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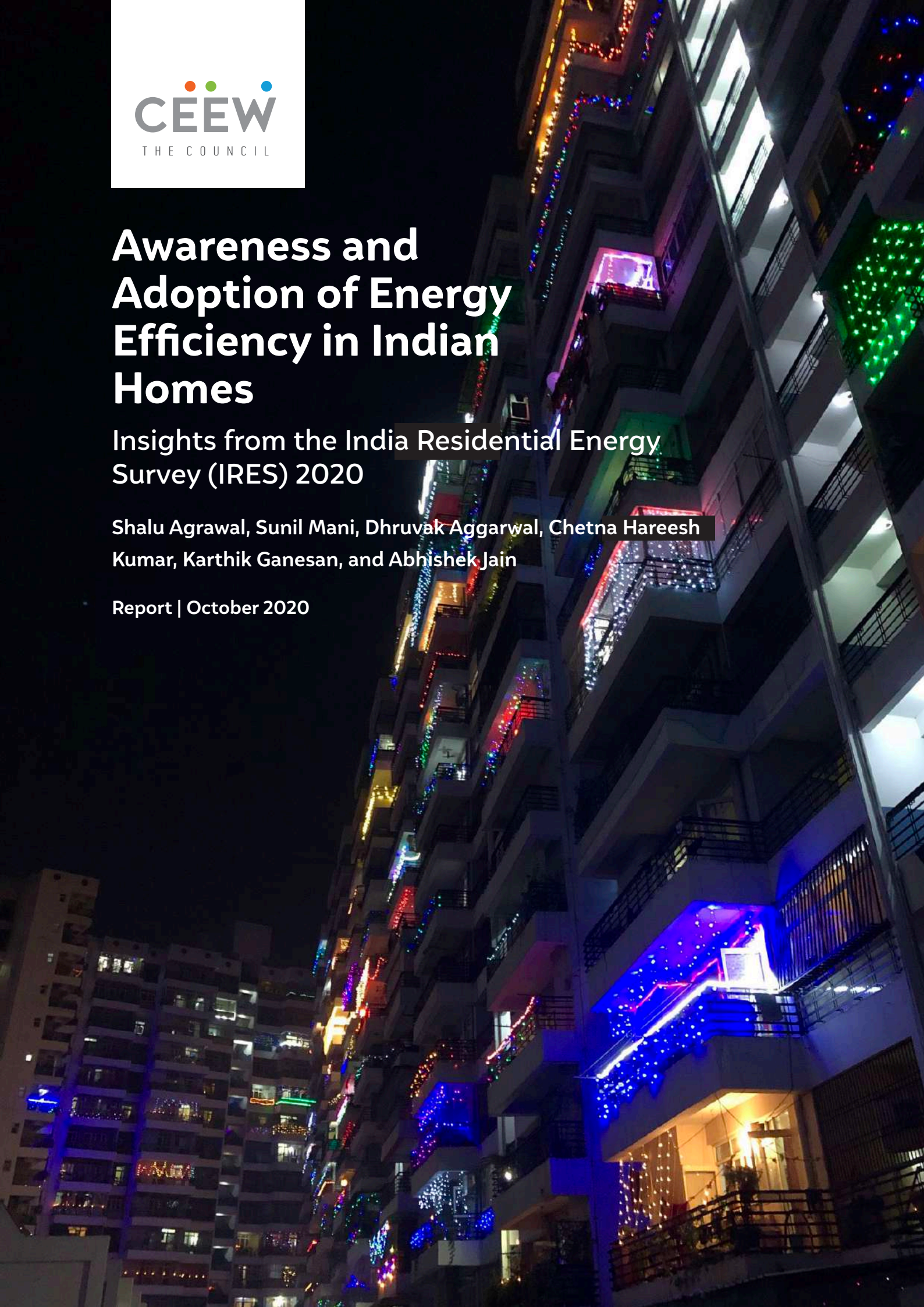
Insights from the India Residential Energy Survey (IRES) 2020

Shalu Agrawal, Sunil Mani, Dhruvak Aggarwal, Chetna Hareesh Kumar, Karthik Ganesan, and Abhishek Jain

Report | October 2020



Given the rise in summer temperatures, India is expected to witness an exponential growth in use of air-conditioners.

Image: Shalu Agrawal/CEEW

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

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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.

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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).

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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 like to express our sincere gratitude towards 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. We would also like to thank the appliance manufacturers, retailers, and representatives from state nodal agencies, who we interviewed as part of this study.

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. Aditi Chaudhary interned with us and helped us conduct data quality checks and data cleaning; we highly appreciate her contribution.

Our reviewers—Aditya Chunekar, Fellow, Prayas (Energy Group); Dr Nikit Abhyankar, Scientist, the International Energy Analysis Department at the Lawrence Berkeley National Laboratory; PK Mukherjee, Senior Technical Advisor, CLASP; Neha Dhingra, Manager – India Program, CLASP; Dr Satish Kumar, President and Executive Director of the Alliance for an Energy-Efficient Economy (AEEE); and Dr Vaibhav Chaturvedi, Research Fellow, Council on Energy, Environment and Water (CEEW)—provided critical feedback and comments that went a long way in refining this report. We would also like to acknowledge the valuable feedback from Anukriti Pathak, Bhawna Tyagi, Deepak Tiwari, and Jaydeep Bhadra from AEEE, and PVN Kishore Kumar from CLASP. To all our reviewers, we owe our sincere gratitude.

Finally, our Outreach team and editors 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

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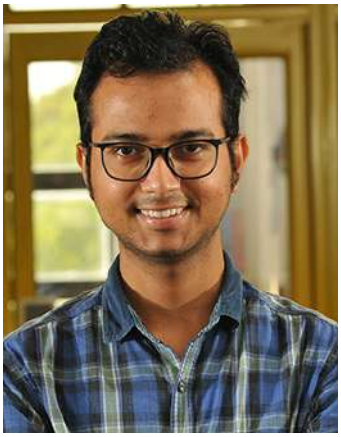
A Programme Lead at CEEW, Shalu's research focuses on the changing residential energy landscape and exploring the role of institutional, technology, and policy reforms to enable access to affordable, reliable, and sustainable energy for all. She also supports The Council's work on power sector reforms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

"As more Indian households climb the appliance ladder to enjoy the services unlocked by improved electricity access, there is a need for an aggressive policy push to mainstream the discourse on energy efficiency in smaller towns and rural India."

Shalu Agrawal led the execution of the entire project; designed the survey strategy and survey instrument; co-authored executive summary and chapters 1-5; and edited the entire manuscript.



Sunil Mani
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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.

"Since millions of new households are now part of the grid infrastructure, there is a significant need to increase energy efficiency awareness among them for optimising electricity demand. All governments must learn from the best practices of others to implement the necessary mix of market and regulatory policies to increase the penetration of energy efficient appliances."

Sunil Mani contributed to design, field-testing, and revision of the survey instrument, training of the enumerators, data monitoring, cleaning, and analysis; and co-authored chapters 3-5.

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A Research Analyst at The Council, Dhruvak's research interests centre around the intersection of power markets and regulation, energy efficiency policy, and cyber security regulation in the power sector. He holds an MPhil in technology policy from the University of Cambridge and a BTech in mechatronics engineering from Manipal University, Jaipur.

"In the long-term energy efficiency is a two-way street. While it needs to be made the default option for consumers, they need to be aware that the endgame is to reduce gross consumption. And it's no longer a low-hanging fruit."

Dhruvak Aggarwal co-authored the chapters 3 and 5.

Chetna Hareesh Kumar
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As an energy efficiency intern, Chetna has been closely involved in The Council's research on consumer finance for energy efficient household appliances. She is currently pursuing her Master's degree in international economic policy at Sciences Po, Paris and holds an undergraduate degree in economics (honours) from Lady Shri Ram College for Women, Delhi University.

"Energy efficiency enables households to use more power to meet their needs without inflating their electricity bills or carbon footprints. Awareness and access to finance, in turn, empower households to become efficient. India's national energy policy towards the residential sector must double down on these key prerequisites."

