Such challenges in metering and billing in Uttar Pradesh are also evident from the fact that average monthly expenses on grid-electricity by households, in the state, are similar across all socioeconomic groups (Figure 4.4). This clearly illustrates that electricity expenses in Uttar Pradesh are not adequately linked to electricity consumption patterns shown in Annex 4.2.

In the other three states studied, expenditure on grid-electricity increases with household socioeconomic status, and is linked to patterns of consumption. This also reflects that even households with limited capacity to pay, in these states, can meet their electricity needs at affordable costs. For instance, in Odisha, which has favorable statistics on meter coverage and regular billing, a fourth of grid-users incur electricity bills of less than INR 110 per month. These are comparable with expenses on kerosene use by un-electrified households.

Figure 4.4: Household expense on grid-electricity, by socioeconomic status



In order to ensure that rural households find grid-electricity affordable, it would be important to improve meter coverage and ensure timely and accurate payment collection systems.

Difficulties in Getting a Grid Connection

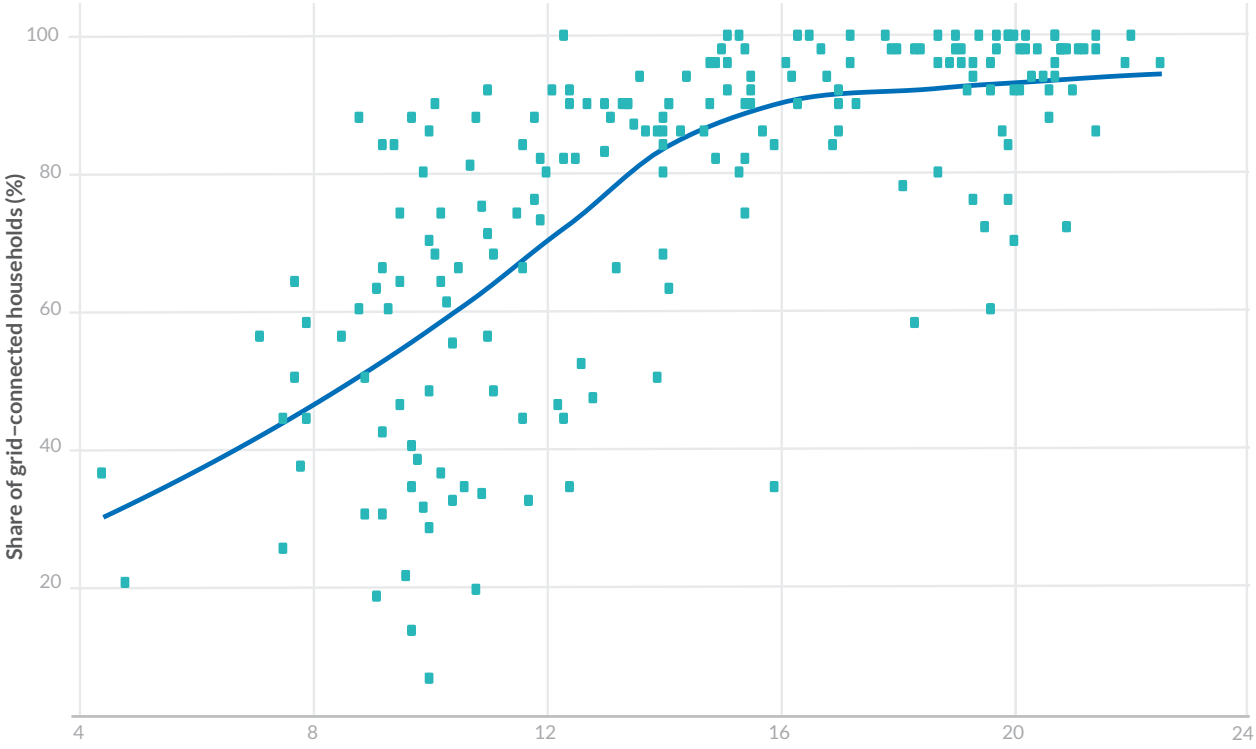
Under the *Saubhagya* scheme, state electricity departments have been organizing awareness camps and fast-tracking applications for grid connections. Despite the ease of processes, a significant share of the households cite difficulty in getting a connection (Figure 4.1).

Findings supplemented with qualitative interviews reveal that some households missed the opportunity to participate in these camps because they were away from their village at that time. Others did not have proper documentation, such as proof of residence, and for that reason they could not get a connection.

The lack of documentation as a reason is also confirmed by other studies. Households with low levels of education face difficulty in preparing paperwork, including applications for grid connections.[xviii] Additionally, field insights point towards delays in the processing of applications by distribution companies, especially in Uttar Pradesh.[xix]

Government statistics report that household electrification is close to saturation levels, which indicates that these concerns are being addressed. However, for households yet to be electrified, the challenges of getting a connection are likely to become even higher, as many of these are *rural poor* households with less education, often located farther away in difficult and remote terrains.

Figure 4.5: Correlation between adoption of grid-electricity and duration of power supply among households



Note: *The blue line represents Loess or local regression curve.*

Inadequate and Unreliable Power Supply

Power that is available when rural households need it the most can be, at best, a tenuous affair; one in two households with grid-electricity face a power cut of at least eight hours per day. During evening hours, more than a third face power cuts of at least three hours. Besides the inconvenience, a lack of reliable—and adequate—hours of power supply is also likely to deter potential users, especially those with limited resources.

Survey findings show that the share of grid-connected households is higher in villages with a longer duration of power supply (Figure 4.5).[10] This also aligns with the finding that Uttar Pradesh, with the lowest share of grid-users, also has the lowest number of hours of average daily and evening power supply, at 12 hours and 3 hours, respectively.

An important concern associated with inadequate and unreliable power supply is the need for backup lighting and electricity sources, together with the associated expenditure. Eighty-six percent of grid-connected households use at least one additional source of electricity or lighting, with kerosene as the most popular backup.

In addition to paying electricity bills, grid-users have to spend INR 78 per month on kerosene use, which is comparable to what un-electrified households spend, at INR 94 per month. For economically weaker households on the grid, this implies additional expenditure on backup sources. Apart from the inconvenience and discomfort, power outages also contribute to perceptions that grid-electricity is unaffordable.

10. This association should be viewed with caution. It is also likely that hours of power supply is higher in villages with greater number of grid-users, which serves as an incentive for DISCOMs.

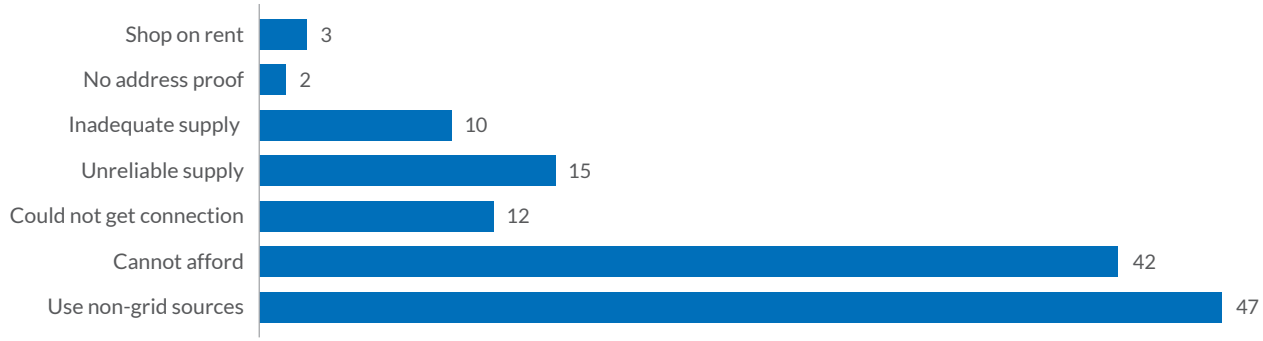
Rural Enterprises

Enterprises cite multiple reasons for not using grid-electricity (Figure 4.6), including lack of documented proof of address for the shop, or a lack of ownership of the shops that are rented.[11]

Research findings, however, point to two key factors that explain why certain rural enterprises do not use grid-electricity, despite its availability:

- The use of non-grid sources, which obviates the need for grid-electricity, and
- The perception that grid-electricity is expensive and unaffordable.

Figure 4.6: Reasons for not connecting to electric grid, by enterprises



The Use of Non-Grid Sources

Rural enterprises surveyed in Bihar and Uttar Pradesh are well aware of non-grid sources and find these readily available. For instance, among surveyed enterprises in these states, more than 90% have heard about the solar home systems, and around 50% are aware of mini-grid electricity.

In cases where grid-electricity appears expensive and unattractive, enterprises have adopted cheaper alternatives. Table 4.1 shows that enterprises using non-grid sources, with the exception of private diesel generators, incur smaller electricity expenses than those using grid-electricity. Even though grid-users also have higher electricity consumption, these numbers indicate that many rural enterprises have chosen to reduce their electricity costs by adopting alternative solutions to suit their electricity needs.

For instance, in Uttar Pradesh, enterprises using mini-grid or a connection from diesel generator operators, incur half the average monthly expenditure of grid-electricity users. Preferences for alternative solutions are also linked to the economic status of enterprises; a majority of those without grid-electricity operate at small or medium scales.

However, some enterprises also use expensive sources like diesel generators with high capital and operational costs. Most are located in Uttar Pradesh and use diesel generators because they do not find grid-electricity reliable and adequate. These enterprises, which operate high-powered appliances such as welding machines and flour mills, can benefit from access to reliable and cheaper electricity services, making them attractive customers for electricity utilities in rural areas.

11. During field visits, many enterprises operating from rented shops were found using katiya (illegal) connections in Uttar Pradesh.

Table 4.1: Average monthly expenditure of enterprises on different electricity sources

Electricity source	Overall	Uttar Pradesh	Bihar	Odisha	Rajasthan
Grid-electricity	492	468	498	375	963
Solar mini-grid	288	235	390	-	-
Rechargeable battery	103	93	18	70	560
Diesel generator (connections)	315	242	344	-	-
Diesel generator (private)	5,699	6,545	4,924	1,778	-

Note: *This excludes the top 5% values to avoid distortion due to outliers.*

Acronym: INR, Indian Rupee.

An Inability to Afford Grid-Electricity

As in the case of households, on the basis of monthly expenditures, grid-electricity is within the purchasing capacity of most enterprises. For example, 75% of the enterprises who cite affordability as a concern earn more than INR 5000 per month.

If these enterprises were to use grid-electricity for basic lighting and cooling needs, a majority would incur less than INR 250 per month, as seen in Annex 4.3. This constitutes less than 5% of their monthly income and is comparable with the 4% (on average) expenses incurred by grid-connected enterprises. However, this level of expenditure holds true only if enterprises can avail themselves of metered electricity connections and receive bills at regular intervals. In Bihar and Uttar Pradesh, less than 60% of enterprise grid connections are metered and less than 40% receive bills on a regular basis (Figures 4.7 (a) and (b)).

High up-front costs for grid-electricity connections are another challenge faced by rural enterprises. Data reveal that enterprises have to pay INR 2800 on average as a connection fee. This is a prohibitive cost for many rural enterprises, particularly those with limited electricity needs and a low capacity to pay. In addition, power outages, particularly during the evening, further reduce the attractiveness of grid-electricity.

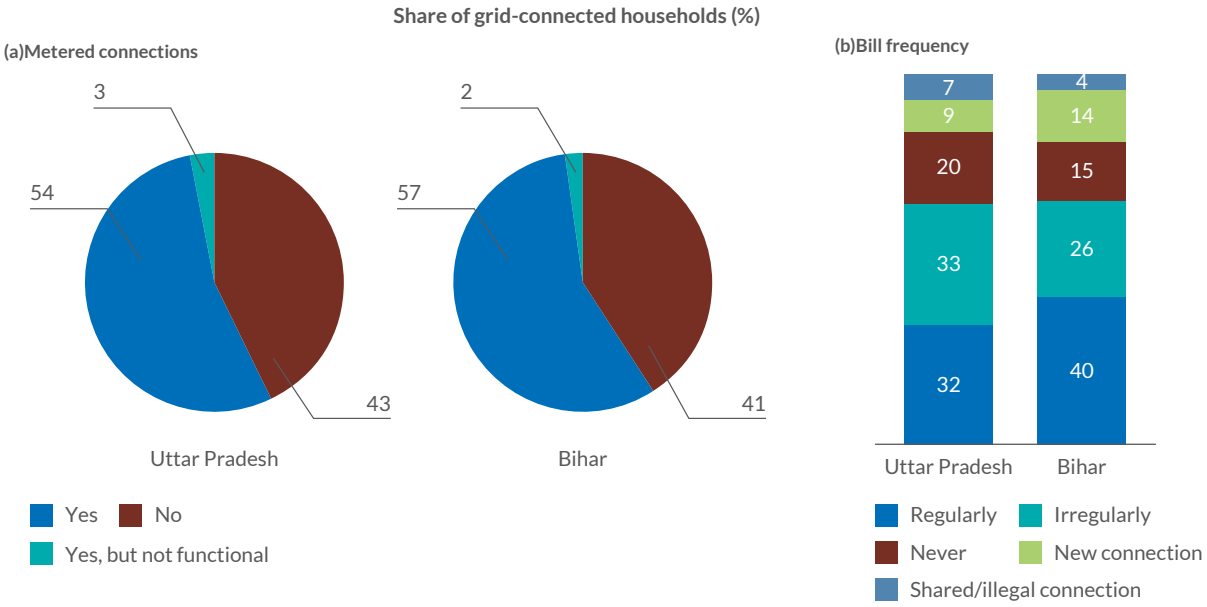
Factors influencing Customer Satisfaction

Rural Households

Household electrification is approaching saturation levels under the *Saubhagya* scheme, primarily on account of easy availability of grid-electricity connections for no fee or at a subsidized connection fee. However, there are concerns about the sustained use of electricity for recently electrified households, particularly in the absence of satisfactory services.[xx]

Survey data show that 40% of household users do not express satisfaction with their grid-electricity services.

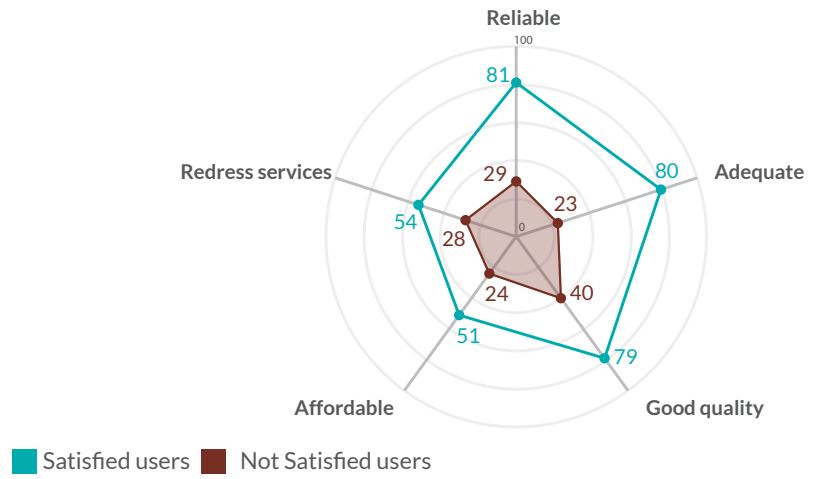
Figure 4.7 (a&b): Share of enterprises with metered grid-electricity connections and frequency of receipt of bill



To better understand drivers of customer satisfaction, users were asked about their perceptions toward different attributes of grid-electricity service.[12] Figure 4.8 shows that satisfied customers hold a positive perception about most service attributes, particularly the reliability, adequacy, and quality of supply. Thus, the customer satisfaction is driven mainly by reliability, adequacy, and quality of electricity supply, even more than the perception about affordability.

In contrast, lack of satisfaction with grid-electricity is associated with negative perception towards supply parameters as well as affordability. If these concerns are not addressed, some of the dissatisfied customers may not find value for money —affecting their willingness to pay for and use of electricity on a sustained basis. As per the survey, unsatisfied customers typically have a lower willingness to pay for reliable electricity supply as compared to those who are satisfied.[13]

Figure 4.8: Household users' perceptions about grid-electricity, by satisfaction level



12. Customer perception is measured on a three-point scale, by asking whether they agree or disagree with the (positively framed) statements about each of the service attribute. For example: "Do you agree or disagree with the following statements about grid-electricity? a. Grid-electricity is reliable. 1. Disagree, 2. Neutral, 3. Agree."

13. Respondents were asked to share their maximum willingness to pay for uninterrupted electricity supply that would allow them to use all desired appliances.

CUSTOMER PERCEPTION AND SATISFACTION

Customer Satisfaction with electricity is driven by their perceptions towards different attributes of electricity services.

USERS
SATISFACTION
WITH GRID ELECTRICTY

HOUSEHOLDS — **59%** Satisfied

ENTERPRISE — **62%** Satisfied

PERCEPTION
OF GRID ELECTICITY

USERS Satisfied Households
- RELIABLE **81%**
- GOOD QUALITY **79%**
- ADEQUATE **80%**

USERS Unsatisfied Households
- ADEQUATE **23%**
- AFFORDABLE **24%**
- EASY REDRESS **28%**

NON USER Households
- AFFORDABLE **20%**
- EASY REDRESS **25%**

NON USERS
AWARENESS
OF GRID ELECTRCITY

HOUSEHOLDS
- **60%** Non users have grid electricty available near their house
- ONLY **27%** Non users think its easy to get grid connection

ENTERPRISE
- **70%** Non users have grid electricty available near their house
- ONLY **50%** Non users think its easy to get grid connection

USERS Satisfied Enterprises
- RELIABLE **74%**
- GOOD QUALITY **80%**
- ADEQUATE **78%**

NON USER Enterprises
- AFFORDABLE **34%**
- EASY REDRESS **38%**

USERS Unsatisfied Enterprises
- ADEQUATE **27%**
- EASY REDRESS **38%**
- AFFORDABLE **36%**

HOUSEHOLDS · ENTERPRISES · POOR PERCEPTION

Satisfaction levels vary across the states, with one out of two grid-users in Uttar Pradesh and Bihar not satisfied with grid-electricity. Odisha, on the other hand, has a high share of satisfied customers (Figure 4.9). The grid-electricity customers in Odisha receive good quality and reliable services at a lower cost than any of the other states in this study. Odisha's experience underscores a key finding: customers in states with higher satisfaction levels typically receive longer hours of power supply, face fewer instances of voltage drops, and receive bills timely (Table 4.2). Additionally, one of the differences in the case of Odisha is that many parts of the state are served by private distribution franchisees, and that may have a role to play in largely positive customer experiences.

