CEEW
THE COUNCIL

State of Electricity Access in India

Insights from the India Residential Energy Survey (IRES) 2020

Shalu Agrawal, Sunil Mani, Abhishek Jain, and Karthik Ganesan

Report | October 2020

Electricity access is fundamental to achieving multiple developmental goals ranging from education to health to employment generation. Children going to school in Vizianagaram, Andhra Pradesh.

Image: CEEW/Market Xcel

CEEW
THE COUNCIL

State of Electricity Access in India

Insights from the India Residential Energy Survey (IRES) 2020

Shalu Agrawal, Sunil Mani, Abhishek Jain, and Karthik Ganesan

CEEW Report
October 2020
ceew.in

Suggested citation: Agrawal, Shalu, Sunil Mani, Abhishek Jain, and Karthik Ganesan. 2020. *State of Electricity Access in India: Insights from the India Residential Energy Survey (IRES) 2020*. New Delhi: Council on Energy, Environment and Water.

Disclaimer: The views expressed in this report are those of the authors and do not necessarily reflect the views and policies of the Council on Energy, Environment and Water.

Cover image: iStock.

Peer reviewers: Dr Michaël Aklin, Associate Professor, University of Pittsburgh; Dr Rebekah Shirley, Chief Research Officer, Power For All; Aditya Chunekar, Fellow, Prayas (Energy Group); and Rishabh Jain, Manager – Market Intelligence, CEEW Centre for Energy Finance.

Publication team: Alina Sen (CEEW), Mihir Shah (CEEW), Venkatesh Krishnamoorthy, Aspire Design and Friends Digital.

Organisation: The **Council on Energy, Environment and Water** (ceew.in) is one of Asia's leading not-for-profit policy research institutions. The Council uses data, integrated analysis, and strategic outreach to explain and change the use, reuse, and misuse of resources. It prides itself on the independence of its high-quality research, develops partnerships with public and private institutions and engages with the wider public. In 2020, CEEW has once again been featured across nine categories in the *2019 Global Go To Think Tank Index Report*. It has also been consistently ranked among the world's top climate change think tanks. Follow us on Twitter @CEEWIndia for the latest updates.

Council on Energy, Environment and Water
Sanskrit Bhawan, A-10, Qutab Institutional Area
Aruna Asaf Ali Marg, New Delhi - 110067, India

About CEEW

The **Council on Energy, Environment and Water (CEEW)** is one of Asia's leading not-for-profit policy research institutions. **The Council uses data, integrated analysis, and strategic outreach to explain — and change — the use, reuse, and misuse of resources**. The Council addresses pressing global challenges through an integrated and internationally focused approach. It prides itself on the independence of its high-quality research, develops partnerships with public and private institutions, and engages with the wider public.

The Council's illustrious Board comprises Mr Jamshyd Godrej (Chairperson), Mr Tarun Das, Dr Anil Kakodkar, Mr S. Ramadorai, Mr Montek Singh Ahluwalia and Dr Naushad Forbes. The nearly 100-member executive team is led by Dr Arunabha Ghosh. CEEW is certified as a **Great Place To Work®**.

In 2020, CEEW once again featured extensively across nine categories in the *2019 Global Go To Think Tank Index Report*, including being ranked as **South Asia's top think tank (15th globally) in our category for the seventh year in a row**. CEEW has also been ranked as South Asia's top energy and resource policy think tank for the second year running. It has consistently featured among the world's best managed and independent think tanks, and twice among the world's 20 best climate think tanks.

In ten years of operations, The Council has engaged in 278 research projects, published 212 peer-reviewed books, policy reports and papers, created 100+ new databases or improved access to data, advised governments around the world nearly 700 times, promoted bilateral and multilateral initiatives on 80+ occasions, and organised 350+ seminars and conferences. In July 2019, Minister Dharmendra Pradhan and Dr Fatih Birol (IEA) launched the CEEW Centre for Energy Finance. In August 2020, Powering Livelihoods — a CEEW and Villgro initiative for rural start-ups — was launched by Minister Mr Piyush Goyal, Dr Rajiv Kumar (NITI Aayog) and H.E. Ms Damilola Ogunbiyi (SEforAll).

The Council's major contributions include: The 584-page *National Water Resources Framework Study* for India's 12th Five Year Plan; the first independent evaluation of the *National Solar Mission*; India's first report on global governance, submitted to the National Security Adviser; irrigation reform for Bihar; the birth of the Clean Energy Access Network; work for the PMO on accelerated targets for renewables, power sector reforms, environmental clearances, *Swachh Bharat*; pathbreaking work for the Paris Agreement, the HFC deal, the aviation emissions agreement, and international climate technology cooperation; the concept and strategy for the International Solar Alliance (ISA); the Common Risk Mitigation Mechanism (CRMM); critical minerals for *Make in India*; modelling 222 scenarios for India's low-carbon pathways; India's largest multidimensional energy access survey (ACCESS); climate geoengineering governance; circular economy of water and waste; and the flagship event, Energy Horizons. It recently published *Jobs, Growth and Sustainability: A New Social Contract for India's Recovery*.

The Council's current initiatives include: A go-to-market programme for decentralised renewable energy-powered livelihood appliances; examining country-wide residential energy consumption patterns; raising consumer engagement on power issues; piloting business models for solar rooftop adoption; developing a renewable energy project performance dashboard; green hydrogen for industry decarbonisation; state-level modelling for energy and climate policy; reallocating water for faster economic growth; creating a democratic demand for clean air; raising consumer awareness on sustainable cooling; and supporting India's electric vehicle and battery ambitions. It also analyses the energy transition in emerging economies, including Indonesia, South Africa, Sri Lanka and Viet Nam.

The Council has a footprint in 21 Indian states, working extensively with state governments and grassroots NGOs. It is supporting power sector reforms in Uttar Pradesh and Tamil Nadu, scaling up solar-powered irrigation in Chhattisgarh, supporting climate action plans in Gujarat and Madhya Pradesh, evaluating community-based natural farming in Andhra Pradesh, examining crop residue burning in Punjab, and promoting solar rooftops in Delhi and Bihar.

Acknowledgments

The authors would like to acknowledge the valuable support of a number of people who contributed to this study.

Market Xcel Private Ltd, the survey agency, and its survey team was the force behind efficiently administering the survey and collecting the data braving several on-ground difficulties, including harsh weather conditions in many states and safety risks amid the tensions and protests related to National Register for Citizens and the Citizenship (Amendment) Act. Our deepest gratitude goes to them. Special thanks to Prasenjit Saha, Associate Project Director, Market Xcel Private Ltd, who was instrumental in completing the exercise by his efficient oversight of the implementation of the India Residential Energy Survey (IRES). We would also like to thank the MacArthur Foundation for financially supporting the study.

Prof. Johannes Urpelainen, Director and Prince Sultan bin Abdulaziz Professor of Energy, Resources and Environment at the Johns Hopkins School of Advanced International Studies displayed admirable grace in giving us regular inputs and feedback during various stages of survey planning and study design. We are indebted to him. The questionnaire design took final shape as Anna Agrawal, Fellow, Centre for Policy Research; Aditya Chunekar, Fellow, Prayas (Energy Group); Sudha Setty who was then Director, AEEE; and Piyush Varma, Green Building Analyst, Environmental Design Solution gave in no small measure their valuable inputs. We profusely thank them.

Our colleagues at The Council—Harsimran Kaur, Selna Saji, Milan Jacob, Nikhil Sharma, Kangkanika Neog, L. S. Kurinji, and Hem Dholakia—carried on their shoulders the difficult task of translating the questionnaire to regional languages and training the enumerators. Thank you, our fellow travellers on the co-journey at The Council, for without you this wouldn't have been possible. We would be remiss if we did not thank Bharat Sharma for helping us design the various maps for the study and Kanika Balani for providing valuable pieces of information during the analysis stage. Aditi Chaudhary interned with us and helped us conduct data quality checks and data cleaning; we highly appreciate her contribution.

Our reviewers—Dr Arun Kumar Verma, former Joint Secretary, Ministry of Power, Government of India; Aditya Chunekar, Fellow, Prayas (Energy Group); Dr Rebekah Shirley, Chief Research Officer, Power For All; Dr Michaël Aklin, Associate Professor, University of Pittsburgh; and Rishabh Jain, Manager—Market Intelligence, CEEW Centre for Energy Finance—provided critical feedback and comments that went a long way in refining this report. To them, we owe our sincere gratitude.

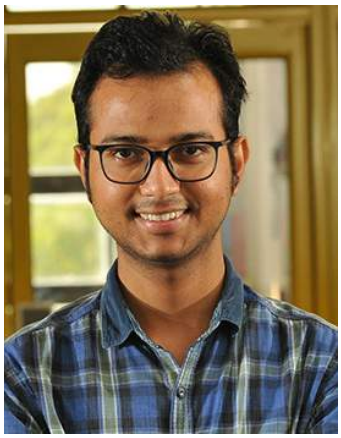
Finally, our outreach team and editors, who guided us through the publication and outreach process. We are very grateful to the entire team and especially convey our warm thanks to Alina for her role in ensuring that the report meets the CEEW's quality standards.

The authors

Shalu Agrawal
shalu.agrawal@ceew.in | @ShaluAgrawal12

A Programme Lead at CEEW, Shalu's research focuses on the changing residential energy landscape and exploring the role of institutional, technology, and policy reforms to enable access to affordable, reliable, and sustainable energy for all. She also supports The Council's work on power sector reforms and solar-powered irrigation. Shalu holds an MSc from University College London and a BTech in Electrical Engineering from IIT Roorkee.

"With nearly all households electrified, India's energy policy and actors must now focus on sustaining electricity use and consumer satisfaction. Reliable supply, efficiency in revenue collection, and consumer-centric service delivery would be central to achieving these goals."



Sunil Mani
sunil.mani@ceew.in | @sunilmani02

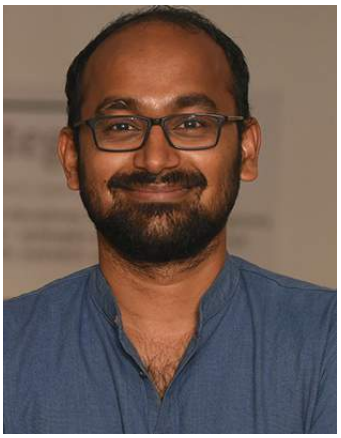
A Programme Associate at The Council, Sunil's work, for the last four years, has centred around collecting and using primary data to understand and improve the energy access situation at the household and community level in India. He holds a master's degree in economics from Shiv Nadar University, India.

"After Saubhagya, the next goal for India is 24x7 power for all. However, to achieve that we need to understand the supply situation and other related challenges at the household level. Here, we bring out those challenges and suggest some policy insights to move towards the ultimate goal of 24x7 power for all."

Abhishek Jain
abhishek.jain@ceew.in | @ajainme

As a Fellow, Abhishek built and leads The Council's practices on energy access, rural livelihoods, and sustainable food systems. He is directing 'Powering Livelihoods', a $3 million initiative. He co-conceptualised and leads CEEW's flagship research on ACCESS (Access to Clean Cooking energy and Electricity—Survey of States). With more than nine years of experience, Abhishek has worked on multiple issues at the confluence of energy, economics, and environment. He is an alumnus of the University of Cambridge and IIT Roorkee.

"As India achieves universal household electrification, this timely report helps us understand the on-ground electricity access across the country, associated customer satisfaction, and the state of metering, billing, and collection. It highlights the remaining frontiers to conquer to achieve affordable and sustainable 24x7 power for all."



Karthik Ganesan
karthik.ganesan@ceew.in | @KarthikGanesan6

Leading The Council's work on the power sector, Karthik has focused his research on the operational reform of discoms in India and the competitiveness of power generation sources. He holds a master's degree in Public Policy from the Lee Kuan Yew School of Public Policy at the National University of Singapore. He also holds an BTech in Civil Engineering and an MTech in Infrastructure Engineering from IIT Madras.

"Universal electrification opens the door to many opportunities for households, but it also brings with it the challenges of maintaining supply quality and recovering revenues from consumers. We find consumers are by and large satisfied with service levels. However, with increased awareness of their rights as consumers, discoms will have an endurance race ahead in keeping up with their expectations and remaining financially solvent."

India has witnessed extensive electrification over the past decade extending to remote villages. Shot in Rohidi, Barmer district, Rajasthan.

Contents

Image: Shalu Agrawal/CEEW

Figures

Tables

Acronyms

ACCESS	Access to Clean Cooking energy and Electricity—Survey of States
AT&C	aggregate technical and commercial
CEA	Central Electricity Authority
CEEW	Council on Energy, Environment and Water
CESC	Calcutta Electric Supply Corporation
CI	confidence interval
CSCs	common service centres
Discoms	distribution companies
DT	distribution transformer
IRES	India Residential Energy Survey
IT	information technology
kWh	kilowatt-hour
LEDs	light-emitting diodes
MBC	metering, billing and collection
MoP	Ministry of Power
MSEDCL	Maharashtra State Electricity Distribution Company Limited
NCT	National Capital Territory
NSSO	National Sample Survey Organisation
PPS	probability proportional to size
PuVVNL	Purvanchal Vidyut Vyapar Nigam Limited
RGGVY	*Rajiv Gandhi Gram Vidhyutikaran Yojana*
Saubhagya	*Pradhan Mantri Sahaj Bijli Har Ghar Yojana*
SDG	Sustainable Development Goal
SERCs	State Electricity Regulatory Commissions
SHGs	self-help groups
SoPs	Standards of Performance

Acronyms for Indian states used in the study

AP	Andhra Pradesh	MH	Maharashtra
AS	Assam	DL	Delhi
BR	Bihar	OR	Odisha
CH	Chhattisgarh	PB	Punjab
GJ	Gujarat	RJ	Rajasthan
HR	Haryana	TN	Tamil Nadu
HP	Himachal Pradesh	TS	Telangana
JH	Jharkhand	UP	Uttar Pradesh
KA	Karnataka	UK	Uttarakhand
KL	Kerala	WB	West Bengal
MP	Madhya Pradesh		

Image: CEEW/Market Xcel

To support the clean energy transition, India needs to institutionalise residential energy surveys to inform future policies and programmes. CEEW's Shalu Agrawal with a respondent.

Executive summary

The India Residential Energy Survey (IRES) captures the state of energy access and use in Indian homes

As one drives across different parts of rural India, it is heartening to see the electric wires lining the landscape as far as one can see. They carry not just power but hope to the millions who use electricity to meet their lighting, cooling, life and livelihood needs. With the aggressive implementation of *Pradhan Mantri Sahaj Bijli Har Ghar Yojana* (*Saubhagya*) since September 2017, 26.3 million households were given grid-electricity connections at subsidised rates or free of cost (Ministry of Power 2019). As per the *Saubhagya* dashboard, all 'willing' households in India are electrified, as of 31 March 2019.

In 2015 and 2018, the Council on Energy, Environment and Water (CEEW) conducted two rounds of energy access surveys (Access to Clean Cooking energy and Electricity—Survey of States [ACCESS]) in rural households across six of India's energy-poor states—Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh, and West Bengal. As rapid electrification sweeps over the country, it is desirable to have a survey across the nation to find answers to questions such as: (i) Once electrified, do all households also have seamless access to electricity supply? (ii) Has India delivered on the dream of '24x7 power for all'? and (iii) importantly, how do consumers respond to supply disruptions from the grid?

Providing reliable electricity services is linked to the ability of power distribution companies (discoms) to collect commensurate revenue from the consumers. However, most Indian discoms are under severe financial distress, in part due to gaps in metering, billing, and collection (MBC) (Ganesan, Bharadwaj, and Balani 2019). With many new households wired to the grid, it is essential to know how has the needle moved on the MBC front. India is at the cusp of a new decade of change and growth in the power sector. An independent assessment of the state of electricity access in the country and identifying gaps in that access therefore becomes necessary.

Study objectives

To understand the state of access to electricity, we undertook a nationally representative survey covering nearly 15,000 households spread across 21 states of India. The survey, which we call the India Residential Energy Survey (IRES), was conducted in collaboration with the Initiative for Sustainable Energy Policy (ISEP) and covers different dimensions of energy use in households. In this report, we answer the following questions:

1. With the Ministry of Power's Saubhagya portal showing universal electrification of willing households, does the ground assessment sufficiently back this claim?
2. What is the state of quality and reliability of supply, and consumer satisfaction with the electricity services across the country?
3. How are the discoms handling the metering, billing, and payment collection (MBC) process across households?

We present the results of the IRES 2020 survey and based on our assessment, we propose strategies to fill the remaining gaps to realise the goal of universal, affordable, and reliable electricity access in India.

India Residential Energy Survey (IRES)

Survey specs

6 researchers

20 field managers

40 supervisors

154 enumerators

300 days

MAR/19-JUN/19

Research Design

- Research focus
  Energy access and use
- Sampling strategy
  Multi-stage stratified
- Questionnaire design
  35-minute long

JUL/19-SEP/19

Survey Preparation

- Vendor selection
  Market Xcel
- Questionnaire translation
  10 languages
- Pilot studies
  3 states
- Questionnaire coding
  SurveyToGo

OCT/19-APR/20

Survey Execution

- Enumerator trainings
  9 locations
- Data collection
  Nov 19- Mar 20
- Data monitoring and cleaning

21 STATES
covering 97% population

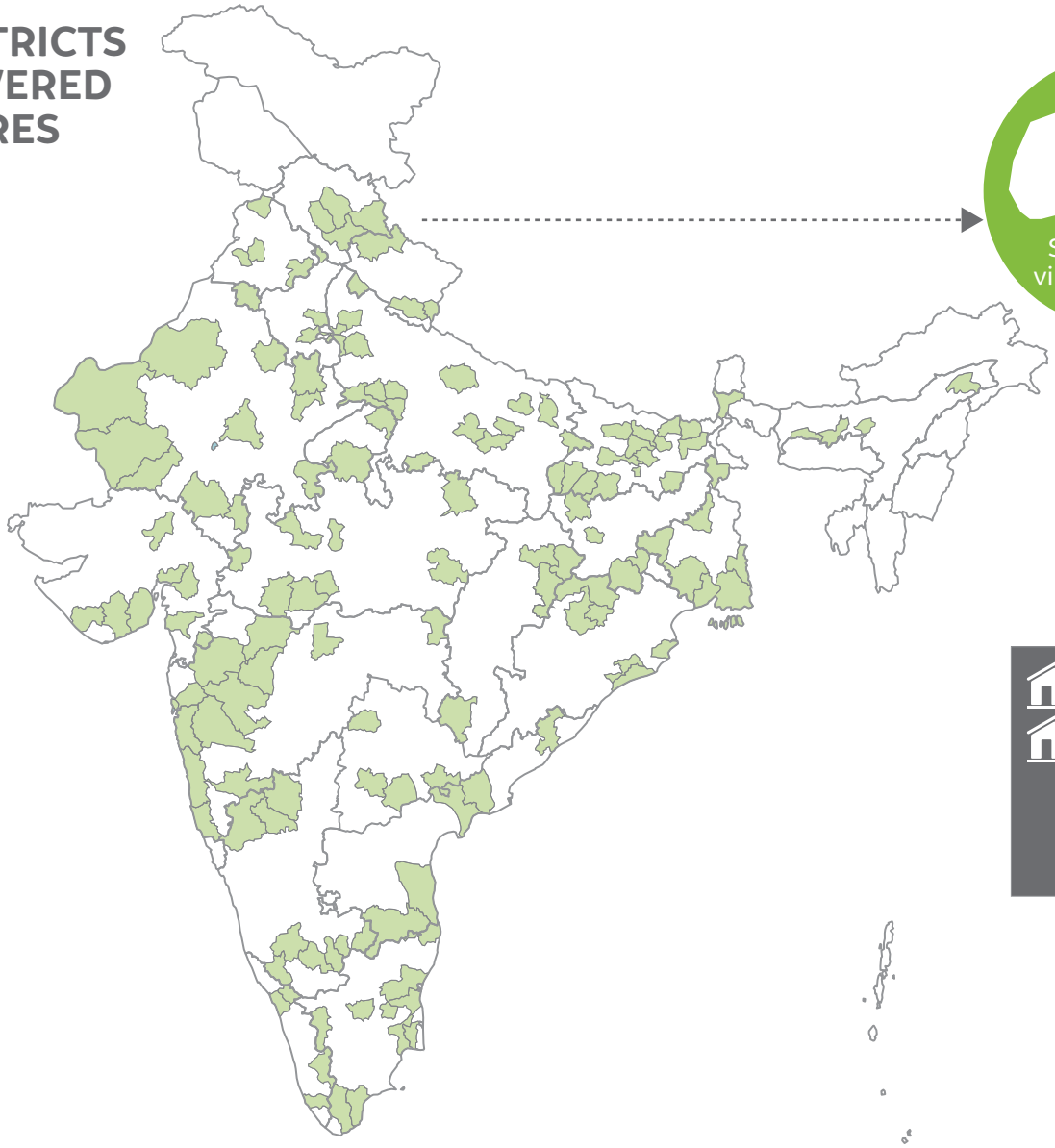
152 DISTRICTS
Cluster sampling

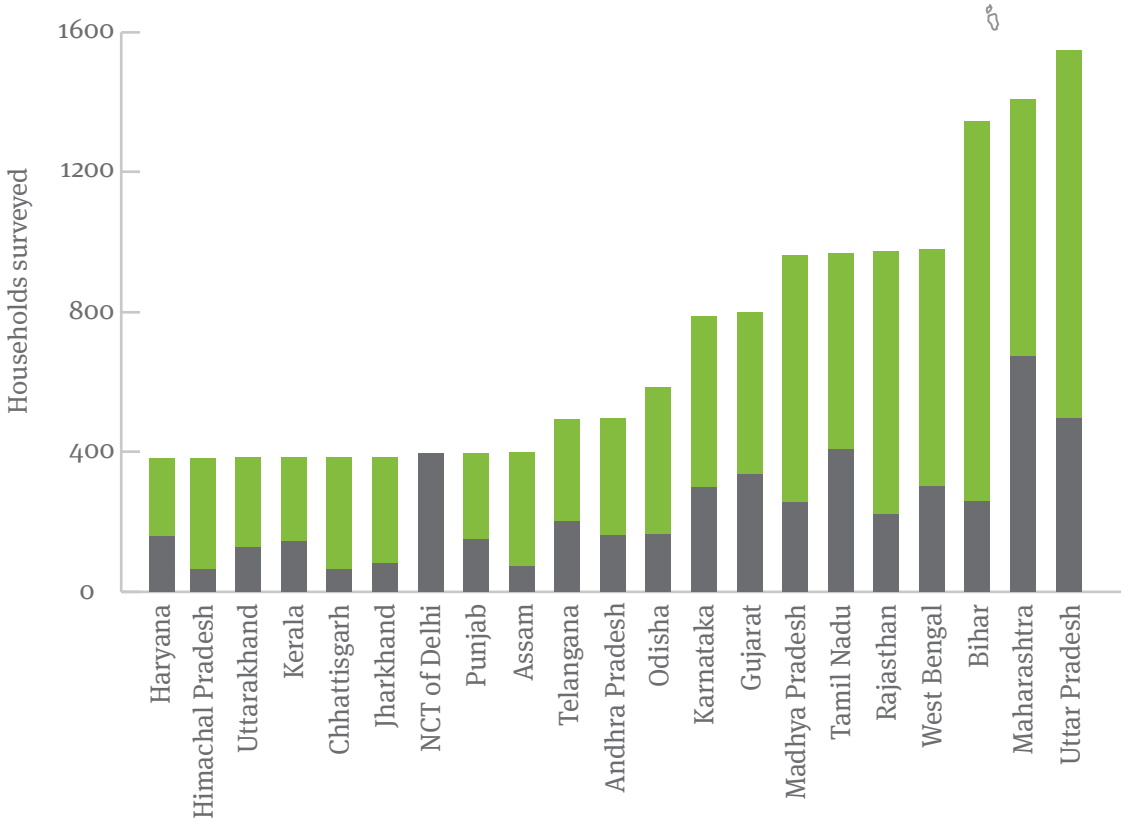
1210 VILLAGES & 614 URBAN WARDS
Cluster sampling

14,850 HOUSEHOLDS
8 from each village/ward

4 MILLION DATA POINTS

DISTRICTS COVERED IN IRES





Rural
66%

Urban
34%

Source:
Authors' analysis

Key findings

As per IRES 2020, nearly 97 per cent of Indian households are electrified. India has made a commendable effort on household electrification, as 96.7 per cent of Indian households are now connected to the grid, with another 0.33 per cent relying on off-grid electricity sources. However, 2.4 per cent of Indian households still remain unelectrified (Figure ES1). Most of the unelectrified households are concentrated in the rural areas of Uttar Pradesh, Madhya Pradesh, Rajasthan, Haryana, and Bihar (Figure ES2).