Chetna Hareesh Kumar co-authored the chapters 1 and 5.

Karthik Ganesan
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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 a BTech in Civil Engineering and an MTech in Infrastructure Engineering from IIT Madras.

"Energy efficiency needs a customised approach because what households seek in appliances is different. Some want it cheap, some want a brand and good features, and some want to save money over the lifetime. How do we roll it all into one?"

Karthik Ganesan co-conceptualised the project; gave inputs at all stages; authored chapter 6, and reviewed the entire manuscript.

Abhishek Jain
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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.

"Over the past decade, India has built a strong regulatory framework to promote energy-efficient household appliances, and its impact is visible in the adoption of key appliances like ACs and fridges. In the coming decade, these efforts must expand to other household appliances and target consumers beyond urban areas to lead Indian homes towards an energy efficiency path."

Abhishek Jain co-conceptualised the project; gave inputs at all stages; and reviewed the entire manuscript.

Energy efficiency is integral to addressing the energy trilemma of our times—providing affordable, reliable, and sustainable energy for all.

Contents

Image: Shalu Agrawal/CEEW

Figures

Tables

Acronyms

ACs	air conditioners
AEEE	Alliance for an Energy Efficient Economy
BEE	Bureau of Energy Efficiency
BLDC	brushless DC
BLY	*Bachat Lamp Yojana*
CFLs	compact fluorescent lamps
CI	confidence interval
CRT	cathode-ray tube
CSOs	civil society organisations
ECB	energy conservation behaviour
EESL	Energy Efficiency Services Limited
EMI	equated monthly instalment
HERs	home energy reports
ICAP	India's Cooling Action Plan
ICL	incandescent lamps
IEC	information, education, and communication
IRES	India Residential Energy Survey
ISEP	Initiative for Sustainable Energy Policy
LCD	liquid crystal display
LED	light-emitting diode
MFIs	microfinance institutions
MoEFCC	Ministry of Environment, Forest, and Climate Change
MoP	Ministry of Power
MoSPI	Ministry of Statistics and Programme Implementation
NBFCs	non-banking financial institutions
NCT	National Capital Territory
NFHS	National Family Health Survey
NSSO	National Sample Survey Organisation
OBF	on-bill financing
REC	residential electricity consumption
S&L	standards & labelling
SDAs	State Designated Agencies
SERCs	State Electricity Regulatory Commissions
SFBs	small finance banks
SMEs	small and medium enterprises
TFLs	tubular fluorescent lamps
TV	television
UJALA	*Unnat Jyoti* by Affordable LEDs for All

State acronyms used in the study

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

Residential energy consumption surveys provide crucial information on the changing consumer preferences regarding energy use in homes.

Image: CEEW/Market Xcel

Executive summary

Electricity use in Indian homes accounts for a quarter of the country's total electricity consumption and has been growing steadily over the past two decades (MoSPI 2019). With rising incomes, the residential electricity consumption in India is projected to at least double over the next decade. Energy efficiency can play a crucial role in addressing the energy trilemma of our times—providing affordable, reliable, and sustainable energy for all. The Bureau of Energy Efficiency (BEE) has been pushing for energy efficiency in homes through initiatives such as the standards & labelling (S&L) programme, consumer awareness campaigns, and market transformation initiatives.

Electricity consumption in Indian homes is projected to at least double over the next decade

However, not all Indian states have made equal progress in their pursuit of energy efficiency. A lack of outcome-based indicators hinders the comprehensive assessment of consumers' behavioural response to policy interventions. Many independent consumer surveys conducted in different states have assessed household awareness about energy efficiency initiatives in recent years, but these studies have represented very small geographical areas or strata of the population. A large-scale assessment using a geographically and socio-economically representative sample is needed to draw reliable inferences about the state of energy efficiency in Indian households.

Study objectives

Realising the need to assess the impact of existing energy efficiency initiatives on household awareness levels, preferences, and behaviour concerning efficiency in electricity use, we have undertaken a first of its kind, nationally representative survey of nearly 15,000 households across 21 states of India. We call this the India Residential Energy Survey (IRES), which was conducted in collaboration with the Initiative for Sustainable Energy Policy (ISEP). IRES covers different dimensions of electricity and cooking energy use in households. In this report, we answer the following questions:

i. How aware are Indian households about BEE's star label? Which consumer categories and states would require more attention going forward?

ii. What appliances do Indian households run using electricity? What share of those appliances are energy-efficient?

iii. What influences appliance purchase decisions of Indian households? What role can appliance financing play in nudging consumers towards more efficient products?

IRES captures the energy use patterns, awareness and adoption of energy-efficiency in Indian homes

Based on our research and findings, we propose strategies to accelerate the energy-efficiency transition in India's residential sector.