Figure 4.9: Satisfaction levels of rural households with grid-electricity, by state

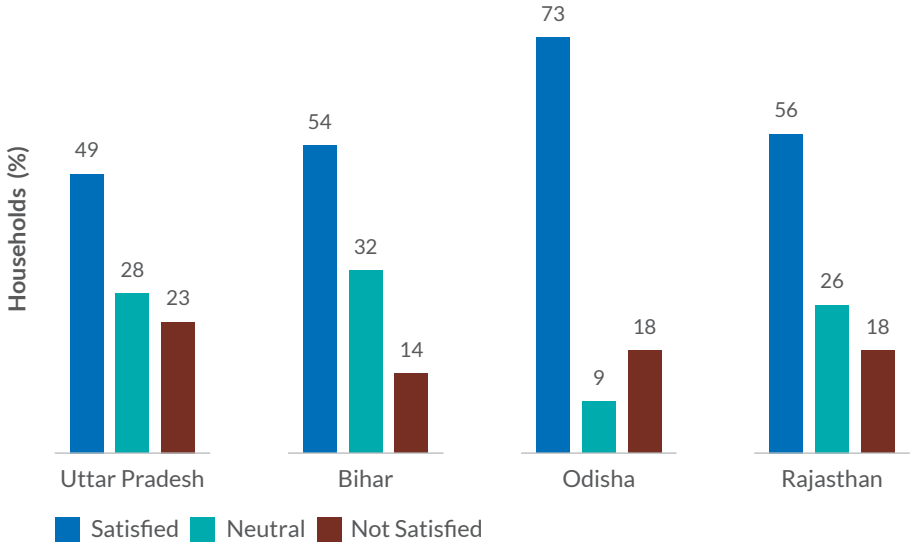


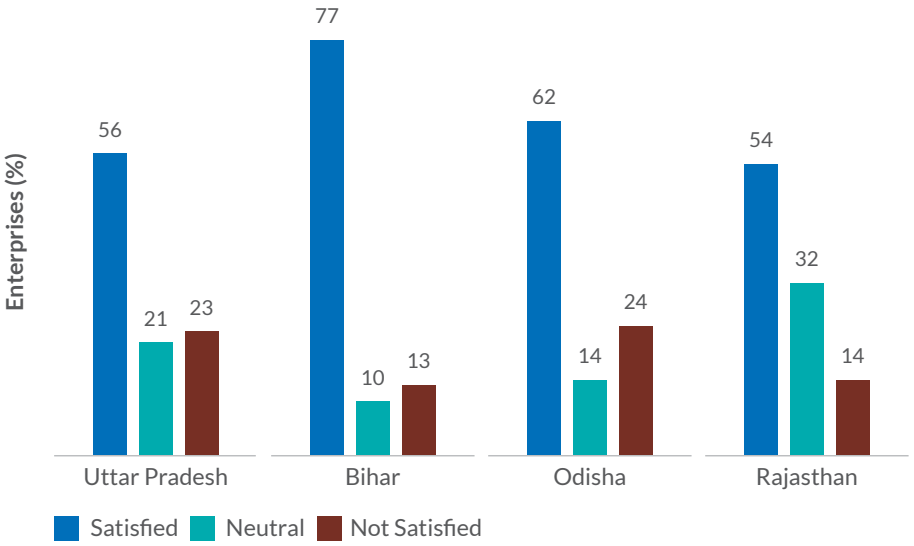
Table 4.2: Parameters of grid-electricity service across states

Parameters of grid-electricity service	Uttar Pradesh	Bihar	Odisha	Rajasthan
Daily supply hours (average)	11.6	14.8	19.1	16.7
Evening supply hours (average)	3.2	4	4.4	4.3
Days with low voltages per month (average)	2.6	1.9	1.1	1.2
Metered connections	48%	71%	86%	79%
Regular billing	21%	40%	87%	78%
Average electricity bill (INR/month)	360	223	250	560

Rural Enterprises

As per the survey, a significant 38% of the enterprises who use grid-electricity are either indifferent or explicitly dissatisfied with their connections. The satisfaction levels also vary across states (Figure 4.10).

Figure 4.10: Share of enterprise customers satisfied with grid-electricity, by state



Note: *A high number of enterprise users were satisfied with grid-electricity in Bihar.*

These are gaps in customer satisfaction that should be a cause of worry for distribution companies, and for two reasons.

1. A lack of satisfaction can influence the willingness of existing users to pay for their electricity bills. The survey finds satisfied users are willing to pay a higher electricity bill for reliable power supply, as compared to those who are not satisfied (Annex 4.4).

2. A lack of satisfaction implies that these grid-users do not hold positive perceptions of grid-electricity. Together with the presence of other barriers to adoption, the negative perceptions of current users can lead to negative word-of-mouth reviews. The perception of non-users toward grid-electricity is positively correlated with that of grid-users.[14] In villages where users of the grid have a negative outlook, any non-users also tend to have a predominantly negative outlook, possibly due to the word-of-mouth effect (Figure 4.11).

While these trends are visible across all states studied, the extent of dissatisfaction with different service attributes also varies across states.

- Lack of reliable and adequate power supply is an issue across all states, predominantly in Uttar Pradesh.

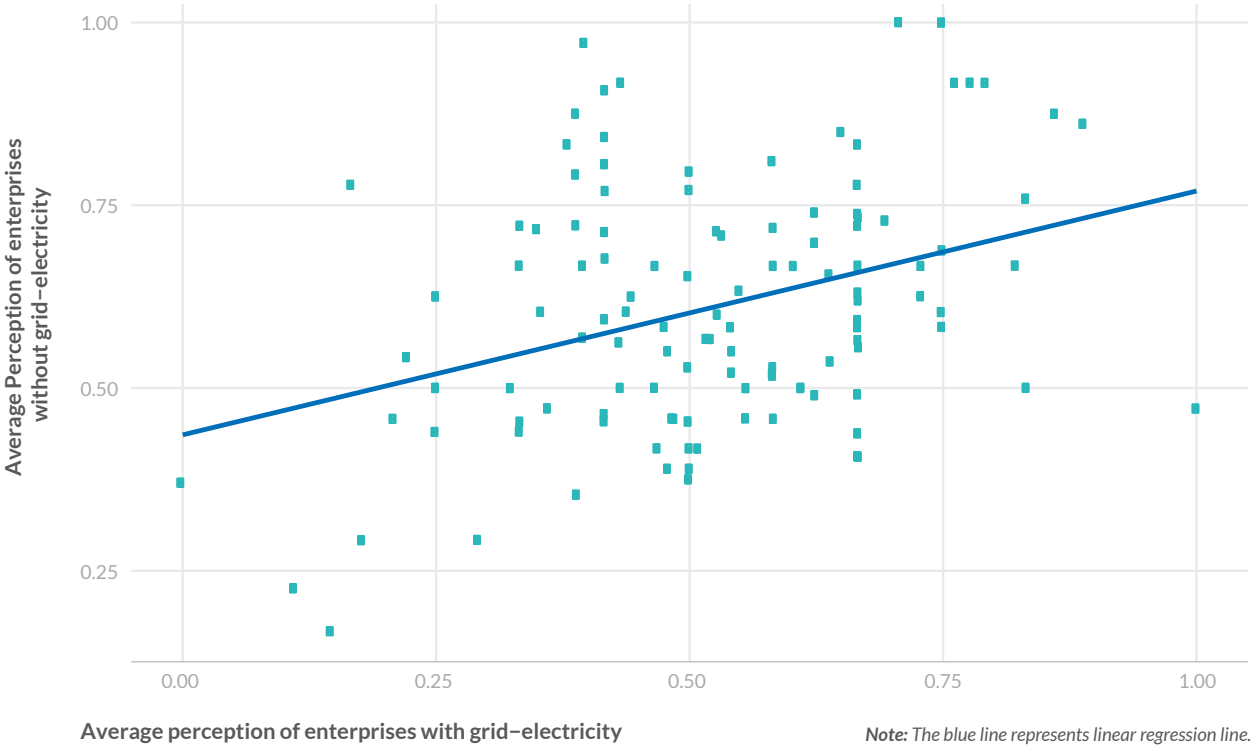
- The most pressing concern for enterprises surveyed in Bihar is the potential lack of redress services, which may adversely limit productive activities.

14. The analysis is done at a village level, as people-to-people interaction is stronger within village boundaries, rather than across it. It is based on a continuous Perception Index. Value 0, 0.5 and 1 represent negative, neutral and positive perception of grid-electricity service. See Annex 4.5 for details on methodology.

Electricity utilities need to work toward improving customer satisfaction levels in order to ensure sustained use of electricity, and they also need to attract more enterprises to take up grid-electricity connections.

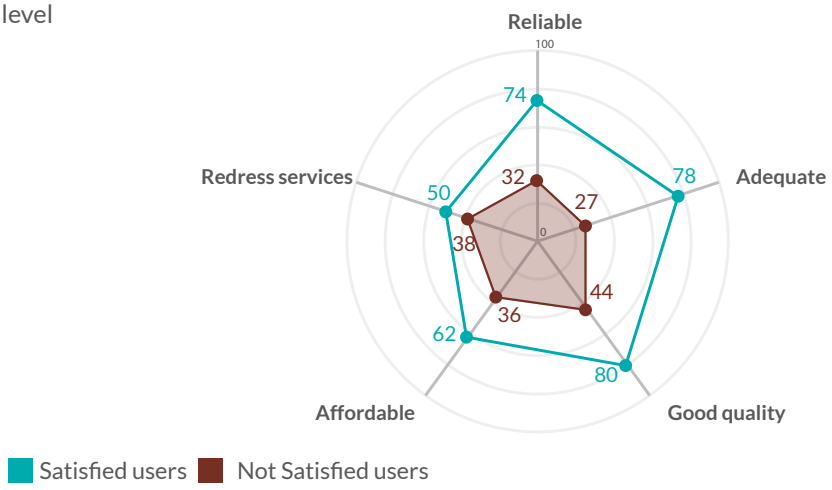
Improving customer service parameters is an important part of the efforts needed: A majority of dissatisfied users find grid-electricity unreliable, of poor quality, unaffordable, and difficult to get serviced in time (Figure 4.12). Electricity suppliers could address these concerns by making connection fee charges less daunting, increasing the availability of metered connections, ensuring the regular collection of bills, and guaranteeing the provision of a reliable and quality power supply.

Figure 4.11: Correlation between perceptions of users and non-users regarding grid-electricity



Note: *The blue line represents linear regression line.*

Figure 4.12: Enterprise users' perceptions regarding grid-electricity, by satisfaction level



Learning from the Experiences of Mini-Grid Customers

Solar mini-grids are an important solution for tackling the challenge of rural electricity access. This section provides insights on the adoption of mini-grid electricity based on surveys of users and non-users of solar mini-grids across 50 villages in Uttar Pradesh and Bihar.

Awareness, Availability, and Adoption of Mini-Grid Electricity

As part of this study, 2,510 households and 504 enterprises were surveyed in 50 villages with solar mini-grids.

Findings reveal that 75% of the rural population in these villages is aware of solar mini-grids. While 72% of households reported having heard about solar mini-grids, the share is higher among enterprises at 88%.

Additionally, about 43% of households and 76% of enterprises in villages with mini-grids also agree that they know many people who use mini-grid electricity. Yet the fact remains that only 7% of households and 34% of enterprises surveyed use mini-grid electricity.

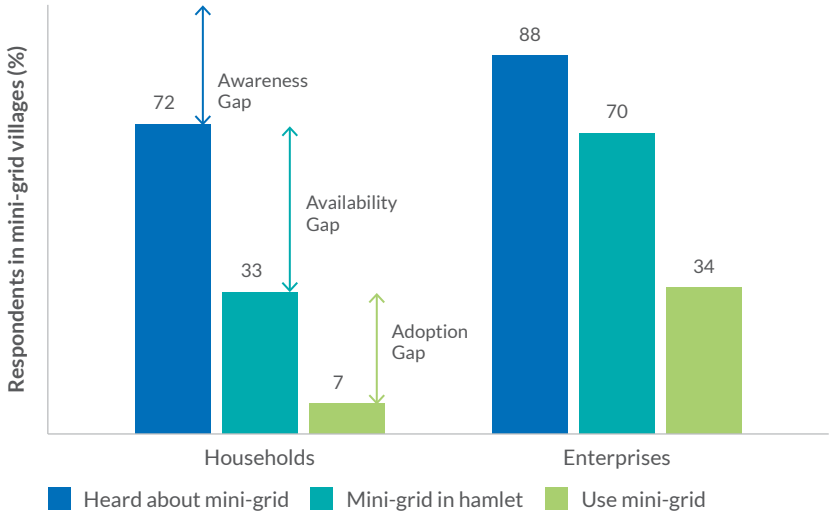
Even though awareness about mini-grids plays a crucial role in their adoption, the wide gap between awareness and adoption could be partly attributed to the fact that villages have a limited amount of mini-grid coverage.

Only 33% of all households in a village have a mini-grid available in their hamlet; this share is 70% for rural enterprises.[15] This is in line with the typical strategies adopted by mini-grid companies; the mini-grids are located close to commercial market areas, with a focus on promoting electricity access for productive purposes. [xxi]

Figure 4.13 illustrates the gap between availability and adoption of mini-grid connection. While half of the rural enterprises with a mini-grid available in their hamlet have taken the connection, only one in five households with mini-grids in their hamlet use mini-grid electricity.

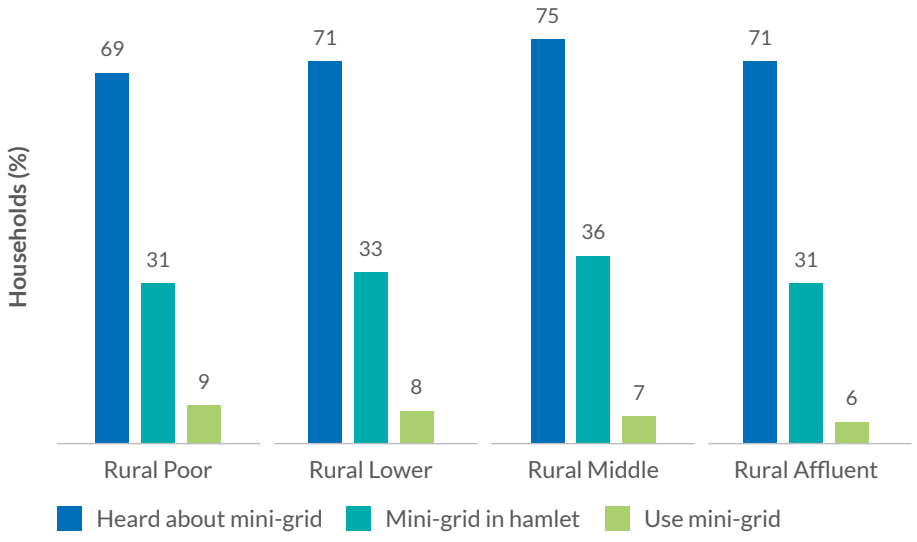
15. Assuming that unaware households and enterprises do not have the technology in their hamlet. The majority of those who don't want to continue

Figure 4.13: Awareness, availability, and adoption of mini-grid electricity



The use of mini-grid electricity also varies with the socioeconomic profile of households and the type of commercial activity pursued by enterprises. Even though awareness and availability levels are comparable across households belonging to different socioeconomic groups, 80% of households using mini-grids belong to the rural lower and rural middle categories (Figure 4.14).

Figure 4.14: Use of mini-grid electricity, by household socioeconomic status



Satisfaction and Perceptions About Mini-Grid Electricity

Survey results reveal that a vast majority of mini-grid users are satisfied with their connections. Data show that 80% of household users and 90% of enterprise users in the mini-grid villages say they are satisfied or very satisfied with their connections.

The degree of customer satisfaction is also reflected in the fact that more than 90% of mini-grid customers agree that they will recommend the mini-grid electricity to others. Additionally, 80% of household users and 90% of enterprise users reported that they would like to continue with their mini-grid connections.[16]

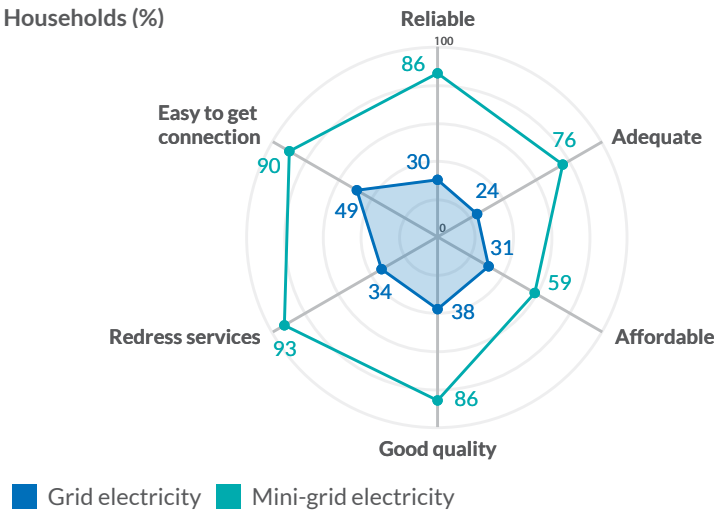
Satisfaction for mini-grid users can be gauged from their perceptions about mini-grid service.[17] Figures 4.15 and 4.16 show that the majority of mini-grid users find mini-grid electricity reliable, adequate, of good quality, and easy to get serviced in case of faults. In contrast, few mini-grid users hold positive perception about the various service attributes of grid-electricity.

More than three-fourths of mini-grid users find mini-grid electricity adequate and reliable for their needs, despite availing themselves of an average of 7 hours of daily power supply. In contrast, grid-electricity users in these villages receive 12 hours of power supply, yet only 40% of them find the electric grid adequate and reliable.

These different perceptions of adequacy and reliability can be explained by the fact that mini-grid users receive uninterrupted electricity during the critical evening hours (typically 5:00 p.m. to 11:00 p.m.), while electric grid-users have to face, on average, 3 hours of power cuts during evening hours. This suggests that rural customers find solar mini-grid electricity an attractive option because of the uninterrupted and quality power supply especially during evening hours, and the easy access to repair or redress services when required.

However, a significant proportion of mini-grid customers do not find mini-grid electricity affordable, though this doesn't seem to influence their satisfaction with the services. *This reinforces that a better service experience is a more important factor versus pricing.*

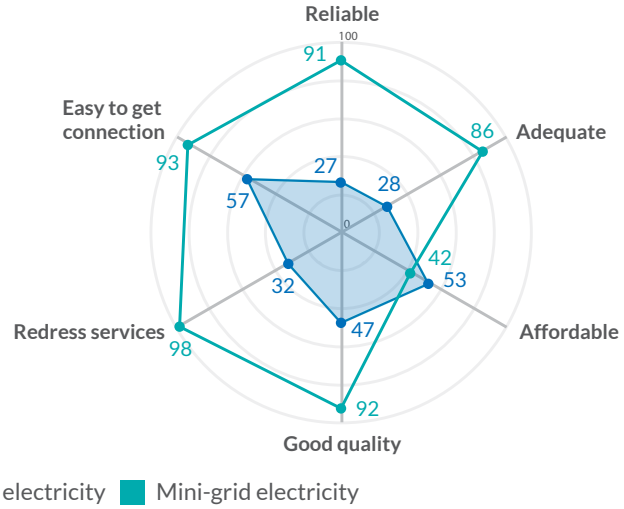
Figure 4.15: Perceptions of household mini-grid users



16. The majority of those who don't want to continue their connection are the ones who find mini-grid expensive

17. Customers' perception about mini-grid electricity measured for six key service attributes: ease of getting grid-electricity connection, ease of getting repair services, affordability, reliability, adequacy and quality of power supply. Customer perception is measured on a three-point scale, by asking whether the respondent agrees or disagrees with the positively-framed statements on each of the service attribute.

Figure 4.16: Perceptions of enterprise mini-grid users
Enterprises (%)



Key Takeaways

- 35% of rural enterprises in the study area do not have electric grid connections. Electricity access for rural enterprises is a critical challenge that needs attention from policy makers and DISCOMs in future electrification efforts.

- Factors that hinder the adoption of grid-electricity include:
    - Poor customer service that leads to customers' negative perceptions and dissatisfaction.
    - Affordability challenges that are related to lack of metering and gaps in billing and collections.
    - Other affordability concerns, in the case of rural enterprises, that are mainly associated with high connection costs and the availability of alternatives.
    - Reliance of several high-electricity-consuming rural enterprises on diesel generators—an expensive alternative—which highlights the opportunities for DISCOMs to expand their customer base.
    - An uncertain power supply and the long duration of power cuts that deters potential customers from taking electric grid connections and additionally poses risks to the sustained use of electricity from the electric grid.

- The study also finds that around 40% of grid-electricity users are not satisfied with current levels of service. Customer perceptions of the reliability, adequacy, and quality of service are the important drivers of customer satisfaction, even more than perceptions about affordability.

- Service providers need to look for ways to improve customer satisfaction, and they could learn from the experiences in Odisha, which has comparatively better service parameters than the other three states studied. This parallels insights from the experiences of mini-grid customers, who also confirm that improved services lead to higher satisfaction levels and to more satisfied customers.

5. Characterizing Rural Electricity Demand

Household Electricity Consumption 55
Electricity Consumption of Rural Enterprises 59
Electricity Consumption in Agriculture 63
Electricity Consumption at the Village Level 66
Key Takeaways 71

The earlier chapters discussed how rural communities rely on various, and often multiple, sources of electricity. Chapter 4 also discussed the factors that drive satisfaction with those sources. This chapter sheds light on electricity consumed by rural households, enterprises, and agricultural users, and it identifies the drivers of increased rural electricity consumption.