A majority of the unelectrified households cited their inability to afford grid-connection as the reason for not having a connection. Given the availability of free-connection under *Saubhagya* scheme, some of households were likely not aware of the scheme, not able to access it, or were deterred by the recurring monthly expenditure of paying electricity charges. Most of these households are multidimensionally poor, characterised by reliance on labour activities for sustenance, life in a *kachha* house, non-ownership of a motorised vehicle, and use of traditional biomass as the primary cooking fuel. Other reasons for households not having access to electricity are lack of grid supply in the neighbourhood, refusal of connection due to inadequate documents, and application under process.

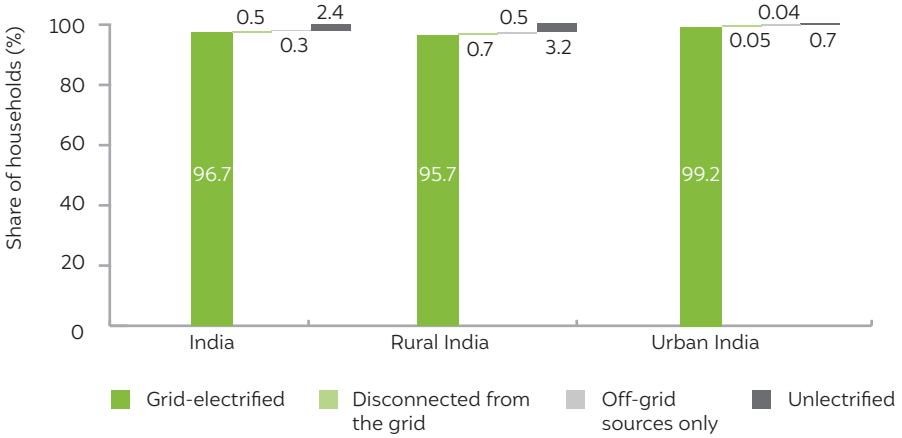


Figure ES1
With only 2.4 per cent of households lacking access to electricity, India is close to achieving universal electrification

Source: Authors' analysis

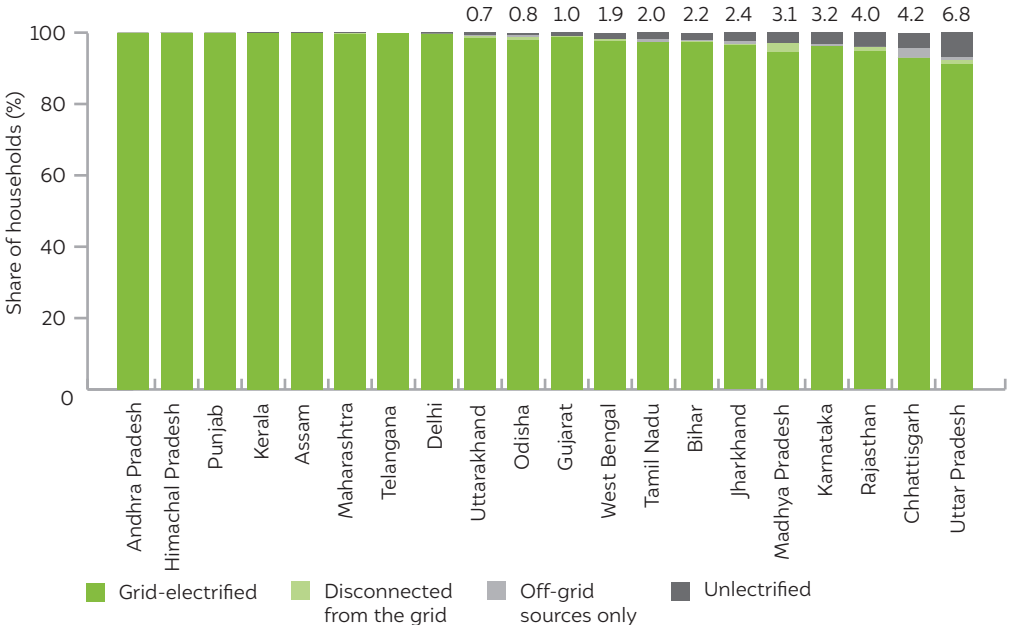


Figure ES2
A few north-central states have a majority of the unelectrified households

Source: Authors' analysis

As per IRES 2020, nearly 97%of Indian households are electrified

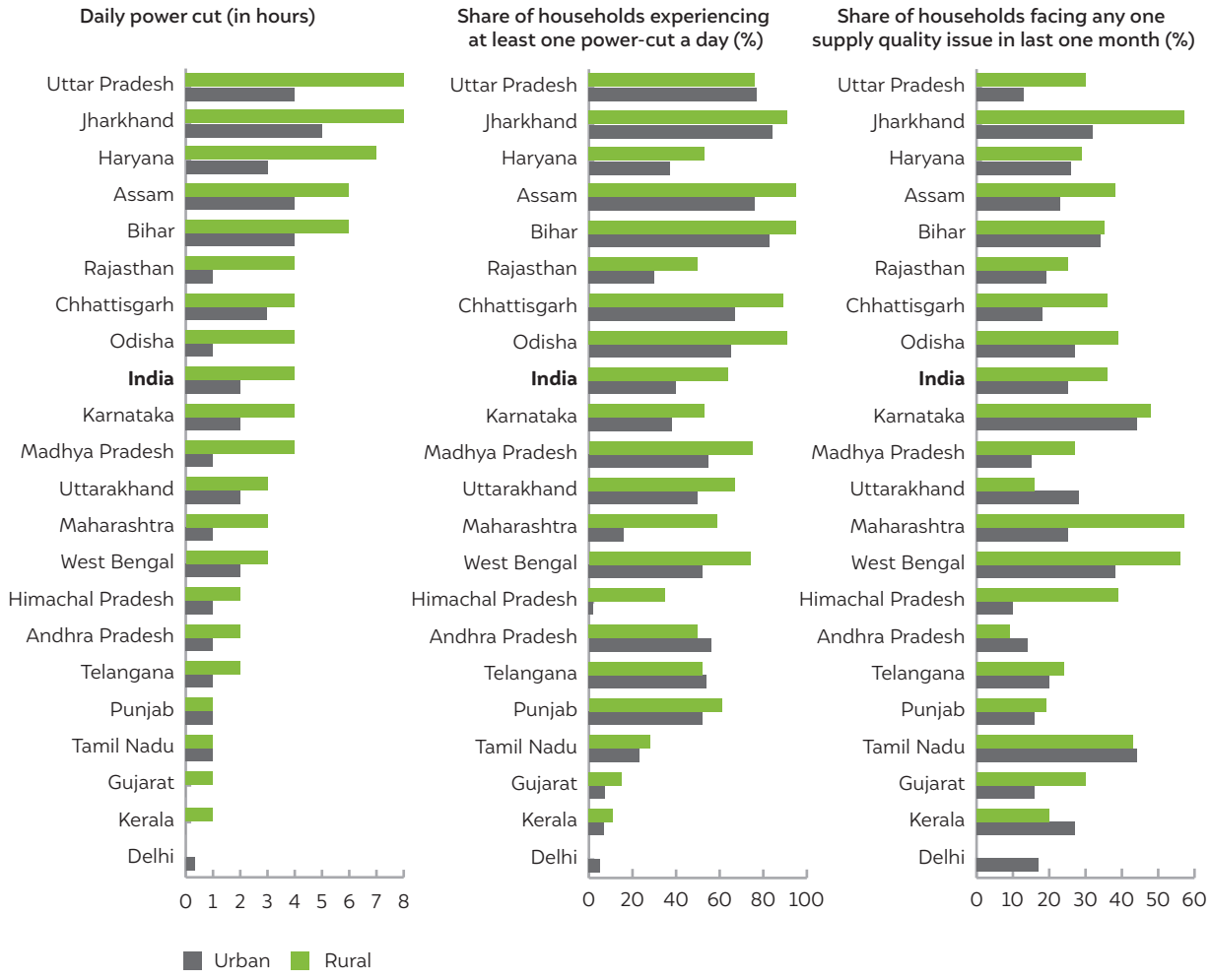
An average Indian household receives 20.6 hours of power supply from the grid. The average daily supply in urban areas (22 hours) is longer by a couple of hours than in rural areas (20 hours). Delhi, Kerala, and Gujarat are the top states, maintaining slightly over 23 hours of average supply in both urban and rural areas. In contrast, households in Uttar Pradesh, Jharkhand, Haryana, Assam, and Bihar face the longest power outages, with rural households in these states facing six or more hours of daily outages (Figure ES3).

An average Indian household receives 20.6 hours of power supply from the grid

However, the current supply situation has significantly improved in rural India, especially in the six ACCESS states (Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh, and West Bengal), where daily power supply to rural households is around 18.5 hours in 2020 compared to 12.5 hours in 2015 and 15 hours in 2018.

Most households faced unanticipated supply interruptions (76 per cent). Two-thirds of rural and two-fifths of urban households face outages at least once a day. Power outage duration and frequency are higher in Uttar Pradesh, Jharkhand, Assam, Bihar, and Haryana (Figure ES3). A third of households also faced at least one of the three supply quality issues—long blackouts, low voltages, or appliance damage due to voltage fluctuations—during the month preceding the survey. Only six per cent households reportedly registered a compliant in the past six months, indicating high consumer inertia or low awareness about their rights as electricity consumers.

Figure ES3 Power cut duration, frequency, and gaps in supply quality vary across Indian states



Source: Authors' analysis

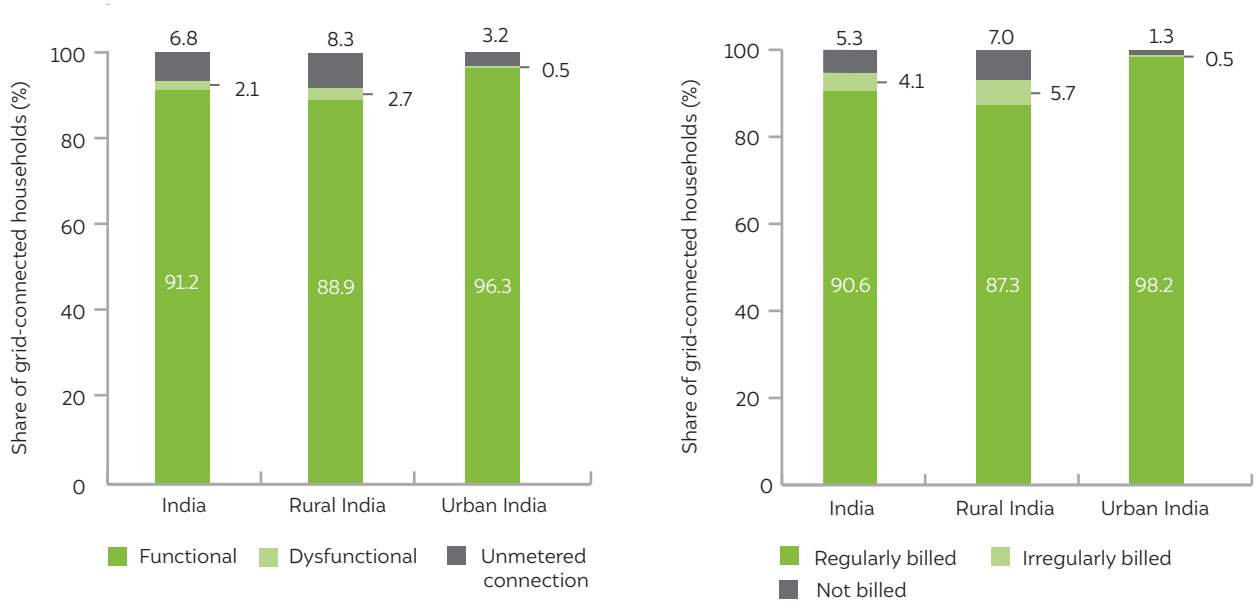
Of all grid-electrified households in India, 93 per cent have metered connections and 91 per cent are billed regularly. Metering and regular billing is critical for revenue collection and financial health of discoms. While most ACCESS states have improved metering rates over the past five years, with a six-fold improvement in Uttar Pradesh, the issue of unmetered connections and dysfunctional meters is more pronounced in rural areas (Figure ES4), particularly in Jharkhand and Madhya Pradesh. Further, metering gaps are higher in the case of households electrified over the past three years (20 per cent). A respondent from Kharagpur village of Palamu district of Jharkhand stated that, "the meter is kept in the house but has not been installed".

Of all grid-electrified households in India, 93% have metered connections and 91% are billed regularly

While four per cent of grid users receive bills irregularly (few times in a year or once in a few years), another 5 percent of grid users have never seen a bill, though most of these households have been electrified for more than a year. Billing issues are pronounced in rural areas, mainly due to the high transaction cost and absence of an adequate billing mechanism. Jharkhand has the lowest share of grid users billed regularly (55 per cent), followed by Bihar (64 per cent). Billing irregularities are high in Assam, Uttar Pradesh, and Madhya Pradesh as well.

Discoms face losses in many states in India due to low collection efficiency. While we did not investigate payment compliance (due to problem of desirability bias), we assess payment modes used by households. Most households in India pay their bills in cash through discom payment counters and collection agents. Only 17 per cent of billed consumers pay their bills digitally (27 per cent in urban India and 12 per cent in rural India). This is despite the fact that 70 per cent of Indian households have a smartphone.

Figure ES4 More than 10 per cent of rural households do not have a functional electricity meter



Source: Authors' analysis

More than three-fourths of the grid users are satisfied with their electricity situation. In the six ACCESS states, the satisfaction levels among rural consumers increased from 23 per cent in 2015 to 55 per cent in 2018 to 73 per cent in 2020, which is in tandem with the consistent improvement in supply hours. This is a reason to celebrate. Yet, there remain several gaps in electricity service and these partly explain the existing gaps in consumer satisfaction (Figure ES6).

More than three-fourths of the grid users are satisfied with their electricity situation

As many as 87–97 per cent of grid users in Delhi, Odisha, Andhra Pradesh, Himachal Pradesh, Maharashtra, Punjab, and Gujarat are very highly satisfied with electricity service, as typically power outages are less than two hours per day on average in these states, barring Odisha and Maharashtra. In contrast, more than 25 per cent of grid users are not satisfied with electricity services in Assam, Madhya Pradesh, Jharkhand, and Uttar Pradesh.

A major driver of household satisfaction is the duration of power supply, with reliability of supply and voltage stability also being significant factors. Regular billing is also associated with satisfaction among rural households. Our analysis underscores the importance of providing uninterrupted and reliable power supply to consumers along with regular billing.

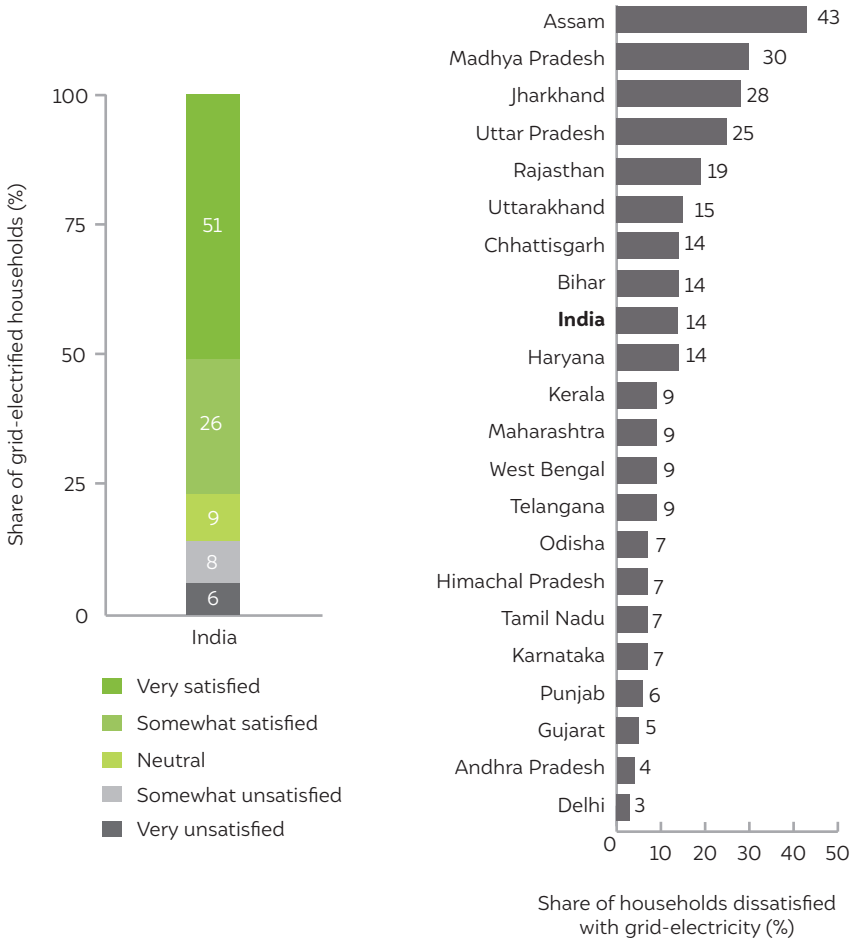


Figure ES5
Majority of the dissatisfied households are in northern and eastern India

Source: Authors' analysis

Concluding remarks and way forward

When our team was conceptualising the survey, in the summer of 2019, India had already achieved a milestone that was celebrated widely—electrifying nearly all households across the length and breadth of the country. Our study confirms the progress that India has made in terms of enabling access to electricity to its people. The share of households using electricity as the primary source of lighting has risen from 26 per cent in 1980 to 97 per cent in 2020. Over the past two decades alone, successive government schemes have brought nearly 800 million Indians out of darkness.

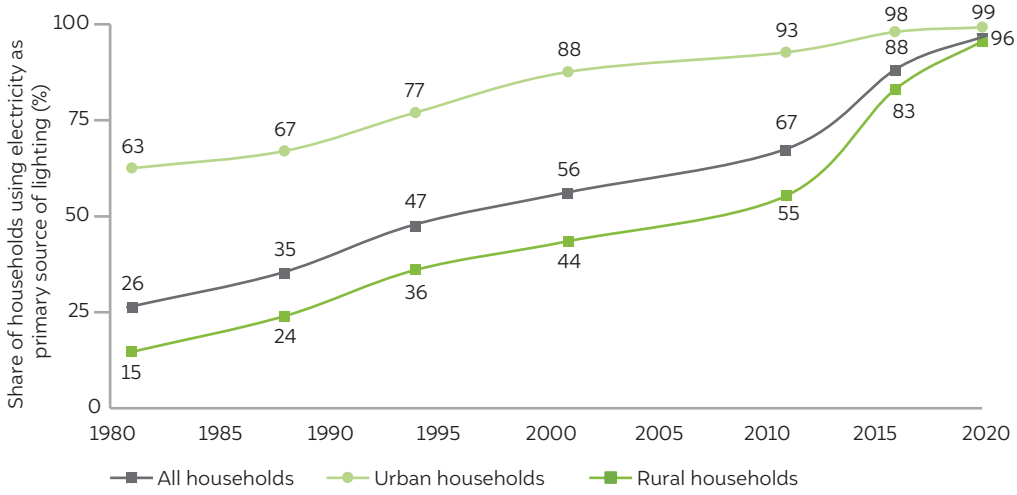


Figure ES6
India's progress on household electricity access (1980-2020)

Source: Authors' compilation based on Census, National Sample Survey Organisation (NSSO) survey, and IRES data

However, India is yet to achieve "access to affordable, reliable, sustainable and modern energy for all" (a subset of Sustainable Development Goal 7 of the United Nations to be achieved by 2030). We make the following recommendations to bridge the gap.

Identify and electrify the remaining 2.43 per cent unelectrified households. As most unelectrified households are concentrated within the rural areas of a few states, discoms must undertake targeted efforts to address the gap in (i) awareness about government schemes for electrification, (ii) documentation challenges, and (iii) adequate infrastructure to extend a connection.