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

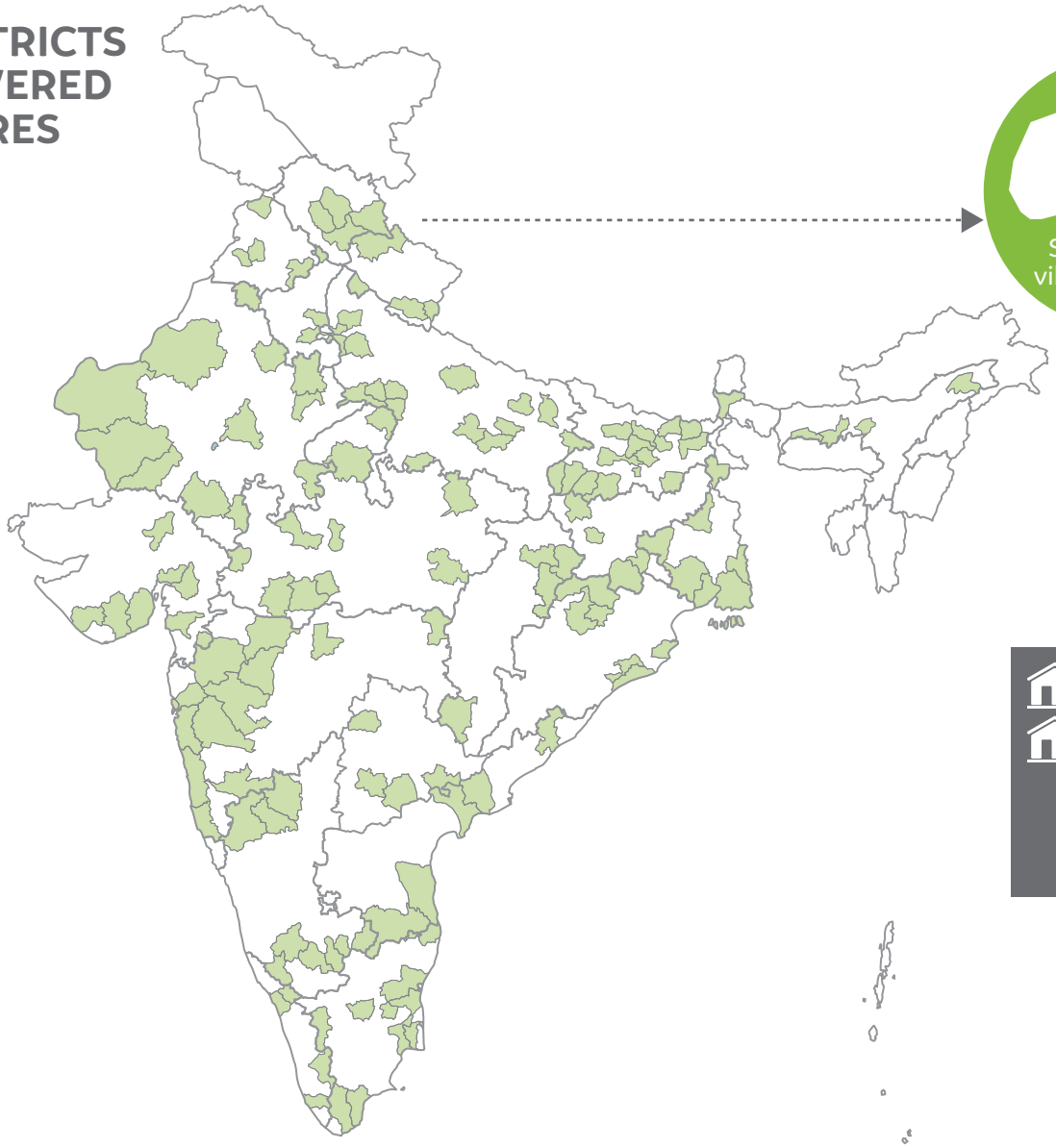
152 DISTRICTS
Cluster sampling

1210 VILLAGES & 614 URBAN WARDS
Cluster sampling

14,850 HOUSEHOLDS
8 from each village/ward

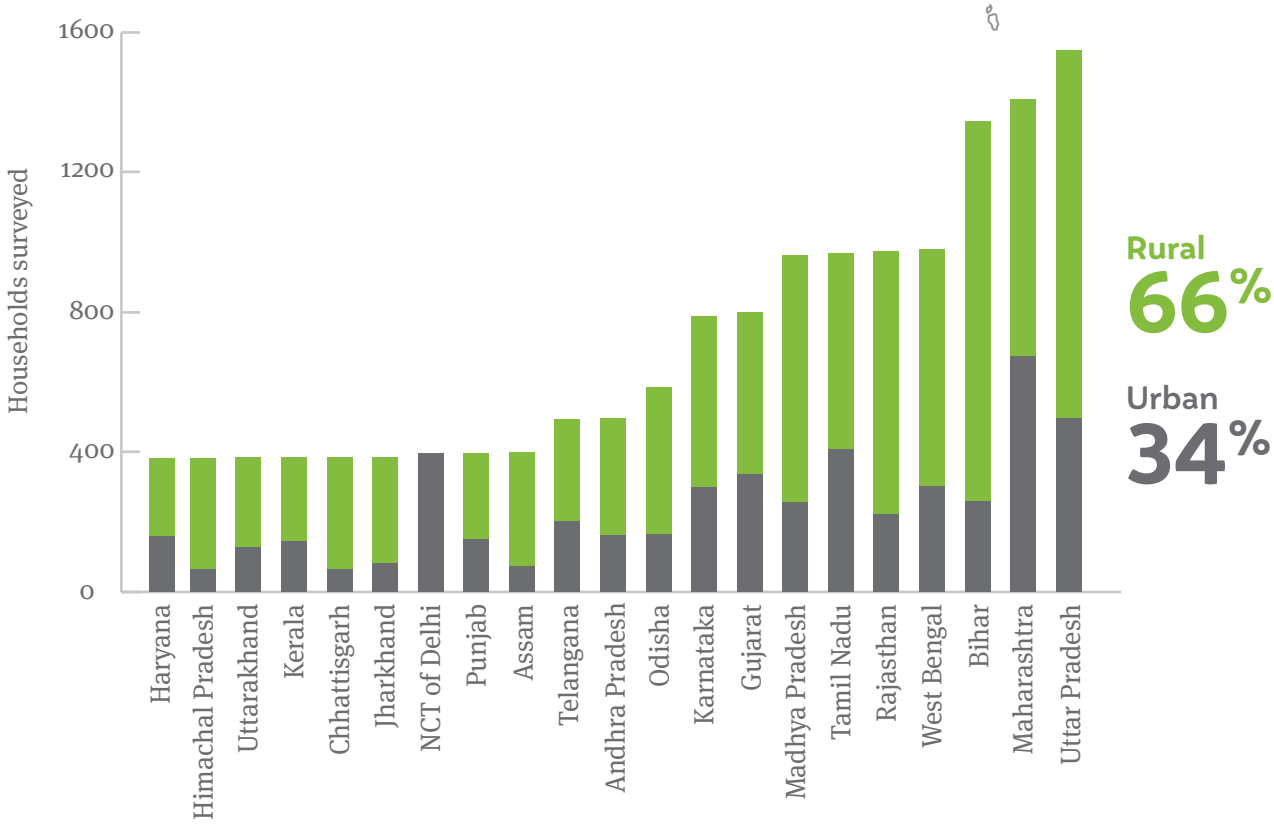
4 MILLION DATA POINTS

DISTRICTS COVERED IN IRES



Selected 12 villages/wards

Selected 8 households



Rural 66%

Urban 34%

Key findings

As per IRES, one in four Indian households is aware of BEE's star label. The BEE launched the S&L programme in May 2006 to "provide the consumer an informed choice about the energy saving and thereby the cost saving potential of the relevant marketed product" (BEE 2020). The larger objective of the programme is to nudge the Indian market towards energy-efficient products by creating awareness among consumers through media campaigns, celebrity endorsements, and engaging with students.

After almost a decade and a half since the launch of S&L programme, only a quarter of the electrified Indian households have heard of star labels. The awareness is relatively lower among rural population (Figure ES1). States with richer, more urban population, more educated households, and higher ownership of appliances covered under mandatory scheme typically have higher awareness levels (Figure ES2). Going forward, the focus of awareness campaigns needs to shift to smaller towns and rural areas, as households in these areas are expected to add more appliances in future.

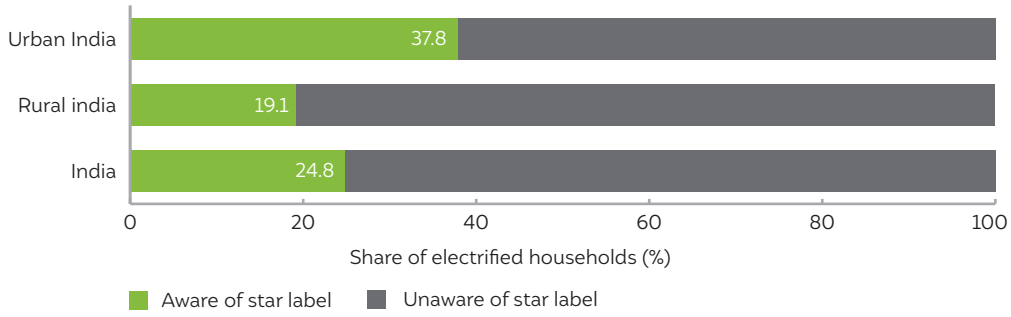
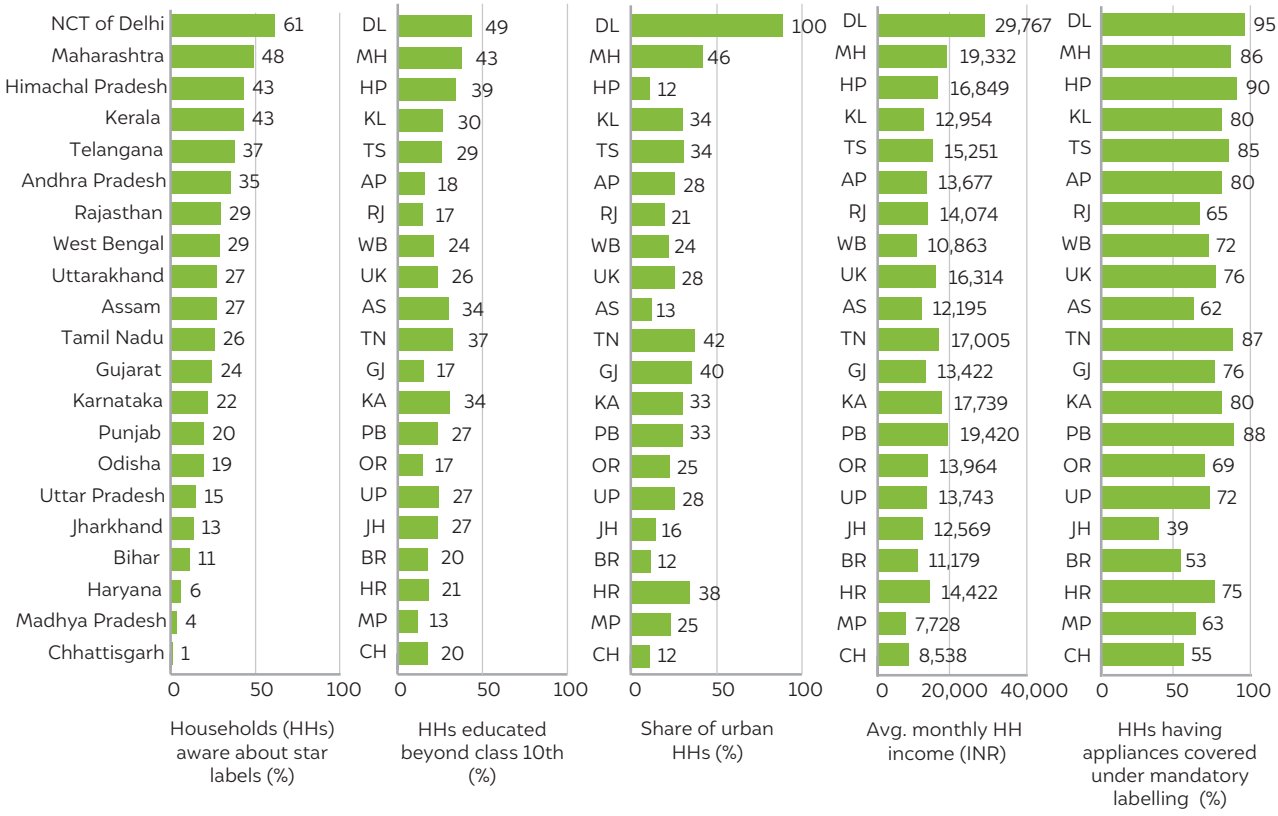