To estimate consumption, the study analyzed the ownership and use of appliances for residential, commercial, and agricultural purposes in rural areas. Helping categorize consumption levels is the World Bank's Energy Sector Management Assistance Program (ESMAP): the multitier matrix (MTM), a useful tool to evaluate levels of electricity access.

This study thereafter aggregated the estimates of electricity consumption for domestic, commercial, and agricultural purposes into a general baseline of demand of an average surveyed village.

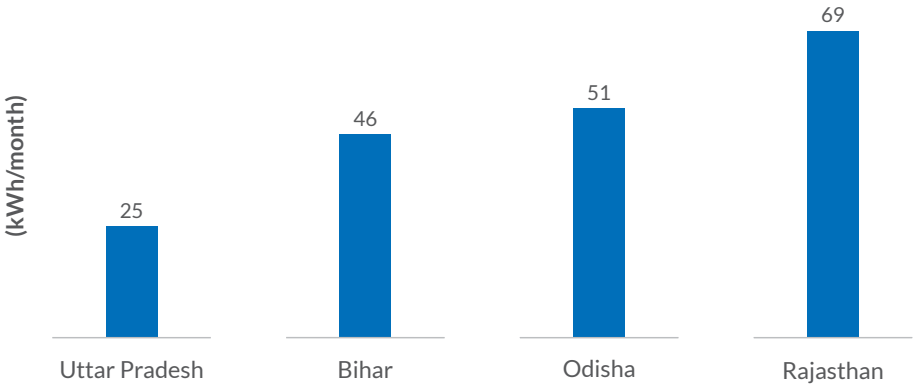
Household Electricity Consumption

The average electricity consumption of rural households, in the study area, from all sources of electricity, is 39.3 kWh/month.

The average electricity consumption of rural households in the study area, from all sources of electricity, is 39.3 kWh/month.[18,19] This translates to a per capita annual consumption of 87 kWh, approximately half the all-India average for residential customers at 153 kWh.[xxii]

Average consumption levels vary across states. Uttar Pradesh, where 40% of households surveyed do not use grid-electricity, has comparatively lower consumption levels than other states (Figure 5.1).

Figure 5.1: Average electricity consumption of households, by state



Household consumption levels also vary with the type of electricity source in use. As per this survey, households using only grid-electricity consume on average about 51 units per month. This estimate is similar to the rural household consumption estimate (53 units per month) from the Consumer Expenditure Survey 2011–12.[20]

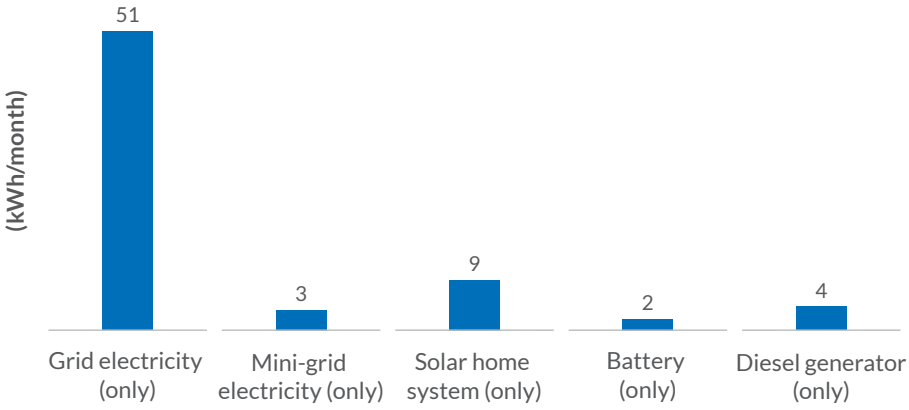
The data also show that the electricity consumption of households using grid-electricity is much higher than that of households using only non-grid sources (Figure 5.2). For instance, the average demand of "grid-only" users is six times that of "solar home system only" users and 15 times that of "mini-grid only" users.

18. See Annex 5.1 for details on framework used to estimate baseline electricity consumption of households.

19. This includes households which use no electricity at all (i.e. zero value).

20. Undertaken by India's National Sample Survey Organization (NSSO). Sampling methodology of the surveys vary in terms of village and respondent selection.

Figure 5.2: Average electricity consumption of households, by electricity source



The low consumption of non-grid users is due to multiple reasons:

- Most households with non-grid sources use smaller capacity systems or packages. Two cases in point illustrate this: 99% of solar home system users own a system of up to 200 watt peak capacity, which limits their consumption to less than 1 kWh/day; 90% of mini-grid users have availed themselves of fixed price packages that they use for LED bulbs, charging their mobile phones, and using a few fans for 5 to 8 hours in a day.[21]

- It is households with limited needs and an inability to pay who use non-grid sources as an exclusive electricity source.

Using the Multitier Matrix to Assess Levels of Electricity Access for Households

Developed by the World Bank's ESMAP,[xxiii] the MTM is a useful tool for evaluating the level of electricity access for a household. The tool goes beyond binary metrics of whether or not a household has an electricity connection. This tool helps better understand variations across surveyed households.

On the MTM, household electricity consumption ranges from "no electricity use" (Tier 0) to "highest consumption tier" (Tier 5). Tier ranges are linked to the amount of electricity consumed, along with an indication of the purpose for which electricity is used (Table 5.1).

The survey finds electricity consumption varies significantly across households (Figure 5.3).

- 36% of households surveyed fall in Tier 1 and Tier 2, i.e. use electricity for general lighting, air circulation, or televisions.
- Another 38% fall in Tier 3, i.e., use some medium power appliances.
- Only 9% of households consume more than 100 units per month, i.e., fall in Tier 4 and Tier 5.

The state of household electricity access varies widely across states (Figure 5.3). The share of Tier 1 and Tier 2 households is higher in Uttar Pradesh and Bihar. In contrast, more than two-thirds of households in Odisha and Rajasthan fall in Tier 3 and above.

21. As per the survey, 93% (i.e. 101/109) of households, which use mini-grid exclusively, own only light bulbs and mobile phones, and the remaining 7% also use a table or ceiling fan.

Table 5.1: Multitier matrix for classifying household electricity consumption

Consumption tiers	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Consumption level (kWh per month)	(0-0.36)	[0.36-6)	[6-30)	[30-100)	[100-250)	[250, above)
Indicative appliances in use, as per the MTM	None	Task lights and mobile phones	General lights, mobile phones, televisions, and fans (if needed)	Tier 2 and any medium-power appliances	Tier 2 and any high-power appliances	Tier 2 and any very high-power appliances
Indicative appliances in use, as per the survey	None	Lights and mobile phones	Lights, mobile phones, fans, televisions	Tier 2 and food processors, refrigerators	Tier 3 and electric irons, desert coolers, washing machines	Tier 4 and submersible water pumps, electric stoves

Figure 5.3: Distribution of households across MTM tiers of electricity consumption in kWh/month, by state

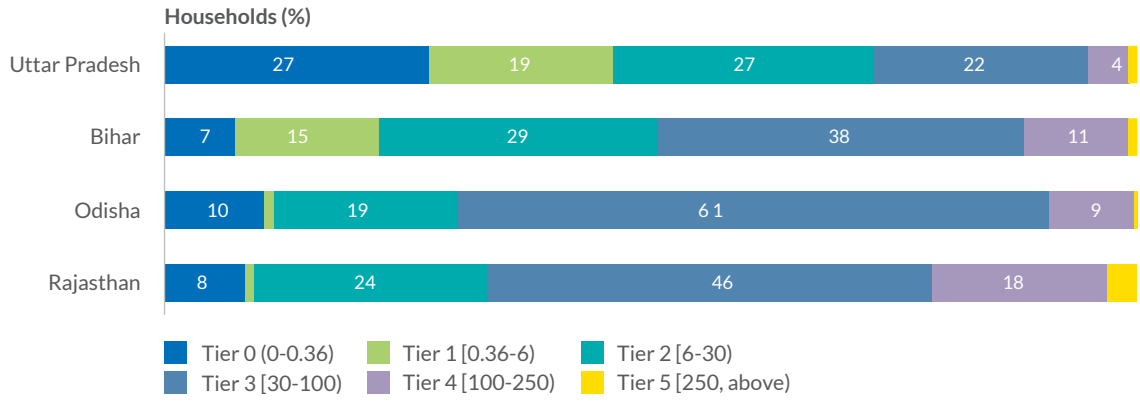
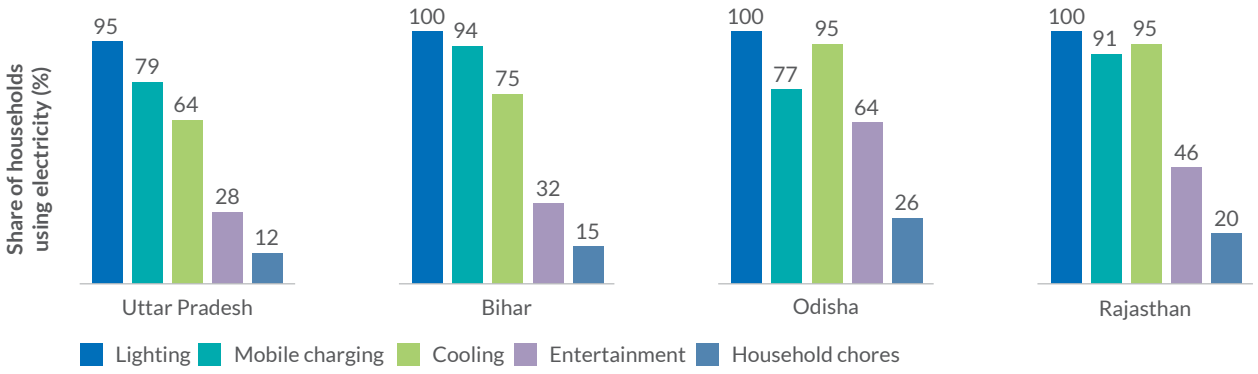


Figure 5.4 shows how households use electricity across states; the use of electricity for cooling, entertainment,[22] and household chores,[23] is highest in Odisha, followed by Rajasthan, Bihar and Uttar Pradesh. These medium to high-power appliances constitute the bulk of electricity used by the households, explaining variations in household distribution on MTM tiers.

22. These include television sets, radios, and music systems.

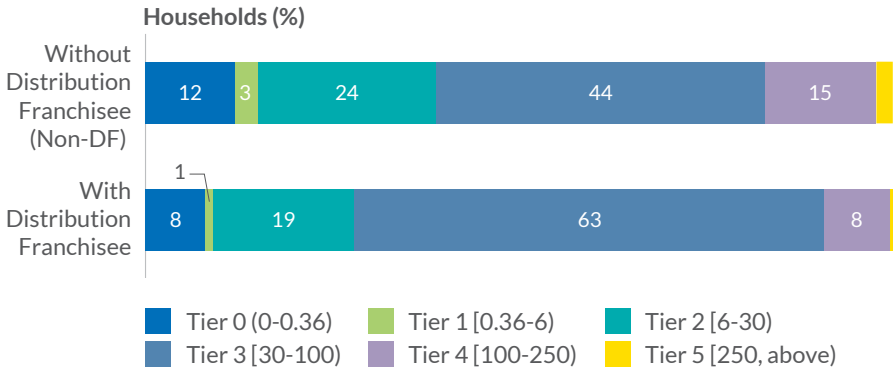
23. These include appliances such as refrigerators, foor-processors/mixer-grinders, washing machines, water pumps, irons and stoves.

Figure 5.4: Purpose of electricity use among rural households, by state



The data show that there is also a correlation between the presence of alternative electricity delivery models and the levels of electricity access in households. Villages with private electricity distribution franchises have a higher share of households in higher-level tiers, as compared to similar villages[24] with only public distribution companies (Figure 5.5). However, more evidence is needed to assess the causal impact of such interventions on electricity access.

Figure 5.5: Distribution of households across MTM tiers of electricity consumption, by village category



What Drives Electricity Demand Among Rural Households?

The MTM framework is useful when evaluating the state of electricity access and experiences with electricity services. However, there are factors that influence the amount of electricity consumed, acting either as drivers of or barriers to electricity demand. A linear regression analysis was conducted to investigate these aspects, which then identified four key predictors of household electricity demand. The highlights are presented below, with details in Annex 5.3.

1. The economic status of households:

On average, and with other factors remaining equal, households with a higher economic status consume more electricity than those with a lower economic

24. Villages were sampled to ensure comparability of villages with alternative delivery models and those without them (see Annex 1.1 for sampling details). Annex 5.2 illustrates the socioeconomic profile of households in different village categories.

status. This may be because households with a higher economic status tend to have larger houses, higher asset ownership and a higher capacity to pay, as profiled in Chapter 2.

2. The education level of the head of household:

On average, and with other factors remaining equal, households where primary decision makers are educated up to and beyond Class 10, use more electricity than other households.

3. Primary sources of household income:

Households where salaried jobs or businesses are the primary source of income tend to consume more electricity than those who rely on agriculture or labor. It is potentially a reflection of uncertainty and seasonality in income flows associated with the latter two activities.

4. Hours of grid-electricity supply in the village:

On average, households in villages with longer hours of grid-electricity supply, consume more electricity. Access to reliable and longer hours of electricity supply can facilitate the use of appliances for longer hours. In addition, a steady supply encourages households to adopt the grid and invest in more appliances.[25] Findings also suggest that each hour of a power cut negatively influences electricity demand among rural enterprises, implying that unreliable electricity supply acts as a barrier to higher electricity use.

Table 5.2 shows the economic status, education, and income source of households falling under each of the MTM Tiers. It is evident that households in Tier 0 and Tier 1 generally belong to *rural poor* and *rural lower* categories, have heads of household with little schooling, and depend on labor-intensive activities for their livelihood.

A majority of households in Tier 2 and Tier 3 belong to the *rural lower* or *rural mid* categories, have heads of household with some education, income from agriculture, and at times, from labor-intensive activities. Households in Tier 4 and Tier 5 belong to the *rural affluent* or *rural mid* categories, have well educated heads of household, most with income from salaried jobs, business, or agricultural activities.

Most households in Tier 3 and above levels of access are in villages that receive at least 12 hours of grid-electricity supply.

Table 5.2 also shows that many households in Tier 3 and above are in villages that receive at least 12 hours of grid-electricity supply. In contrast, households in Tier 0 and Tier 1 are concentrated in villages with less than 12 hours of grid-electricity supply.

Electricity Consumption of Rural Enterprises

This study surveyed rural enterprises found in marketplaces of targeted villages; these enterprises ranged from retail shops to those providing various services. The electricity demands of these enterprises, similar to those of households, is generally low, with an average consumption of 39.5 units a month (Figure 5.6).

25. There is a moderate correlation between the variables hours of grid-electricity supply and the stock of appliances (wattage).

Table 5.2: Demand drivers and level of access for rural households

Household Characteristics	ESMAP multitier matrix						
	Tier 0 (0-0.36)	Tier 1 [0.36-6)	Tier 2 [6-30)	Tier 3 [30-100)	Tier 4 [100-250)	Tier 5 [250, above)	Total
Socioeconomic status of households							
1: Rural Affluent	0	1	5	9	27	47	7
2: Rural Middle	7	17	37	51	57	50	36
3: Rural Lower	60	67	53	38	16	3	48
4: Rural Poor	33	15	5	2	0	0	9
Total (%)	100	100	100	100	100	100	100
Highest education level of household heads							
1. Class 10 and above	13	17	23	27	38	44	23
2: Up to class 9	41	41	42	47	41	38	44
3: No formal education	46	42	35	26	21	18	33
Total (%)	100	100	100	100	100	100	100
Primary source of houshold income							
1: Salaried job or business	12	14	24	31	43	49	25
2: Agriculture and livestock	28	37	27	26	29	39	28
3: Labor activities	60	49	49	43	28	12	47
Total (%)	100	100	100	100	100	100	100
Daily hours of grid-supply in village							
1. More than 18 hours	14	4	20	45	45	35	28
2: Up to 18 hours	25	31	42	38	43	46	37
3: Less than 12 hours	61	65	38	17	12	19	35
Total (%)	100	100	100	100	100	100	100

Low High

Note: *Darker shades are associated with comparatively higher share of customers.*

Figure 5.6: Average electricity consumption of rural enterprises, by state

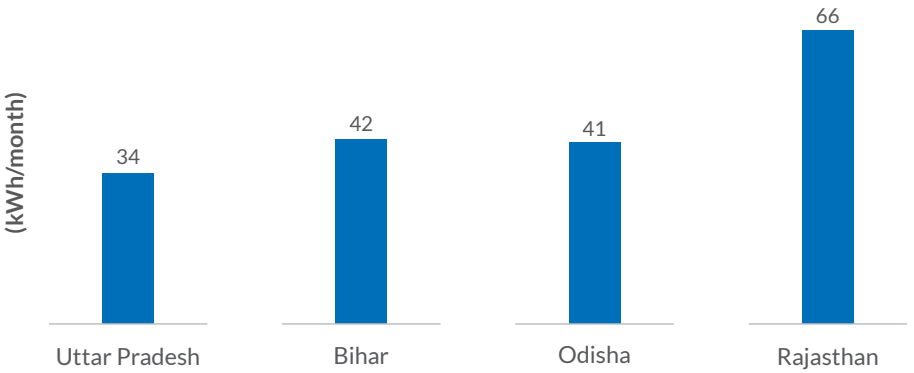
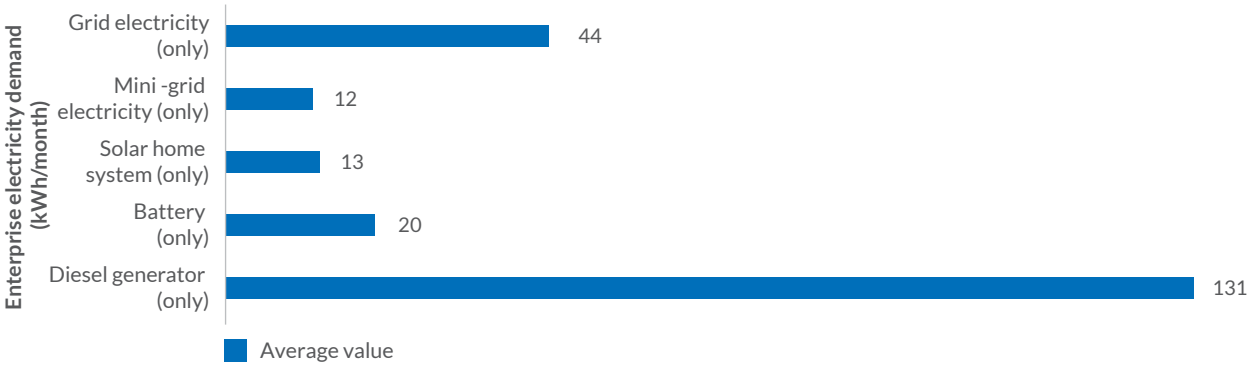


Figure 5.7: Average electricity consumption of enterprises, by electricity source



Enterprise consumption levels also vary with the type of electricity source in use (Figure 5.7). Estimates for "grid-only" enterprise users are higher—an average of 44 units per month—than those using non-grid sources such as solar home systems, mini-grids, and rechargeable batteries.

However, some enterprises use diesel generators – either privately owned diesel generators, or connections from diesel generator operators. The average consumption of such users is many times higher than that of others, because of relatively high electricity consumption by enterprises like flour mills that rely on these diesel generators. These high use customers are potential grid-electricity customers, as they are used to paying for expensive sources.

Using the Multitier Matrix to assess levels of electricity access for enterprises

The MTM for electricity consumption was also used to analyse electricity use by enterprises.[26] Sixty percent of rural enterprises surveyed in this study use less than 30 units per month, i.e. they fall into Tier 1 or Tier 2 (Figure 5.8). Only a fourth of rural enterprises are in higher tiers, implying the use of medium to high power appliances.

Enterprise consumption also varies across states; the share of enterprises falling in Tier 3 and above is higher in Odisha and Rajasthan. The share of Tier 1 enterprises is higher in Bihar and Uttar Pradesh, primarily due to the high use of non-grid sources.