Review and consistently implement ultra-low tariffs for poor households with lifeline consumption to sustain electricity use in an affordable manner. We observed that poor households are reluctant to get an electricity connection due to unaffordable recurring costs and electrified households getting disconnected because of their inability to pay the electricity bill (at times due to irregular billing leading to a large outstanding amount). This situation calls for streamlining the billing operations. While all states in India have differentiated power tariffs, there is scope for inter-state learning. We call upon states with relatively higher tariff incidence on low-consumption category to consider implementing ultra-low tariffs and help the poorer households in sustaining their electricity access. More research is required on the principles and definition of a lifeline tariff.

Improve information on real-time supply quality and address bottlenecks. Nearly 90 per cent of distribution transformers (DTs) in urban India and 64 per cent in rural India are already metered (Ministry of Power 2020). In the absence of direct communication with households, DTs remain

the source of how electricity supply is experienced by households. Discoms can use this data to improve transparency on supply situation, identify areas with losses and plan other technological upgradations.

Strict enforcement of Standards of Performance (SoPs) and empowering consumers to demand mandated service levels. Discoms in India are mandated to follow SoPs related to supply quality, metering, and billing and are required to compensate consumers in case of violations. However, very few consumers register complaints as a result of low awareness about their rights and the complex process of claiming compensation for supply inadequacies. Besides promoting consumer education, electricity regulators must enforce compliance by imposing penalties on discoms for failure to meet the standards. Regulators could also consider a provision for 'automatic compensation' to consumers based on independent monitoring of supply quality.

Leverage technology and innovative solutions to ensure universal and timely metering, billing, and collection. Although discoms have achieved a phenomenal increase in metering and regular billing, some gaps remain. In addition to the upgradation of information technology (IT) infrastructure and billing systems, discoms should consider local and context-relevant solutions and create incentives for actors to help achieve the metering and billing targets. Another Achilles heel of discoms, collection efficiency, could be enhanced by offering digital modes of payment for consumers such as provisioning for online payment channels through IT kiosks, microentrepreneurs (local shops/youth), and existing public and private institutions to serve those unfamiliar with direct online payments. Less than one-fifth of consumers pay their electricity bills through online modes though 70 per cent of them have smartphones. Developing user-friendly mobile applications in vernacular languages, financial incentives, and consumer education are also needed to attract more consumers towards direct digital payment modes.

The high levels of consumer satisfaction stand testimony to the sustained efforts made over the last few decades by discoms. Supply duration, reliability, and quality along with bill regularity are important drivers of consumer satisfaction, which also keeps evolving. To sustain consumer trust and satisfaction, discoms need to adopt a proactive approach to resolving any outstanding issues in service delivery besides improving transparency in their overall operations.

To sustain consumer trust and satisfaction, discoms need to adopt a proactive approach to resolving any outstanding issues in service delivery

Aspirations for a better quality of life, urbanisation, and a growing population are all contributing to the changing energy landscape in India.

Image: CEEW/Market-Xcel

1. Context and objectives

The last pan-India assessment of energy-use at a household level was in 2011-12 by way of the consumer expenditure survey (68th Round of the National Sample Survey (NSSO)). Till now, our understanding of how households consume energy, how much they spend on it, what variations exist between the rich and the poor or the urban and the rural dweller are all based on this 2011–12 assessment.

Over the past decade, India has seen significant changes on both electricity supply and consumption front

In the intervening years much has changed, especially from the perspective of the consumer base that electricity utilities have to serve across the country. Household electrification in India is nearing saturation levels. The Government of India's *Pradhan Mantri Sahaj Bijli Har Ghar Yojana* (*Saubhagya*) portal shows that 100 per cent electrification has been achieved for all 'willing'[1] Indian households, as of 31 March 2019 (Ministry of Power 2019). Technologies like rooftop solar-photovoltaics and energy storage have enabled consumers to produce power in their own premises, adding to the lexicon a new word *prosumer-consumers*, who are no longer completely dependent on distribution companies (discoms) for their power needs. The cost of delivering electricity has increased tremendously from 2012 and has directly impacted what households are expected to pay for electricity service and how attractive emerging technology options become (PFC 2020; 2017). Advances in communication technology has enabled discoms to measure and track their demand and performance efficiency.

Despite tremendous achievements on these fronts, the finances of discoms have not improved in any significant way in the last decade (CRISIL 2020), constraining necessary investments to improve their service levels. As service upgrades have not kept pace with the spectacular surge in the number of consumers, urban and rural households continue to face several supply-side challenges such as power outages, low voltages, and voltage fluctuations (Jain et al. 2018; Phadke, Park, and Abhyankar 2019). Poor supply metrics have been linked to consumer dissatisfaction with the utility (Aklin et al. 2016). Despite statutory requirements, the delivered service quality by discoms across the country has not achieved expected levels of efficiency (Mandal et al. 2019). Even though several schemes are being rolled out to help discoms improve their services, there needs to be a proportionate focus on tracking the progress periodically to facilitate the revision of targets and offer incentives in tune with the progress made.

A key factor afflicting discoms' financial health is the revenue shortages arising from tariff gaps and an inefficient billing and payment collection system (Ganesan, Bharadwaj, and Balani 2019). This revenue shortfall has forced discoms to depend on subsidies from governments, the erratic disbursal of which puts discoms in a tight spot each year (Das et al. 2019). Alternative distribution models and the focus on private sector participation in

1 Though there is no formal definition of this term, it could imply households interested in getting electricity connections.

electricity supply, as proposed in recent policy drafts, might change the playing field from the consumers' perspective. They can demand more accountability and expect services appropriate to the level of payments they make. However, are consumers being engaged well and are they aware of the economic reality of the electricity supply business? Building an informed consumer base remains a challenge, as evident in the shocked responses of the more aware urban consumers in some parts of the country, when post-lockdown electricity bills were sent to them by discoms. Characterising our consumer base and understanding their experience with utilities today is the first step to transforming consumer experience.

CEEW's ACCESS 2018 survey highlighted several gaps in electricity service provision

1.1 Tracking the state of electricity access

Sensing the importance of power for homes, our team at the Council on Energy, Environment and Water (CEEW) set out in 2014 to assess electricity access and its multidimensional nature, with a primary survey of around 9,000 rural households across six of India's energy-poor states (Jain et al. 2015). We highlighted the plight of millions of citizens in India's rural heartland who, after nearly seven decades of independence, were still not capable of achieving a decent standard of living and livelihood opportunity, all for want of an electricity connection. We followed the 2014 survey with an assessment in 2018 to study the impact of a sustained electrification drive by the government, especially through *Saubhagya*. We found that the government's efforts had made a tangible difference to the ground reality (Jain et al. 2018). Despite discoms providing supply for longer hours and more households having electricity access, gaps were visible in the quality and reliability of supply, and 16 per cent households did not have a grid electricity connection.

At the dawn of the new decade, we felt the need for a nation-wide independent assessment of electricity access in terms of (a) urban and rural divide and (b) the geographic disparity between different regions. If we don't solve the challenges pertaining to the various facets of electricity supply, we cannot progress to more nuanced discussions of where the distribution system is headed.

1.2 Changing contours of electricity demand

Studies point out that residential electricity demand in India is expected to increase multi-fold in the near future, given the newly electrified households, continuous increase in population, urbanisation, and incomes (Khosla and Chunekar 2017). As per the 68th round of NSSO, the ownership of most home appliances, particularly consumer durables such as fridge, cooler, air conditioners, or washing machine, remained low (less than 20 per cent). In the coming decades, a high growth in the ownership of such energy-intensive appliances can be expected (Parikh and Parikh 2016). The rising electricity consumption and their changing patterns place heavy demands on the utility's ability to provide reliable electricity services at affordable prices, manage peak demand, and reduce the carbon footprint of the electricity sector as a whole. To get a grip of the situation, discoms need to have a clear understanding of the electricity services that households are receiving and seeking at present and also their future needs. They also need to evaluate the range and quality of appliances, particularly white goods, their use patterns, and the appliance purchase behaviour to gain insights into the factors shaping power consumption in India's residential sector.

India has made many strides in mainstreaming energy efficiency at the end-user level and also in defining appliance efficiency standards, which is the focus of our approach as well. The Bureau of Energy Efficiency (BEE) at the national level, and respective nodal agencies at the state level, are engaged in efforts to get households shift to more efficient appliances. Some of the past evaluations, focused on urban India, point towards the changing consumer

perceptions and awareness about these initiatives (Dhingra, Walia, and Mukherjee 2016). Efforts have also been made to periodically gauge the preparedness and progress of Indian states to implement energy efficiency policies (Kumar et al. 2018).The large-scale shift to light-emitting diodes (LEDs) for lighting needs at the household level is the most successful outcome achieved. However, there is little by way of a comprehensive evaluation of how far the initiatives on energy efficiency across the range of appliances have fared - in promoting an understanding of energy or electricity bill saving and facilitating access to efficient products among the end consumers, including in rural areas.

The country stands at the cusp of change and spectacular growth in the power sector. So a better understanding of the current state of energy supply and demand in the country, and factors driving the decisions made by the households, are essential to chalk out future plans.

As India pursues the goal of 24x7 power for all, we felt the need for a nation-wide independent assessment of electricity access and use

1.3 Study objectives

Sensing a compelling need to gain an understanding of the prevailing situation, we have endeavoured to assess the supply and demand of electricity in the residential sector, through a nationally representative survey across 21 states of India. We term this the India Residential Energy Survey (IRES). The survey covers various dimensions of electricity and cooking energy use in households, but we limit our assessment to electricity supply and use in this report. This study answers the following questions:

1. With the Ministry of Power's Saubhagya portal showing universal electrification of willing households, does the ground assessment sufficiently back this claim?
2. What is the state of quality and reliability of supply, and its associated consumer satisfaction levels across the country? How do various states compare to each other on this front?
3. What is the state of metering, billing, and payment collection across households?

Based on our assessment, we propose strategies to fill the existing gaps to realise the goal of universal electricity access in India.

1.4 Organisation of the report

We have structured the report along the following lines. While in Chapter 2 we describe the survey sampling, questionnaire design, and data collection protocols, we move on to provide a descriptive assessment of the grid electrification status of households and identify the reasons for the gaps we observe, in Chapter 3. In Chapter 4, we examine the state of electricity supply duration, supply quality, and reliability, and discuss how consumers respond to supply disruptions.

In Chapter 5, we give a snapshot of how successful different states have been in laying the fundamental building blocks of a viable electricity distribution system. What share of the consumers are metered and billed, and how discoms collect electricity charges from them are also covered in this chapter.

In Chapter 6, we bring together the various aspects of electricity service discussed in the previous chapters to identify what determines a satisfied consumer. We close each chapter with a few key lessons. In Chapter 7, the final one, we synthesise the findings and provide suggestions and recommendations for policymakers and various state-level actors.

Field testing the questionnaires is a critical step of conducting surveys. CEEW's Sunil Mani leading the pilots in Patna, Bihar.

Image: CEEW/Market-Xcel

2. Survey design

IRES 2020 is a nationally representative survey of 14,850 urban and rural households spread across 152 districts in 21 most populous states of India including NCT of Delhi. The chosen states together account for 97 per cent of the Indian population. A brief description of the survey design and data collection process follows.[2]

IRES employed a stratified multistage probability sampling strategy

2.1 Sampling

A stratified multistage probability design was adopted for the survey sampling, as shown in Figure 1 on next page. Districts are the primary sampling units, while households are the ultimate stage units.[3] Within each state, a select number of districts (d) were sampled randomly from d/2 number of strata. Within each of the sampled districts, two basic strata were formed: (i) rural stratum and (ii) urban stratum, respectively, comprising all the revenue villages and urban wards in the district as per Census 2011. In each district, a total 12 villages/wards were sampled from the urban and rural strata, in proportion to the urban and rural population in the district. From each village/ward, eight households were randomly sampled. Overall, 96 households were sampled from each of the sampled districts. To factor in the unequal probabilities of selection, we use design (base) weights to estimate population estimates for our analysis.

2.2 Questionnaire design

The IRES questionnaire was designed to capture the socio-economic status of the households, state of electricity and cooking energy access, energy use pattern and equipment characteristics for major end-uses (cooking, lighting, space cooling, heating, entertainment, and other household needs), appliance purchase behaviour, and awareness about government schemes concerning energy-efficient appliances. Figure 2 depicts the major parameters captured in the survey.

2 A detailed description of study design can be accessed here: http://bit.ly/IRES1

3 We define a household as a group of people living together and taking food from a common kitchen.

Figure 1 IRES 2020 employed stratified multistage probability sampling method and covered 152 districts in 21 Indian states

India Residential Energy Survey (IRES)

Survey specs

6 researchers

20 field managers

40 supervisors

154 enumerators

300 days

MAR/19-JUN/19

Research Design

- Research focus
  Energy access and use
- Sampling strategy
  Multi-stage stratified
- Questionnaire design
  35-minute long

JUL/19-SEP/19

Survey Preparation

- Vendor selection
  Market Xcel
- Questionnaire translation
  10 languages
- Pilot studies
  3 states
- Questionnaire coding
  SurveyToGo

OCT/19-APR/20

Survey Execution

- Enumerator trainings
  9 locations
- Data collection
  Nov 19- Mar 20
- Data monitoring and cleaning

21 STATES
covering 97% population

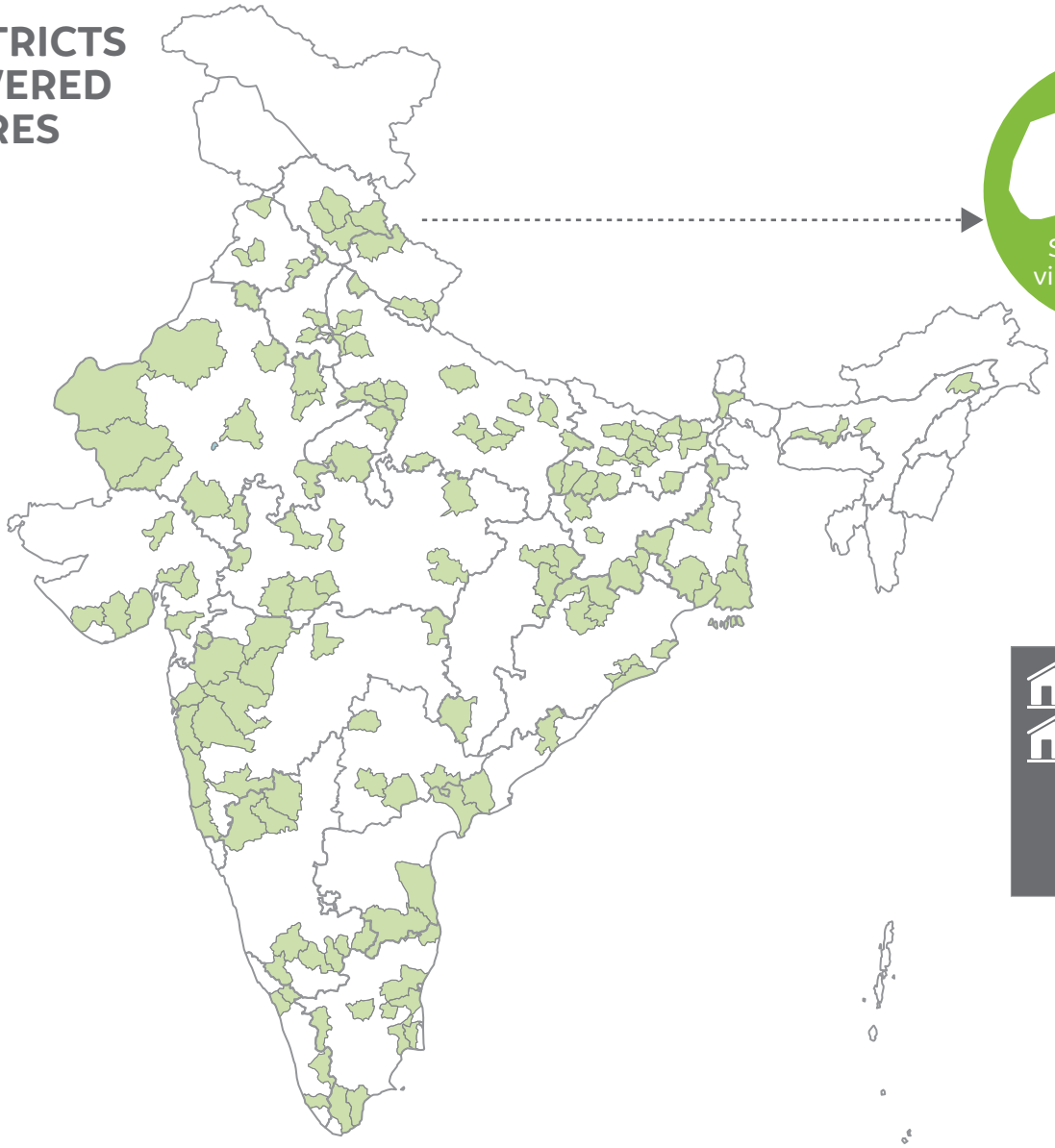
152 DISTRICTS
Cluster sampling

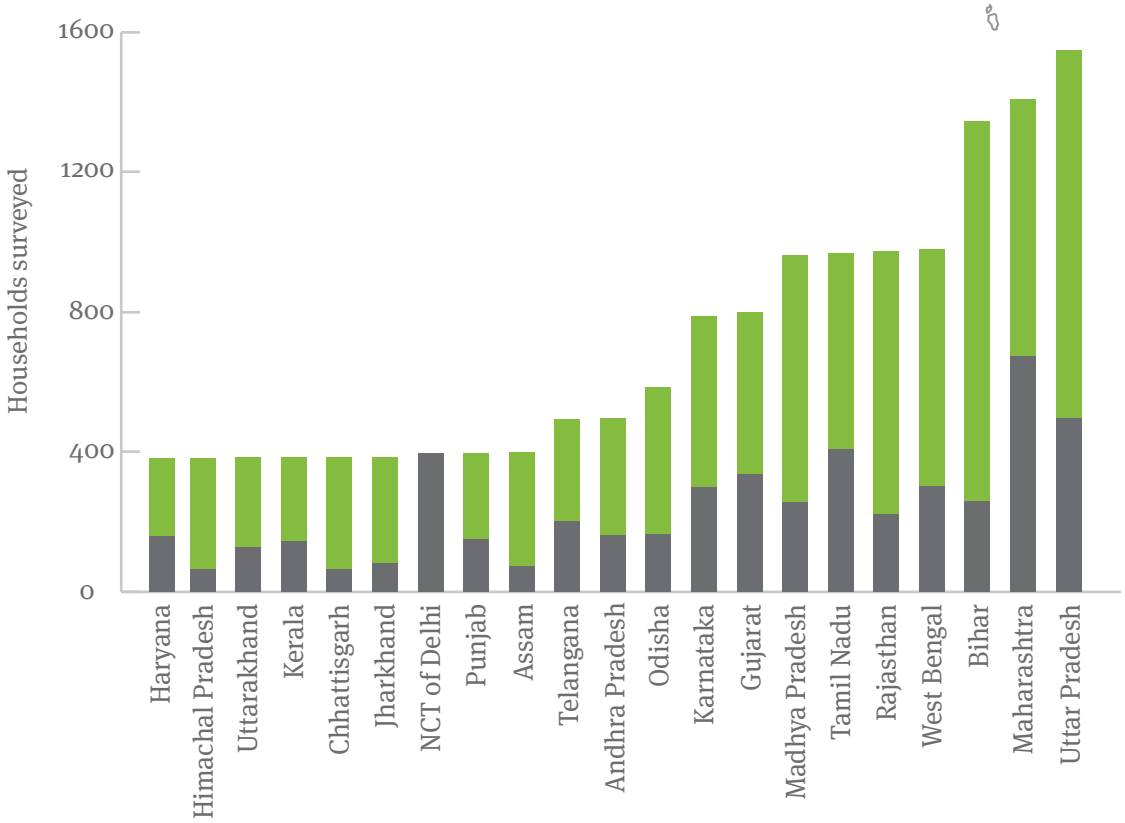
1210 VILLAGES & 614 URBAN WARDS
Cluster sampling

14,850 HOUSEHOLDS
8 from each village/ward

4 MILLION DATA POINTS

DISTRICTS COVERED IN IRES





Rural
66%

Urban
34%

Figure 2 The IRES 2020 questionnaire framework

Source: Authors' analysis

2.3 Data collection

In-person interviews (using the IRES 2020 questionnaire) were done by trained interviewers who used handheld tablets for recording data. A team of 154 enumerators (one-third of them females) and 40 supervisors was formed for the survey and all of them were provided thorough training involving classroom discussions, role-play exercises, and mock surveys in the field. The survey was conducted in 11 Indian languages: Assamese, Bangla, Hindi, Kannada, Malayalam, Marathi, Odia, Punjabi, Tamil, Gujarati, and Telugu. The questionnaires were administered between November 2019 and March 2020 and the median time taken per interview was 35 minutes.

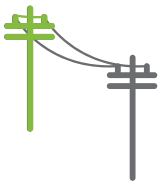
A team of 154 enumerators, a third of them females, and 40 supervisors conducted the surveys between November 2019 and March 2020

2.4 Data quality and limitations

Survey data is vulnerable to multiple errors arising out of recall bias, enumerator bias, or measurement error. The IRES data is no exception. To minimise these errors and ensure data quality, we employed multiple strategies, including thorough data quality checks. A key limitation of our data is a non-response rate of 26 per cent, primarily from urban areas and districts with a higher share of economically better-off households. So, we presume that aggregate estimates for parameters that are strongly correlated with household wealth/income levels are likely be under-estimated whose extent might vary across geographies.

3. Electrified or not?

As one drives across different parts of rural India, it is heartening to see the electric wires lining the landscape as far as one can see. They carry not just power but hope to the millions who use electricity to meet their lighting, cooling, life and livelihood needs. With the aggressive implementation of *Saubhagya* scheme since September 2017, 26.3 million households were given grid-electricity connections at subsidised rates or free of cost (Ministry of Power 2019). The *Saubhagya* dashboard reveals that all 'willing' households in India have been electrified, as of 31 March 2019. However, so far, no independent study has assessed the status of nation-wide electrification and estimated the share of households still living without electricity.