Figure ES1 **One-fifth of rural and two-fifths of urban households are aware of BEE star label**

Source: Authors' analysis

Figure ES2 **States with more urban, richer, and educated consumers have higher awareness levels about BEE star label**



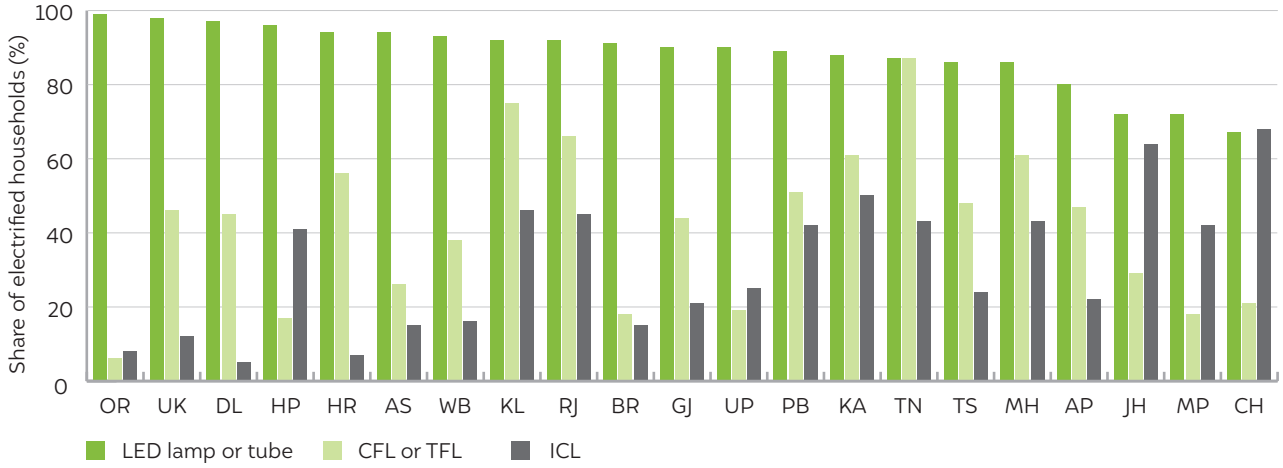
Source: Authors' analysis

The UJALA scheme has brought energy-efficient LEDs to almost every Indian home. Until recently, energy-inefficient incandescent lamps (ICL) were mainly used for lighting in Indian homes. To promote efficient lighting solutions, the Government of India launched the *Unnat Jyoti by Affordable LEDs for All* (*UJALA*) scheme in 2015. Under a demand-aggregation model, Energy Efficiency Services Limited (EESL) distributed light-emitting diode (LED) lamps to households at significantly lower price than the prevailing market rate by lowering the LED cost through bulk procurement.

Nearly 90% of Indian homes have switched to LED lamps

As per our survey, nearly 90 per cent of Indian homes now have switched to LED lamps. Moreover, two-thirds of the total lighting stock of 1 billion lamps and tubes in Indian homes is now LED-based. The share of households using LED lamps is highest in Odisha followed by Delhi, Uttarakhand, and Himachal Pradesh, mainly due to proactive government schemes. Jharkhand, Madhya Pradesh, and Chhattisgarh have the lowest share of households adopting LEDs (Figure ES3). Overall, 9 per cent of urban and 14 per cent of rural households in India do not use any LED light, mainly due to lack of awareness about LED lamps and their relatively higher upfront cost.

Figure ES3 More than 80 per cent households in all except three central states use LED lamps for lighting



Source: Authors' analysis

Note: The sum of shares is more than 100 due to the use of multiple lighting types in many homes.

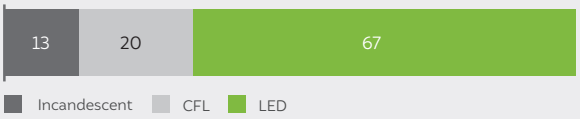
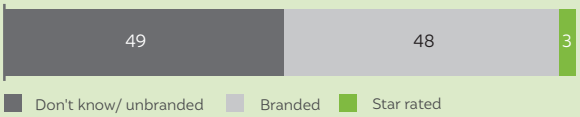
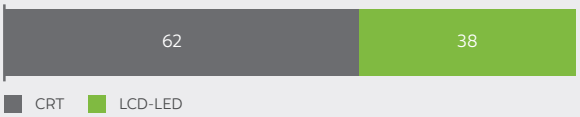
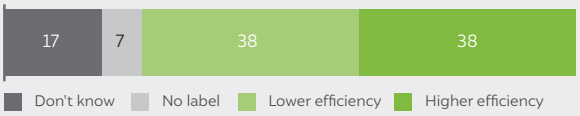
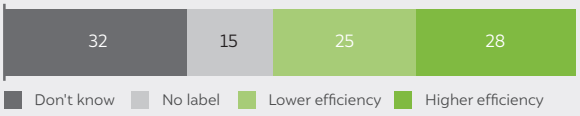
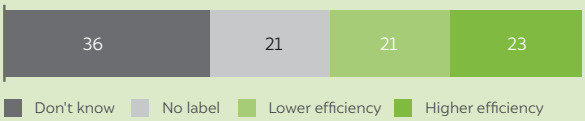
India has made significant progress in adopting energy efficient ACs and refrigerators. After lighting, fans, televisions (TVs) and refrigerators are the most common electric appliances in Indian homes (Table ES1). These are followed by mixer-grinders, electric iron, coolers, immersion rods, washing machine, water geysers, laptops, and air-conditioners (ACs). Of these, four appliances (AC, TV, geyser and refrigerator) fall under BEE's mandatory labelling scheme, two (fans and washing machine) are under the voluntary scheme, and laptops come under endorsement scheme. The remaining appliances are currently out of the ambit of S&L programme.

We find that more than 75 per cent of AC users have star-labelled ACs, which reflects the positive impact of mandatory labelling scheme on one of the most energy-intensive household appliances. However, one-sixth of the AC users do not know about the star labels on their ACs. Adoption of labelled refrigerators and awareness about the labels is lower in comparison to ACs. We also found that 15 per cent of refrigerators in use were more than ten years old (bought before implementation of the refrigerator labelling scheme). We also observe presence of unlabelled refrigerators among newer purchases, which may reflect second-hand buys or availability of unlabelled products in some markets.

We also find that there is an increasing shift towards energy-efficient liquid crystal display (LCD) and LED TVs. However, two-thirds of TV users still have cathode-ray tube (CRT) models. Among other appliances, we find a moderate progress in adoption of energy-efficient geysers and washing machines, which were respectively brought under mandatory and voluntary labelling since 2016 and 2018.