Electricity consumption also varies by commercial activity, which in turn determines the types of productive use appliances needed by rural enterprises. Overall, 5% of enterprises fall in Tier 4 and Tier 5, and use high power appliances. A majority of these are either flour mills, photo studios, cybercafes, or mobile repair shops.

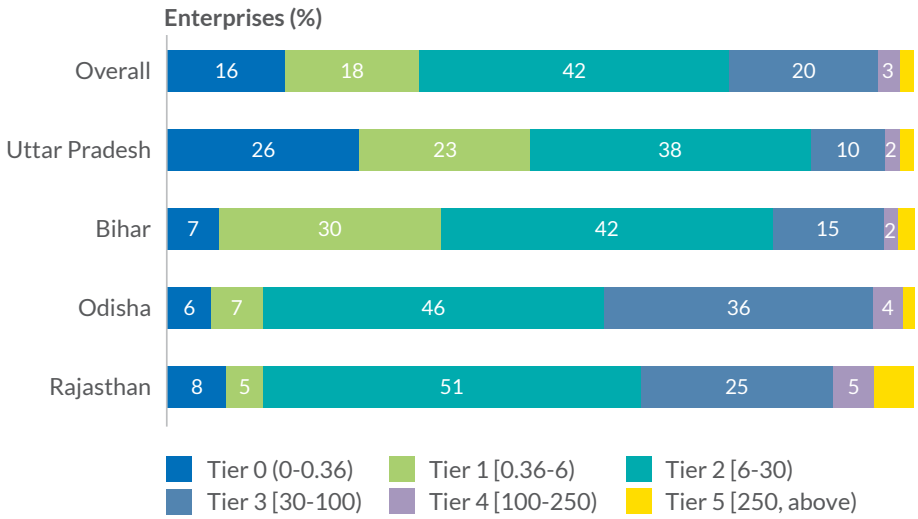
Table 5.3 shows the average monthly consumption of enterprises grouped by the type of product, or services provided by them. Flour mills have, on average, the highest levels of consumption, at around 800 units a month. This is 20 times the average for the whole sample, mainly because flour mills need high-power motors—typically 10HP—for milling purposes. Similarly, enterprises providing technology-enabled services consume 1.5 times the average consumption of all enterprises together.

26. The classification is meant for measuring household electricity consumption. However, in absence of any comparable classification for microenterprises, where energy needs can vary widely, we employ the household MTM framework, to facilitate comparison.

27. These include grocery shops, and shops selling fruits, juices, sweets, clothes, bags, medicines, electronic items, jewellery, etc.

28. These include tailoring shops, carpentry shops, cycle, bike or car repair shops, medical clinics, and warehouses.

Figure 5.8: Distribution of rural enterprises, by MTM tier of electricity consumption



Enterprises engaging in retail trade[27] or other services[28] use electricity primarily for lighting and air circulation, with the occasional use of other appliances, including refrigerators, weighing scales, and air compressors. A significant share of retail and service-based enterprises do not use any electricity at all. This lowers the average electricity consumption of rural enterprises. Annex 5.4 lists the electricity consumption of different types of enterprises surveyed.

What Drives Electricity Demand Among Rural Enterprises?

A linear regression analysis conducted to identify key predictors of enterprise electricity demand, resulted in four variables emerging as significant predictors as presented below. Annex 5.5 further details the results.

1. The enterprise's scale of operation:

On average, and with other factors remaining equal, enterprises with a larger scale of operation have a significantly higher electricity consumption as compared to those operating on a smaller scale. This is mainly because enterprises with larger scales of operation are the ones with greater need, capacity to pay, more assets, more employees, and a shop of their own – as profiled in Chapter 2.

Table 5.3: Variation in monthly electricity consumption, by enterprise type

Enterprise type	Sample size	Average for all enterprises (kWh/month)
Retail trade	1316	21
Services	483	16
Technology-enabled services	165	57
Flour mills	44	793
All rural enterprises	2019	40

2. The nature of commercial activity:

Enterprises with motor-based usage and those engaged in technology-enabled services have significantly higher consumption rates, as compared to those providing other services, or operating retail shops. This is because the nature of commercial activity dictates the electrical appliances needed by an enterprise, in turn determining their consumption levels.

3. The education level of the enterprise owner:

Enterprises with more educated owners, have, on average, slightly higher electricity consumption than other enterprises, even when controlling for the scale of operation.

4. Hours of grid-electricity supply in the village:

All other things being equal, enterprises located in villages with longer hours of grid-electricity supply, have higher electricity consumption. This suggests that each hour of a power cut is negatively associated with electricity demand among rural enterprises, essentially acting as a barrier to higher electricity use for productive purposes.

Table 5.4 shows the scale of operation and commercial activity of rural enterprises under each MTM tier. It also shows the distribution of enterprises by hours of grid-electricity supply available to that tier, based on the survey.

A majority of enterprises in higher consumption Tiers 4 and 5 are flour mills, or provide technology-enabled services like cyber-cafes and photo studios.

A majority of enterprises in Tiers 4 and 5 are flour mills, or provide technology-enabled services. Most of these are rural large or rural mid scale enterprises, reflecting a higher capacity to pay. Tier 2 and Tier 3 enterprises are mainly *rural mid* scale and many engage in retail trade and service activities. Tier 0 and Tier 1 enterprises are typically very small enterprises with limited ability to pay and limited assets.

Table 5.4 also shows that most enterprises in Tier 2 and above, are in villages that receive at least 12 hours of grid-electricity supply. In contrast, enterprises in Tiers 0 and 1 are concentrated in villages with less than 12 hours of grid-electricity supply. We also observe that several enterprises in villages with long power cuts are in higher tiers. But this is due to their reliance on backup sources such as private diesel generators.

Electricity Consumption in Agriculture

A significant portion of rural households in India rely on agriculture for their livelihood and the sector accounts for more than a fifth of power consumption in India.[xxiv] This study also explores electricity demand for agricultural use in the surveyed rural areas.

Electricity for Irrigation

Electricity on Indian farms is almost exclusively used for running irrigation pumps; other farming equipment is powered by other fuels like crude oil and diesel.[xxv] This study captured agricultural demand for electricity by collecting information on the ownership and use of both electric and diesel irrigation pumps.[29]

29. Diesel pumps are also included. More than 9 million farmers in India use diesel pumps, due to poor power supply or inability to get electricity connections for agriculture. Thus, the use of diesel pumps amounts to equivalent electricity consumption by way of electric pumps, if these were made available to the farmers.

Table 5.4: Demand drivers and level of access for rural enterprises

Drivers of Enterprise Electricity Demand	ESMAP multitier matrix						
	Tier 0 (0-0.36)	Tier 1 [0.36-6)	Tier 2 [6-30)	Tier 3 [30-100)	Tier 4 [100-250)	Tier 5 [250, above)	Total
Scale of operation							
1: Rural Large	4	11	18	26	32	67	18
2: Rural Mid	44	57	62	65	61	30	58
3: Rural Small	52	32	20	9	7	3	24
Total (%)	100	100	100	100	100	100	100
Commerical activity							
1: Flour mills	0	0	0	0	4	80	2
2: Technology enabled services	1	3	6	18	53	3	8
3: Other services	48	24	23	14	16	5	25
4: Retail trade	51	73	71	68	27	12	65
Total (%)	100	100	100	100	100	100	100
Highest education level of enterprise owner							
1. Diploma or graduate	9	16	21	24	36	8	19
2. Class 10 or 12	20	34	41	43	41	35	37
3: Up to class 9	51	43	33	31	23	57	37
4: No formal education	20	7	5	2	0	0	7
Total (%)	100	100	100	100	100	100	100
Daily hours of grid-supply in village							
1. More than 18 hours	8	11	30	54	52	20	28
2: Up to 18 hours	30	36	42	31	34	50	37
3: Less than 12 hours	62	53	28	15	14	30	35
Total (%)	100	100	100	100	100	100	100

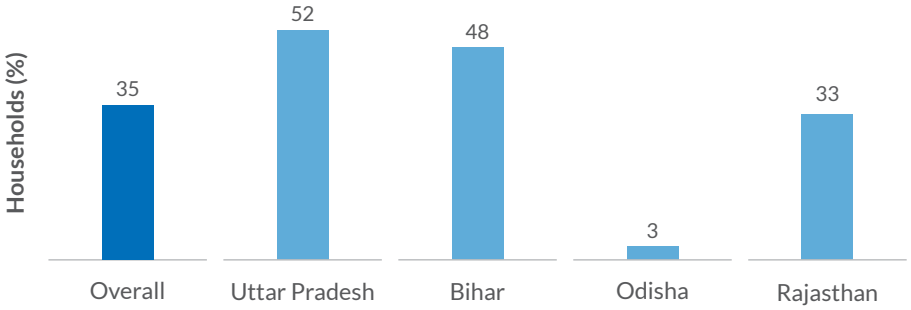
Low High

Note: *Darker shades represent comparatively higher share of customers.*

The survey reveals that 35% of total households surveyed use irrigation pump sets, underscoring the scale and importance of irrigation in the rural economy. The prevalence of pump irrigation significantly varies across states, as shown in Figure 5.9. While almost half of the total households in Uttar Pradesh and Bihar use motorized pumps for irrigation, the share is much lower in Rajasthan and Odisha. Such state-wise variations could also indicate the extent of groundwater usage for cultivation. Annex 5.6 details these findings.

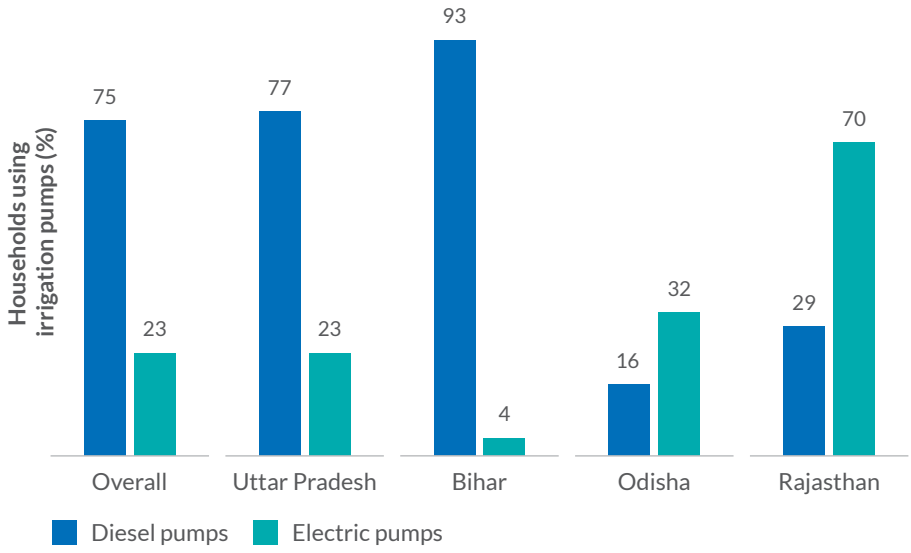
The survey shows that diesel irrigation pumps are more prevalent than electric ones. Less than a fourth of households that irrigate use electric pumps. This indicates that despite high subsidies on agricultural electricity,[xxvi] there remains a gap in use of grid-electricity for agricultural purposes.

Figure 5.9: Share of households that used irrigation pump sets, by state



The type of irrigation pumps also varies across states, with higher presence of diesel pumps in Bihar (Figure 5.10). Annex 6.5 details state-wise statistics on the share of electric and diesel-powered irrigation in the four surveyed states.

Figure 5.10: Type of irrigation pumps used, by state



Note: The sum is less than 100, as few users reported pumps running on other fuels, or manual pumps.

Electricity Consumption and Its Variations

On average, farmers using irrigation pumps consume an equivalent of 954 units of electricity per year,[30] i.e., approximately 80 units per month, for operating their irrigation pumps.[31] However, consumption varies significantly across states, as households in Rajasthan consume 4.5 times the average consumption levels, and those in Odisha and Bihar use less than half of the overall average. The wide variation across states can be partly attributed to the differences in ground water level.

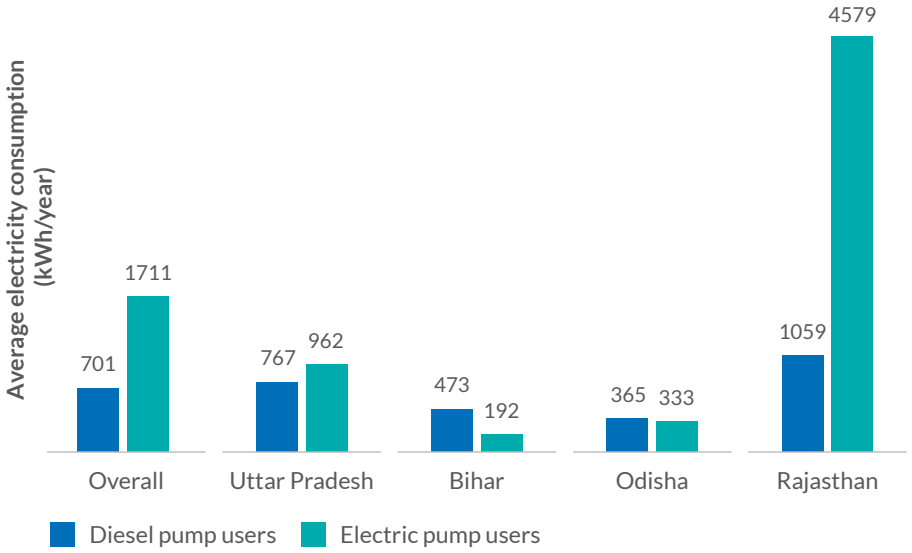
Consumption does not vary much with the source of electricity used to run irrigation pumps, except in Rajasthan. A lack of variation in Bihar, Uttar Pradesh, and Odisha, may be partially due to under-reporting of consumption hours by

30. Annual estimates are reported here, unlike the monthly estimates in case of households. This is because electricity consumption in agriculture is seasonal, and concentrated over less than 90 days in a year for 90% users.

31. Average estimated for households using either diesel or electric irrigation pumps. See Annex 6.7 for details on methodology used for estimating electricity consumption for diesel and electric pumps.

electric pump users, evident in the unusually high per unit electricity cost observed in the survey data. Figure 5.11 shows the electricity consumption of electric and diesel pump users across all four states.

Figure 5.11: Annual electricity consumption of households for irrigation (kWh/year), by state



Electricity Consumption at the Village Level

This study attempted to create a baseline of electricity consumption in each *revenue village*. It used estimates of electricity consumption by rural households, rural enterprises and, separately, for agricultural activities. This chapter presents key findings, with additional details available in Annex 5.8.

Baseline Consumption and Its Variation Across Villages

The average daily electricity consumption of *revenue villages* surveyed in this study is 1826 kWh per day.[32] However, the estimated electricity consumption, aggregated at village-level, varies widely, from 350 to 12,000 kWh per day across surveyed villages. Figure 5.12 shows the distribution of villages according to their daily electricity consumption.

Village-level electricity demand also varies across states. More than 90% of villages in Bihar, Odisha, and Uttar Pradesh, consume less than 3,000 kWh per day (Figure 5.13).

Households account for a majority of the electricity use in villages in Bihar and Odisha. But, in Rajasthan and Uttar Pradesh, village demand is mainly driven by high electricity consumption for irrigation. While rural enterprises represent a smaller share of village-level electricity demand, the share is consequential and densely clustered (Annex 5.9).

On an average, households account for half of the consumption in the village, while agriculture and rural enterprises account for 41% and 7% of village demand, respectively.

32. Like in case of households and enterprises, these estimates reflect electricity consumption from both grid and off-grid sources. However, these do not include consumption within institutional settings, such as that of banks, ATMs, education and health facilities, etc.

Figure 5.12: Distribution of survey villages, by daily electricity consumption (kWh/day)

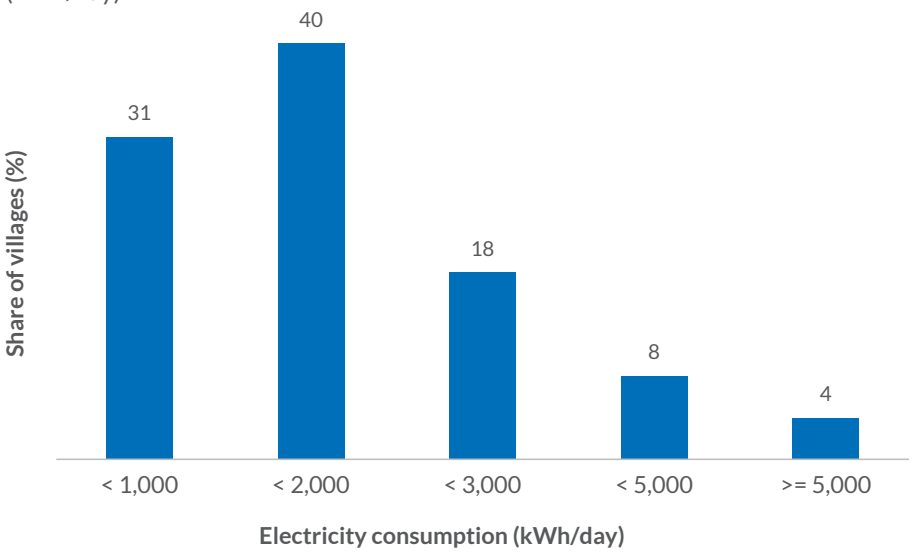
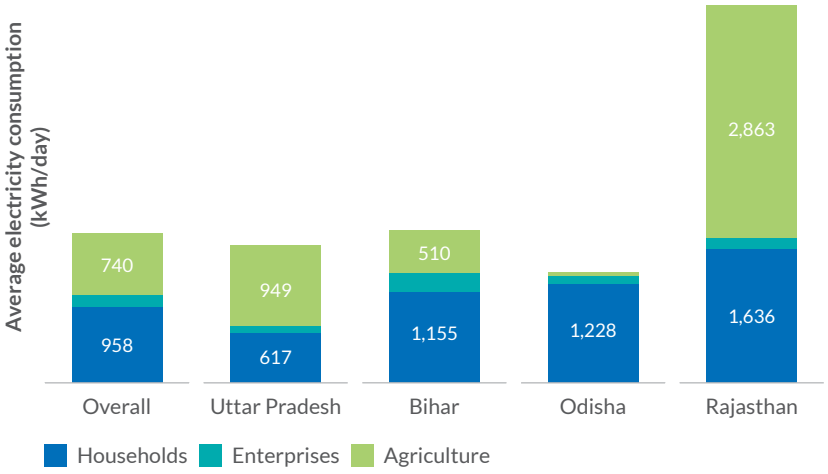


Figure 5.13: Composition of village-level electricity demand, by state



What Drives Electricity Demand in Villages?

Electricity demand in a village is determined by the size of the village, the number of households, the extent of commercial activity, and the share of electricity use for irrigation. Survey results showed villages with higher consumption levels have more households and enterprises, and also display a significantly higher share of electricity use for agriculture (Table 5.5).

Electricity use for agriculture is influenced by a variety of factors, such as local climate, cropping patterns, groundwater levels, and availability of pumping equipment, together with state policies on irrigation.

The electricity demand of households and enterprises depends on the types of appliances used, which this study explores in greater detail.

Table 5.5: Characteristics of villages segmented by electricity consumption

Statistic	Across 200 sampled villages				
	Village segments by daily consumption (kWh)				
	< 1,000	< 2,000	< 3,000	< 5,000	>= 5,000
No. of villages	62	79	35	16	8
No. of households per village	547	743	1,169	1,466	1,873
No. of enterprises per village	66	83	158	137	205
Number of flour mills per village	1.1	1.3	2.9	2.4	5.6
Share of household demand (%)	56	65	50	50	35
Share of enterprise demand (%)	9	8	9	5	5
Share of agricultural demand (%)	34	28	41	45	60
Average aggregate electricity demand (kWh/day)					
Households	432	907	1,218	1,962	2,399
Enterprises	66	109	211	174	330
Agriculture	259	392	979	1,798	4,750
Village	757	1,408	2,407	3,934	7,479

Household Appliances Driving Village Electricity Demand

At the village level, appliances for air circulation and space cooling account for most of the electricity used. This is followed by the use of appliances for lighting, household chores, and entertainment purposes (Figure 5.14).