As per IRES, 96.7% of Indian homes have grid-connections and 0.33% rely on off-grid solutions exclusively

3.1 Household electrification rates

Our survey confirms that household electrification in India, though not universal, is nearing saturation levels. Around 96.7 per cent of Indian households are connected to the grid,[4] and 0.33 per cent of them rely exclusively on off-grid solutions including solar home system, solar mini-grids, battery storage, and diesel gensets.[5] More than 99 per cent of the urban homes are electrified, but the share is lower in rural areas at 96 per cent (Figure 3). Around 0.5 per cent of all households that once had grid electricity were disconnected from the grid, largely due to non-payment of bills. However, 2.43 per cent [95% confidence interval (CI): 2.18–2.69%] households are still unelectrified and most of these are in rural parts of the country.

4 Ninety-five per cent confidence interval (95% CI] for grid-connected households: 96.44–97.03 per cent.

5 Overall, 6.8 per cent households have non-grid solutions, of which 95 per cent use them as a back-up source along with grid electricity, while the rest rely on them exclusively.

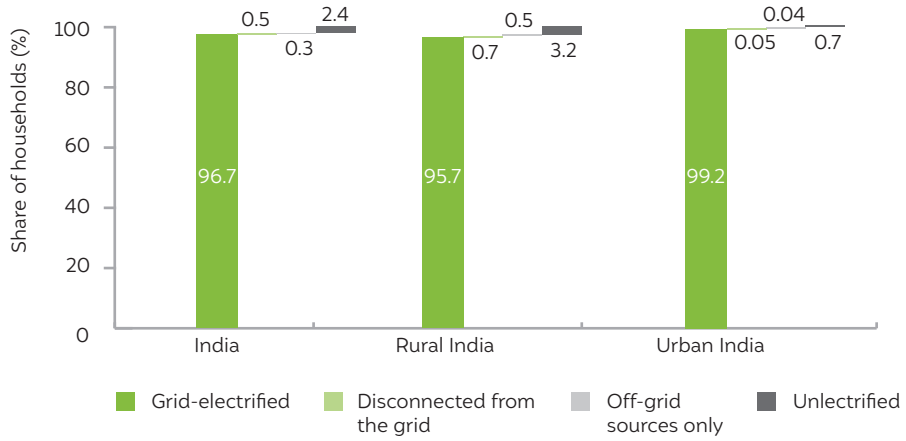


Figure 3
Household electrification in India is nearing saturation levels

Source: Authors' analysis

The government's efforts over the past decade in providing electricity access to the country's population have been commendable. The share of Indian households using electricity as a primary source of lighting rose from 67 per cent in 2011, as per Census 2011, to more than 96 per cent in 2020, as per our study.[6] The states of Andhra Pradesh, Assam, Delhi, Himachal Pradesh, Kerala, Punjab, Maharashtra and Telangana have achieved 100 per cent electrification (Figure 4). However, Chhattisgarh, Haryana, Rajasthan, and Uttar Pradesh have 4 per cent or more households without electricity.[7] Uttar Pradesh alone accounts for more than one-third of the unelectrified households, while Madhya Pradesh, Rajasthan, Haryana, and Bihar account for a further one-third of them. Future efforts to fill the electrification gaps need to focus on these states.

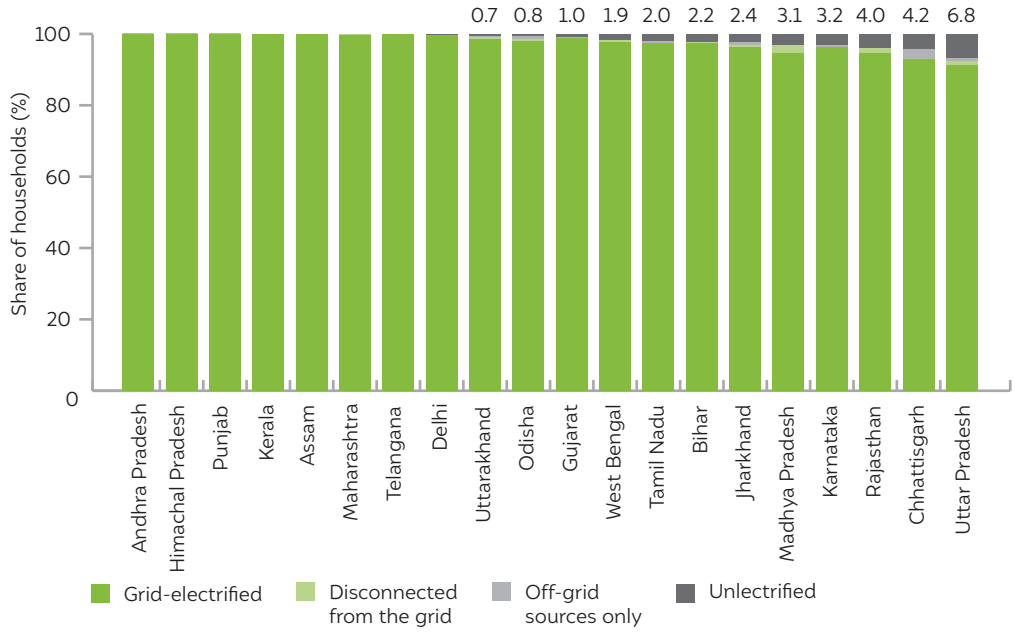


Figure 4
Majority of the unelectrified households are in a few states in north-central India

Source: Authors' analysis

6 This also includes 0.37 per cent of households that got grid connections but are yet to receive electricity supply.

7 Relatively a high share of unelectrified households in Haryana is partly due to small sample size and inclusion of just 4 out of 21 districts in the state.

3.2 Why are some households in India still unelectrified?

We asked all unelectrified households the reasons for why they are not having a grid connection. The key reason cited by majority of the households is their inability to afford grid electricity (connection) because of their low income (Figure 5). Connection cost is subsidised (zero for poor households) under the *Saubhagya* scheme.[8] It is possible that some poor households were unaware of the scheme, had difficulty in applying for the scheme, or may have not opted for the connection to avoid recurring monthly expenditure. We found in the Access to Clean Cooking energy and Electricity—Survey of States (ACCESS) in 2018 that several unelectrified households were unwilling to get an electric connection even if they were offered it free of cost (Jain et al. 2018). These households were found to have a limited capacity to spend on electricity bills or appliances.

A majority of the households that were disconnected from the grid after obtaining a connection (0.5 per cent) are in the states of Madhya Pradesh, Rajasthan, and Haryana. While such disconnection drives signal the much-needed action on part of the distribution companies regarding revenue collection, they also reflect the inability of many poor households to pay their bills. This could be partly on account of irregular billing by the discoms and the households' inability to pay huge sums in one go (details in chapter 5). In fact, 0.65 per cent of all households explicitly reported drawing electricity by hooking on to the wire illegally. This could still be a conservative figure as only a few households would admit to electricity theft.

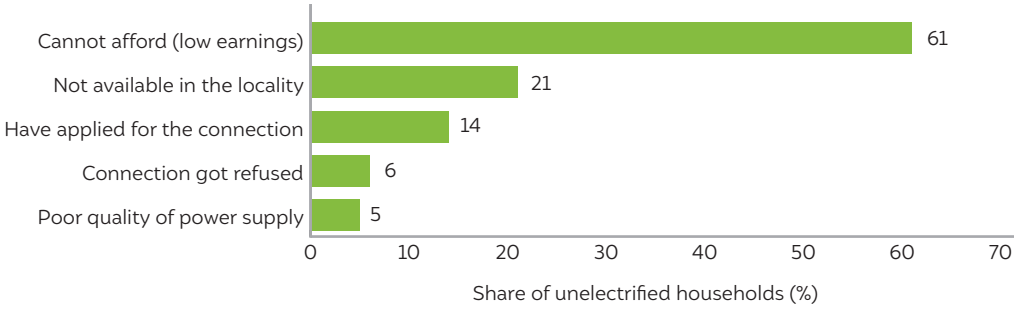


Figure 5
Inability to afford grid electricity is keeping some households off the grid

Source: Authors' analysis

Note: The numbers sum up to more than 100 due to multiple responses by some households

Nearly one-fifth of the unelectrified households cited lack of grid supply in their neighbourhood as the reason for not getting a connection. A majority of these households are from a few villages in select districts of Chhattisgarh (Bijapur and Jashpur), Rajasthan (Baran and Jaisalmer), and Uttar Pradesh (Mainpuri). This shows that there are still a few pockets where the grids are far off even as the *Saubhagya* scheme has largely overcome the challenge of access to infrastructure.

Among the unelectrified households, 14 per cent had already applied for a connection but are yet to get it. Among the applicants, six per cent of the electrified households had their connections refused as discoms cited failure of the applicants to furnish documents such as address proof or ration card. To enable electricity access to the remaining households so as to achieve universal electrification, suitable measures need to be taken by the government in relaxing norms for getting a connection.

Among the unelectrified households, most belong to the marginalised section of the society. Figure 6 shows the comparison between electrified and unelectrified households in rural areas, as only a few urban households remain unelectrified. Unlike electrified households, a

8 Under *Saubhagya*, all willing households in rural areas and poor families in urban areas can get free electricity connections. Poor households are those having at least one deprivation as per Socio-Economic and Caste Census (SECC) 2011. Households not found eligible as per SECC data can get electricity connection on payment of INR 500 per household, which is recovered by respective discoms in instalments.

higher proportion of the unelectrified households rely on labour activities, spend their life in a *kachha* house, do not have any motorised vehicle, and use traditional biomass as primary cooking fuel.

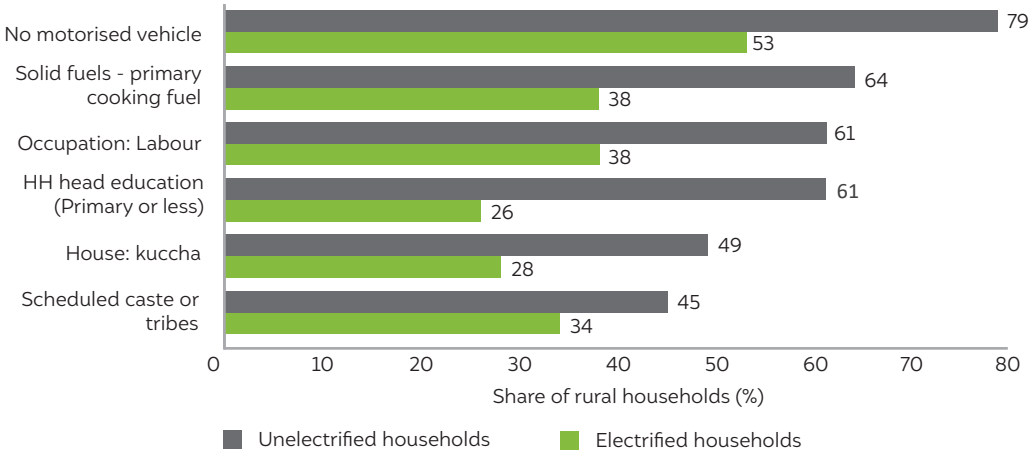


Figure 6
A majority of the unelectrified rural households are socially and economically marginalised

Source: Authors' analysis

Way forward

India has made a commendable effort on household electrification in achieving a near-universal coverage. The remaining 2.4 per cent of Indian households that remain unelectrified are located mostly in rural areas. A socio-economic assessment of the unelectrified households shows that most of them are multidimensionally poor. Based on our assessment of current gaps and their causes, we propose the following actions to achieve universal electrification.

- **Identify households yet to be electrified and electrify them by extending the grid-connection or through off-grid solutions (e.g. solar home system) in remote regions.** As most of the unelectrified households are concentrated in only a few villages in some states, targeted efforts to address the issues of infrastructure gap and documentation challenges are required for providing them a grid connection. Further, off-grid options such as a solar home system must be explored to provide poor households access to electricity.
- **Review and implement ultra-low tariffs for poor households with lifeline consumption to enable sustained use of electricity in an affordable manner.** Our survey shows that 0.5 per cent of Indian households that had grid connections earlier had them disconnected, mainly due to non-payment of bills. This raises concern that some households given free connections under Saubhagya may find it difficult to bear the recurring electricity costs, particularly after the COVID-19-induced economic slowdown. While all states in India have differentiated power tariffs for households, there is significant variation in the energy charges for low consumption categories across states. The states of Andhra Pradesh, Punjab, Chhattisgarh, Delhi, Gujarat, Odisha, Telangana, and Tamil Nadu charge zero or less than INR 100 for those consuming 30–50 kWh/month.[9] All these states, except Odisha, didn't report any cases of disconnection as per our survey. States that are presently charging high tariff for low-consumption categories could also implement ultra-low tariffs to help the marginalised households in sustaining their electricity access. However, more research is required on principles and definition of a lifeline tariff.

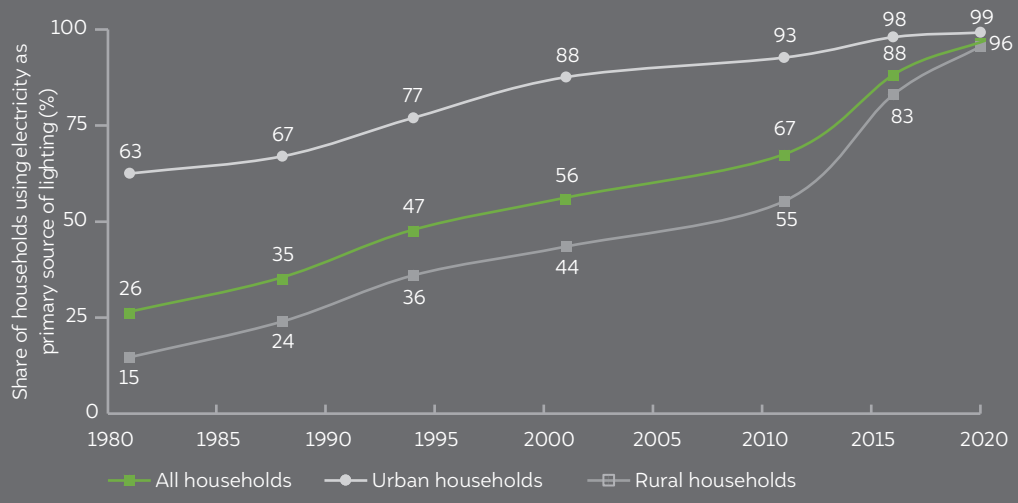
9 Based on the assessment of 2019-20 tariff orders of states in India.

Spotlight: Tracing the journey to universal household electrification

Since India's independence, electrification of urban households has progressed organically, but the electrification of rural households significantly lagged behind until recently. In 1981, 63 per cent of urban households were electrified, but only 15 per cent of rural India had access to electricity (Census of India 1981). Various governments in the past have, therefore, introduced targeted schemes for rural electrification. The earlier programmes focused on electrification of villages to enable functioning of irrigation pumpsets (1950s to 1980s). Later targeted household electrification coupled with infrastructure expansion became the government's priority (Palit and Bandyopadhyay 2017).

Figure 7 shows the share of households using electricity as their primary source of lighting at different points in time.[10] The pace of electrification of rural households received a significant boost from two schemes: Rajiv Gandhi Gram Vidhyutikaran Yojana (RGGVY) launched in 2005 (later subsumed under Deen Dayal Upadhyay Gram Jyoti Yojana) and Saubhagya scheme (launched in 2017). As a result, the share of households using electricity as primary lighting source in rural India more than doubled from 44 per cent in 2001 to 96 per cent in 2020. In short, successive government schemes have brought nearly 800 million Indians out of darkness over the past two decades, bringing India closer to the achieving the sustainable development goal (SDG) 7 of the United Nations.

Figure 7 India has made a remarkable progress in enabling household electricity access during the past decade



Source: Authors' compilation based on various surveys (NSSO, NFHS and IRES) and Census data

10 Annexure 1 provides source of data used to create this timeline and the details of the various government schemes.

India has made a significant progress in providing improved electricity services to households. A cowshed within a house in Barmer, Rajasthan.

Image: Shalu Agrawal/CEEW

4. Are the wires charged 24x7?

Our survey confirms that more than 97 per cent of Indian households are now connected to the grid. But do they also have seamless access to electricity supply? Has India delivered on the dream of '24x7 power for all'? Is the supply quality good? Importantly, how do consumers respond to supply disruptions from the grid? We shed light on these questions in this chapter.[11]

4.1 Duration of electricity supply

Indian households receive an average electricity supply of 20.6 hours per day [95% CI: 20.54–20.68] as per our survey results.[12] Urban households receive supply for 22.3 hours per day, but the rural households receive supply only for 19.9 hours per day. However, national level aggregates belie the wide variation in supply provided across the states in India (Figure 8). Delhi, Kerala, Gujarat, and Tamil Nadu are the top performing states in terms of duration of supply, where both urban and rural households receive electricity supply for 23 hours or more, on average daily. In contrast, households in Uttar Pradesh, Jharkhand, Haryana, Assam, and Bihar face the longest power outages, with rural households in these states facing six or more hours of daily power cuts on average.

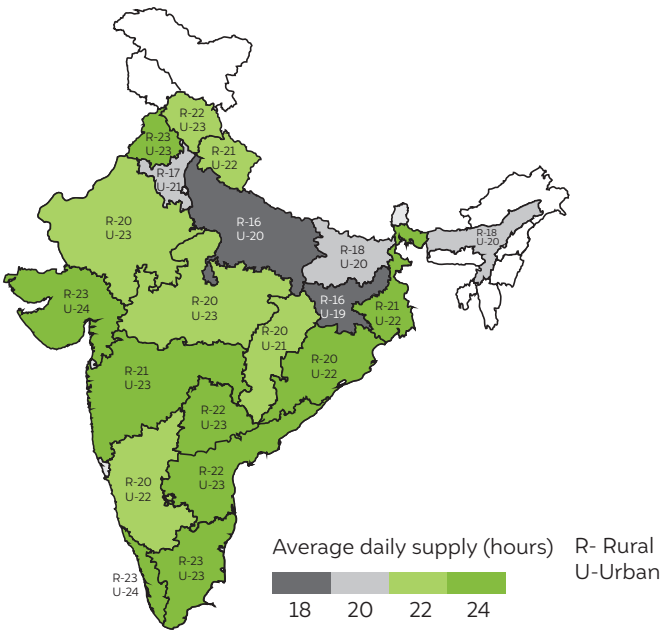


Figure 8
Rural households in many northern and eastern states typically receive less than 20 hours of grid supply

Source: Authors' analysis

11 Around 0.3 per cent of the grid-connected households were yet to receive power supply at the time of survey. In this and the subsequent chapters, we focus on households that receive grid electricity supply.

12 Our estimates of supply duration and quality are likely optimistic as the survey was conducted during the winter months when electricity demand is at its lowest in the year. In contrast, supply-related issues are more pronounced during summers when the residential power demand is at its peak.

As cross-sectional data does not shed light on how supply quality has changed over time, we rely on insights from past surveys to determine the trend. In 2015 and 2018, the CEEW conducted the first and second rounds of the ACCESS survey of around 9,000 rural households in six Indian states—Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh, and West Bengal (Jain et al. 2018).

Between the three surveys, in a gap of five years, the average daily supply has gone up by six hours across these six states: from 12.5 hours in 2015 to 15 hours in 2018 to 18.5 hours in early 2020.[13] Figure 9 shows the supply trends across the six ACCESS states, and it is upward sloping for all of them. Electricity supply in rural Bihar doubled from an average supply of 9 hours in 2015 to 18 hours in 2020. The current supply situation is a significant improvement over the service levels in the past, though a lot more needs to be done.

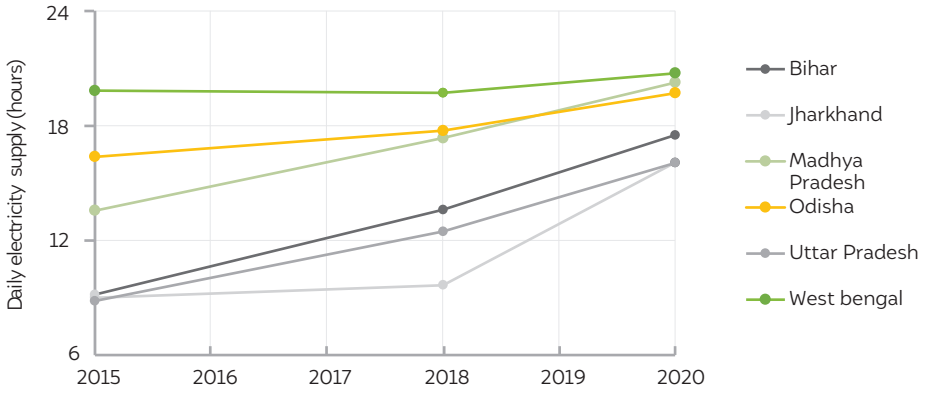


Figure 9
Rural electricity supply has improved significantly in all ACCESS states from 2015 to 2020

Source: Authors' analysis

For external validation, we also compare the supply hours reported by households in our survey with that reported by government. We find that households report lower supply hours than that reported at the feeder level across all states. We observe an average deviation of 1.8 hours/day and 1.27 hours/day in case of rural and urban households, respectively (see Annexure 2). This deviation could arise from faults and outages downstream from the feeder (typically at the distribution transformer (DT)), which translate into mean poorer supply to the end consumers than what is measured at the feeder level.

This underscores the need to monitor supply duration at the DT or the household level. As of 1 August 2020, 88 per cent of all DTs in urban areas and 64 per cent of them in rural areas are metered (Ministry of Power 2020). To plug leakages, discoms should build an internal capacity to use this metering data to track and address supply-related issues at the consumer end (Agrawal et al. 2020). Without granular monitoring, transparent reporting, and the associated corrective actions, it would be very difficult to ensure that the benefits of improved power supply reach every household relying on the grid.

Households report lower supply hours than that reported at the feeder level across all states

Predictability and frequency of power outages

Even though power cuts are undesirable, sometimes discoms have to undertake load shedding for repair and maintenance work. In such cases, utilities are expected to communicate scheduled outages well in advance so that consumers can plan their activities accordingly. Only 24 per cent households agreed that they had prior knowledge about power cuts and a majority of these households are located in Maharashtra, Tamil Nadu, Kerala, and Gujarat, the states with the lowest duration of power cuts.