The adoption of energy-efficient ceiling fans, however, remains dismal, which could be due to their relatively higher cost and limited availability in the market. Ceiling fans, which make up a major portion of residential electricity use, are under the voluntary programme since 2009. Thus, voluntary scheme has had limited impact on nudging the market towards higher efficiency fans.

Table ES1 Ownership and efficiency levels for key appliances used in Indian homes

	Appliances	Ownership rate (%)	Proportion of efficient and/or branded appliances (%)
	Lights (LED)	100 (90)	
	Ceiling fans	90	
	Television	72	
	Refrigerator	35	
	Air-conditioners	3*	
	Geysers	3*	
	Washing machine	8*	

Source: Authors' analysis

Note: The graph for lights displays the composition of total lighting stock. Remaining graphs display efficiency and/or make-up of most-used appliances in the surveyed households. Appliances in grey background have mandatory labelling; those in green have voluntary labelling.

** These estimates are conservative due to high non-response rate in more urban and economically better-off districts.*

Appliance purchase behaviour reflects households' preference for low-cost models. In our survey, 40 per cent of the households ranked appliance cost as the most important factor in their purchase decision, followed by other parameters such as brand popularity, durability, and energy savings. Price sensitivity further dominates purchase decisions in rural households and those belonging to lower economic strata. Making energy-efficient appliances affordable through bulk procurements, advance market commitments, or end-user financing is therefore the need of the hour to drive adoption of efficient appliances.

As per our survey, only four per cent of the households have used financing for appliance purchase. However, there is a high untapped demand for home appliance financing in India, as nearly one-sixth of the households expressed interest in buying appliances on credit and a higher share of low-income households want to exercise this option (Figure ES4). Refrigerators and TVs are most popular consumer durables that people would like to buy with appliance financing, followed by space cooling appliances.

Nearly one-sixth of Indian households expressed interest to buy appliances on credit

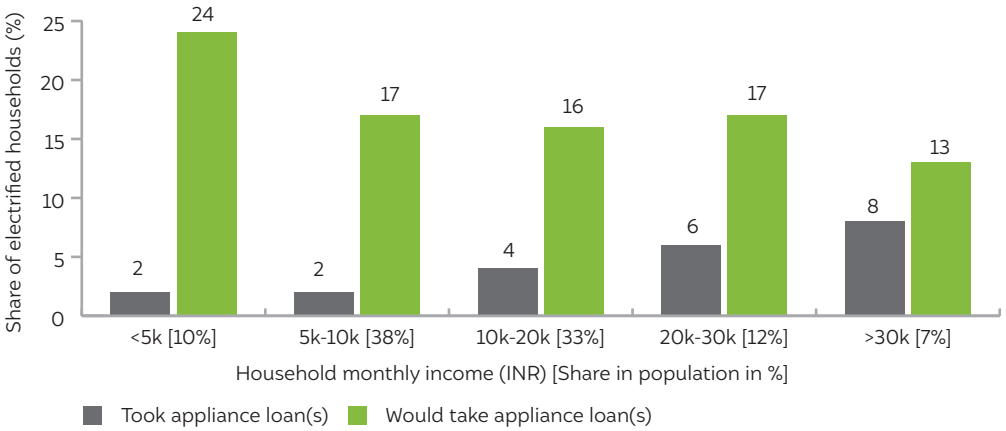


Figure ES4
Aspiration for appliance-related credit is higher among lower income households

Source: Authors' analysis

Household's appliance use patterns are far from those advocated for energy savings. Energy savings are realised not only by purchasing energy-efficient equipment but also through energy conservation behaviour. We observed that among AC-owning households:

- Only 40 per cent run ACs at a temperature setting of 24 degrees Celsius or above.
- Only 20 per cent *always* use a ceiling fan with AC.
- Only 55 per cent get their AC serviced by a technician every year.

So, consumer education is necessary to apprise them of optimising AC energy use through periodic servicing, by optimal temperature setting, and using fan with ACs as appropriate.

The choice of higher efficiency models, entailing higher investment, depends upon frequency and duration of equipment use. For instance, one-third of washing machine owners use it only once a week, while one-fourth use it for more than four times a week. However, we do not observe any variation in the choice of star-labelled washing machine among households with different use frequency. Both retailers and consumers should be made aware of including appliance usage frequency in their purchase decisions for consumers to make informed choices.

Recommendations

Recognising the role that energy efficiency can play, India was an early mover in the framing of the *Energy Conservation (Act)* at the turn of the century. BEE, a product of the same legislation, has been at the forefront of formulating approaches to deliver energy efficiency at scale for various sectors of the economy. BEE's focus on appliances used within households has certainly yielded benefits. India has seen significant adoption of efficient technologies, particularly those covered under mandatory labelling programme. Based on the study's findings, we make the following suggestions to further energy efficiency in the residential sector.

Discoms should take lead in educating households about energy saving tips

Design an aggressive, consumer-centric, and decentralised consumer awareness strategy

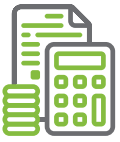
Low awareness levels about BEE star label highlight the need for year-round and sustained awareness campaigns, in regional languages and through diverse media, to capture the attention of consumers in smaller towns and rural areas. For this purpose, it would be helpful to leverage local institutions such as *gram panchayats* in rural areas, residents' welfare associations and municipal councils in urban areas, and grassroots organisations.

Given their regular touch-point with consumers, power distribution companies (discoms) should take the lead in initiatives on consumer awareness, drawing inspiration from other discoms that are already active in the energy efficiency campaigns. For instance, discoms in Maharashtra provide energy-saving tips on their bills and a discom in Delhi is sending 'home energy reports' to consumers as part of a pilot study. As most consumers rely on word-of-mouth, BEE could consider a pilot programme to identify and train local 'champions of energy efficiency' to lead the campaign on energy efficiency among the local community.

Improve the market availability of energy-efficient products by bringing more residential-use appliances within the fold of mandatory S&L scheme

Our study confirms the stronger influence of the mandatory labelling programme in ensuring greater adoption of the energy-efficient appliances. However, developing and enforcing a mandatory labelling programme is a resource-intensive exercise. BEE needs to continuously evaluate and identify key appliances driving residential electricity demand through a robust mechanism.

The voluntary programme for ceiling fans, which contribute a major share to household electricity use, has achieved negligible success. To make energy-efficient fans part of Indian households, BEE plans to bring them under mandatory labelling from 2022. India's fans market is highly unorganised and BEE should, therefore, engage with and support the industry associations of small-scale manufacturers to bring them under the ambit of the mandatory scheme without jeopardising their business prospects. Further, a strict enforcement of the minimum performance standards would ensure the removal of unlabelled or spurious products from the market.



Demand aggregation, consumer financing and on-bill financing can support mass adoption of energy-efficient appliances

Make energy-efficient appliances affordable

Enforcement of minimum standards often raises the appliance cost. This is mainly a concern for appliances used for meeting basic domestic needs, such as fans, because a majority of Indian consumers tend to be price-sensitive.

Innovative business models, such as demand aggregation as in case of LED lamps, are required to bring down the cost of energy-efficient products for other uses, particularly ceiling fans. EESL has recently partnered with discoms in Delhi to facilitate the adoption of energy-efficient ACs through a dedicated e-commerce platform (EESL mart). Discoms must explore similar approaches for diverse products as part of their demand-side management strategy. Discoms could also consider on-bill financing programmes under which consumers pay for the energy-efficient appliance purchase through their utility bills. However, pilot studies are needed to design suitable business models and test consumer response to such interventions.

Our study highlights the inclination of consumers for availing credit for home appliance purchases. Interestingly, top brands are found to influence the choice of appliances (second only to the cost of appliances). Credit purchase of appliances provides an excellent opportunity for industry leaders to coordinate with key stakeholders such as discoms and demand aggregators and shift the market towards efficient and affordable appliances. Further, BEE could incentivise financial institutions that extend loans on consumer appliances to encourage these institutions to provide more favourable loan terms—such as longer tenure or lower interest rate—for the purchase of energy-efficient products.