Overall, nine household appliances account for 95% of the electricity demand of rural households in the study area (Figure 5.15).

Appliances for air circulation, such as ceiling fans, table fans, and desert coolers together account for 57% of household electricity use within a typical village. As seen in Figure 5.15, there is an opportunity to further increase the ownership of these appliances and this could also drive future electricity demand in rural areas.

Lighting accounts for 24% of village demand. Presently, LED lights at 60% ownership levels, constitute less than 5% of household lighting electricity demand, with the rest coming from incandescent bulbs.

Figure 5.14: Type of appliances that drive household electricity demand

Household electricity demand (%)

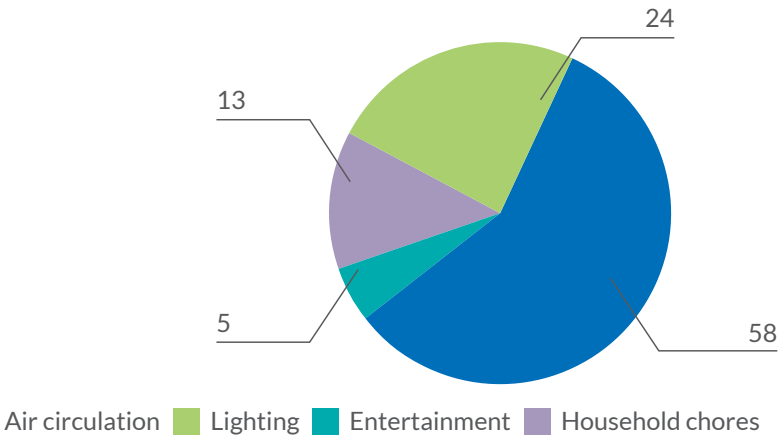
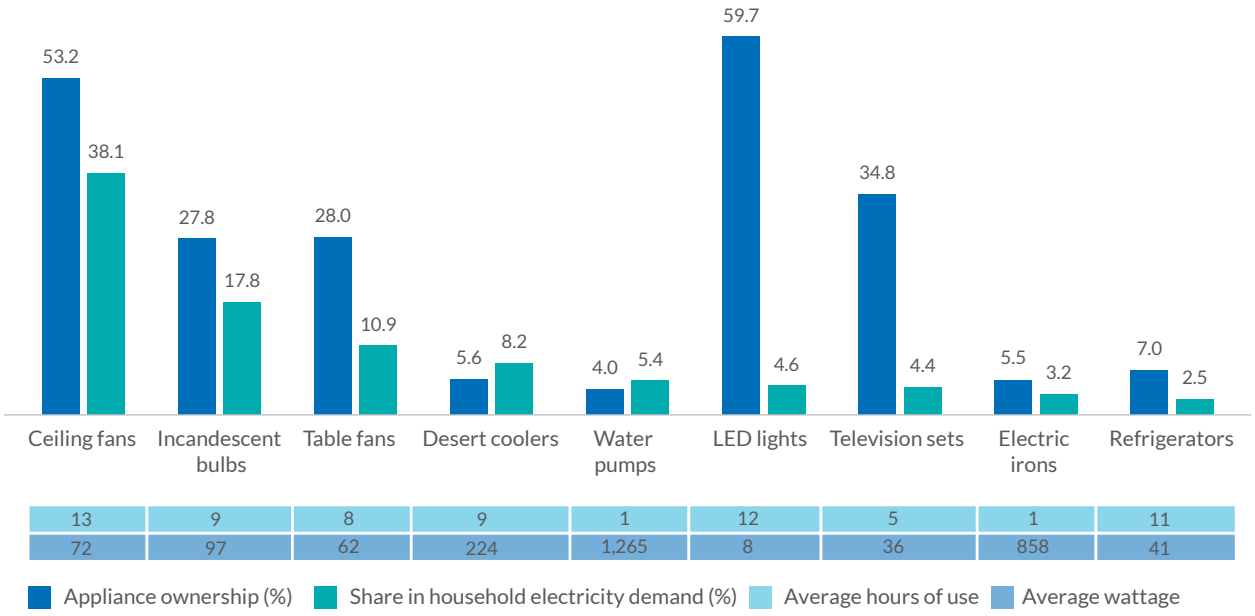


Figure 5.15: Ownership and use of key household appliances



Submersible pumps for extracting drinking water is an important household appliance. They constitute 5% of total household consumption; in the absence of piped water supply in most rural areas, richer households are turning toward individually owned water pumps.

Appliances such as refrigerators and electric irons are used by less than 7% of households, but still constitute 5% of household demand. The ownership of such medium to larger power appliances is limited within rural areas at present. Future increases in the ownership and use of such medium to high power appliances could act as an important driver of electricity demand.

Enterprise Appliances Driving Village Electricity Demand

The *productive use* of electricity is the major constituent of electricity demand for all rural enterprises considered together. This is followed by electricity use for air circulation and lighting purposes (Figure 5.16).

Flour mills, followed by photocopying machines and printers, refrigerators, and welding machines, are key appliances driving the *productive use* of electricity. Electricity use for air circulation is driven by ceiling fans and table fans. Overall, nine appliances account for 90% of overall electricity demand by rural enterprises, across the four surveyed states (Figure 5.17).

Figure 5.17 illustrates how certain appliances, despite their low ownership, constitute a major part of enterprise electricity demand in rural areas. For instance, flour mills are used by just 2% of enterprises, but account for 40% of electricity demand of all enterprises taken together. Similarly, welding machines account for 3% demand, despite being used by less than 0.5 % of enterprises. This highlights the immense potential to stimulate electricity demand by supporting *productive use* activities.

Figure 5.16: Type of appliances that drive enterprise electricity demand

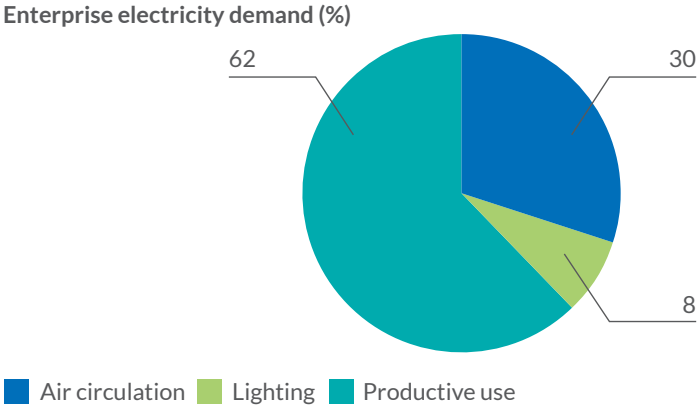
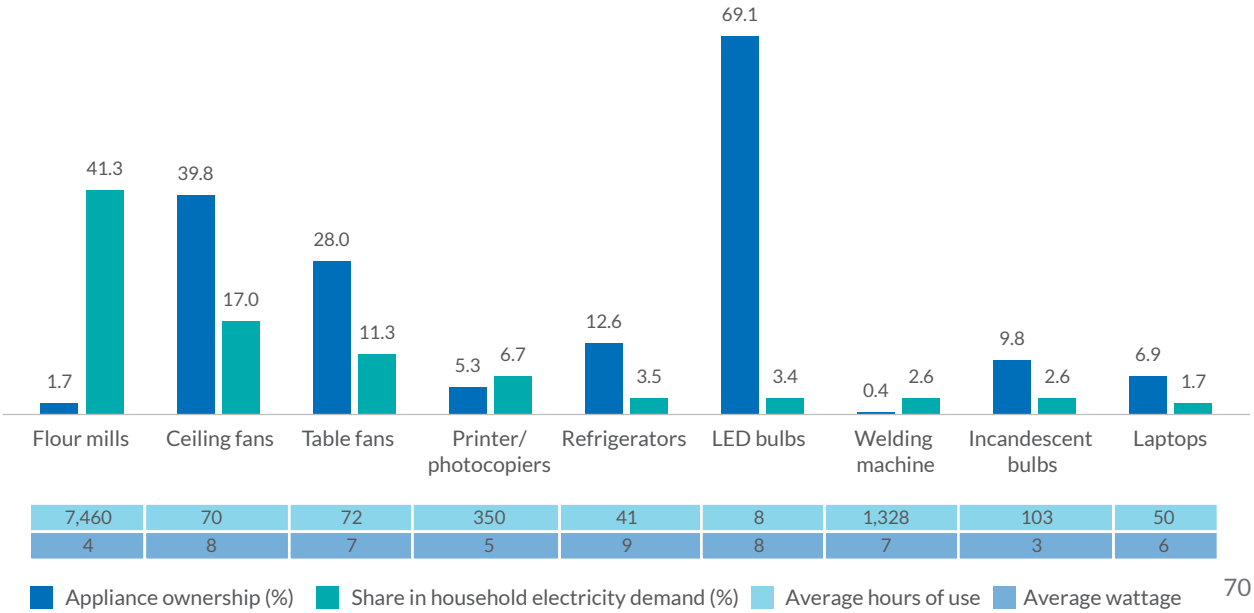


Figure 5.17: Ownership and use of key appliances used in rural enterprises



Key Takeaways

- Understanding electricity consumption is crucial for the effective planning and delivery of electricity services. Using survey data, this study finds that both rural households and enterprises use electricity for varied purposes. Most households use electricity for lighting, mobile charging and air circulation, with some also using it for entertainment and household chores. Rural enterprises use electricity largely for lighting and cooling purposes, and only few use electricity to power appliances of *productive use*.

- Electricity consumption of rural households and enterprises is typically low, around 39 kWh per month. It varies significantly across households and enterprises. It also varies with states, and with the type of electricity sources and appliances in use.

- Electricity demand of rural households is positively correlated to:

  - The economic and educational status of households
  - Reliable and longer hours of electricity supply
  - Access to salaried jobs or business.

- Electricity demand of rural enterprises is positively correlated to:

  - Reliable and longer hours of electricity supply
  - Scales of operation
  - The nature of the enterprise
  - Education levels of the owner.

- Increased ownership of appliances including those for air circulation could fuel electricity demand.

- Increased ownership and use of productive appliances can build enterprise demand. Currently, a majority of the enterprises that have moderate to high consumption levels are flour mills or shops providing technology-enabled services, including cybercafes and mobile repair shops.

- A third of rural households use irrigation pumps, of which 75% use diesel-powered pumps; the remainder mostly use electric pumps.

- An average village in the surveyed sample has a total electricity demand of 1,826 kWh per day, with an estimated 52% contributed by households and 7% by enterprises.

- Villages with alternative delivery models like private distribution franchises for grid-electricity have a higher share of households in higher consumption tiers of the MTM as compared to those without.

6. Planning for Success

This study was conducted to identify the barriers faced by rural customers in getting access to electricity, and to identify the drivers of customer satisfaction and rural electricity demand.

The findings, based on the primary data from 10,049 rural households and 2,019 rural enterprises, highlight the need for coordinated efforts on multiple fronts to ensure higher adoption rates and the sustained use of electricity. The lessons learned from the experiences of customers of alternative electricity delivery models like mini-grids and distribution franchises also highlight the benefits of focusing on customer service.

Recommendations from this study, presented in this section, could be instrumental in realigning policy priorities and efforts toward universal access to reliable, affordable, and sustainable electricity for all.

Bridge Gaps in Rural Electricity Access by Addressing Adoption Barriers

The ongoing Saubhagya scheme continues at pace; as of January 10, 2019, 99.5% of all willing households in the country have been connected to the central grid.[xxvii] When the survey was conducted in April, May, and June of 2018, 75% of households had grid connections. The increase in connections since the survey is an effort that rightly deserves praise.

However, willingness is a curious concept. While 99.5% of all "willing" households in rural India may now be connected to the grid, there still remain 5.8 million households that are unconnected and currently classified as unwilling.[33] That is a significant number, and one that poses challenges especially in states like Uttar Pradesh, which has the highest share of un-electrified households.

> *Future efforts on electrification need to concentrate on low-income households, particularly in Uttar Pradesh, where a significant share remains un-electrified.*

Even as households are increasingly connected to the grid, a significant number of rural enterprises remain unconnected. In the study area, only 65% of enterprises had grid-electricity connections; the share is more than 90% in Odisha, but lower than 60% in Uttar Pradesh and Bihar. There are low connection rates in the latter two states despite the availability of grid-infrastructure in close vicinity. It is reflective of a lack of policy focus on the electrification of rural enterprises, which are vital to rural economic growth.

> *At their core, rural enterprises are attractive customers with a steady demand for a good quality supply of electricity. Some of these enterprises currently pay for expensive non-grid sources, such as diesel generators—and that is revenue lost for local utilities. This should encourage policy makers and DISCOMs to expand the focus of their electrification efforts beyond households to include rural enterprises engaged in non-farm activities.*

Bridging current gaps in electricity access would require measures to help rural households and enterprises adopt electricity. Most households without grid-electricity cite affordability as a key barrier. While some of these households

33. The Saubhagya scheme was launched in September 2017, to electrify around 30 million households by December 2018. As per the Union Power ministry's Saubhagya dashboard, 24.2 million households have been electrified (as of January 10, 2019), leaving a balance of 5.8 million un-electrified households.

are economically deprived, concerns about affordability are also a manifestation of gaps in meter coverage and billing efficiency, due to which customers have to bear disproportionately higher electricity bills. A third of rural households rely only on non-grid sources, highlighting the importance of solutions that give customers the flexibility to manage their costs.

In the case of rural enterprises, poor access to grid services, and the availability of affordable and reliable non-grid alternatives, are the major reasons behind low rates of adoption; 60% of enterprises without grid connections rely on non-grid-electricity sources. This is because enterprises using grid-electricity have to pay a high connection fee of INR 2800 on average, and a high recurring expenditure of INR 500/- month, as per the survey. Non-grid solutions, such as solar home systems and mini-grids, allow enterprises to meet their desired electricity needs with better reliability and service.

> *Access to electricity is not merely a function of infrastructure provisioning, but also perceptions of electricity service and its affordability. Measures such as universal meter coverage, and timely billing and payment collection, can help alleviate negative concerns about the affordability of grid-electricity, by bringing in transparency in consumption and bill amounts.*

These are benefits that the Indian government is pursuing under the Ujwal DISCOM Assurance Yojana (UDAY) scheme. Under this initiative, the government is pursuing universal metering of all electricity connections by 2019. In tandem, the *Saubhagya* scheme includes new meters with every connection. Study data show that several gaps in metering remain, including installed meters that are not working. At scale, this can have important implications for plans related to the universal installation of pre-paid meters as envisaged under the draft amendments to the National Tariff Policy, 2016.

> *Current gaps in metering and billing systems indicate that appropriate measures would be needed to install and maintain smart or pre-paid meters; they would be exposed to risks related to tampering, meter failure, or network connectivity issues.*

Despite the presence of electric grid-infrastructure in villages across the country, there are still non-grid sources in use across rural areas that bridge electricity access gaps. While some customers use non-grid sources as a supplement to their grid-electricity connection, many use non-grid sources as the primary electricity source, and as a preferred alternative to grid-electricity. Driving their choices is a sense of control over the supply of electricity and the ability to receive desired services at a reasonable cost. Solutions such as mini-grids continue to serve gaps in access through the provision of basic electricity access, especially for rural enterprises.

> *Given the role of non-grid solutions in facilitating electricity access, there is a parallel need for continued policy support for these solutions. They could supplement as well as complement the efforts for grid-based rural electrification.*

Improve Customer Service to Drive Satisfaction with Service Delivery

The provision of an electricity connection is the first step toward electricity access, but cannot remain the last one. It is important to ensure that customers obtain services that meet their expectations. This research finds only around 60% of grid-users are satisfied with their services, while the remaining 40% are dissatisfied, or indifferent. Such high levels of dissatisfaction should be cause for concern, as they are linked to negative perceptions of electricity service. An inter-state comparison confirms that states with better service parameters, such as Odisha, have a higher share of satisfied customers.

> *Electricity service providers need to adopt a customer-first approach and consciously work towards improving customer satisfaction levels. The experience of electric grid-users in Odisha—where most districts are under the distribution franchise model—suggests that better service parameters can lead to more satisfied customers.*

The importance of customer focused service can be gauged from the experiences of mini-grid electricity users. Around 7% of households and 34% of enterprises in the 50 villages with mini-grids use mini-grid electricity. The study finds that a vast majority of mini-grid users are satisfied or very satisfied with their connections, despite citing affordability challenges and availing, on average, just 6 hours of electricity a day. Good service experiences influence their perceptions, especially in terms of the certainty and quality of power supply. In addition, supply during evening hours, easy access to timely services, and continual engagement between service provider and customers shape their positive experiences. In contrast, fewer users hold positive perceptions about grid-electricity.

> *Insights from the experiences of mini-grid customers suggest that a high-quality, reliable, and customized electricity service can help improve customer satisfaction.*

A majority of grid-users who are not satisfied find the service unreliable, of poor quality, and unaffordable. This is understandable, as one out of every two grid-users in the study area faces a power cut of at least 8 hours on a daily basis. Besides the inconvenience, unreliable power supply forces customers to bear additional expenses on backup sources; those backups can be economically prohibitive for those with a limited capacity to pay. This puts the sustained use of grid-electricity at risk, especially among those who have been recently connected and have ready access to non-grid alternatives.

> *Satisfaction levels among customers of rural electricity are driven far more by perceptions of reliability and adequacy; both qualities rank above perceptions of affordability. The study recommends that electricity service providers prioritize improvement in the reliability and quality of their supply. This will ensure that customers find value for their money, and continue to use electricity on a sustained basis. It may also encourage new customers, as the perceptions of non-users are positively linked with that of current users.*

Efforts are already underway to address many of the gaps identified in this study. Under the "24x7 Power for All" program, the Indian government is aggressively pursuing the target of providing a 24x7 reliable power supply by April 1, 2019. Other studies confirm gradual but significant improvements in the hours of supply and meter coverage.[xxviii] However, this study's findings show that much more ground needs to be covered, particularly in the states of Bihar and Uttar Pradesh.

Build Rural Electricity Demand through Quality Supply and Appliance Penetration

In order to provide satisfactory services, electricity suppliers need to understand electricity consumption patterns as well as the needs of diverse customer segments. As per this study, the average electricity demand of rural households is around 39 units per month, which is significantly lower than their urban counterparts. Electricity demand varies with the household economic status and primary income source, as well as the education level of household decision makers. A third of households are known to consume less than 30 units of electricity per month, using it mainly for lighting, mobile charging, and air circulation. Another half are known to consume more than 30 units per month; their share is highest in Odisha, followed by Rajasthan, Bihar, and Uttar Pradesh.

Enterprises consume, on average, around 39.5 units per month. Electricity demand varies with commercial activity as well as scale of operation, which is determined by the type of productive appliances used. For instance, 5% of enterprises consume more than 100 units per month; most of these enterprises are flour mills that currently use non-electric motors, or shops providing technology-enabled services such as printing and cybercafes. However, a majority of rural enterprises engaged in retail trade and services use less than 30 units per month, highlighting the need for solutions that cater to these levels of demand in a viable manner.

> *Current consumption levels in rural areas are typically low when assessed using the ESMAP's multitier matrix. Efforts are needed to boost rural electricity demand by expanding electricity services to both unserved and underserved customers, particularly rural enterprises. The latter can serve as high-paying customers for service providers, as they incur higher electricity expenses and display a higher willingness to pay as compared to household customers.*

Wide variations observed in electricity consumption across rural customers underscore the need to better understand electricity demand and its drivers. Policy makers and DISCOMs should facilitate access to disaggregated consumption data in public domain for evidence-based decision-making.

Low consumption in rural areas is also on account of fewer appliances currently in use. Appliances for air circulation like fans and coolers account for approximately 60% of electricity demand of rural enterprises, even though the penetration of these appliances is far from saturation. Similarly, less than 20% of households have appliances for household chores such as refrigerators, irons, food processors, water pumps, etc.; these account for a sixth of household electricity demand. Future increases in electricity demands by rural households will be driven by the adoption of such appliances, which are ubiquitous in urban settings.