In most villages and towns, power outages are largely unpredictable and people have to tolerate multiple interruptions on a daily basis (Figure 10). Nearly two-thirds of rural

13 A similar comparison of median supply hours across the three surveys shows that supply has improved from 12 hours in 2015 to 16 hours in 2018 to 20 hours in early 2020 across these six states.

households and two-fifths of urban households in India face power cuts at least once a day. Only 9 per cent of rural and 23 per cent of urban grid users reportedly receive almost an uninterrupted supply.

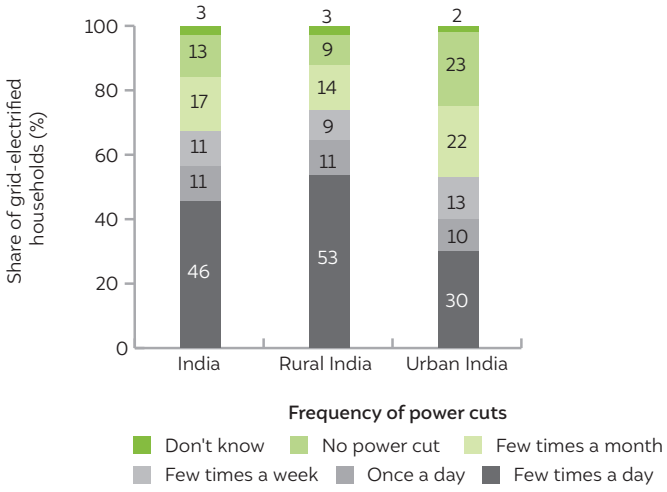


Figure 10
A majority of grid users in India face power outages at least once a day

Source: Authors' analysis

Rural households are most inconvenienced by interruption of supply that often happens during the evening hours, with half of them facing daily power cuts between 6 p.m. and midnight (Figure 11). But most of the urban households enjoy an uninterrupted supply during the evening hours.

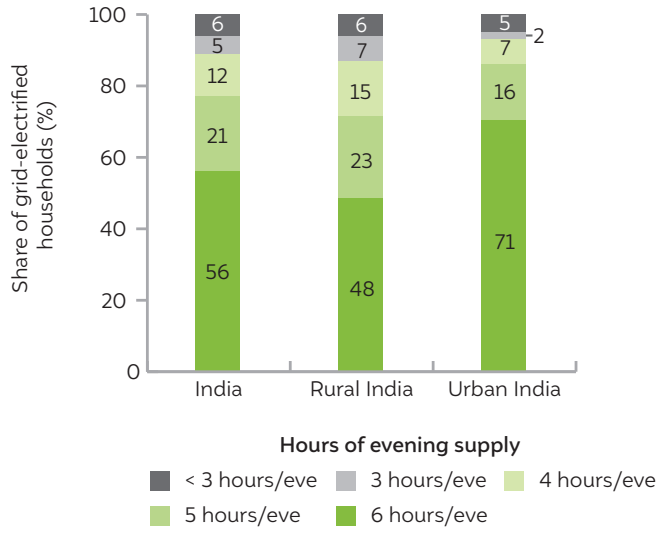


Figure 11
More than half of rural households in India face power cuts in the evening

Source: Authors' analysis

Unpacking outages in rural areas

Recently electrified villages were found to face both daily and evening power outages to a higher extent. Figure 12 shows that median power outage in villages is six hours per day for an average age of grid connection up to five years. The villages of Chhattisgarh, Jharkhand, and Uttar Pradesh, which have seen high rates of electrification under the *Saubhagya* scheme, were found to suffer average daily outages, which is strongly and positively correlated (0.6) with average outages during evening hours when supply is most needed.

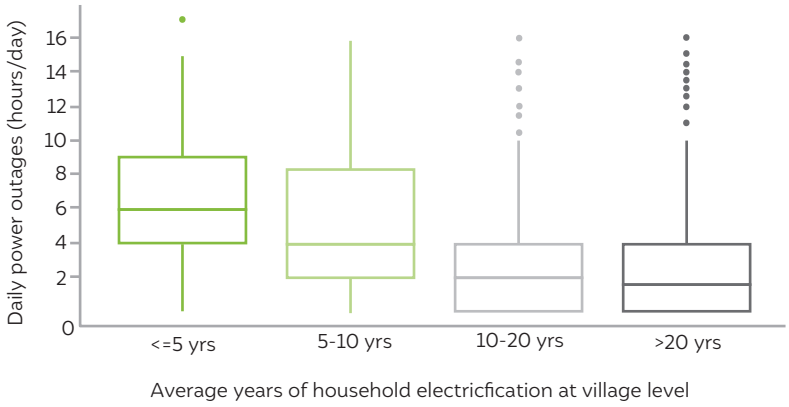


Figure 12
Power outages are higher in villages with newly electrified households

Source: Authors' analysis

Note: In this boxplot, the boxes represent the inter-quartile range and the line dividing the box is the median. The whiskers (vertical lines) connect the minimum and the maximum values

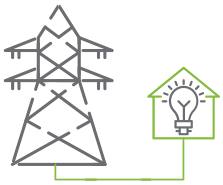
The reasons for power outages in rural areas can vary—faults due to strong winds, unscheduled shutdowns for repair work, and even animal intrusion at various parts of the distribution system. Equally, discoms have been found to indulge in load shedding in other areas, such as Notified Town Areas (Agrawal et al. 2020). Similarly, rural areas in many states face regular power-cuts even when nearby urban areas receive reliable supply during the same time (Phadke, Park, and Abhyankar 2019).

Tariffs for domestic consumers, particularly in rural areas, are significantly lower than the utility's cost of supply (Phadke, Park, and Abhyankar 2019), leading to discoms losing money on every additional unit supplied to rural consumers (PFC 2020). Therefore, discoms may be unwilling to provide full supply to some areas and may shed load during peak hours (or when procuring from the market is expensive) (Sengupta 2017). But ensuring availability of supply during all hours, across all consumer base, is of paramount importance, particularly during the evening hours, especially in areas that have been recently electrified. Improved supply would also help improve the willingness to pay the electricity bill among consumers (Kennedy, Mahajan, and Urpelainen 2019).

4.2 Supply quality and gaps

Besides the duration and predictability of supply, electricity access must also result in good quality supply, i.e. voltages within the prescribed ranges. This is crucial for the safety of both consumers and the electrical appliances. As per our survey, 19 per cent of the grid users reportedly faced very low voltages for one or more days during the month preceding the survey, while 11 per cent faced appliance damage due to voltage fluctuations in the previous month.

Besides the voltage related issues, reliability of electricity also remains a challenge. We asked households to report number of days in the past one month with outages longer than 12 hours/day in urban areas and 20 hours/day in rural areas. We find that every fifth grid user faced one or more days of long-duration outages (blackouts) over the previous month. Such long outages often happen due to faults in the distribution network as opposed to load-shedding.



Every fifth grid user faced one or more days of long-duration outages (blackouts) over the previous month

The prevalence of these issues is lower in cities and towns as compared to villages due to better network planning, maintenance, and faster resolution of complaints. However, nearly one-fourth of all households could not relate to the presence or absence of voltage related issues (due to limited awareness), implying that the extent of problem might be underreported.[14]

14 These estimates are conservative as our survey was conducted during the winter months when supply-related issues are less pronounced.

We also notice that the proportion of households affected by disruptions in supply varies across the states (Table 1). While some households in all states face supply-related issues, Jharkhand, Maharashtra, and West Bengal have the highest share of households suffering long duration outages, low voltages and voltage fluctuations. In contrast, Andhra Pradesh has the lowest share of households citing quality issues. Notably, Assam, Bihar, and Haryana, which resort to highest levels of outages (Figure 4), also fare poorly when blackouts are measured.

States like Himachal Pradesh, Odisha, and Tamil Nadu have a high proportion of households facing blackouts, despite low incidence of voltage issues, which could be attributed to weather-related faults/shutdowns. The majority of the surveys were conducted between the months of December and February in 2020, usually when Himachal Pradesh experiences snow, Odisha confronts tropical cyclones (e.g. *Bulbul* in November 2019), and Tamil Nadu receives the retreating monsoon and also witnesses some incidence of floods. These situations highlight the need for enhancing the resilience of power infrastructure to (extreme) weather events, particularly in view of their increasing frequency due to climate change.

Table 1 Households in some Indian states report higher instances of poor supply quality

State	Share of households facing long-duration outages at least once in last month (%)	Share of households facing low-voltage issues at least once in last month (%)	Share of households facing equipment failure due to voltage fluctuation in the last month (%)
Tamil Nadu	38	16	6
Himachal Pradesh	33	7	2
Karnataka	33	24	12
Jharkhand	32	38	26
Maharashtra	30	27	22
West Bengal	30	44	20
Assam	29	19	11
Odisha	26	15	3
Haryana	26	3	3
Bihar	24	17	11
Rajasthan	18	13	8
Uttar Pradesh	18	14	9
Uttarakhand	13	9	5
Telangana	13	11	9
Madhya Pradesh	13	15	10
Gujarat	12	14	9
Delhi	12	6	4
Chhattisgarh	10	27	8
Punjab	7	11	5
Kerala	4	17	7
Andhra Pradesh	4	7	3
All India	**22**	**19**	**11**

Source: Authors' analysis

0–5% 5–10% 10–20% 20–30% >30%

To gain an insight into geographical distribution of supply disruptions across states, we looked at the share of households that report any one of the three issues: (i) low voltages, (ii) appliance damage due to voltage fluctuation, or (iii) blackouts. Figure 13 shows that there is a significant intra- state variation in the quality and reliability of supply received by households. and these issues are more pronounced in certain districts, indicating infrastructural gaps. We urge the discoms to identify the trouble spots (districts or regions where electricity supply quality is not optimal) and make suitable interventions such as upgrading the capacity of distribution network and enforcing voltage regulation to ensure provision of reliable and quality supply.

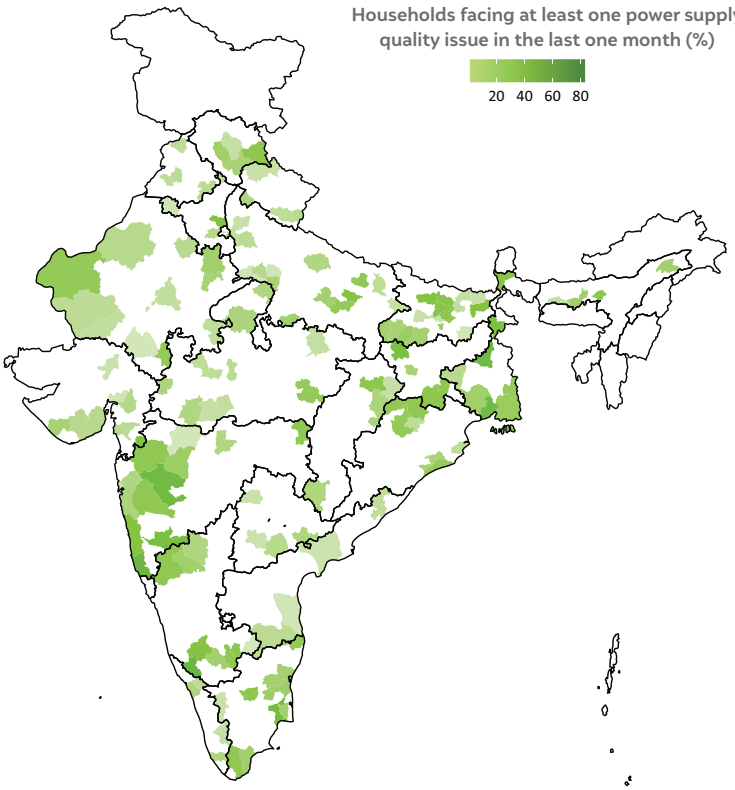


Figure 13
Poor quality and reliability of supply are pronounced in some districts of India

Source: Authors' analysis

4.3 Consumer response to supply disruptions

Most grid users in India face several supply-side issues, as explained so far, such as voltage drops, fluctuations, and day-long blackouts. However, discoms in India, as the supply licensees, are obligated to comply with the specified Standards of Performance (SoPs), and consumers are liable to be paid compensation if SoPs are not met (see Box 1 for details). Given these provisions, one would expect the electricity consumers to be aware of their rights under the SoPs and that they actively report the issues they face and get their supply situation fixed or claim compensation for deficiency in services. But what did we actually find on the ground?

When we asked if anyone in the family registered any complaint related to electricity fault or maintenance, only six per cent of the grid users reported 'yes'. Kerala was the only state where the complaint rates are as high as 13 per cent despite fewer supply issues. This may be due to high citizen engagement in decision making and politically active population in the state (Centre for Development Studies 2005). If households are more politically active, they are more likely to be aware about their rights, including those related to electricity supply provisions, and hence more inclined to register complaints. However, this hypothesis needs to be tested.

Only 6% households registered complaints about electricity fault or maintenance during past six months

Box 1: Standards of performance (SoPs)

In accordance with the provisions of the Electricity Act (2003), all the State Electricity Regulatory Commissions (SERCs) in India have notified SoPs for discoms. The SoPs specify performance targets for addressing issues related to power supply (outages), quality (e.g., voltage fluctuations), metering, and billing in a time-bound manner (Mandal et al. 2019).

To show compliance with SoPs, discoms are mandated to periodically submit their performance data to SERCs and compensate consumers in case these standards are violated. For instance, the electricity supply code in Uttar Pradesh prescribes various time limits for discoms to meet the performance targets for certain types of faults (Table 2). In case these targets are exceeded, discoms are liable to pay INR 50 to the affected consumers, but the claim for compensation has to be made by the consumers.

The supply code also directs discoms to inform the consumers in advance about any unscheduled or scheduled outages through various media, but discoms in Uttar Pradesh hardly adhere to this code. However, a few discoms at present report on their performance to SERCs with complete information and in a timely manner (Mandal et al. 2019).

Table 2 Performance targets for discoms in Uttar Pradesh

Type of fault/incident	Time limit to address the certain faults	
	Urban areas	Rural areas
Fuse blown from distribution mains/service pole	4 hours	8 hours
Overhead line breakdown	8 hours	48 hours
Distribution transformer failure	24 hours	72 hours

Source: Authors' compilation from UP Electricity Supply Code, 2005

Only 15% of the grid users are aware of the helpline number to register complaints about power supply issues

Our survey results show that only 15 per cent of the grid users in the country are even aware of the helpline number to register complaints regarding issues in supply. Low awareness means lower levels of complaints being registered. Surprisingly, the share of households preferring complaints is comparable in urban and rural areas despite rural households receiving relatively poorer standards of supply. However, discoms take a relatively shorter time to resolve complaints in urban areas. While every second urban household got their complaint resolved within six hours, only a third of rural households received such a quick response (Figure 14).

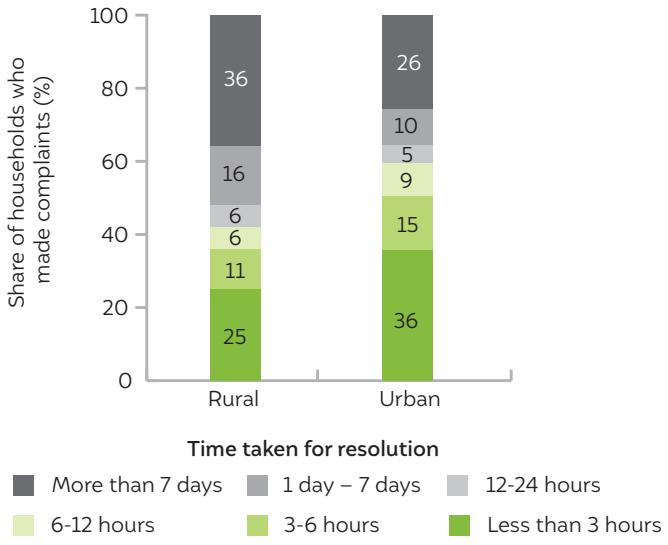


Figure 14 Complaint resolution efficiency is significantly better in urban India

Source: Authors' analysis

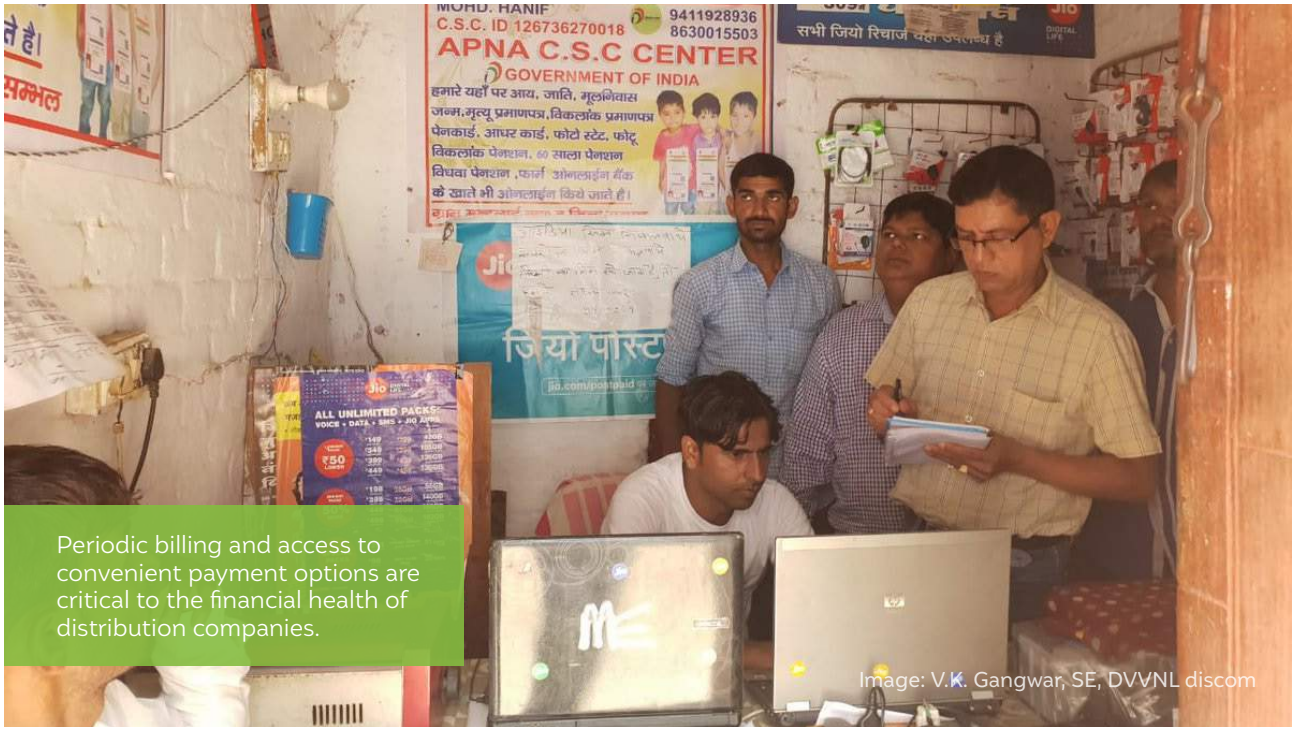
Rural areas are usually characterised by low housing density and are typically served by a 'power house' (utility office) that is located far away. This arrangement compounds accessibility challenges, which could be one of the reasons for discoms aggravating delay in repair and maintenance. A slower response in rural areas could also be due to lower standards (higher time limits) for complaint resolution prescribed in the SoPs for rural consumers than for urban consumers (Mandal et al. 2019). We strongly feel that there is a need to educate consumers about their rights regarding the provisions of the SoPs and for discoms to provide a consumer-friendly mechanism to register complaints. Further, SERCs must revise SoPs periodically to bridge the gap between urban and rural standards over time, especially as rural tariffs become increasingly closer to urban tariffs.

Way forward

India, having achieved commendable levels of electrification a decade ahead of the SDG target, has also made significant progress in providing improved electricity services to households, especially in some of the larger and economically less developed states. However, problems persist in the duration, quality, and reliability of supply in several states, particularly in rural areas. Service quality, even in the traditionally industrialised states, where high rates of electrification have been achieved much early, still shows some yawning gaps, which call for appropriate measures of improvement. The unpredictability of supply imposes significant costs on households. This ranges from reduced economic activity (home-based productive activity) to disruption of the normal course of life (often in case of the poor), both of which necessitate the households to pursue solutions to cope with unreliable supply (Zhang 2019). We strongly recommend that ongoing efforts should be sustained to strive for the aspirational goal of 24x7 power for all. We also suggest a few solutions for achieving this mission.

- **Real-time monitoring of power supply duration and quality at the DT level to identify areas with persistent issues and take corrective action.** Rural areas are most affected by power outages, especially those electrified recently. We also observed that the gap in supply quality is pronounced in certain districts. Planned outages as well as the poor health of distribution network in some areas are found to be the causes of supply quality issues. Infrastructure upgrades need to be undertaken regularly, but we recommend regular monitoring of the supply quality so as to institute improvements through targeted measures. Discoms must leverage ongoing efforts for DT metering to move towards an automatic meter reading facility. These targets were mandated in the bailouts that discoms have received in the past, including the recently concluded Ujwala Discom Assurance Yojana (UDAY). Thus, monitoring the progress of discoms at the national level and an independent audit of investments need to be undertaken to ascertain the infrastructure linkages created. Using data from this assessment, fund disbursals to improve metering and supply quality should be provisioned in the forthcoming schemes.
- **Educating consumers about their rights to register complaint and strict enforcement of SoPs.** Only a few consumers register complaints to discoms regarding supply quality issues, largely due to low awareness about their rights and the complex process of claiming compensation for the violations prescribed under the SoPs (Mandal et al. 2019). Consumer education on SoPs may be the need of the hour, but consumer activism does not serve as a panacea to the ills of supply quality issues. A strict enforcement of regulatory compliance by SERCs in form penalties (as specified in the regulations) on discoms for failure to meet SoPs would ensure even more a robust streamlining of discom operations. We also call upon SERCs to consider an alternate provision for 'automatic compensation' to consumers based on an independent monitoring of supply quality. If the compensation is contingent on receiving a complaint from the consumer and processing it, it is unlikely to elicit compliance from discoms.

5. Are the households being metered and billed regularly?



Periodic billing and access to convenient payment options are critical to the financial health of distribution companies.

Image: V.K. Gangwar, SE, DVVNL discom

The momentum for sustaining the aspirational goal of 24x7 power for all (elaborated in the previous chapter) could be sustained only if utilities realise increased revenue as well. One of the dimming lights in an otherwise brightening power scenario in India is the severe financial distress of discoms; more than half of the public discoms had aggregate technical and commercial (AT&C) losses of over 20 per cent in FY 2018–19 (PFC 2020). A key reason for the high losses is gaps in metering, billing, and collection (MBC) (Ganesan, Bharadwaj, and Balani 2019).