An aggressive policy push is necessary to make energy efficiency integral to electricity use in Indian homes

Concluding remarks

As per IRES, India is close to achieving universal residential electrification, with more than 97 per cent homes already electrified (Agrawal et al. 2020). Increasing access to electricity means millions of households would also add more appliances to the nation's existing stock. Given this scenario, an aggressive policy push is necessary to make energy efficiency an integral part of electricity use in smaller towns and rural India. Information campaigns that promote energy-efficient products must reach all households that consume electricity across the country.

All stakeholders in the electricity sector should brave the pandemic that is now sweeping the world to bring in an energy efficiency revolution. Only the use of energy-efficient products and energy-saving practices by households can help consumers manage their rising electricity bills and help discoms manage the power situation in the coming years. The time is also ripe to build new domestic supply chains for components used in energy-efficient appliances, given the large base of consumers who are yet to adopt these appliances. Most importantly, getting smaller manufacturers to shift to the supply chains of energy-efficient appliances would be crucial in firmly lodging the concept of energy efficiency throughout the value chain.

Both the appliance efficiency and usage behaviour determine residential electricity consumption. A Delhi resident storing food in her 3-star labelled refrigerator.

Image: CEEW/Market Xcel

1. Motivation for the study

Electricity use in Indian homes accounts for one-fourth of the country's total electricity consumption (MoSPI 2019). India's residential electricity consumption (REC) is growing at an average annual rate of 8.2 per cent since 2001, second only to commercial consumption (Figure 1). The consumption is projected to at least double from 217 billion units (kWh) in 2015 to 452 billion units (kWh) in 2030 concomitant with the expected jump in appliance ownership and use due to rapid urbanisation, rise in household incomes, and universal electricity access (Ali 2018). Thus, household choices concerning appliance adoption and use would play a critical role in India's energy transition.

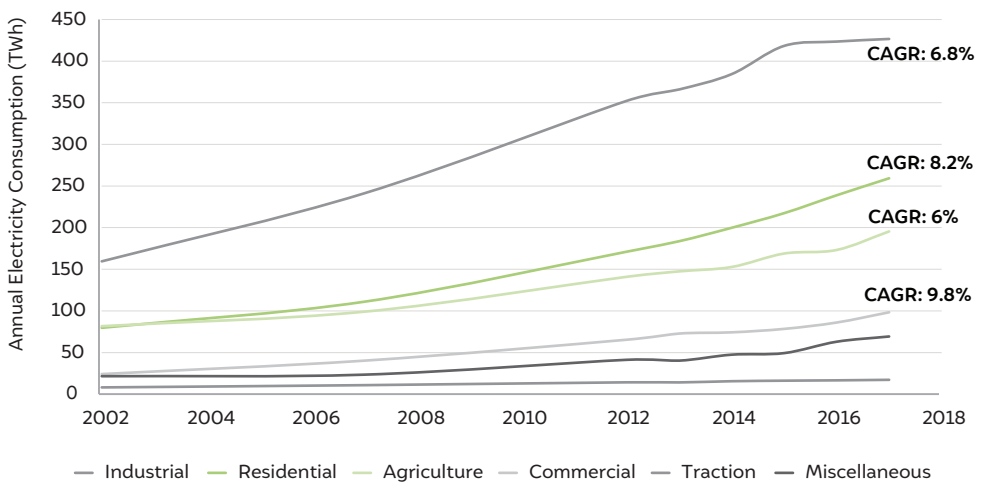


Figure 1
Residential sector is the second fastest growing electricity consumer in India

Source: Author's compilation from Central Electricity Authority (CEA) general reviews

Note: We calculate compound annual growth rate (CAGR) since 2001.

1.1 Role of energy efficiency in India

The Bureau of Energy Efficiency (BEE) estimates that 12 per cent of India's energy-saving potential by 2031 would come from the residential sector (PwC and BEE 2019). As more households are brought onto the electricity grid, utilities can make demand-side interventions to reduce the need for additional energy supply, thus saving on infrastructure investment (Khosla 2018; IEA 2019; Kuldeep et al. 2019). The use of energy-efficient appliances brings down the energy bill, which, in turn, makes electricity affordable for consumers, while reducing subsidy burden on the government (Phadke, Park, and Abhyankar 2019). Thus, energy efficiency is an important component in addressing the energy trilemma of providing affordable, reliable, and sustainable energy for all.

Energy efficiency can make electricity use affordable for consumers and reduce the subsidy burden on the government

1.2 Energy efficiency policies and programmes in India

National-level energy efficiency programmes in India are designed and enforced by the BEE and the Energy Efficiency Services Limited (EESL). At the state level, nodal agencies like the State Designated Agencies (SDAs), State Electricity Regulatory Commissions (SERCs), and distribution companies (discoms) are required to create awareness about energy efficiency among consumers. Several policies and programmes have been implemented in India in the last two decades to drive energy efficiency as part of the overall national energy policy, with a specific focus on residential energy use (Figure 2).

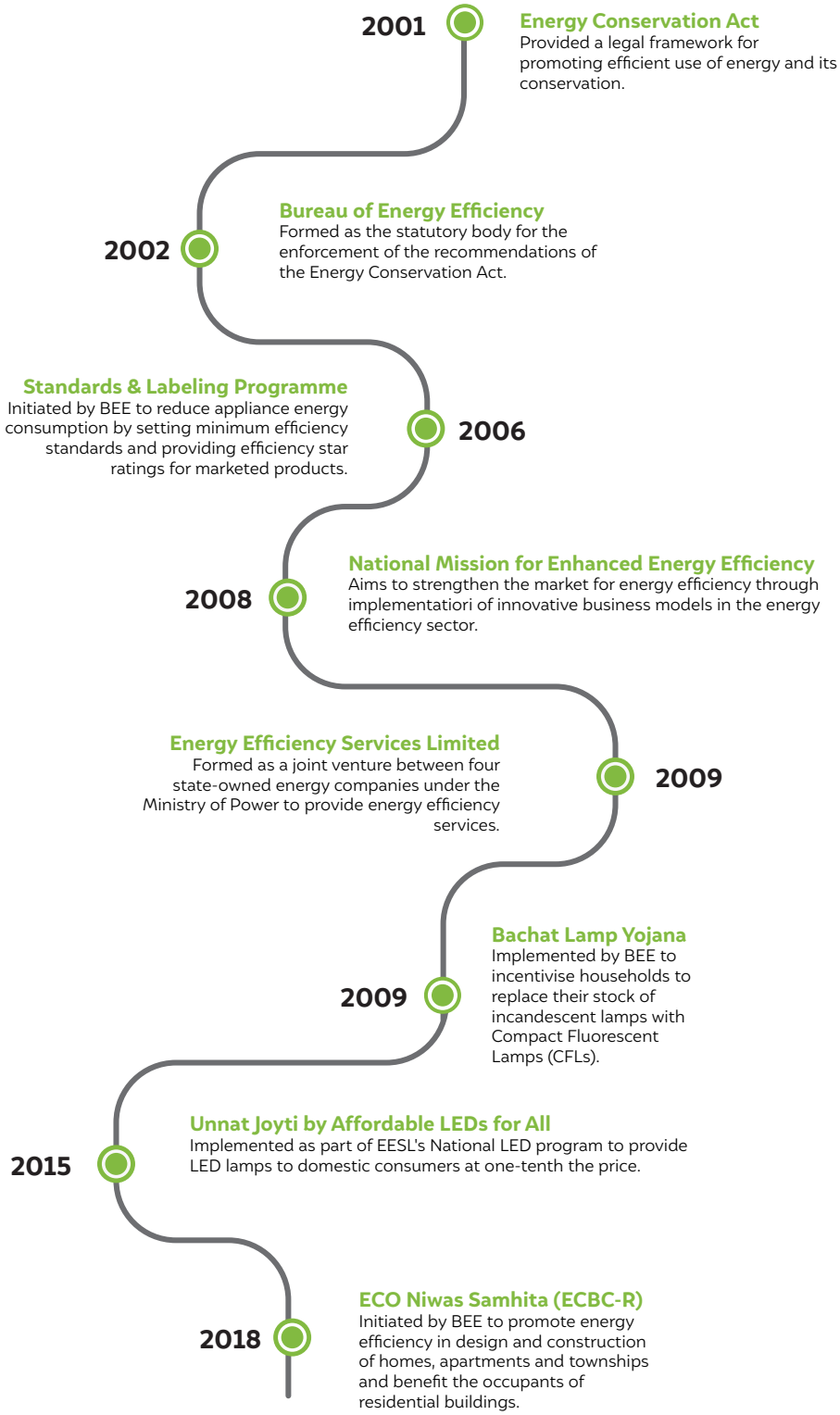


Figure 2
Key policies and initiatives targeted at energy efficiency in India's residential sector