Most rural households are yet to adopt medium-to-high-wattage appliances, which would drive future increases in household electricity demand. This implies that demand levels are not yet set for households. Policy makers and other stakeholders can stimulate electricity demand in rural households by facilitating the adoption of medium-to-high-power appliances.

In the case of rural enterprises, appliances for productive use account for more than 60% of enterprise electricity demand, even though only a third of enterprises currently use them. Flour mills constitute just 2% of the enterprises surveyed, but account for 40% of electricity demand of all enterprises taken together. Similarly, welding machines account for 3% of the demand, despite their being used by less than 0.5% of enterprises. Photocopying machines, printers, and refrigerators are other key appliances driving the productive use of electricity.

At present, only a third of rural enterprises use appliances for productive use and even fewer use medium-to-high-wattage appliances. Policies need to drive adoption of appliances in rural services and productive applications. This can be instrumental in stimulating rural electricity demand, besides contributing to increased non-farm livelihood opportunities.

Another key driver of electricity demand in rural areas is the reliability of power supply, measured as hours of electricity supply per day. This is because access to reliable and longer hours of electricity supply can facilitate the use of appliances for longer hours and incentivize customers to buy more appliances. On average, rural households and enterprises in villages that get longer hours of grid-electricity supply have higher levels of electricity consumption. In the absence of a reliable power supply, 86% of grid-connected households use at least one additional source of electricity or lighting, with kerosene as the most popular backup source.

The use of non-grid alternatives is also high among rural enterprises. More than a third in Bihar and Uttar Pradesh use non-grid sources exclusively, which is reflective of the electricity demand unmet by grid-electricity.

Provision of reliable and adequate electricity supply can significantly contribute toward higher electricity demand in rural areas, by way of incentivizing the adoption of more appliances and their use for longer durations.

Concluding Remarks

The study presents a customer's outlook of electricity access so as to improve understanding about the current gaps in this area, and identifies key barriers to electricity adoption and drivers of customer satisfaction. The study's findings highlight the need for coordinated efforts on multiple fronts to ensure higher adoption and sustained use of electricity. Learnings from the experience of customers served by alternative delivery models—mini-grids and distribution franchise—also highlight the benefits of a customer-first approach to delivery of electricity services.

It is hoped that the report's findings and recommendations are useful for realigning policy priorities and strengthening efforts towards achieving the goal of universal access to reliable, affordable and sustainable electricity for all.

Annexures

Annex 1: Research Design and Methodology

This section discusses the sampling strategy employed for this study, along with details on the design of survey instruments and the data collection process. It also lists key limitations of the study.

A.1.1 Sampling Strategy for Social Surveys

The study employed a combination of purposive and stratified random sampling strategies for its household and enterprise surveys. The primary stratum comprised different types of villages that were classified on the basis of presence or absence of two particular delivery models—solar mini-grids and distribution franchises. This approach allowed measurement and comparison of attitudes, perceptions, and satisfaction of electricity users and non-users who had access to different types of electricity services.

Table A.1.1 contains a description of four categories of villages; table A.1.2 contains the list of districts covered under each category.

Table A.1.1: Four categories of villages considered in this study

Village Category	Abbreviation	Description
Mini-grid villages	MG-villages	Villages with operational SPRD mini-grids. There are 91 villages spread across 19 districts in Uttar Pradesh and Bihar.
Non mini-grid villages	Non MG-villages	Villages in the same district as SPRD villages, but without mini-grids. These are villages which could serve as prospective sites.
Distribution franchise villages	DF-villages	Villages in districts being served by the distribution franchises. These are mainly located in 8 districts within Odisha.
Non distribution franchise villages	Non DF-villages	Villages in 20 districts across four states, which could be prospective sites for distribution franchises.

It should be noted that the study was restricted to villages which shared some structural similarities with existing mini-grid villages (MG villages). This was done because a minimum level of electricity demand is essential for commercially viable operations by electricity providers; MG villages provide a good point of reference, as these are chosen after due site assessment processes.

Table A.1.3 highlights the criteria used to prepare the profile of a typical village, using data from both Census 2011 and SPI's mini grid site evaluations.

[a] Sources:
Asher, S., Nagpal, K., & Novosad, P. (2017). The cost of remoteness: Evidence from 600,000 Indian villages (working paper, April). Retrieved from conference.iza.org/

Table A.1.2: Districts used for sampling villages, by intervention category

Village Category	State	Districts from which villages were sampled
MG and non-MG villages	Bihar	Araria, East Champaran, Gaya, Gopalganj, Saran, Siwan, Supaul, West Champaran
	Uttar Pradesh	Balrampur, Farrukhabad, Hardoi, Kushinagar, Lakhimpur Kheri, Pratapgarh, Rae Bareli, Shajahanpur, Shrawasti, Sitapur, Unnao
DF villages	Odisha	Puri, Nayagarh, Khorda, Cuttack, Jagatsinghpur, Kendrapara, Dhenkanal, Anugul
Non-DF villages	Bihar	Munger, Rohtas
	Odisha	Ganjam, Balangir, Deogarh, Kalahandi, Kandhamal, Sambalpur
	Rajasthan	Kota, Ajmer, Baran, Bikaner, Dhaulpur, Jhalawar, Karauli, Sawai Madhopur
	Uttar Pradesh	Agra, Azamgarh, Jhansi, Mirzapur

Andreas, K. (2006). Regional disparities in electrification of India–do geographic factors matter? Centre for Energy Policy and Economics Working Paper No. 51. Zurich: Centre for Energy Policy and Economics.

In order to sample 200 villages, researchers created a separate sampling frame for each village category (as discussed in Table A.1.1). The frame excluded all revenue villages failing to meet the first two criteria. *From each sampling frame, researchers then randomly sampled 50 villages, in proportion to the number of villages per district, but blocking the sampling by district.* Table A.1.4 shows the distribution of sampled villages across different states and intervention categories.

Table A.1.3: Criteria used for selecting villages sharing structural similarities with existing mini grid villages

Criteria	Rationale	Values for a typical SPRD village
Population of census village	Determines the number of customers and electricity demand at village level.	2,000 - 12,000
Distance from nearest town	Indicator of village remoteness, which has been found to be negatively correlated with household and village electrification as well as with rural living standards.	5 km - 36 km
Presence of clustered shops/ enterprises	Determines the electricity demand for productive purposes.	Presence of at least 20 rural enterprises

Table A.1.4: Distribution of sample villages across states

State	MG villages	Non-MG villages	DF villages	Non-DF villages
Bihar	11	11	0	6
Uttar Pradesh	39	39	0	17
Odisha	0	0	50	12
Rajasthan	0	0	0	15
Total	50	50	50	50

In the absence of secondary data on the number of enterprises in villages, field verification was the only way to ascertain whether sampled villages met the third criteria. As a result, a waiting list was created to allow replacement of villages that did not have at least one market area that contained a minimum of 20 enterprises/shops. *Overall, one in two villages had to be replaced due to an inadequate number of enterprises/shops. This is also a reflection of how commercial markets in rural areas are currently limited to certain villages.*

From each of the 200 sampled revenue villages, surveys were conducted with 50 households, 10 enterprises, and a village leader (Sarpanch or his/her representative). All households and enterprises were sampled randomly within the geographic boundaries of the revenue village, using the strategy shown below.

A. Strategy adopted for sampling households:

> The survey team entered the revenue village and consulted Panchayat officials or village elders to obtain information about up to the six biggest hamlets in the village and the number of households in each of them. The sample of 50 survey households was allocated to these hamlets in proportion to the total number of households in each. Within each hamlet, the survey team selected a random spot (say a temple, water tank, etc.). From that location, the team selected a random direction and sampled every 10th household in that direction. If a household refused to participate, the next neighboring household was surveyed.

B. Strategy adopted for sampling enterprises (shops):

> There are a variety of commercial entities in villages, such as retail shops (grocery, fruits/juice stand, etc.), service shops (photocopying, cybercafe, mobile repair, etc.), and commercial processing entities (flour mills, etc.). Researchers devised an innovative strategy for sampling enterprises within villages that ensured a representative sampling, while capturing different types of shops.
>
> The survey team first conducted a mapping exercise to count different types of shops available in the village, and categorized the shops into three broad

groups. In villages with more than 300 shops, rather than list every shop, every 10th shop was counted as part of the mapping exercise. Using this information, a sample of 10 survey shops was allocated to each of the three groups in proportion to the total shops encountered within each group. The survey team then selected a random spot in the market and chose a random direction, in which every 10th shop was identified and assessed for sampling. The shop was surveyed only if the category to which it belonged did not have enough shops of the same kind already surveyed. If a shop owner refused to participate in the survey, then the neighboring shop was assessed for sampling.

A.1.2 Sampling Strategy for Qualitative Interviews

For the purpose of qualitative interviews, 5 intervention and 5 non-intervention villages were selected from the 200 sampled villages. In each such village, qualitative interviews were conducted with 5 households and 5 enterprises. Care was taken to ensure that entities surveyed in quantitative surveys were not interviewed again, so as to obtain a fresh perspective and additional information each time. Efforts were made to ensure that those being interviewed comprised grid-electricity users and non-users, as well as those using other alternatives.

A.1.3 Design of Survey Instruments

Detailed questionnaires (survey instruments) for each of the planned social surveys and interviews were developed, all of which were administered by handheld tablet device. Initial drafts of questionnaires were based on the review of existing survey instruments and insights from a weeklong field visit in Hardoi (Uttar Pradesh).

Field vists involved qualitative interviews with households, enterprises, and village heads, to understand the range of challenges faced by rural communities and the diversity of electricity sources and appliances in use. The questionnaires underwent several rounds of revisions, particularly after two pilot surveys were conducted in Saran (Bihar) and Bhubaneshwar (Odisha), which yielded detailed inputs on the ease of administration, the nature of responses, and the proficiency of enumerators in data coding. In order to reduce errors during data entry, and enable closer monitoring and periodic data quality checks, the surveys were conducted using handheld tablets. Accordingly, the digital versions of questionnaires were thoroughly tested and revised, based on inputs from pilot surveys and classroom training exercises.

The final household and enterprise questionnaires (designed to be completed within 45 minutes) comprised questions in the following broad categories:

1. Social, economic, and demographic profile
2. Current sources of electricity and lighting
3. Expenditures and satisfaction with electricity and lighting sources
4. Ownership, hours of use, and power ratings of electric appliances
5. Awareness and attitude toward alternative electricity sources, particularly mini-grids
6. Willingness to pay for different levels of electricity services

A.1.4 Data Collection and Cleaning

All surveys were conducted in the local language of the states (Hindi in Bihar,

Rajasthan, and Uttar Pradesh, and Odiya in Odisha). Two survey teams, comprising 35 enumerators for Hindi-speaking states and 20 enumerators for Odisha, were given in-person training by the research team. The training sessions, spread over four days each, involved classroom training on the basics of electricity sources and appliances, a detailed discussion of all survey questions, role plays by enumerators, and dry runs in nearby pilot villages.

During the survey, periodic data quality checks were conducted on batches of survey data. This allowed for early identification and resolution of missing data points and faulty data entries, through data recollection and enumerator training, where needed.

A.1.5 Study Limitations

This study has been designed to fulfill multiple research objectives and the utmost care has been taken to ensure robust inference and analysis. However, there are a few limitations of the study design, which have a bearing on the findings.

1. The findings are specific to the four states in India where the survey was conducted. Even though the findings offer rich insights, which can be extended to other states, they are most specific to Uttar Pradesh, Bihar, Odisha and Rajasthan.

2. The study sample is not representative at the state level due to the choice of purposive sampling of villages.

3. The study estimates electricity consumption of rural households and enterprises based on the stated responses collected through in-person surveys. This was necessary, as electricity meter coverage is quite low in several parts of Uttar Pradesh and Bihar, where the study was focused. Therefore, the surveys rely on the ability of the respondents to recollect information about the appliances they used, their power ratings, and their daily hours of use. This raises some concerns about the accuracy of estimates. An attempt has been made to overcome some of these issues by conducting a follow-up observational survey with 300 households and around 100 enterprises across 10 villages. A comparison of consumption estimates from main survey data with the follow up observational survey yielded small error statistics.

4. There were several instances of missing data, particularly for questions focused on power rating of non-lighting appliances. In order to fill such gaps, assumptions had to be made to arrive at electricity consumption estimates, which would have contributed to some errors. To minimize this, the researchers collected information on appliance power rating from multiple sources, including surveys of electrical appliances used by shop owners in every village and secondary market research.

5. Rigorous training of enumerators was conducted to ensure that they understood the purpose behind each of the survey questions and were able to properly administer the questionnaire. A continuous follow up through quality checks on early batches of data was also undertaken and retraining conducted by the team leaders whenever it was found to be necessary. However, it is possible that some questions were improperly administered and some amount of enumerator bias and reporting errors cannot be overruled.

Annex 2: Personifying the Rural Electricity Customer

A.2.1: The Methodology Behind Personification of Rural Households

There are two approaches to measuring household living standards. The first, and the more popular, approach is to use *direct* measures such as income or expenditure.

The second approach is to use a *proxy* measure, in which a wealth index is constructed using the information on housing characteristics and ownership of durable assets. The SEC system (socioeconomic classification) adopted by the Market Research Society of India is one such classification. However, it uses "electricity connection" as one of the assessment parameters for classification and is hence not used for the purposes of this study.

For this study, researchers used the proxy approach to measure and categorize rural households by their living standards.

This method is particularly useful in assessing the long-term economic status of households. It is preferred over the direct approach, because households often under-report, or do not report, their incomes, because it is difficult to adequately capture expenditure data.

Twelve percent of the respondents in this survey, for example, declined to share income-related information. To measure household living standards, researchers constructed an *asset score*, using survey information on housing characteristics, ownership of durable assets, and access to public amenities.

Each of these assets was given a score as shown in Table A.2.1. To facilitate segregation, most items have a score of 1, while a few high-value items have a higher score of 2 or 4. The total score for each household was computed on the basis of items owned by the household and the weights assigned to each asset. The range of this asset score is [0–24]; households without any of the specified assets have a score of 0 and households having all specified assets have a score of 24.

Using the asset score, researchers classified households into the following four categories:

Asset score 0–6: Rural Poor
Asset score 7–12: Rural Lower
Asset score 13–18: Rural Middle
Asset score 19–24: Rural Affluent

Table A.2.2 lists assets owned by households under different categories. Researchers validated this classification by assessing the direct measures of living standards, such as income and expenditures. Table 2.1 in Chapter 2 shows that the average income and expenditures of a household steadily rise with the asset category.

Assessments of primary sources of income also indicate that a majority of poor households rely on labor activities, with very few having salaried jobs or businesses of their own. When viewing households across categories, from *rural poor* to *rural affluent*, a key observation is lesser reliance of households on agriculture and greater reliance of salaried jobs and businesses.

Table A.2.1: Assets and scores used for measuring household living standard

Criteria	Score
Housing characteristics	
House type	
Kutcha	**1**
Semi - pucca	**2**
Pucca	**4**
Number of rooms	
1	**1**
2-3	**2**
> 4	**4**
Availability of toilet	**2**
Durable assets	
Ownership of land	**2**
Vehicles	
Bicycle	**1**
Motorised two-wheeler	**2**
Motorised four-wheeler	**4**
Appliances	
Television	**1**
Fan	**1**
Public amenities	
Bank account	**1**
LPG connection	**1**
Grid connection	**1**

Researchers note that it is important to interpret these categories, or labels, in the context of the study, and its target of rural markets in low-income states. For example, the *rural middle* category and to a lesser extent the *rural lower* category represent households that meet their basic needs. As compared to urban areas, the consumption basket available in the rural areas is quite restricted. There is no direct equivalence between the rural and urban consumption categories.

A.2.2: The Methodology Behind Classifying Rural Enterprises

Commercial enterprises are heterogeneous in terms of the commercial activity being pursued, and their scale of operation. Given the diversity of economic activity pursued by enterprises, researchers employed a scoring methodology to capture the scale of operation of rural enterprises.

Table A.2.2: Assets and amenities owned by households

Asset ownership	Rural Poor	Rural Lower	Rural Middle	Rural Affluent
Kutcha house	68%	25%	3%	0%
Semi-pucca house	28%	39%	19%	4%
Pucca house	4%	37%	78%	96%
Number of rooms [1]	64%	25%	5%	0%
Number of rooms [2-3]	36%	68%	57%	11%
Number of rooms [>= 4]	0%	7%	38%	89%
Availability of toilet	4%	29%	68%	92%
Ownership of land	18%	52%	68%	97%
Bicycle	53%	76%	83%	84%
Motorised two-wheeler	1%	10%	58%	98%
Motorised four-wheeler	0%	0%	3%	45%
Television	1%	19%	56%	72%
Fans	11%	52%	88%	97%
Grid connection	27%	67%	92%	98%
LPG connection	14%	38%	71%	87%
Bank account	89%	97%	99%	99%

Low High

In order to classify enterprises by their scale of operation, researchers followed the proxy approach, similar to that employed for households.

A scale index was constructed using the survey information on building characteristics such as shop area, type of structure, and ownership, as well as information about number of employees working at the shop and the estimated value of the shop inventory, Each of these variables was given a score as shown in Table A.2.3.

Most variables have a score of 1, while high-value characteristics are given a higher score of 2 or 4, so as to facilitate segregation. The total score for each enterprise was computed using these scores and enterprise characteristics. The range of this scale index is [4–16].

Using a scale index, researchers classified rural enterprises into three categories as shown below.

1. Asset score 4–6: Rural Small enterprises
2. Asset score 7–10: Rural Mid enterprises
3. Asset score 11–16: Rural Large enterprises

See Table A.2.4 for details on enterprise characteristics for each category.