The addition of nearly 10 per cent of Indian households to the grid over the last three years has exacerbated the existing challenges of discoms on the MBC front. The high costs they incur in procuring electricity further piles up the financial stress of discoms also plagued by non-recovery of consumption charges from consumers. The financial analysis of discoms lies outside the scope of our survey, but we are of the view that prompt realisation of revenue from billed consumers would go a long way in supporting truly needy consumers by way of subsidies. It is critically important for discoms to put in place mechanisms to collect charges from billed consumers diligently. Our analysis of MBC challenges prompt us to take a recourse to technology to address those challenges efficiently.

93% of the grid-electrified households in India have metered connections, although about two per cent are dysfunctional

5.1 Progress and gaps in metering household consumption

Metering is the first step in measuring power consumption and signalling to the consumers that the intention is to charge them commensurate to the 'service' delivered. We find that 93 per cent of the grid-electrified households in India have metered connections, although about two per cent are dysfunctional. Further, unmetered connections and dysfunctional meters are more prevalent in rural India, as shown in Figure 15.

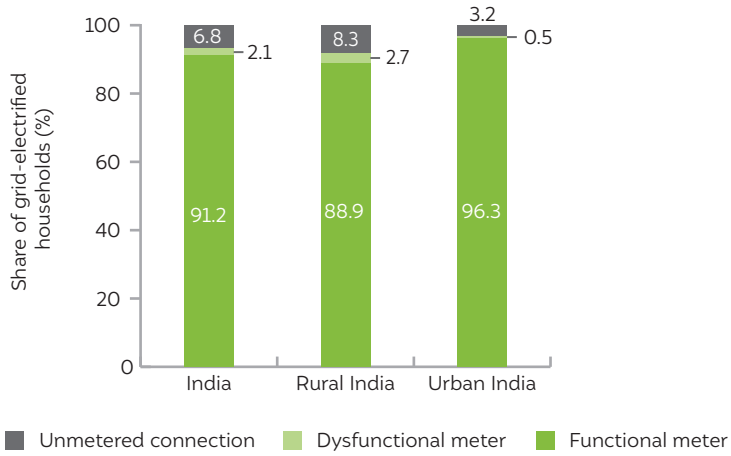


Figure 15
More than 10 per cent rural households do not have a functional electricity meter

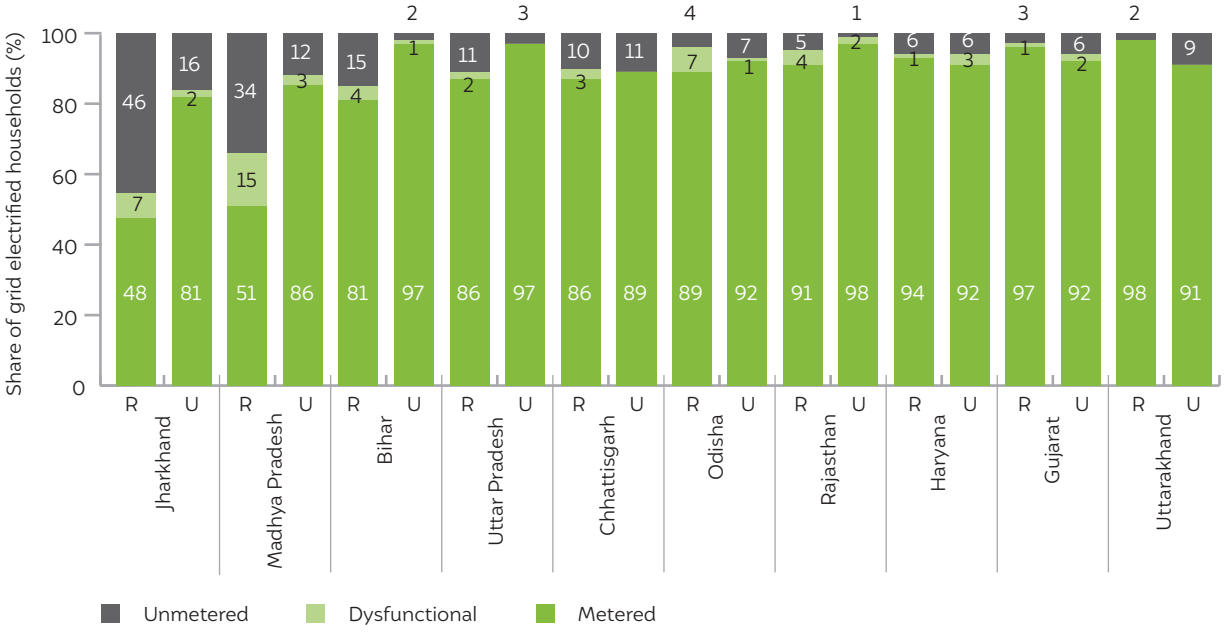
Source: Authors' analysis

A respondent to our survey from Kharagpur village of Palamu district of Jharkhand reported that, "the meter is kept in the house but has not been installed"

The gaps in metering are higher in the case of households electrified over the past three years - with 16 per cent having unmetered connections and 4.2 per cent having dysfunctional meters. A respondent to our survey from Kharagpur village of Palamu district of Jharkhand reported that, "the meter is kept in the house but has not been installed". The non-installation or non-activation of meters in newly electrified households means that those households cannot be billed, which in turn is a direct revenue loss for discoms.

Metering rates fluctuate between states, with all the grid-electrified households in Telangana, Andhra, and Himachal Pradesh having a metered connection, but only less than two-thirds of grid users in Jharkhand and Madhya Pradesh having meters. Overall, more than 5 per cent of the households have unmetered connections in 10 out of 21 states surveyed (Figure 16) and this is a significant number.

Figure 16 **Nearly half of the surveyed states have less than 95 per cent metering**



Source: Authors' analysis
Note: R = rural, U = urban

Though rural Jharkhand performs the worst on metering, a comparison with the ACCESS 2018 data suggests that household metering in the state has more than doubled in the last two years from 21 per cent to 55 per cent. Another household survey in rural Jharkhand

conducted between July and August 2019 found similar (51 per cent) metering rates in the state (Aklin et al. 2020). This surge in metering could be the result of the mandatory metering of new households electrified under the *Saubhagya* scheme. In fact, the share of metered connections has improved across all the six ACCESS states (Figure 17).

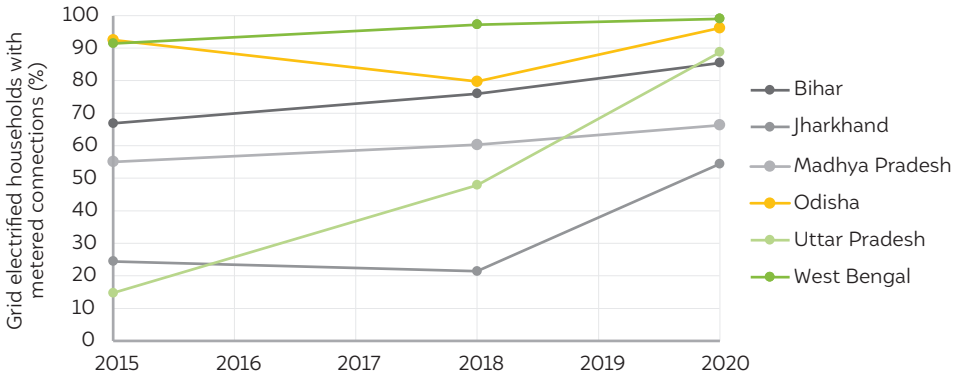


Figure 17
Uttar Pradesh has registered a commendable surge in metering its rural households

Source: Authors' analysis

Rural Uttar Pradesh has made an impressive surge of a six-fold rise in metered connections to 90 per cent in the last five years. West Bengal and Odisha displayed relatively high metering rates even in 2015. Rural Madhya Pradesh still lags behind in metering as 34 per cent of grid connections are unmetered and 15 per cent of users have dysfunctional meters. This indicates that the pace of installing meters in Madhya Pradesh has not kept up with providing new electricity connections under the *Saubhagya* scheme.

While many states in India have made significant progress on residential metering, more efforts are required to bridge the existing gaps in states like Jharkhand, Madhya Pradesh and Bihar. Metering all the electrified households is crucial for not only alleviating the commercial losses of discoms in India but also strengthening the consumer trust in billing.

5.2 Billing and its irregularity

The failure of discoms to deliver bills to electricity consumers directly reflects as their loss of revenue. As per our survey, 91 per cent of the grid-connected households in India are billed regularly, while another 4 per cent receive bills irregularly (a few times in a year or once in a few years).[15] About five percent grid users in the country have never seen a bill, even though most of them have been using grid electricity for more than a year. The problem of billing looms large in rural areas where 13 per cent grid users have either never received bills or get them irregularly (Figure 18).

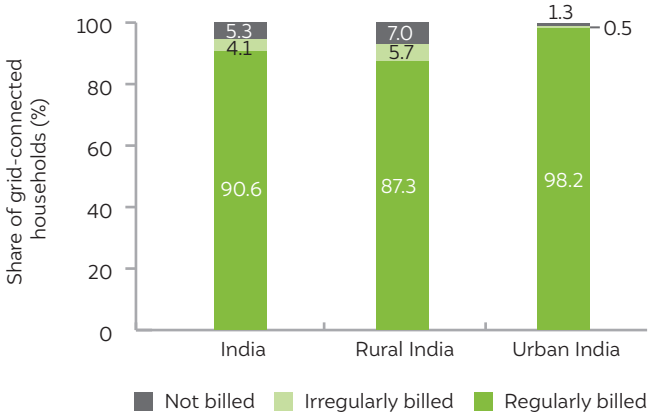


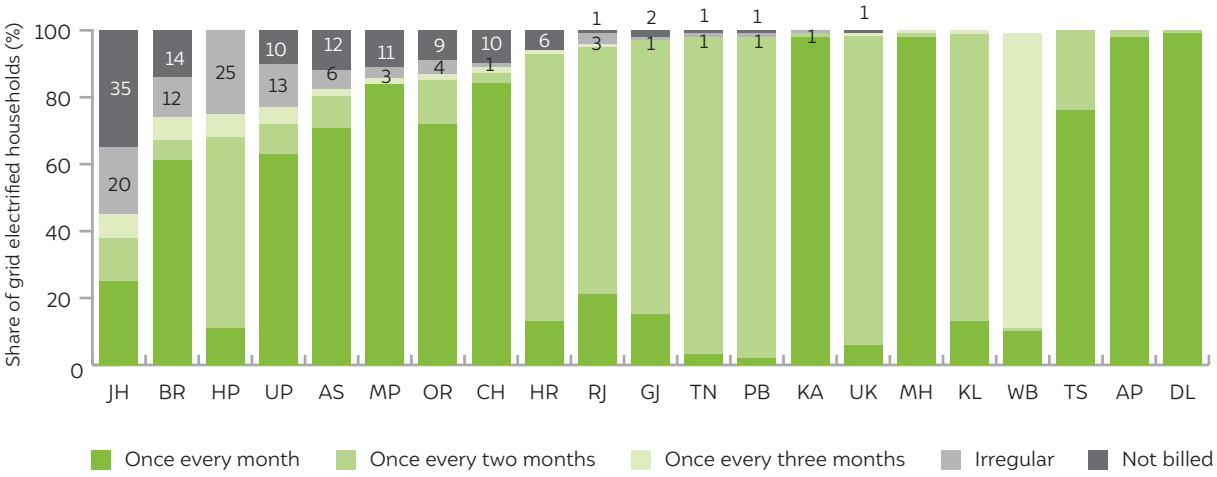
Figure 18
Around one-tenth of grid users in India receive electricity bills irregularly or none at all

Source: Authors' analysis

15 Households that are billed once in a month, once in two months, or once in three months are referred to as regularly billed households.

As with other issues, gaps in billing are prevalent in some states as shown in Figure 19. Jharkhand has the lowest share of grid users billed regularly (55 per cent), followed by Bihar (64 per cent). The problem of irregular or no billing is concentrated in a few districts of Assam, Uttar Pradesh, and Madhya Pradesh, as these states also have a high share of 'unbilled' or 'irregularly billed' households. For instance, in Uttar Pradesh, Purvanchal Vidyut Vyapar Nigam Limited (PuVVNL)—the poorest performing among the five public discoms in the state that reported aggregate losses of 40 per cent in fiscal year 2018–19[16]—holds around half of the unbilled households the eastern districts of Basti, Ballia, Gorakhpur, and Pratapgarh. Almost all of the irregularly billed households in Himachal Pradesh are concentrated in difficult-to-access districts like Kinnaur in the greater Himalayas, which could be a seasonal issue.[17]

Figure 19 **Grid users without regular bills are mainly located in a few states of north India**



Source: Authors' analysis

A 2018 study in Uttar Pradesh found that households that are billed regularly and frequently are more likely to pay on time and pay in full compared to households that are not (Ganesan, Bharadwaj, and Balani 2019). We therefore recommend that discoms must bill their consumers on a regular basis, so that the latter do not face the financial burden of accumulated bills while making the payments.

The choice of billing frequency by discoms is driven by several factors. While more frequent billing (once a month) would imply a lower carrying cost (specially as power procurement forms the major share of electricity costs), it would also require higher resources for bill generation and delivery. Discoms in most states generate bills once every month. But discoms in some states such as Punjab, Kerala, Gujarat, Rajasthan, and Tamil Nadu bill their consumers once every two months. West Bengal is a curious case, where most households are billed once every three months, except those served by the Calcutta Electricity Supply Corporation (CESC) Pvt Ltd who pay bills every month.[18]

Billing irregularities are aggravated in rural areas mainly due to due to high transaction costs and absence of adequate billing mechanisms. However, irregular billing would require consumers to pay charges for several months in one go, which can be a significant amount. Consumers, particularly those with low incomes, may find it difficult to pay such bloated bills. In fact, majority of the households that receive irregular bills are involved in

Majority of the households that receive irregular bills rely on agriculture or labour as their primary economic activity

16 As per PuVVNL filling for ARR & Tariff for FY 2019–20.

17 Household surveys in Himachal Pradesh were conducted in the month of February and March due to limited access in the month of December and January due to snowfall.

18 CESC serves Kolkata and parts of adjoining districts like Howrah, Hooghly, and South and North 24-Parganas districts.

agriculture or labour as their primary economic activity. For discoms, irregular or no billing directly reflects as lost revenue. Figure 20 shows that discoms in states with a high share of households with no or irregular billing typically report higher AT&C losses (PFC 2020). The AT&C losses result from multiple factors, but the moderate correlation (0.56) with gaps in billing underscores the need to fix the billing issues.

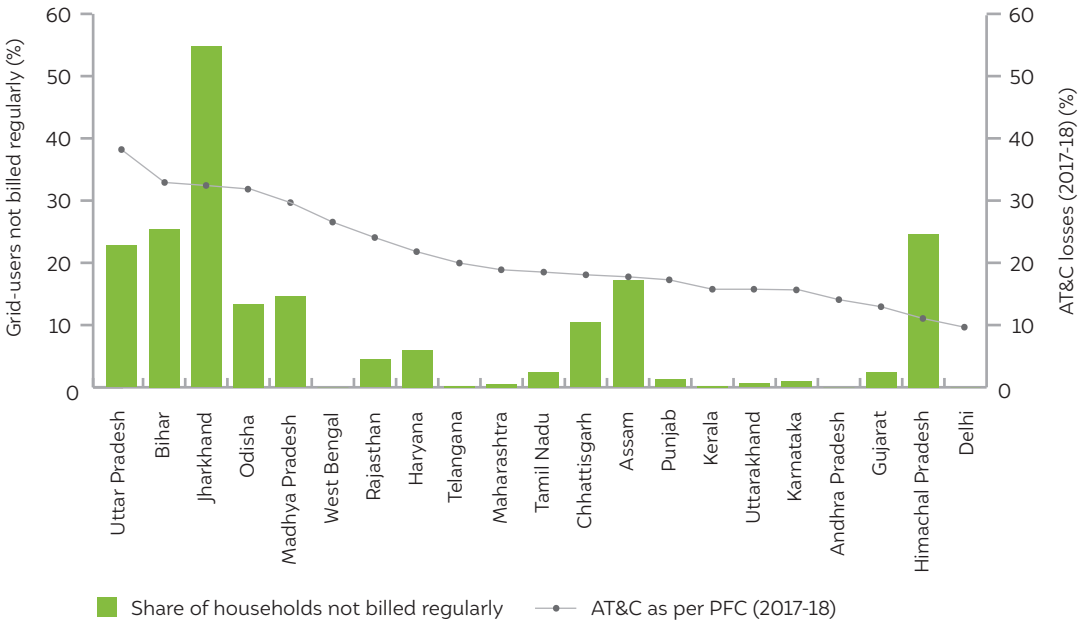


Figure 20
States with significant gaps in consumer billing also report high AT&C losses

Source: Authors' analysis

During our field visits and unstructured interactions in the field, many households also complained that their bills were higher than their expectations and often erroneous. This is a reflection of, on one hand, low levels of consumer trust in the utility and its agents (Ganesan, Bharadwaj, and Balani 2019) and, on the other, limited information about appliance usage and consumption patterns at homes (Agrawal et al. 2020).

Even though discoms may find it administratively and financially draining to issue bills to all its consumers, particularly in rural areas with low consumer density, investments to improve MBC as a whole can go a long way in building consumer trust and have positive returns in the medium term (Ganesan, Bharadwaj, and Balani 2019).

Less than 20% of the electricity users use digital payment modes to pay their bills

5.3 Tracking payment modes and consumer preferences

The aim of metering and billing the consumers is to generate revenues for the service provided and using excess revenue over cost to deliver quality services. In our assessment, nearly five per cent of the grid users have never received electricity bills and therefore have never paid for their electricity use. As regards the rest of the consumers, there are several ways they pay discoms for electricity services. What modes are preferred then by these consumers for making payments? This is an important question, as often customers' access to convenient and cost-effective payment modes is important for achieving a high collection efficiency.[19]

We find that a large chunk of electricity users in India pay their bills in cash, and just 17 per cent of billed consumers pay them using online modes. Payment in cash is primarily done through payment counters of electricity departments and also through collection agents (Figure 21). Nearly a fourth of urban consumers prefer online payments as it appears to be

19 Due to the problem of desirability bias, we did not capture information about payment frequency and compliance, and only focussed on payment modes used whenever the household paid its electricity bill.

more convenient than going to payment counters, banks, post offices, or the panchayat office to pay electricity bills.

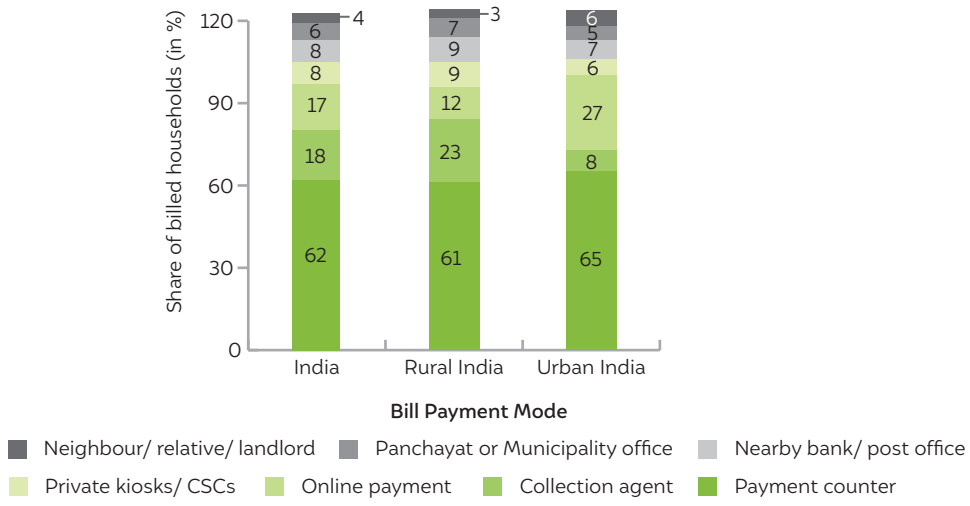


Figure 21
Most Indian households pay their electricity bills in cash

Source: Authors' analysis

Note: Many households rely on multiple payment options due to which the sum is greater than 100

A state-level assessment reveals that digital payments are most popular among consumers in Delhi, Tamil Nadu, Uttarakhand, and Maharashtra. But the uptake of digital payments is generally low in other states.[20] Bill collection agents collect payment from more than 80 per cent of electrified households in Odisha, which has the lowest uptake of digital payments. Karnataka, Bihar, Telangana and Andhra Pradesh are other states with high prevalence of door-to-door collection. But this is a costly and error-prone mechanism from discoms' perspective.

Nimble, efficient, and yet customer-friendly payment solutions, including digital payments and payment kiosks, can bring efficient results in this digital age. But, in our survey, consumers were less inclined towards digital payments. Past research shows that consumers' habit to use cash, perceived complexity of online payments, and concerns about fraud or hidden charges are the key factors behind low uptake of digital payments of electricity bills (Shah et al. 2016).

To understand the consumer's perception towards online payments, we asked the respondents about their experience of having made any digital payment before and their thoughts about the ease of paying their electricity bills through an online platform. Apart from the households that pay their bills digitally, only eight per cent of the households we surveyed admitted to making any type of digital payments ever. Another 19 per cent of those surveyed said that they may find it easy to pay their bills online though they have not done so before (Figure 22).

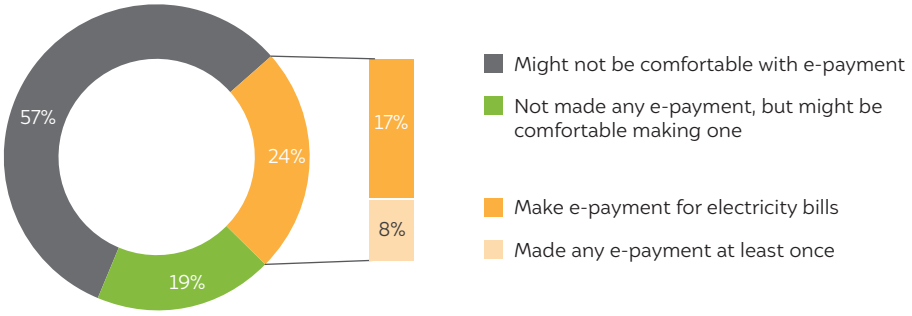


Figure 22
Less than one-fourth of Indian households admit to making any digital payment

Source: Authors' analysis

20 See Annexure 3 for details of payment modes popular across various states.

In our survey, we find that a majority of Indian households are not comfortable with the idea of digital payments. It is pertinent to note that 98 per cent of the households we surveyed have a phone and 70 per cent have a smartphone. Even though the technology gap is shrinking, the digital literacy gap remains. Our survey also revealed that households with at least one graduate member in the family are significantly more likely to make online payments as compared to other households.[21] To attract more consumers to direct digital payments, discoms would need to employ a multipronged approach, as described in the following.