Source: Authors' collation from various sources

The State Energy Efficiency Preparedness Index, jointly prepared by the Alliance for an Energy Efficient Economy (AEEE) and BEE, measures the preparedness of Indian states to implement energy efficiency. Based on this index, only three Indian states (Haryana, Karnataka and Kerala) are in the 'achiever' category of energy efficiency performance in 2019. Sixteen states attained the lowest rankings on this index, and not a single state achieved the highest possible category of 'forerunner', indicating how a lot more needs to be done on this front (Kumar et al. 2019). However, these scores are calculated based on states' adoption of policies and regulations, presence of institutional capacity, and financial mechanisms for energy efficiency rather than an evaluation of the impact of actual policy. Due to a lack of outcome-based indicators to assess performances, this Index falls short of measuring how far these policies have been successful in meeting their energy-saving objectives.

IRES survey captures the energy use patterns, awareness and adoption of energy-efficiency in Indian homes

Several independent consumer surveys in recent years have assessed household awareness levels regarding energy efficiency initiatives like BEE star labelling, penetration of efficient appliances, their perceived benefits, and the socio-economic and behavioural barriers to their uptake (Kusaka, Kojima, and Watanabe 2012; Sharma and Gupta 2013; Dhingra et al. 2016; R. Khosla and Chunekar 2017; Neto-Bradley, Choudhary, and Bazaz 2019). However, these studies do not depict a nation-wide representative status, as they were usually restricted to major urban areas, a single or a handful of districts, or a sample of highly educated respondents. A comprehensive and nationally representative assessment to understand household awareness levels and behaviour concerning energy efficiency has not been undertaken so far.

1.3 Objectives of the study

The India Residential Energy Survey (IRES) aims to assess the impact of the existing energy efficiency initiatives on household awareness, preferences, and behaviour regarding efficient electricity use. It is a nationally representative survey comprising nearly 15,000 households spread across 21 states of India. The IRES, conducted in collaboration with the Initiative for Sustainable Energy Policy (ISEP), covers all aspects of electricity and cooking energy use in Indian households. This report, second in the series, focuses on state of energy efficiency in Indian homes. Being national in scope and cutting across demographics, the survey throws light on socio-economic barriers to energy efficiency in Indian households, which could be used for targeted policymaking. The study answers the following research questions.

i. How aware are Indian households about BEE's star label? Which consumer categories and states would require more attention going forward?

ii. What appliances do Indian households run using electricity? What share of those appliances are energy-efficient?

iii. What influences appliance purchase decisions of Indian households? What role can appliance financing play in nudging consumers towards more efficient products?

Based on our research and findings, we propose strategies to accelerate the energy-efficiency transition in India's residential sector.

A team of 154 enumerators, a third being females, and 40 supervisors conducted survey with 14,851 households across 21 Indian states.

Image: CEEW/Market Xcel

2. Survey design

IRES 2020 is a nationally representative survey of 14,851 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.[1] Figure 3 depicts the key stages in the survey design and details the sampling strategy and distribution. A brief description of the survey design and data collection process follows.

A stratified multistage probability design was adopted for the survey sampling

2.1 Sampling

A stratified multistage probability design was adopted for the survey sampling (see Figure 3). Districts are the primary sampling units, while households are the ultimate stage units.[2] 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 of 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 4 depicts the major parameters captured in the survey.

1 A detailed description of study design can be accessed here.

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

Figure 3 India Residential Energy Survey – stages in survey design, preparation and execution