Table A.2.3: Criteria and scores used to measure enterprises' scale of operation

Criteria	Score
Enterprise Characteristics	
Shop Structure	
Kutcha or semi-pucca	**1**
Pucca	**2**
Shop ownership	**2**
Shop Area	
< 100 sq.ft.	**1**
100-250 sq.ft.	**2**
> 250 sq.ft.	**4**
Number of employees other than owner	
None	**1**
One	**2**
More than one	**4**
Shop Inventory Value	
< INR 30,000	**1**
INR 30,000- 150,000	**2**
> INR 150,000	**4**

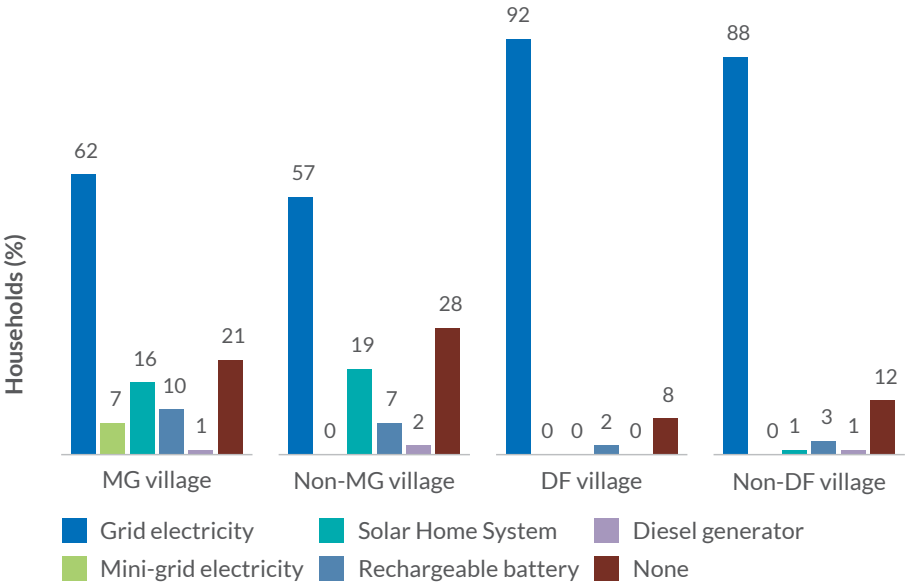
Table A.2.4: Assets and amenities owned by enterprises

Enterprise characterisitic	Enterprises categorized by their scale of operation		
	Rural Small	Rural Mid	Rural Large
Kutcha or semi-pucca structure	53%	27%	16%
Pucca structure	47%	73%	84%
Shop area: < 100 sq.ft.	90%	56%	14%
Shop area: 100-250 sq.ft.	10%	40%	47%
Shop area: > 250 sq.ft.	0%	4%	39%
Ownership of shop	34%	66%	82%
Number of employees: None	91%	63%	22%
Number of employees: One	9%	31%	35%
Number of employees: More than one	0%	6%	42%
Inventory: < INR 30,000	71%	21%	3%
Inventory: INR 30,000- 150,000	29%	58%	27%
Inventory: > INR 150,000	0%	21%	70%

Low High

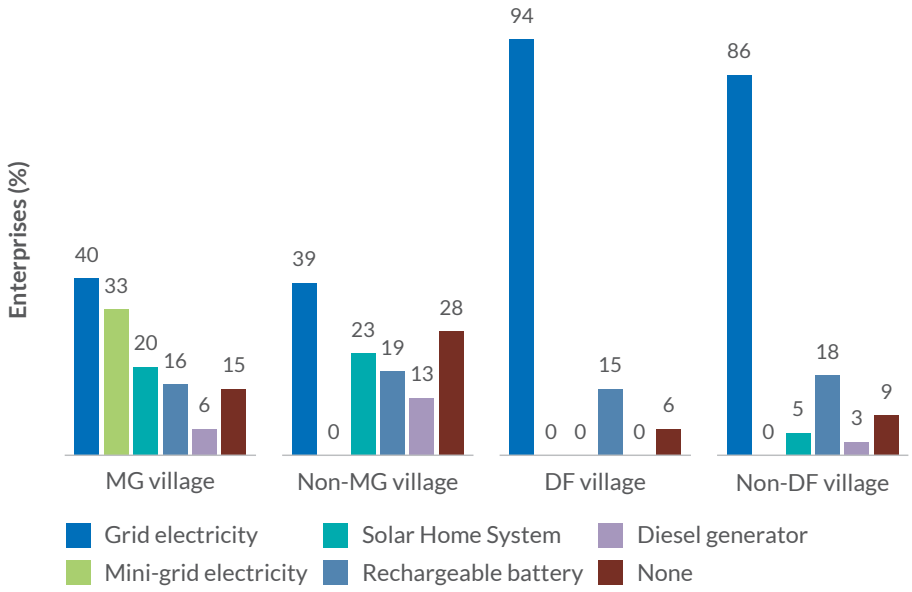
Annex 3: Sources of Electricity

Figure A.3.1: Electricity Sources Used by Households, Across Village Categories



Note: *In DF and non-DF villages, where a higher share of households used grid-electricity, use of non-grid sources was limited.*

Figure A.3.2: Electricity Sources Used By Enterprises, Across Village Categories



Notes: *Mini-grid electricity was the second-most popular electricity source in MG villages.*
In DF and non-DF villages, where a higher share of enterprises used grid-electricity, use of non-grid sources was limited.

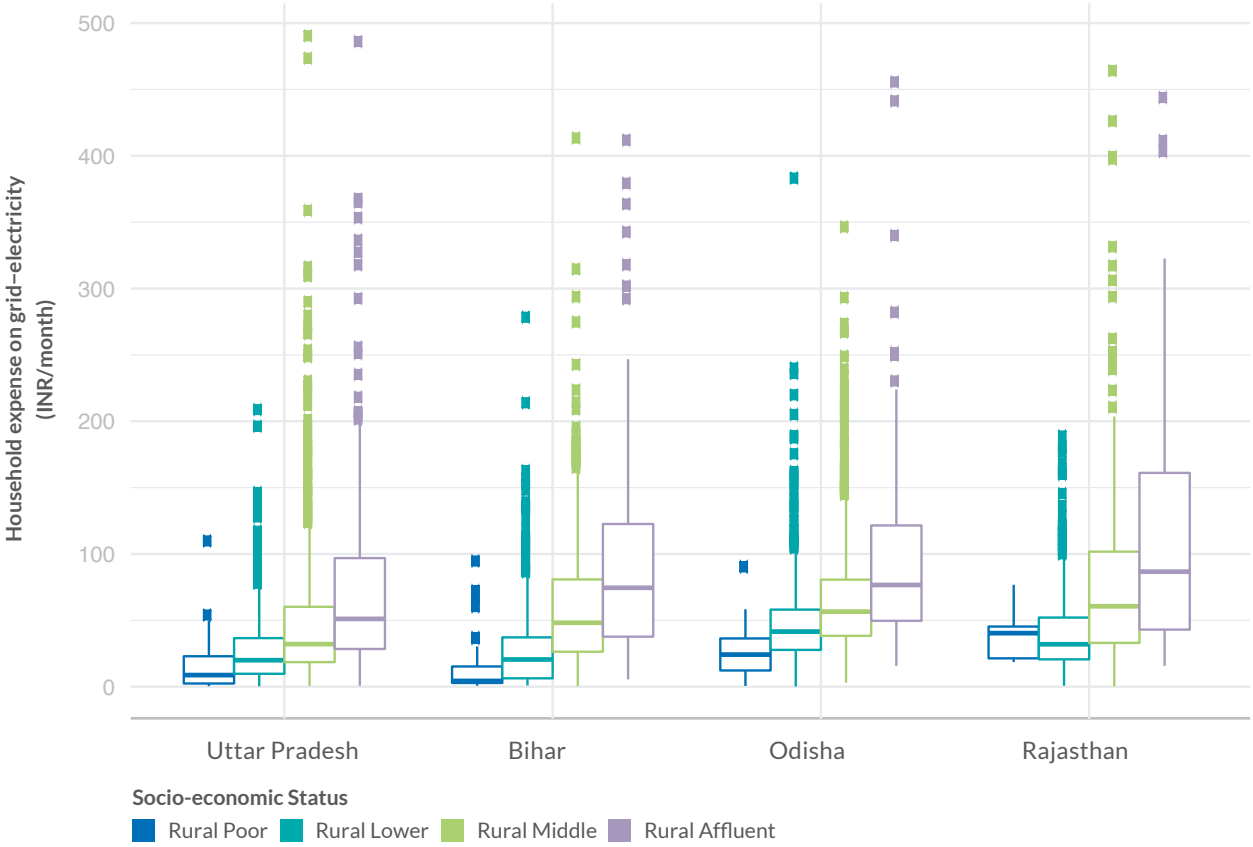
Annex 4: Drivers of Customer Satisfaction

Table A.4.1: Prescribed power tariffs for domestic connection, fiscal year 2018, by state

State	Consumption category	Fixed charges (INR/month)	Energy charges (INR/unit)
Uttar Pradesh	Unmetered	400	-
	Up to 100 units/month	50/kW	3.00
	100–150 units/month		3.50
Bihar	Kutir Jyoti (unmetered)	350	
	Kutir Jyoti (up to 50 units/ month)	10	3.05[a]
	Up to 50 units/month	20/kW	3.05[a]
	50–100 units/month		3.30[a]
	100 units and above		3.60[a]
Odisha	Kutir Jyoti (up to 30 units)	80	0
	Up to 50 units/month	20/kW	2.50
	50–200 units/month		4.30
Rajasthan	BPL (Up to 50 units/month)	100	3.50
	Up to 50 units/month	100	3.85
	50–150 units/month	200	6.10

a: *These include state government prescribed subsidies.*
Source: *Tariff order of respective states for the fiscal year 2018–2019.*

Figure A.4.2: Electricity consumption patterns of rural households across states, by socioeconomic status



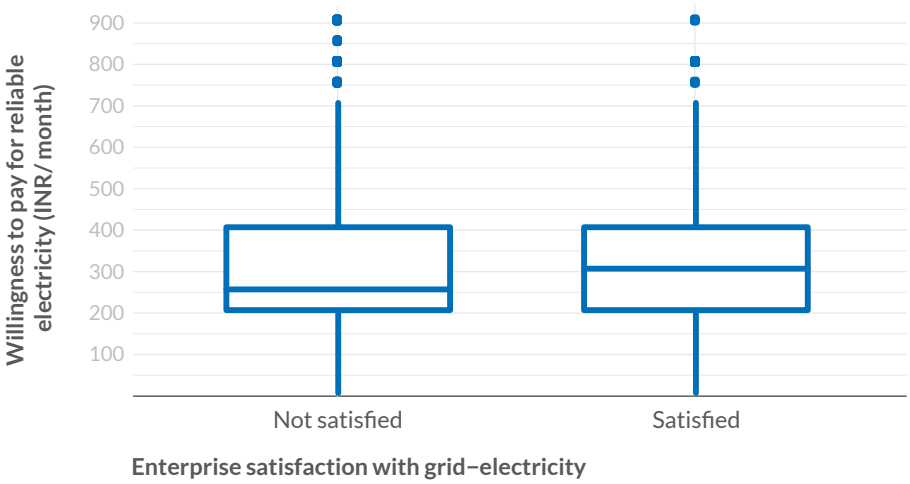
Note: *Electricity consumption progressively rose with households' socioeconomic status across state*

Table A.4.3: Prescribed power tariffs for non-domestic connection, 2018–2019, by state

State	Consumption category	Fixed charges (INR/ month)	Energy charges (INR/unit)
Uttar Pradesh	Unmetered	**1,000**	**-**
	Metered	**95/kW**	**5.00**
Bihar	1–100 units	**30/kW**	**6.40**
	101–200 units		**6.95**
	200 units and above		**7.50**
Odisha	1–100 units	**30/kW**	**5.40**
	101–300 units		**6.50**
	300 units and above		**7.10**
Rajasthan	1–100 units	**230 (up to 5 kW load)**	**7.55**
	101–200 units		**8.00**
	200 units and above		**8.35**

Source: *Tariff order of respective states for the fiscal year 2018–2019.*

Figure A.4.4: Willingness to pay for uninterrupted electricity supply, by satisfaction level



Note: *Satisfied users had higher willingness to pay for better-quality supply.*

A.4.5: Perception Index

The perception of survey respondents is illustrated with the help of a Perception Index, constructed to obtain an overall attitude of a given respondent toward grid-electricity. The Perception Index is constructed using perceptions of enterprise users toward various attributes of grid-electricity service. These include the ease of getting a grid-electricity connection, the ease of redressal or getting repairs done, affordability, reliability, adequacy, and quality of power supply.

Customer perception is measured on a three point scale, by asking whether they agree or disagree with the (positively framed) statements about each of the service attribute. For example: "Do you agree or disagree with the following statements about grid-electricity? a. Grid-electricity is reliable. 1. Disagree, 2. Neutral, 3. Agree." Three-point was used in place of five-point scale, as the latter was leading to high attrition among the respondents during the pilot surveys.

The Index was created in three stages:

1. Normalizing responses to each of the six perception questions
2. Adding all the normalized variables
3. Normalizing the final variable again

Thus, the perception of a respondent toward attributes of grid-electricity is represented on a scale of 0 to 1 on the Perception Index. They represent negative and positive perceptions about all service attributes. A Perception Index rating of 0.5 indicates an overall neutral outlook toward grid-electricity.

Annex 5: Characterizing Demand for Rural Electricity

A.5.1: Estimating Electricity Consumption of Households and Enterprises

The study employed *energy use surveys* to estimate electricity consumption of households and enterprises. These involve dwelling- or shop-level surveys to collect data on existing appliance ownership and hours of electricity use, and has been found to yield reliable demand estimates with errors lower than the surveys that collect aspirational electricity demand.[xxix]

The study used the following formula for estimating monthly electricity demand (kWh/day) for each household. Electricity demand of rural enterprises was estimated using the same formula.

E_j = ***Sum of*** $[W_i * H_i] * 30/1000$ *for all i, where:*

E_j is the monthly electricity demand of j^{th} household in kWh
i is the type of electric appliance
W_i is the power rating of i^{th} appliance in use
H_i is the number of hours for which all of the i^{th} appliance are used per day

Assumptions used for appliance power rating

In the survey, data on the power rating of each appliance used by the households/ enterprises was recorded. In many cases respondents reported wattages which didn't match the expected wattages from secondary research. The study winsorized such data points using upper and lower bound, which were identified with the help of secondary research and interviews with owners of shops selling electric appliances. Further, a significant share of respondents didn't know appliance wattages, particularly with appliances for non-lighting uses. In all such cases, the study assigned the mean values of wattages from the survey data (while excluding the erroneous data entries). Table A.5.1 and Table A.5.2 present the assumptions used for cleaning the appliance wattage data for households and enterprises, respectively.

For some appliances, like TVs and refrigerators, where very few respondents were in a position to report the appliance wattages, the study collected information on the appliance capacity (inches for TVs and liters for refrigerators). With the help of this information and secondary analysis, typical wattage values were assigned to all respondents who were using these appliances. The assumptions used for certain household appliances are listed below:

- ***Television:*** The power consumption of TVs varies with size. Using the survey data on TV sizes (in sq. inches) and an aspect ratio of 16:9, we estimated power rating of televisions using the following formulae.
  - Area of TV = ((size in inches ^2) *(16/9)) / (1 +16^2/9^2)
  - Watt of TV = 0.18 *Area of TV

The study uses the maximum annual power consumption of 1-star rated LCD TVs (BEE 2016–2017 standards) for estimating the effective wattage of TVs. LCDs were chosen over the CRT and plasma market segments as over the past few years, the LCD TV segment has significantly captured the Indian market.[xxx] Further, choice of 1-star-rated TV is driven by the fact that rural customers are price sensitive and such a choice covers for the older and low-efficiency stock of TVs. Thus, a 21-inch 1-star rated LCD TV has an area of 121 sq. inches and consumes 35 watts.

- ***Refrigerators:*** In the sample, less than 10% of households used refrigerators, with Samsung, Godrej, and LG being the most popular brands. As households found it difficult to share information on refrigerator size, the study didn't collect this data from them. To estimate the power consumption of refrigerators, the study used a standard rate of 362 kWh/year, which is the average consumption of a 1-star rated 260 liter direct cool refrigerator.[xxxi] This is a conservative figure assuming that rural customers, who are price sticky, would prefer cheaper but low-star rated products. *The assumption roughly translates into a watt rating of 41.32 W.*

  Using a standard number is reasonably accurate, as the power consumption does not significantly vary with refrigerator size (339 units/year for 190 liter and 379 units/year for 310 liter). For households using refrigerators, this would imply inaccuracy of less than 3 units/month. However, the variation is significant with appliance rating, with 5-star rated appliances being 2.5 times more efficient. However, the study survey didn't collect information about this.

- ***Air conditioners:*** The study collected data on the size of air conditioners in tons, common in local parlance. To estimate power consumption, the study used the assumption that 1 ton is equivalent to 1,000 watts, 1.5 tons is equivalent to 2,000 watts, and a compressor activity rate of 75%.[xxxii]

- ***Flour mills and water pumps:*** The power rating of these appliances was collected in horsepower (HP) units, common in local parlance. The following conversion factor was used: 1 HP = 746 watts.

Assumptions used for cleaning data on appliance hours of use

The study collected total hours for which all appliances of a type are used per day (e.g., if 6 LEDs are used for 5 hours every day, the study recorded 30). In order to identify and correct for any potential measurement or reporting errors, the study conducted data quality checks on hours for which each appliance is being used (total hours/number of appliances of a type). The study capped this variable at certain predetermined limits for household data, as shown in Table A.5.3. For enterprises, the total hours for which the shop operates per day, was used as a cap. This helped in correcting a few erroneous data entries.

The socioeconomic profile of households and enterprises varies across villages categorized by the presence and absence of two interventions: mini-grids and private distribution franchise for grid electricity.

The study found that household ***and*** enterprise distribution is similar in mini-grid and non-mini-grid villages. It is also similar in villages with and without *distribution franchises* for electric grid electricity. This is in line with the research design that for every village with an intervention, a comparable village without the intervention in the same/similar districts is sampled (see A.1.1).

The study also found that the *distribution franchise* and *non-distribution franchise* villages have a higher share of households belonging to middle- and high-income groups, as compared to the mini-grid type of villages. This also holds true for rural enterprises categorized by their scale of operation.

Table A.5.1: Assumptions for cleaning the appliance wattage data for households

Appliance name	Lower bound	Upper bound	Mean values (used for filling missing values)
	(All values are in watts, unless specified)		
Incandescent bulb	3	200	97
Compact fluorescent lamp (CFL)	2	100	16
LED bulb	2	40	8
Tube light	5	70	27
Mobile phone		5	
Ceiling Fan	20	120	69
Table Fan	10	120	61
Television	14 inch	55 inch	21 inch
Cooler	60	750	224
Electric stove	500	3,000	1,192
Laptop		50	
Refrigerator		41.32	
Iron for clothes	450	2,500	858
Grinder/mixer	100	1,000	376
Music system/ radio		15	
Air conditioner	1 ton	1.5 ton	1 ton
Washing machine		400	
Fodder cutting machine	1 HP	5 HP	2 HP
Water pump	0.5 HP	10 HP	2 HP

This indicates that *distribution franchises are present in more prosperous villages as compared to villages having mini-grid installations.* This is potentially due to the site selection strategy of the operators of these interventions. While mini-grid companies target populations, which are generally underserved by grid-infrastructure, private entities bid for distribution franchises in areas which have decent penetration of grid-infrastructure and scope for improvements in operational efficiency.

Table A.5.2: Assumptions for cleaning the appliance wattage data for enterprises

Appliance name	Lower bound	Upper bound	Mean values (used for filling missing values)
	(All values are in watts, unless specified)		
Incandescent bulb	3	200	103
CFL	2	100	18
LED bulb	2	40	8
Tube light	5	70	30
Mobile phone	5		
Ceiling fan	20	120	69
Table fan	72		
Television	14 inch	55 inch	23 inch
Desert cooler	60	750	188
Refrigerator	50 litre	600 litre	222 litre
Sewing machine	35	100	45
Laptop	50		
Printer/photocopy machine	350		
Weighing machine	6		
Flour or oil mill	1 HP	25 HP	10 HP

Table A.5.3: Assumptions used for cleaning the data on appliance hours of use

Appliance type	Cap on hours of use per unit of appliance per day
Incandescent bulb	24
CFL	24
LED bulb	24
Tube light	24
Ceiling fan	24
Table fan	24
Television	18
Desert cooler	24
Electric stove	6
Computer or laptop	24
Refrigerator	24
Electric iron	6
Grinder/mixer	2
Music system or radio	6
Air condiitoner	24
Washing machine	6
Fodder cutting machine	6
Water pumps	6
Others	24

Note: *The cap of six hours on certain high-load appliances was based on the field research that had been conducted for the design of survey questionnaires.*

A.5.2 Socioeconomic profile of rural customers, across different villages

The socioeconomic profile of households and enterprises varies across villages categorized by the presence and absence of two interventions: mini-grids and private distribution franchise for grid electricity.

The study found that household and enterprise distribution is similar in mini-grid and non-mini-grid villages. It is also similar in villages with and without distribution franchises for electric grid electricity. This is in line with the research design that for every village with an intervention, a comparable village without the intervention in the same/similar districts is sampled (see A.1.1).