As per IRES 2020, 98% of the households have a phone and 70% have a smartphone, underscoring the potential to promote digital payments

- **Creation of mobile applications with user-friendly interface to allow easy payment through wide array of options, including digital wallets.** These apps could be equipped with interactive videos to guide the consumers about various payment modes. To enhance their utility, discoms could enable multiple features in these apps, such as allowing consumers to track their consumption, view history of bill payments, and lodge complaints. A comparison of various discom apps reveals that apps of utilities in Bengaluru, Delhi, and Maharashtra have a wide range of features (Mandal et al. 2019). While many states have created such applications, there exists significant scope for their further improvement.
- **Give financial incentives, such as discounts, cashbacks, or gifts to consumers for online payment.** Discoms in Delhi, which attract the highest number of online payments, give one per cent rebate on e-payment of electricity bills, while CESC Kolkata gives a flat cashback of INR 50 on Amazon Pay. Discoms should also bear the merchant charges on behalf of the consumers, as their collection cost is lowered. Further, like in Punjab, discoms could also incentivise advance payments by consumers through rebates, which could reduce their working capital requirements.
- **Educate consumers** about the benefits and modes of digital payments through different communication channels and vernacular media on a sustained basis. More efforts would be required in rural areas where the uptake of online payments is currently very low.

Discoms should also promote indirect digital payments by leveraging *microentrepreneurs,* such as grocery shops, general merchants, and medical stores, to facilitate consumers to pay their electricity bills in their locality similar to a mobile recharge. At present, common service centres (CSCs) and information technology (IT) kiosks (such as *e-mitra* in Rajasthan) are used for collection of electricity payments from consumers, besides providing other digital services, in some states. However, their presence is limited as these are licensed agencies. Taking inspiration from the mobile recharge system, discoms must allow voluntary microenterprises to collect and pay electricity bills on behalf of consumers digitally, in lieu of a small commission. For instance, Maharashtra State Electricity Distribution Company Limited (MSEDCL) in Maharashtra has launched *MahaPowerPay*, an online collection system open to small entrepreneurs (MSEDCL 2020).

21 Twenty-six per cent of households having at least one graduate member pay bills online against just 12 per cent of households without a graduate member.

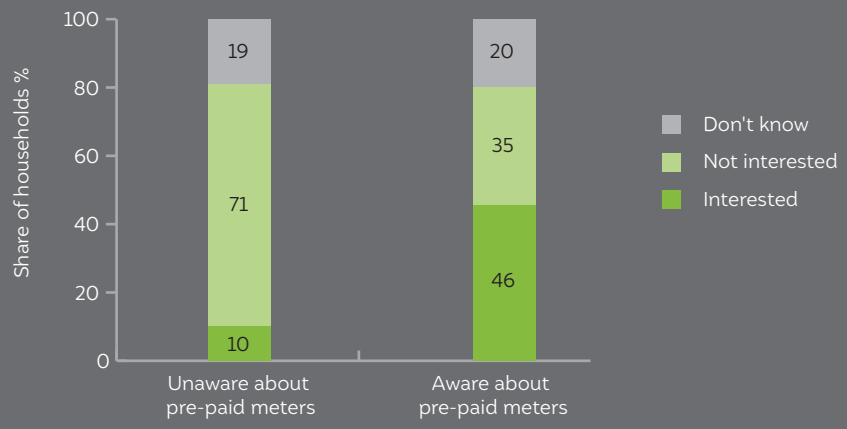
Spotlight: What do consumers think about pre-paid meters

Pre-paid meters have been deployed on a pilot basis across several states in India. They recently hogged the limelight as several government announcements were made calling for their universal deployment in the near future (Jai and Pillay 2020).

Unlike conventional electricity meters, pre-paid meters require consumers to buy electricity in advance like a pre-paid mobile recharge. In case the recharged amount is exhausted, the meter automatically disconnects the supply. Currently, discoms spend a considerable amount of resources on meter reading, bill generation, and revenue collection. Pre-paid metering is expected to shift these responsibilities away from the discoms and secure them timely payments and generate a continuous cash flow. Solution providers also list the benefits for consumers, such as the ability to budget energy expenditure and pay for electricity bills in small amounts, which could be conducive for some economically vulnerable consumers. However, before pursuing a transition to a pre-paid ecosystem for electricity bills in India, it would be pertinent to gather the consumer's perception of this solution.

As per IRES 2020, only 10 per cent of grid users in India have heard about pre-paid meters, with awareness being higher among urban households (14 per cent) than their rural counterparts (9 per cent). Even though meter deployment is the prerogative of the discoms, consumer awareness and social acceptance also matter. Every second household that was aware of pre-paid meters expressed interest in getting them installed in their houses (Figure 23). However, few among those who were unaware of the technology showed no or less interest in its adoption. Several pilot projects on smart meter deployment had faced significant resistance from the consumers (Chatterjee 2019; JnJ Powercom 2016). Thus, consumer engagement to build acceptance for the technology is essential.

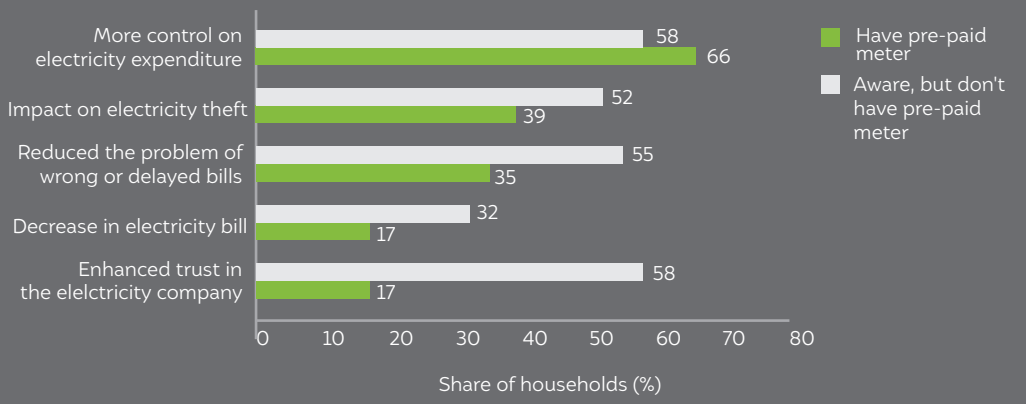
Figure 23 Households with prior awareness about pre-paid meters are more interested in getting them installed



Source: Authors' analysis

More than just awareness of consumers, their perception about benefits from the technology also matter. As per our survey, just 0.6 per cent of grid users have a pre-paid electricity meter, out of which two-thirds are in Assam, West Bengal, Maharashtra, Uttar Pradesh, and Bihar. We compared the difference in the perception of households that have a pre-paid smart meter and the ones that have only heard about it. Most existing users acknowledge that pre-paid meters enable a better control on their electricity expenses, but only a few acknowledge other benefits (Figure 24). In contrast, households that are aware but do not have pre-paid meters appear to be more optimistic about the technology benefits than the actual users.

Figure 24 Non-users of pre-paid meters are more optimistic about benefits of these smart meters than actual users



The above findings underscore the need for more pilot programmes are needed to clearly study its benefits to users as well as utilities so that any implementation issues can be addressed to avoid consumer dissatisfaction following a large-scale deployment. The use of pre-paid meters would entail a significant behaviour change on the part of consumers. Disconnection during odd times, or the inability of certain consumers to recharge in a timely manner, can cause immense inconvenience, as electricity can be considered a basic necessity of life (Swain 2020). Moreover, the availability of suitable pre-payment options and vending infrastructure that is easily accessible to consumers from all socio-economic backgrounds would be crucial.

Way forward

Concomitant with rising electrification, discoms in India have made significant progress in metering domestic consumers in recent years. Ongoing efforts are still needed to plug the gaps highlighted in our assessment. Nearly 10 per cent of the grid users do not receive bills or get them irregularly with no set periodicity. Similar levels of gaps persist on the metering front, especially among newly electrified households. Metering and billing issues are concentrated in a few states in India, which also happen to have high levels of AT&C losses. Ensuring revenue collection from all electricity consumers is another key challenge. Based on our analysis, we recommend the following actions.

- **Discoms must strengthen their billing and consumer information systems and also ensure timely delivery of bills based on metered units.** Given the restrictions posed by the COVID-19 pandemic that is sweeping the world at present, timely billing has become an issue to tackle for discoms across the country (Balani, Mani, and Agrawal 2020). Billing consumers, even based on historic consumption pattern, is possible only if discoms have a system of periodical billing based on metered readings. The respective state regulators must nudge discoms to invest more on improving the metering and billing practices, which would be crucial to bridge the trust gap and ensure higher collection efficiency.
- **Discoms must enable access to multiple and convenient modes of payment, including digital payment options.** In states where the bulk of newly electrified consumers reside, even conventional payment modes are not easily accessible for consumers. Given the poor levels of digital literacy and unfamiliarity with online payments, discoms must leverage microentrepreneurs at the local level, beyond their reliance on IT kiosks and CSCs, which also tend to be inaccessible to many in the rural areas. Discoms could also take inspiration from alternative approaches for billing and revenue collection implemented in Indian states, such as women self-help groups (SHGs) in Odisha and rural revenue franchises in Bihar (Balani, Sharma, and Agrawal 2020). To attract more consumers to make digital payments, offering financial incentives, developing user-friendly mobile applications, and providing widespread consumer education is required. In some areas (distribution circles or zones) with high incidence of commercial losses, discoms could consider deploying advanced metering solutions such as smart pre-paid meters. However, these high-cost technologies would require a systemic deployment approach informed by a robust cost–benefit analysis, in addition to gaining customer engagement and buy-in.

Uninterrupted electricity supply is directly linked to consumer satisfaction. A survey respondent in Hyderabad watching TV.

Image: Milan Jacob/CEEW

6. Are electricity consumers happy with the service?

Now that an almost universal coverage of electrification has been achieved and with service levels going up, a pertinent question to ask is 'are the electricity consumers happy' about their service offering? After all, customer satisfaction is the ultimate hallmark of the success of any service provider, and electricity should be no exception. In this chapter, we discuss the subjective satisfaction of households with their grid-electricity connections along with the factors shaping their perceptions.

6.1 Household satisfaction with grid electricity

Our survey reveals that 77 per cent of the grid-electricity users across the country are satisfied or very satisfied with their electricity service (Figure 25). Nearly 15 per cent grid users are not satisfied with discom's services while another 9 per cent do not have a clear positive opinion.

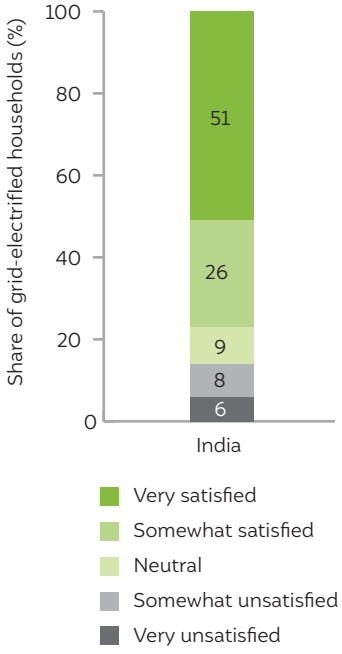


Figure 25
More than three-fourths of Indian households are satisfied with their grid-electricity connection

Source: Authors' analysis

The high level of satisfaction reflect the improvement in electricity services offered by discoms. In case of the six ACCESS states, we observe that rising satisfaction levels among rural consumers: from 26 per cent in 2015 to 57 per cent in 2018 to 71 per cent in 2020, which is commensurate with the consistent improvement in supply hours (Figure 26).

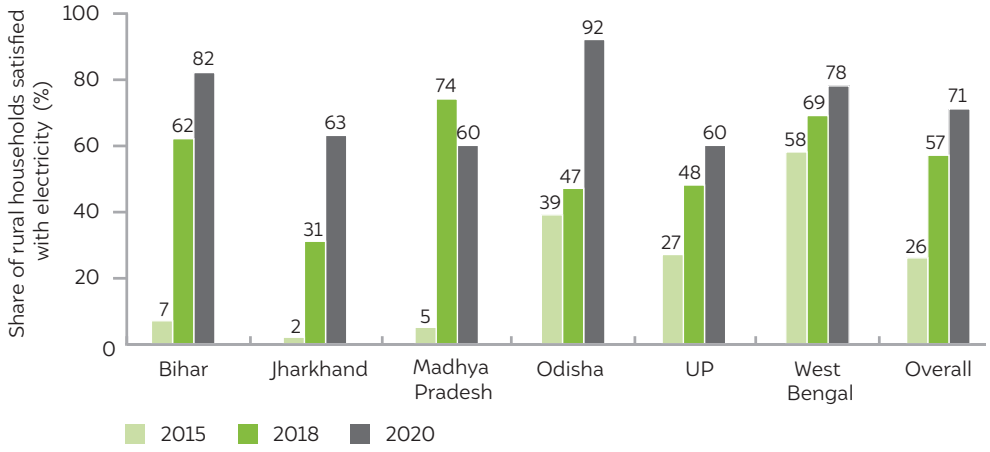


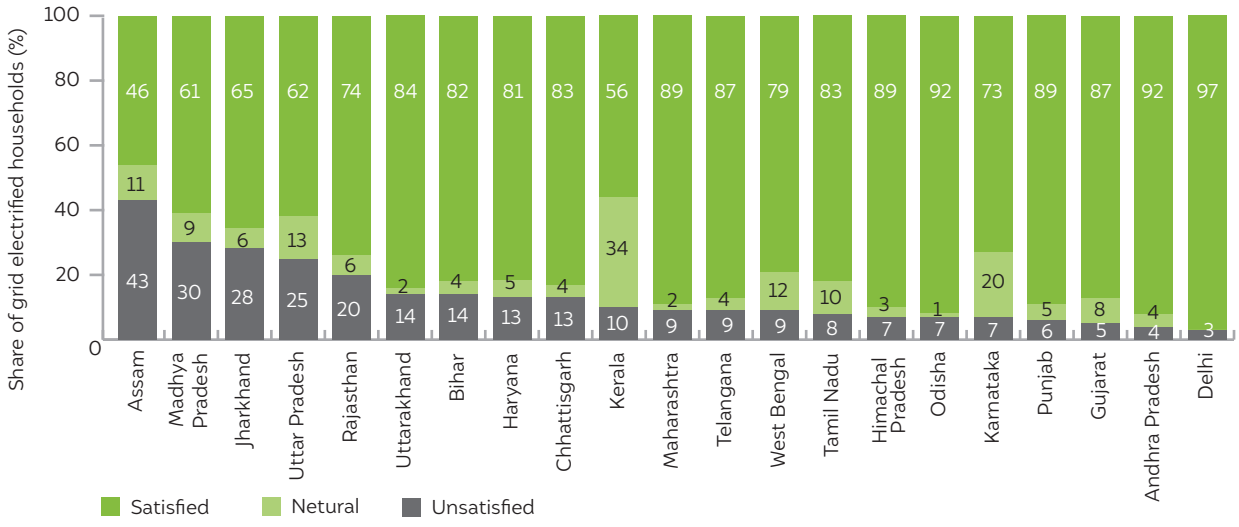
Figure 26
The share of satisfied grid-using rural households improved by nearly three times in the ACCESS states

Source: Authors' analysis

While the satisfaction levels are comparable across rural (76 per cent) and urban (81 per cent) households, we do find variation across states. Delhi, Odisha, Andhra Pradesh, Himachal Pradesh, Maharashtra, Punjab and Gujarat are the top states where ~90-97 per cent of grid users are satisfied. Barring Odisha and Maharashtra, the states where satisfaction levels are very high, outages last for less than two hours. At the other end of the spectrum, more than 25 per cent consumers are unsatisfied in Assam, Madhya Pradesh, Uttar Pradesh, and Jharkhand (Figure 27). As per our survey, some of these states have the highest power outages in the country.

A curious case as per our survey is Kerala, where only 60 per cent of the households expressed satisfaction despite reporting good power supply (23.5 hours/day on average), while one-third surprisingly chose to stay neutral. This reflects how consumer satisfaction is likely subjective to local cultural norms and ethos and may be influenced by other service-related factors.

Figure 27 Majority of the dissatisfied households are in northern and eastern India



Source: Authors' analysis

6.2 Drivers of customer satisfaction with grid electricity

In their assessment of consumer satisfaction with electricity, Aklin et al. (2016) found supply duration as the most important factor; voltage stability and reliability also emerged as significant predictors of consumer satisfaction, but they have only marginal effects. However, their findings are based on a 2014 survey conducted in rural areas of six Indian states. Household electrification and supply situation since then have significantly improved as our surveys show. So, we reassessed the factors linked to consumer satisfaction for urban and rural consumers in India using logistic regression on IRES 2020 data.[22]

22 Annexure 4 contains details of the regression analysis and results.

Our assessment of drivers of consumer satisfaction conform to the earlier finding that household satisfaction levels are strongly linked to the duration of electricity supply. The probability of satisfaction keeps rising with supply hours, with households receiving supply for 18 hours or lower per day less satisfied than those receiving more hours of supply. This holds true for both urban and rural households, with urban households being more sensitive to improved supply.[23] This implies that supply disruptions in urban areas are likely to cause greater dissatisfaction potentially because households in urban areas have been receiving relatively better supply than their rural counterparts and have higher expectations.

Household satisfaction levels are strongly linked to the duration of electricity supply

Interestingly, we find regular billing to be a significant predictor of consumer satisfaction with high marginal effect. Irregular billing results in accumulation of electricity charges (for several months of consumption), which can be challenging for many households to pay in one go.[24] Billing regularity is associated with satisfaction of rural consumers only as they are most subjected to either no billing or irregular billing. Reliability of supply also emerges as a significant factor associated with consumer satisfaction, highlighting the inconvenience caused by long outages. Voltage stability is also moderately associated with satisfaction of urban households.

Way forward

Our results show that with concerted efforts towards improving electricity services in India, more than three-fourths of the grid users are satisfied or very satisfied with their electricity situation. Though this is laudatory from our point of view, consumer expectations continually evolve. Supply duration, reliability, and quality along with bill regularity are important drivers of satisfaction. To sustain consumer trust and satisfaction, we propose the following recommendations.

- **Discoms must adopt a proactive approach to resolving any outstanding issues in service delivery.** The findings from our analysis underscore the importance of providing uninterrupted, reliable, and high-quality power supply to consumers, along with regular billing. Though their relative importance may vary, all these factors together determine the household satisfaction levels. Proactively resolving gaps in electricity services would enable discoms to become more user-centric and maximise consumers' utility from electricity consumption. This, in turn, would set in a virtuous feedback loop as the consumer's willingness to pay for electricity is found to increase with improvement in service delivery (Kennedy, Mahajan, and Urpelainen 2019).
- **Discoms must assess the consumer satisfaction levels and related supply variables on a regular basis.** Our assessment of consumer satisfaction is limited as it relies on cross-sectional data, which does not capture the variation in electricity services over time. Interactions with households during multiple field visits reveal that often consumer satisfaction is determined by the relative improvement in supply hours over time. This may explain some anomalies, such as higher satisfaction rates in Odisha than Gujarat or Telangana, even though households in the former report higher power outages and blackouts. Regulators could mandate the discoms to periodically assess consumer satisfaction, besides reporting on supply metrics. This will enable a much more nuanced understanding of how temporal improvements in supply influence consumer behaviour and expectations. A sustained (even if gradual) improvement in the duration of supply is likely to reap rewards for discoms and improve their ability to recover electricity charges from consumers.

23 Urban households receiving more than 22 hours of supply per day have up to 32 per cent higher probability of being satisfied than those receiving less than 18 hours of supply. For rural households, this probability is up to 20 per cent. We estimate these probabilities using the general rule of thumb: one-fourth of a logistic coefficient gives an upper bound of predictive difference corresponding to a unit increase in the predictor.

24 As compared to households getting less than 18 hours of daily supply, households receiving more than 22 hours of supply are up to ~20 per cent more likely to be satisfied. In comparison, households getting regular bills are 10 per cent more likely to be satisfied than those billed on an irregular basis.

A majority of distribution transformers (DTs) in India are already metered. Monitoring supply quality at the DT level is critical to ensuring good quality supply.

Image: iStock

7. Conclusion

When we were conceptualising the IRES survey, in the summer of 2019, the world was a different place. India had achieved what was considered an impossible milestone in record time—electrifying nearly all households across the length and breadth of the country and opening a world of opportunity for the hitherto unconnected to reap the benefits of household electrification—and that was celebrated widely. The latter half of 2019 was already showing signs of an economic slowdown, with declining power demand being an unmistakeable sign of times to come. The COVID-19 pandemic only helped that slide to deepen further. Newly electrified households or others are still very much connected to the grid, and they remain the only constant in these times of uncertainty. A new wave of the pandemic, further restrictions, or a protracted economic slump will likely impact consumption in other sectors quite intensely. The implications of the ongoing pandemic on various facets of the distribution system and particularly on households is only beginning to play out.

While tariff rationalisation is much needed to provide fillip to industrial and commercial activity, support to deserving poor consumers must be sustained through budgetary support

Our study finds that 2.43 per cent of the households are yet to be electrified, mainly in the rural hinterlands of northern and central India. We suggest that the discoms' approach to electrifying these households should be based on scalable solutions that are fit for purpose and do not burden the utility with excessive capital investment or the consumer with a bill that they cannot afford. There is evidence of many who were connected to the grid but excluded later, presumably because of their inability to pay for the services of the grid. The proposed National Tariff Policy (2020) and the draft amendment to the *Electricity Act (2003)* call for a tariff that brings about more parity across consumer categories along with a parity in service provisions. This implies that the cross-subsidy presently enjoyed by residential consumers in many states is likely to diminish, leaving them to foot a higher bill. This will only hasten the exit of many more consumers from the grid or, even worse, drive them towards illegal access of grid services. While tariff rationalisation is much needed to provide fillip to industrial and commercial activity, in a slowing economy, support to deserving poor consumers must be sustained through budgetary support. For determining who needs support, we need to understand the needs of consumers at various economic rungs—wealth and income classes, and assess which groups need support and to what extent. This report and the underlying survey provide useful insights on this from, though more research is needed on this front.