Figure A.5.1: Socioeconomic profile of rural households, by village category

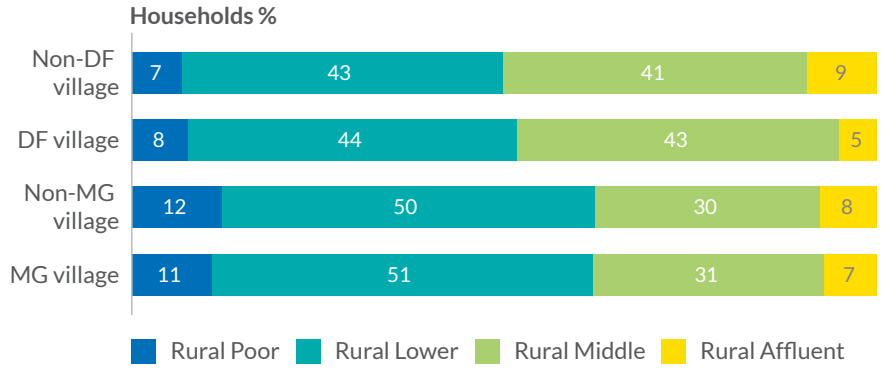
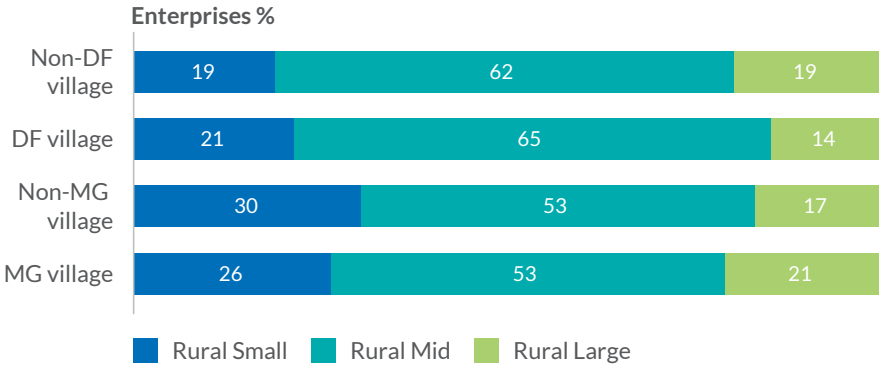


Figure A.5.2: Economic profile of rural enterprises, by village category



A.5.3: Predictors of Household Electricity Demand

In order to identify the predictors of household electricity demand, the study estimated a linear Ordinary Least Squared (OLS) regression model. The monthly household electricity consumption estimates are used as the dependent variable.

The economic category of households (as discussed in Chapter 2), the education level of the household head, and the primary source of income of households, are used as the independent variables. For each of these, the study used appropriate dummy variables (variables ending with a question mark). The study also used average hours of grid supply at the village level as another independent variable, as it can influence the uptake of grid-electricity, the hours for which households can use electricity, and the nature of appliances that households decide to purchase. The model results are shown below:

Table A.5.4: Results of linear regression analysis for household electricity demand

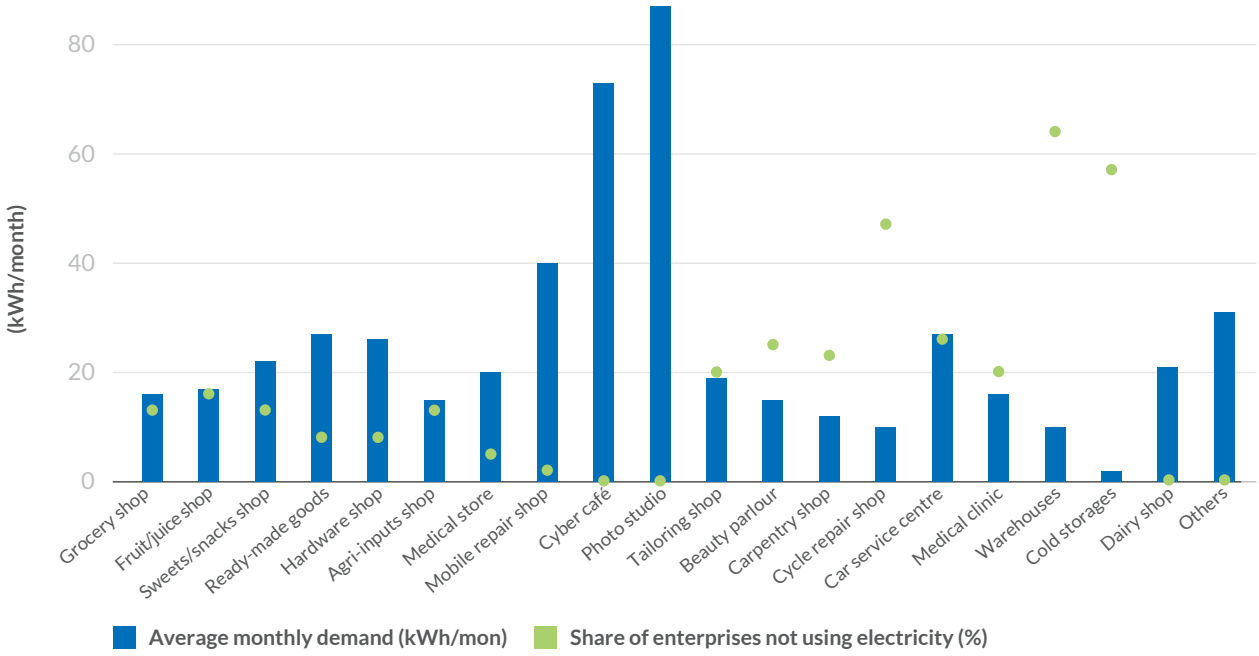
Independent variables:	Dependent variable:
	Household Electricity Demand (kWh/month)
Socioeconomic classification: Rural lower	15.670***
	(1.149)
Socioeconomic classification: Rural mid	40.353***
	(1.732)
Socioeconomic classification: Rural affluent	73.822***
	(3.730)
Education: Up to class 9	0.777
	(0.940)
Education: Class 10 and above	4.013***
	(1.364)
Income: Labor activities	1.239
	(1.288)
Income: Salaried job or business	9.783***
	(1.665)
Daily hours of grid supply in village	3.022***
	(0.383)
Observations	10,049
Adjusted R^2	0.272

Note: *Standard errors clustered at village level. State fixed effects included.*
* p <0.1, ** p <0.05, *** p < 0.01

Note on methodology:
The objective of this regression exercise is mainly to identify the key drivers and barriers of electricity demand. To that extent, the direction and significance of estimates are more important than the magnitude of the coefficients. In order to facilitate simpler interpretation of the results, the two continuous variables in the model have been used in their original units, rather than in their logarithmic form.

A.5.4: Monthly Electricity Consumption of Enterprises (Excluding Flour Mills), by Type

Figure A.5.3: Monthly electricity consumption of enterprises (Excluding Flour Mills), by type



Note: *Flour mills have the highest consumption among all enterprises (not shown in the graph). This is followed by enterprises engaged in technology-enabled services such as mobile repair shops, cybercafes, and photo studios.*

A.5.5: Predictors of Enterprise Electricity Demand

In order to identify the predictors of enterprise electricity demand, the study estimated a linear OLS regression model. The monthly electricity consumption estimates of enterprises are used as the dependent variable.

The economic activity of enterprise, the scale of operation of enterprises (as discussed in Chapter 2), and the education level of the enterprise owner are used as the independent variables. For each of these, the study used appropriate dummy variables (variables ending with a question mark). The study also used average hours of grid supply at the village level as another independent variable, as it can influence the uptake of grid-electricity, the hours for which enterprises can use electricity, and the nature of appliances that enterprise decide to purchase. The model results are shown below:

Note on methodology:
As the electricity consumption of flour mills is multiple times that that of other enterprises, these constitute almost all of the outliers for all enterprises combined. In order to avoid any potential biases due to such extraordinarily high consumption values, all observations for enterprises operating flour mills were dropped for the purpose of this analysis.

The main objective of this regression exercise is to identify the key drivers and barriers of electricity demand. To that extent, the direction and significance of estimates are more important than the magnitude of the coefficients. In order to

facilitate simpler interpretation of the results, the two continuous variables in the model have been used in their original units, rather than in their logarithmic form.

Table A.5.5: Results of linear regression analysis for enterprise electricity demand

Independent variables:	Dependent variable:
	Enterprise Electricity Demand (kWh/month)
Scale: Rural Mid	8.726***
	(1.473)
Scale: Rural Large	25.022***
	(2.956)
Education: Up to class 9	3.733*
	(2.028)
Education: Class 10 or 12th	3.960**
	(1.638)
Education: Diploma or Graduate	8.191***
	(2.008)
Activity: ICT related services	40.327***
	(3.791)
Activity: Other services	1.528
	(2.027)
Daily hours of grid supply in village	1.567***
	(0.321)
Observations	1,975
Adjusted R^2	0.244

Note: *Standard errors clustered at village level. State fixed effects included.*
* p<0.1, ** p <0.05, *** p < 0.01

A.5.6: Statistics on Irrigation and Source of Energy for each State

Table A.5.6: Statistics on irrigation and source of energy, by state

State	Share of cropped area irrigated by groundwater	Irrigated area as a share of total cropped area	Share of electric pumps	Share of diesel pumps
Bihar	34%	55%	29%	67%
Odisha	3%	25%	39%	53%
Rajasthan	19%	24%	72%	28%
Uttar Pradesh	60%	82%	17%	79%

[a] ***Source:*** *Agriculture Census of India, 2010-11.*
[b] ***Source:*** *5th Census of Minor Irrigation Schemes, 2013-2014.*

A.5.7: Estimating Agricultural Electricity Consumption

This study did not involve a dedicated survey to capture electricity consumption for agricultural use. However, the study included few specific questions in the household survey to capture the use of motorized water pumps for irrigation purposes. The study collected data on the ownership and use of electric and diesel-powered irrigation pumps, which are most commonly used in India. Using these data, the study estimated the electricity consumption of each household for agricultural purposes using the formula given below:

$$D_{agri} = P_d * D_d * H_d + P_e * D_e * H_e, \text{ where}$$

- P_d is the power rating of the diesel pump in use
- D_d is the number of days in a year for which the diesel pump was used for irrigation
- H_d is the hours for which diesel pump was used each day of pumping
- P_e is the power rating of the electric pump in use
- D_e is the number of days in a year for which the electric pump was used for irrigation
- H_e is the hours for which electric pump was used each day of pumping

Note on data quality: The study conducted extensive data quality checks before data analysis. Several instances of missing data were observed for the variables capturing the power rating of irrigation pump sets. In such cases, the study assigned the district-level means of pump capacity for electric and diesel pump sets, respectively. This is because pump capacities significantly vary with the water level, which in turn vary across districts. However, the study noticed certain discrepancies between the data on pump usage and information on irrigation expenditure shared by the households. There appears to be under-reporting of data on the hours and days for which a household uses an irrigation pump,[34] as compared to the irrigation expenditure reported by the household. This is the case for almost half of the households using electric irrigation pumps, and around 15% households using diesel irrigation pumps.[35] This discrepancy can be attributed to either willful under-reporting by the respondents, or the errors in administering the survey by the enumerators. Capturing agricultural electricity demand requires a full battery of questions where irrigation demand for each season is asked separately along with crop type, in order to accurately capture information on

34. On average, households use electric pumps for 230 hours per year, which is equivalent to the operational use of 6 hours per day for 38 days in a year. In contrast, average annual pumping hours for diesel pump users are significantly lower at 150 hours, which is equivalent to using the pump for 6 hours per day for 25 days in a year. Further, less than 3% of users operate diesel pumps for more than 600 hours per year, as compared to 10% of electric pump users. The lower pumping hours of diesel pump users can be mainly attributed to their high operation costs as compared to the subsidized power tariffs for irrigation, and conforms to the earlier claims regarding the practice of deficit irrigation by farmers forced to rely on diesel pumps. Almost 40% of the households using irrigation pumps, report annual pumping hours of less than 50 hours per year. Such a low usage appears to be the case of households renting the irrigation pumps or buying water from the pump owners, which is a prevalent practice in Uttar Pradesh and Bihar, where all such households lie.

irrigation practices. But, this could not be accommodated due to the paucity of time, and the focus of the survey on capturing household and enterprise demand. Overall, the estimates on agricultural electricity demand should be seen as conservative estimates.

A.5.8: Estimating Village Level Electricity Demand

The electricity demand of each revenue village is computed by adding the estimates for electricity consumption by households, enterprises, and agricultural loads.

- Household consumption is estimated by multiplying total households in a revenue village with the average household consumption (excluding outliers greater than three standard deviations).
- Enterprise consumption is estimated by multiplying the total number of shops (excluding flour mills) in a *revenue village* with the average enterprise consumption (excluding flour mills). Electricity consumption of flour mills is separately added to estimate the total enterprise consumption, as their consumption levels act as outliers for the small sample of 10 enterprises in a village.
- Agricultural electricity consumption is estimated by multiplying total households in a *revenue village* with the average electricity consumption by households for using electric or diesel (equivalent consumption) irrigation pumps. We assume that the total share of agricultural households in a *revenue village* is similar to the share observed in our survey based on random sampling of the households.

In short, the study used the following formula to estimate the electricity demand for every i^{th} revenue village:

$$E_{vi} = N_{hi} * E_{hi} + N_{ei} * E_{ei} + N_{fi} * E_{fi} + N_{hi} * E_{ai} \text{ for all i, where,}$$

- N_{hi} is the number of households in the village *i*, as per Census 2011
- E_{hi} is the average electricity demand of households in village *i*, as per survey estimates
- N_{ei} is the number of rural enterprises (excluding flour mills) in the village *i*, as per the survey[36]
- E_{ei} is the average electricity demand of enterprises (excluding flour mills) in village *i*, as per survey estimates
- N_{fi} is the number of flour mills in the village *i*, as per survey
- E_{fi} is the average electricity demand of all flour mills, as per survey estimates
- N_{hi} is the number of households in the village *i*, as per Census 2011
- E_{ai} is the average electricity demand for agricultural loads in village *i*, as per survey estimates

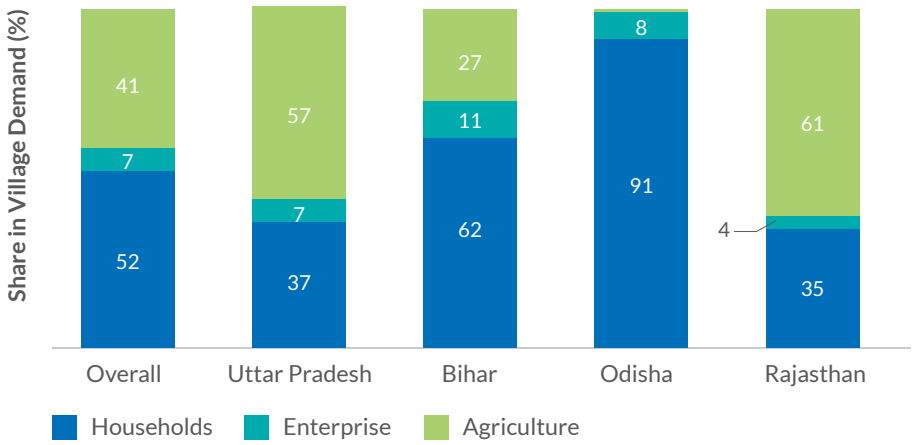
In order to estimate electricity demand for a typical, or average village surveyed in this study, the study calculated the average of the village electricity demand. On average, survey villages have 860 households, 100 shops (including 2 flour mills), and 35% of households that use diesel- or electricity-powered water pumps for irrigation purposes.

35. These are rough estimates based on the expectation that per unit cost of electricity when using electric and diesel pump set should not exceed INR 10/unit and INR 30/unit.

36. For the purpose of sampling enterprises to be surveyed, we conducted a preliminary exercise to map the number of different types of enterprises in each revenue village surveyed. This gave us the data on total enterprises present in each village.

A.5.9: Share in Village-level Electricity Consumption, by States

Figure A.5.4: Share in Village-level Electricity Consumption, by States



Notes:

- *Households were the main drivers of village electricity demand, especially in Bihar and Odisha.*
- *In Rajasthan and Uttar Pradesh, agricultural consumption accounted for 60% of village demand.*

Glossary

Diesel Generator (DG) Connections: Connections from diesel generator operators, who supply diesel-based electricity to a group of customers for pre-defined hours and load capacity.

Distribution Company (DISCOM): A company, mostly public sector, awarded the license to distribute electricity in a designated service area.

Distribution Franchise: Granting of rights to a private agent to manage electricity distribution business in a designated area on behalf of the distribution licensee (Distribution Company or DISCOM).

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 electrical grid, although some types of DRE plants can be set up to buy or sell power to the government grid.

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

Electricity Customers: Current users and potential future users of electricity.

Electricity Demand/Consumption: The actual amount of electricity consumed by an electricity customer measured in kWh.

Electricity Access: The ability to experience and use good quality electricity during all times.

Electricity Adoption: Where there is a willingness to be connected to the available electricity.

Electricity Availability: When electricity infrastructure, i.e., electric distribution pole is within a 50-meter distance entailing no additional costs to be borne by the customer.

Hook-up: The action of connecting to the available electricity.

Kutcha: Building structures made from mud, thatch, or other low-quality materials.

Metered Connections: Electricity connections with energy meters installed that measure and record the amount of electricity consumed by a residence, commercial building and the billing is done based on the reported consumption.

Electric Grid: A synchronized network of electricity generators and customers connected through transmission and distribution lines and controlled by a common control center.

Non-Grid Sources: Electricity sources, other than the electric grid. These include independent DRE-based mini-grids, solar home systems, rechargeable batteries, diesel generator connections from diesel operators, or private diesel generator sets.

Pre-Paid Meters: A device that monitors energy use after a customer has paid for the electricity in advance. A prepaid meter may disconnect service if the customer fails to pay or reaches a certain amount of electricity use.

Private Diesel Generator: Diesel generators owned and used in private capacity by a household or an enterprise.

Productive Use: The use of electricity as a direct input to the production of goods or the provision of services.

Pucca: Building structures made with high-quality materials throughout, including the floor, roof, and exterior walls.

Rechargeable Battery: An energy storage device which can be recharged with any electricity source for repeated use.

Revenue Village: A small administrative region in India, a village with defined borders. One revenue village may contain many hamlets.

Rural Enterprises: Commercial establishments or shops in rural areas, for example:

- *Agricultural input shops:* An enterprise selling inputs used for agricultural cultivation, such as fertilizers, seeds, etc..
- *Beauty parlor:* An enterprise providing personal care services, especially for women, such hair cutting and make-up.
- *Carpentry shops:* An enterprise providing carpentry services such as making or repairing wooden furniture and furnishings.
- *Cybercafe:* An enterprise that offers Internet browsing facilities and houses related equipment such as computers.
- *Dairy or milk chilling centers:* An enterprise that collects, stores, and sells milk and milk products to retail customers or dairy companies.
- *Flour mills:* An enterprise that provides services such as milling of cereals or oil seeds and houses related equipment such as milling machines.
- *Grocery shops:* An enterprise that trades in everyday household use items, including food items and fast-moving consumer goods.
- *Hardware shops:* An enterprise that trades in metal tools, mechanical equipment, electrical supplies, and other hardware goods.
- *Medical clinic:* An enterprise that is a private owned health care facility where one or more medical professional advises outpatients.
- *Mobile repair shops:* An enterprise that provides repair services for mobile phones and related electronic items and sometimes also trades in those.
- *Medical store:* An enterprise that trades in pharmaceutical and medicinal products; a pharmacy.
- *Photo studio:* An enterprise that provides basic photography services.
- *Ready-made goods:* An enterprise that trades in finished textile products, including clothes, bags, shoes, etc.
- *Sweets and snacks shops:* An enterprise that prepares and sells sweetmeats and snacks.
- *Tailoring shops:* An enterprise that provides basic tailoring services.
- *Warehouses and cold storages:* An enterprise that provides storage services for perishable and non-perishable items, such as agricultural produce.

Smart Meters: An advanced metering device that record the consumption of energy on real time basis and communicates the information to utilities for billing and monitoring purposes; can also receive information like pricing signals from utility.

Solar Home System: A stand-alone solar powered system, comprising a solar panel and battery, that typically powers lighting and few low wattage appliances like fans and television sets based on its capacity.

Solar Lantern: A portable lighting-only device powered by solar energy.

Solar Mini-Grid: A small-scale electricity distribution network that provides electricity to a localized group of customers, and generates electricity from solar panels potentially coupled with a storage or backup system. A typical mini-grid has a coverage area of 2–3 kilometers.

Typical: A term used to denote average values or situation.

List of Abbreviations

AT&C losses	Aggregate Technical & Commercial losses
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DF Village	Distribution Franchise Village
DG	Diesel Generator
DISCOMs	Distribution Company
DRE	Distributed Renewable Energy
ESMAP	Energy Sector Management Assistance Program
INR	Indian Rupee
kW	Kilowatt
kWh	Kilowatt Hour
LED	Light Emitting Dioide
MG Villiage	Mini-grid Village
MTM	Multitier Matrix
Sq.ft	Square Feet
SPI	Smart Power India
SPRD	Smart Power for Rural Development
UDAY	Ujjwal DISCOM Assurance Yojana
W_p	Watt peak

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