We find that the aspirational 24x7 power for all has not been achieved in many parts of the country—neither urban nor rural. Supply hours have improved in leaps and bounds in rural areas in the key states such as Uttar Pradesh and Bihar. However, outages in the evening hours and during times of peak demand in the system still suggest that much more needs to be done. Such outages are happening despite the surfeit of power, and is, of course, tied to the financial troubles of distribution utilities, which need sustainable remediation. The top two priorities for the discoms on this front would be to maximise revenue (by streamlining

the metering, billing, and collection mechanisms) to then be able to invest adequately in infrastructure as well as tune up performance management to reduce technical losses, thereby improving their overall operational performance.

We find that the reliability of supply and quality still need to catch up to achieve satisfactory levels. While these issues are concentrated in specific districts or regions, it is pertinent to point out that even in urban areas, unscheduled outages—lasting up to 12 hours—only show how the distribution utilities are flouting standards of performance (SoPs) and without consequences. We find that the average consumer, being unaware of consumer rights, does little to hold the utility accountable for unreliable supply. The onerous task of taking utilities to task is left to a few civil society organisations that represent the issues of the consumer, which is not a scalable and sustainable approach to ensure reliable electricity supply.

Discoms must put in place an automated mechanism for periodic monitoring and reporting on achievement of standards of performance

We propose that a technology-driven monitoring mechanism, with automated and periodic reporting on achievement of SoPs by utilities at all levels, must be put in place. We further call upon the regulators to mandate the installation of these systems in a time-bound manner and prioritise investments to enable discoms to achieve transparent reporting on supply quality and quantum. Compensation to the consumers, in cases of failure of discoms to meet the SoPs, must be time-bound and automated. The recent draft of *Electricity (Rights of Consumers) Rules 2020* contain these provisions, which need to be implemented in coordination with the state government, regulators and discoms. This, of course, would require robust metering and transparency in reporting by utilities. Equally, efforts to educate consumers about their rights also need to be taken up through the right channels. Resources for consumer education provided for in the budgets of discoms are not entirely utilised effectively. Outages and unreliable supply are ultimately bad outcomes and the associated costs could be far higher than what discoms 'save' by not supplying the power. Studies that determine these costs must be carried out and communicated effectively to all stakeholders to help drive demand for a 24x7 reliable power supply.

We strongly believe that consumers have a role to play in making our discoms viable and improving the supply overall—they are the ones who ultimately pay the bills and help generate revenues that flow upstream to generators, fuel providers, and a host of allied sectors. We did a novel assessment of the metering, billing, and collection practices across the states. We find that in recent years there has been a phenomenal increase in metering in some large states and the universal metering metric is likely to be achieved soon. However, the main purpose of metering is to enable delivery of bills on time and ensure regular collection of consumption charges from consumers. Our survey shows that over five per cent of consumers have never received a bill and a few more of them receive bills that are not with a set periodicity. This is detrimental to the consumer–discom relationship, as timely billing and timely payment go hand in hand for continued good services. The discom though has to be the starting point for triggering an improvement in this regime. Streamlining of the MBC process as a whole in enabling delivery of bills based on metered readings is the need of the hour for discoms. There is also an urgent need to make the payment processes seamless and hassle-free for the consumer. The COVID-19 experience calls for innovation to enable some form of regular payments for services. With physical access to the few representative offices and payment centres of the discoms becoming more restricted, other modes of payments, primarily technology-enabled online payments through multiple channels that are available now, should be harnessed effectively. For this transition, consumer trust on every actor in the value chain is important and that trust begins with the electricity bill that is based on a metered reading and generated periodically.

The Covid-19 experience calls for innovative and technology-enabled payment channels to enable regular and hassle-free payments by the consumers

Finally, research has shown that satisfied consumers gladly pay for the services rendered. What determines consumer satisfaction? In our assessment, duration of supply is the prime

influencer. As service delivery evolves, quality of supply and even aspects like a reliable bill that informs consumers about their obligations are important in driving consumer satisfaction. We strongly believe that discoms must work towards meeting consumer expectations. This starts with building trust and improving transparency in their overall operations. Electricity in India is treated as a public good, but to operate the systems, financial viability and establishing value proposition are equally important. We expect reforms proposed in the Electricity Act Amendment Bill (2020) to create an upheaval of sorts in the discom model—more accountability but with a higher price tag.

In forthcoming studies, as part of a series of analyses of the IRES, we will deliberate on how energy efficiency is seen by residential consumers and the approach to improving penetration of efficient appliances to various categories of consumers. We will also deliberate on subsidy targeting and the fiscal room that discoms and states can create for themselves by assessing the consumer profile and determining deserving beneficiaries.

Electricity in India is treated as a public good, but to operate the systems, financial viability and establishing value proposition are equally important

References

Agrawal, Shalu, Sunil Mani, Karthik Ganesan, and Abhishek Jain. 2020. “What Smart Meters Can Tell Us Insights on Electricity Supply and Use in Mathura and Bareilly Households.” New Delhi: Council on Energy, Environment and Water.

Aklin, Michaël, Brian Blankenship, Vagisha Nandan, and Johannes Urpelainen. 2020. “Energy in Rural Jharkhand.” Initiative for Sustainable Energy Policy and Oak Foundation.

Aklin, Michaël, Chao Yo Cheng, Johannes Urpelainen, Karthik Ganesan, and Abhishek Jain. 2016. “Factors Affecting Household Satisfaction with Electricity Supply in Rural India.” *Nature Energy* 1 (11): 1–6.

Balani, Kanika, Sunil Mani, and Shalu Agrawal. 2020. “Solving for Billing and Revenue Collection Challenges.” Navigating India’s Power Crisis During Covid-19: A CEEW Blog Series. 2020. https://www.ceew.in/news/navigating-india’s-power-crisis-during-covid-19-part-2.

Balani, Kanika, Bharat Sharma, and Shalu Agrawal. 2020. “Addressing Discoms’ Revenue Recovery Concerns Post the Pandemic: A Case Study of MVVNL Discom in Uttar Pradesh.” New Delhi: Council on Energy, Environment and Water.

Census of India. 1981. “Census of India - 1981: A Handbook of Population Statistics.” New Delhi: Office of the Registrar General & Census Commissioner, India (ORGI).

Centre for Development Studies. 2005. “Human Development Report 2005 - KERALA.” Thiruvananthapuram: State Planning Board, Government of Kerala.

Chatterjee, Anupam. 2019. “Prepaid Electricity Meters: Early Results Leave More to Be Desired.” Financial Express. 2019. https://www.financialexpress.com/economy/prepaid-electricity-meters-early-results-leave-more-to-be-desired/1742456/.

CRISIL. 2020. “Discom Debt to Hit All-Time High of Rs 4.5 Lakh Crore This Fiscal.” CRISIL Ratings. 2020. https://www.crisil.com/en/home/newsroom/press-releases/2020/06/discom-debt-to-hit-all-time-high-of-rs-4point5-lakh-crore-this-fiscal.html.

Das, Nikita, Ashwini Dabadge, Maria Chirayil, Manabika Mandal, and Ann Josey. 2019. “Elephant in the Room: Implications of Subsidy Practices on DISCOM Finances.” Pune: Prayas (Energy Group).

Dhingra, Neha, Archana Walia, and P.k. Mukherjee. 2016. “Measuring the Impact of India’ Standard and Labeling Program.” In *International Energy Policies & Programmes*

Evaluation Conference,. Amsterdam. https://clasp.ngo/publications/measuring-the-impact-of-indias-standard-and-labeling-program.

Ganesan, Karthik, Kapardhi Bharadwaj, and Kanika Balani. 2019. "Electricity Consumers and Compliance: Trust, Reciprocity, and Socio-Economic Factors in Uttar Pradesh." New Delhi: Council on Energy, Environment and Water (CEEW).

Jai, Shreya, and Amritha Pillay. 2020. "Budget 2020: 100% Smart Prepaid Metering Trips on Target and Funds." Business Standard. 2020. https://www.business-standard.com/article/economy-policy/budget-2020-100-smart-prepaid-metering-trips-on-target-and-funds-120020401818_1.html.

Jain, Abhishek, Sudatta Ray, Karthik Ganesan, Michaël Aklin, Chao-Yo Cheng, and Johannes Urpelainen. 2015. Access to Clean Cooking Energy and Electricity: Survey of States. *Council on Enegry, Environment and Water, and Columbia University*.

Jain, Abhishek, Saurabh Tripathi, Sunil Mani, Sasmita Patnaik, Tauseef Shahidi, and Karthik Ganesan. 2018. "Access to Clean Cooking Energy and Electricity - Survey of States 2018." *Council on Enegry, Environment and Water*. New Delhi.

JnJ Powercom. 2016. "Sharing Odisha Experience on Smart Prepaid System on BOOT Model." National Smart Grid Mission, Ministry of Power, Government of India. https://bit.ly/3dxIBZv.

Kennedy, Ryan, Aseem Mahajan, and Johannes Urpelainen. 2019. "Quality of Service Predicts Willingness to Pay for Household Electricity Connections in Rural India." *Energy Policy* 129 (June): 319–26.

Khosla, Radhika, and Aditya Chunekar. 2017. "Plugging In - A Collection of Insights on Electricity Use in Indian Homes." Pune: Centre for Policy Research, New Delhi and Prayas (Energy Group).

Kumar, Satish, Sangeeta Mathew, Sandeep Kachhawa, Hussain Babu, Rajendra Pandya, Milind Deore, Pravatanalini Samal, and Gautam Anand. 2018. "State Energy Efficiency Preparedness Index." New Delhi: Alliance for an Energy Efficient Economy.

Mandal, Manabika, Sreekumar Nhalur, Aruja Pandey, and Ann Josey. 2019. "Five Stitches in Time." Pune, India: Prayas (Energy Group).

Ministry of Power. 2019. "Pradhanmantri Sahaj Bijli Har Ghar Yojana (Saubhagya)." *Government of India*. http://saubhagya.gov.in/dashboard/main.

Ministry of Power. 2020. "UDAY Natonal Dashboard." UDAY Dashboard. 2020. https://www.uday.gov.in/home.php.

MSEDCL. 2020. "Mahapower Energy Bills Collection Channel." Maharashtra State Electricity Distribution Company Ltd. 2020. https://www.mahadiscom.in/wp-content/uploads/2019/08/MahapowerPay-Brochure-English.pdf.

Palit, Debajit, and Kaushik Ranjan Bandyopadhyay. 2017. "Rural Electricity Access in India in Retrospect: A Critical Rumination." *Energy Policy* 109 (January): 109–20.

Parikh, Kirit S., and Jyoti K. Parikh. 2016. "Realizing Potential Savings of Energy and Emissions from Efficient Household Appliances in India." *Energy Policy* 97: 102–11.

PFC. 2017. “The Performance of State Power Utilities for the Years 2013-14 to 2015-16.” New Delhi: Power Finance Corporation Ltd.

PFC. 2020. “The Performance of State Power Utilities 2017-18.” New Delhi: Power Finance Corporation Ltd.

Phadke, Amol, Won Young Park, and Nikit Abhyankar. 2019. “Providing Reliable and Financially Sustainable Electricity Access in India Using Super-Efficient Appliances.” *Energy Policy* 132 (April): 1163–75. https://doi.org/10.1016/j.enpol.2019.06.015.

Sengupta, Debjoy. 2017. “Wide Power Deficit Discrepancy between NGO and Govt Data in Uttar Pradesh.” The Economic Times. 2017. https://economictimes.indiatimes.com/industry/energy/power/chhattisgarh-consumers-to-get-compensation-for-power-cuts/articleshow/76216352.cms.

Shah, Alpesh, Prateek Roongta, Chilman Jain, Vibha Kaushik, and Abhishek Awadhiya. 2016. “Digital Payments 2020 - The Making of a $500 Billion Ecosystem in India.” Mumai, India: The Boston Consulting Group (BCG).

Swain, Ashwini K. 2020. “Prepaid Power Is Not the Silver Bullet to Solve Problem of Discom Finances.” The Indian Express. 2020. https://indianexpress.com/article/opinion/columns/smart-meters-ministry-of-power-6320887/.

Annexures

Annexure 1
Data and source for estimates of household electricity use

We have compiled the information on household electricity use by referring to various sources, including Census of India, consumer expenditure surveys conducted by the National Sample Survey Organisation (NSSO) and the National Family Health Survey (NFHS) (Table A1). All the government surveys and Census exercise capture the information on the use of electricity as a primary source of lighting in households. However, these do not capture the information on whether or not the household has grid-electricity connection or other sources of electricity. Thus, actual electrification rates at any point of time would be equal to or greater than the estimates on electricity use as a primary source of lighting. Table A2 enlists key government schemes for rural and household electrification.

Table A1 Source of data on use of electricity as a primary source of lighting in Indian homes

Year	Households electrified (%)	Urban households electrified (%)	Rural households electrified (%)	Source of data
1981	26	63	15	Census 1981
1988	35	67	24	NSS 43rd round (1987-88)
1994	47	77	36	NSS 50th round (1993-94)
2001	56	88	44	Census 2001
2011	67	93	55	Census 2011
2016	88	98	83	NFHS 4th round (2015-16)
2020	97	99	96	IRES 2020

Source: Authors' compilation from various sources

Table A2 Several government schemes have driven the efforts for household electrification in India

Year	Schemes and programmes
1988	*Kutir Jyoti Yojana* for providing single point light to below poverty line (BPL) families
2002	*Remote Village Electrification Programme* for electrifying remote villages through off-grid renewable solutions
2002	*Pradhan Mantri Gramodaya Yojana* with electrification as one of its components
2003	*Accelerated Rural Electrification Programme* to provide concessional loans to states
2005	*Rajiv Gandhi Grameen Vidyutikaran Yojana* for village electrification and free connections to BPL households
2009	*Decentralised Distributed Generation* scheme to electrify villages through mini-grids
2014	*Deendayal Upadhyaya Gram Jyoti Yojana* subsuming RGGVY and including feeder separation
2017	*Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya)* scheme for universal household electrification

Source: Authors' compilation

Annexure 2
Hours of power supply: state-wise data

Tables A3 and A4 show the difference in supply estimates reported by the households and the government.

Table A3 Comparison between power outages in rural areas from different sources

State	Daily power outages in rural areas (in hours)		
	Ministry of Power (May 2019)	IRES 2020 (Nov 2019 to Mar 2020): Daily	Difference in daily outage hours
	A	B	C= B – A
Andhra Pradesh	0.10	1.73	1.63
Assam	5.00	6.40	1.40
Bihar	1.90	6.36	4.46
Chhattisgarh	1.00	4.23	3.23
Gujarat	0.00	0.82	0.82
Haryana	6.10	7.21	1.11
Himachal Pradesh	0.00	2.11	2.11
Jharkhand	6.20	7.82	1.62
Karnataka	5.40	3.99	-1.41
Kerala	0.00	0.64	0.64
Madhya Pradesh	0.20	3.57	3.37
Maharashtra	0.00	3.12	3.12
Odisha	3.90	4.14	0.24
Punjab	0.00	1.37	1.37
Rajasthan	3.00	4.42	1.42
Tamil Nadu	0.00	0.96	0.96
Telangana	0.00	1.72	1.72
Uttar Pradesh	6.10	7.83	1.73
Uttarakhand	0.00	3.32	3.32
West Bengal	0.00	3.09	3.09
Average	1.95	3.92	1.80

Source: Authors' analysis based on IRES data and government data sourced from reply to a Lok Sabha query

Table A4 Comparison between power outages in urban areas from different sources

State	Power outages in urban areas (in hours)			
	Ministry of Power (May 2019): Monthly	Ministry of Power (May 2019): Daily	IRES 2020 (Nov 2019 to Mar 2020): Daily	Difference in daily outage hours
	A	B = A/30	C	D = C – B
Andhra Pradesh	2.00	0.07	1.40	1.33
Chhattisgarh	17.30	0.58	2.70	2.12
Gujarat	1.10	0.04	0.40	0.36
Haryana	18.60	0.62	2.60	1.98
Himachal Pradesh	5.30	0.18	0.60	0.42
Karnataka	9.60	0.32	1.70	1.38
Kerala	1.50	0.05	0.35	0.30
Madhya Pradesh	4.20	0.14	1.00	0.86
Maharashtra	2.30	0.08	1.00	0.92
Punjab	10.30	0.34	0.50	0.16
Rajasthan	0.50	0.02	1.50	1.48
Telangana	2.60	0.09	1.00	0.91
Uttar Pradesh	2.80	0.09	4.10	4.01
Uttarakhand	14.10	0.47	1.70	1.23
West Bengal	8.60	0.29	1.90	1.61
Average	6.72	0.22	1.50	1.27

Source: Authors' analysis based on IRES data and government data sourced from reply to a Lok Sabha query

Annexure 3
Electricity bill payment modes

We asked all grid users to share their usage of different payment modes to pay their electricity bills. Table A5 shows the share of households using various modes in all states covered in this study.

Table A5 Electricity bill payment modes across states

	Payment counter/ CSC	Collection agent	Online payment	Private kiosks	Nearby bank/post office	Panchayat/ municipality office	Neighbour/ relative/ landlord
Andhra Pradesh	21	36	12	16	0	34	0
Assam	97	4	3	1	0	0	0
Bihar	52	54	13	3	0	0	1
Chhattisgarh	88	7	12	7	0	0	0
Gujarat	84	5	16	6	4	11	3
Haryana	81	8	19	1	1	1	7
Himachal Pradesh	79	10	16	16	2	0	2
Jharkhand	79	22	3	1	0	0	3
Karnataka	32	66	14	1	4	3	0
Kerala	93	1	14	8	1	0	0
Madhya Pradesh	84	5	7	8	1	2	3
Maharashtra	47	3	22	3	46	11	1
Delhi	47	2	57	7	1	0	9
Odisha	19	90	1	1	0	0	3
Punjab	80	1	8	12	6	3	3
Rajasthan	78	4	13	31	1	2	1
Tamil Nadu	82	1	34	3	1	1	3
Telangana	21	46	13	7	0	42	0
Uttar Pradesh	55	7	19	14	16	3	6
Uttarakhand	78	2	29	26	0	0	5
West Bengal	87	6	17	10	3	1	23
India	62	18	17	8	8	6	4

Source: Authors' analysis

Note: The sum adds up to more than 100 as many people cited more than one mode of payment

Annexure 4
Results from the logistic regression model

To analyse the factors associated with consumer satisfaction, we constructed a logistic regression model with satisfaction as the binary dependent variable (1= satisfied, 0 = unsatisfied or neutral).[25] We included supply duration, reliability, voltage stability, and regularity of billing as the independent variables. These are defined as follows:

- **Duration** is a categorical variable reflecting daily hours of supply. Nearly three-fourths of grid users get supply for more than 18 hours, so keep supply duration of (0–18] hours as the base level.
- **Voltage stability** is a binary variable that takes a value of zero if the household reports any voltage issue (low voltage or fluctuation causing appliance damage) during past one month.
- **Reliability** is a binary variable that takes a value of zero if the household reports any blackout (long-duration outages) during past one month.
- **Regular billing** is also a binary variable that takes a value of zero if the household does not receive bills on a regular basis.

We also control for the household's economic status using wealth (asset) index because supply characteristics are found to be correlated with the household's economic status. We created this wealth index using a principal component analysis of select 12 indicators that together indicate the long-run economic status of a household.[26] To check the model robustness, we conduct regression analysis by replacing wealth deciles with expenditure deciles and find similar results with minor changes in coefficient estimates.

Correlation coefficients between all independent variables are low (less than 0.3), indicating that multi-collinearity is not a concern. We also include district fixed effects because of the correlation between supply-side issues at the district level. Table A6 shows the regression results for all grid-using households in our study. We also conduct separate regression for rural and urban grid-electrified households.

25 We assign the value zero to households staying neutral and treat them as part of not satisfied consumer category, as ideally the distribution companies should aim to maximise satisfaction of all consumers and not limit themselves to alleviating dissatisfaction.

26 Please refer to technical documentation for details.

Table A6 Logistic regression of consumer satisfaction on electricity service parameters

	Dependent variable: Satisfaction		
	All households	Rural households	Urban households
	(1)	(2)	(3)
Duration: (18,20] hours	0.515***	0.518***	0.558**
	(0.113)	(0.132)	(0.239)
Duration: (20,22] hours	0.731***	0.822***	0.761***
	(0.121)	(0.140)	(0.256)
Duration: (22,24] hrs	0.873***	0.799***	1.298***
	(0.120)	(0.148)	(0.249)
Reliability (1 = Reliable; 0 = Unreliable)	0.273***	0.257***	0.332*
	(0.087)	(0.099)	(0.174)
Voltage stability (1 = Stable voltage; 0 = Unstable voltage)	0.168*	0.160	0.272*
	(0.089)	(0.105)	(0.163)
Regular billing (1 = Regular billing; 0 = Irregular or no billing)	0.398***	0.421***	0.037
	(0.120)	(0.128)	(0.402)
Wealth index	0.041*	0.018	0.161***
	(0.023)	(0.029)	(0.039)
Observations	14,054	9,127	4,991
Log likelihood	-5,555.240	-3,690.613	-1,584.211
Akaike Inf. Crit.	11,420.480	7,677.225	3,482.422

*Note: Standard errors are within the parenthesis below the coefficients and are clustered at the village level. District fixed effects included. *p<0.10, **p<0.05, ***p<0.01*

Source: Authors' analysis

As India pursues the goal of universal electricity access, this report highlights the remaining frontiers to conquer to achieve affordable and sustainable 24x7 power for all.

Image: CEEW

COUNCIL ON ENERGY, ENVIRONMENT AND WATER (CEEW)

Sanskrit Bhawan, A-10, Aruna Asaf Ali Marg
Qutab Institutional Area
New Delhi 110 067, India
T: +91 11 4073 3373

info@ceew.in | ceew.in | @CEEWIndia