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

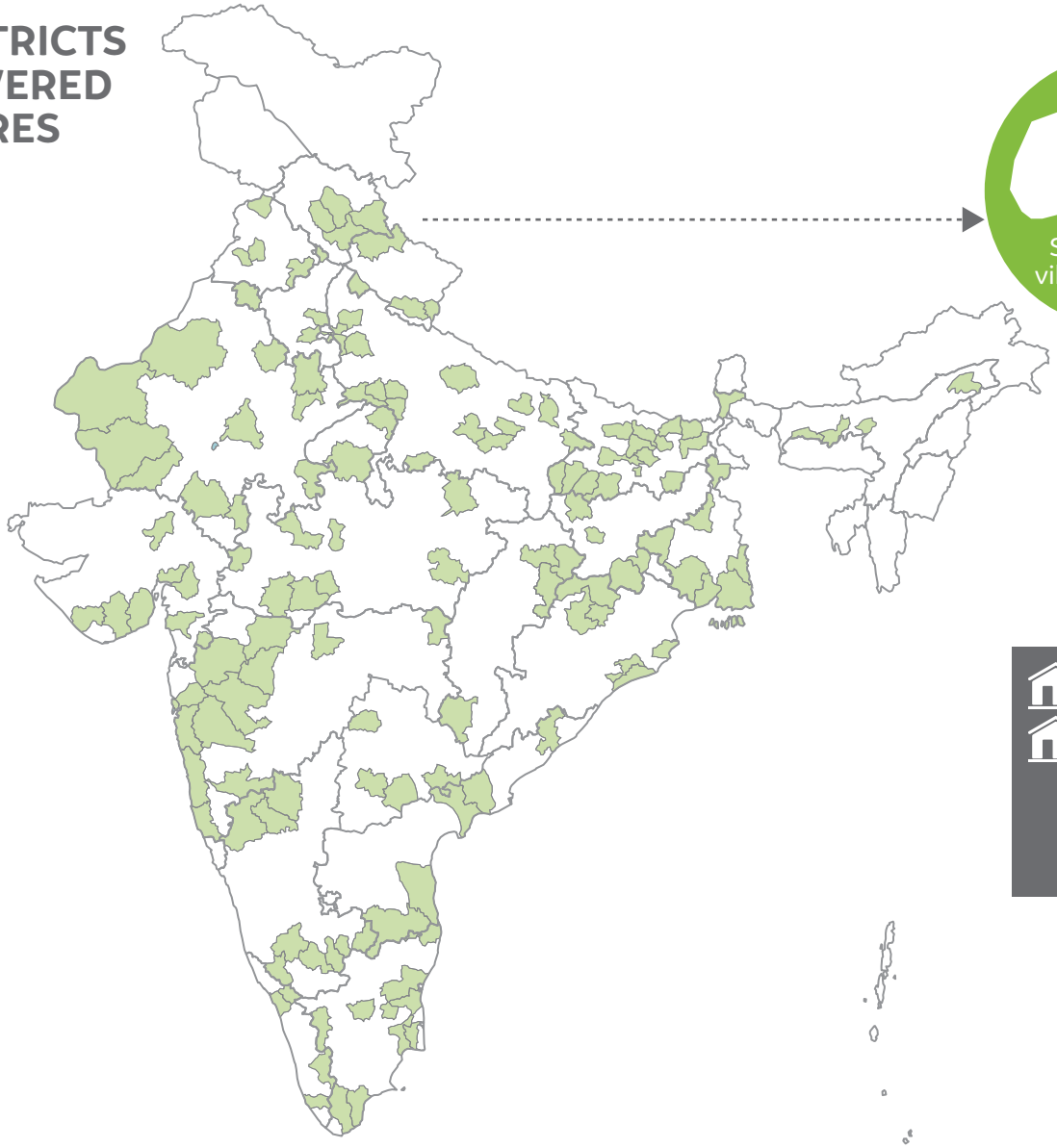
152 DISTRICTS
Cluster sampling

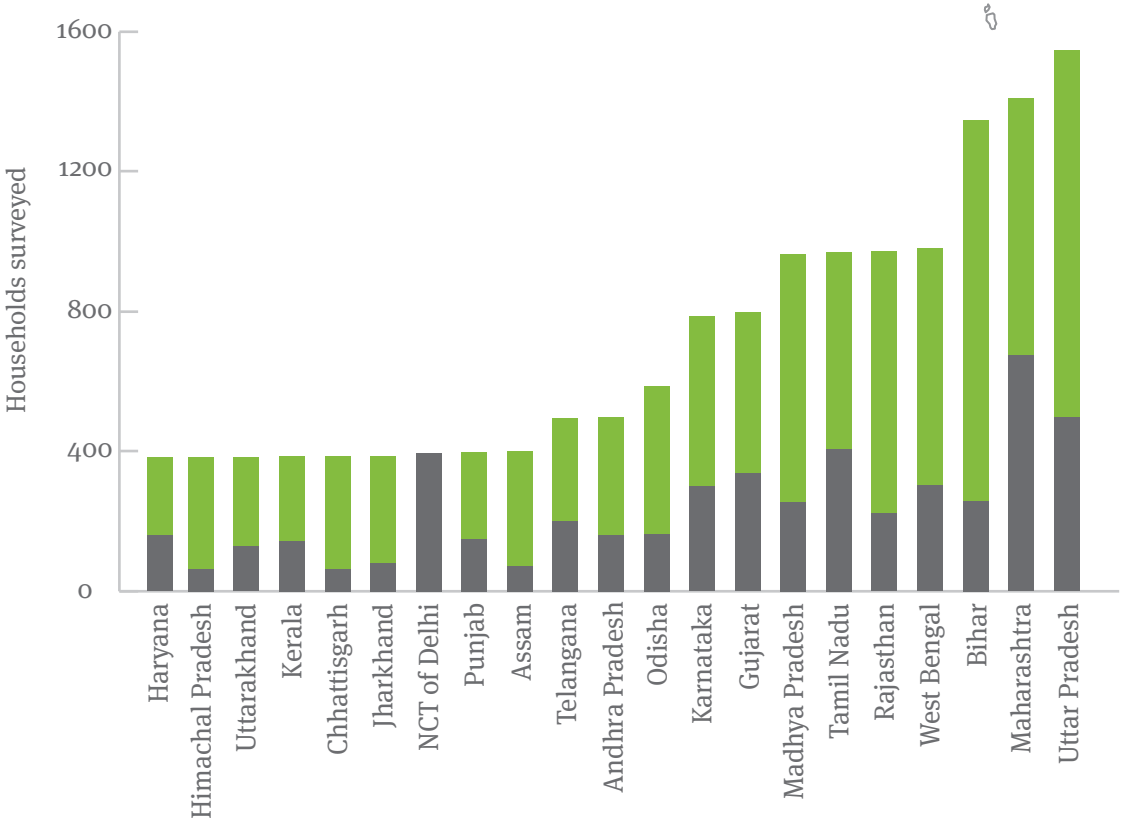
1210 VILLAGES & 614 URBAN WARDS
Cluster sampling

14,850 HOUSEHOLDS
8 from each village/ward

4 MILLION DATA POINTS

DISTRICTS COVERED IN IRES

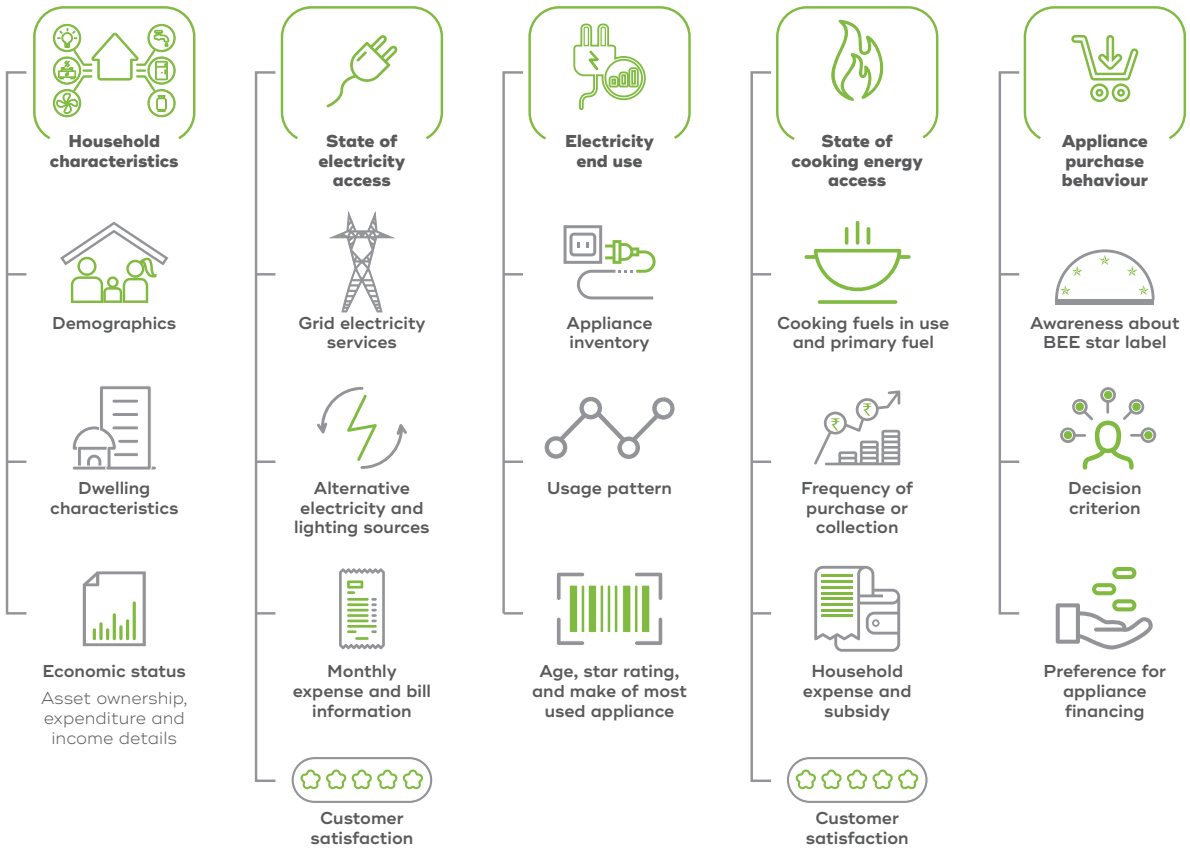




Rural
66%

Urban
34%

Figure 4 The IRES 2020 questionnaire framework



2.3 Data collection

All the surveys were conducted through in-person interviews by trained interviewers who used handheld tablets for data recording. A team of 154 enumerators (one-third of them females) and 40 supervisors was employed for collecting data. The team of enumerators and supervisors was provided an exhaustive 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, Oriya, Punjabi, Tamil, Gujarati, and Telegu. The questionnaires were administered between November 2019 and March 2020, and the median time taken per interview was 35 minutes.

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, such as ownership of air conditioners, computers, and washing machines, may be underestimated. If surveys of this nature were to be conducted with government backing with larger sample size that allows stratification of various consumer segments, the underestimations that we point out may be eliminated. Nevertheless, this survey has covered a large segment of the population, excepting some economically better off households, and we feel this exercise should be institutionalised and undertaken periodically.

Our survey was conducted between November 2019 and March 2020, and in 11 Indian languages

3. Are households aware of star labels?

Retailers can play an important role in guiding consumers about energy-efficient appliances.

Image: Shalu Agrawal/CEEW

Nathaniel Branden, an American Canadian psychologist, said, "The first step toward change is awareness." The same would apply to the adoption of energy efficiency in Indian homes. The market for energy-efficient appliances suffers from a number of market failures, including information asymmetry and high search costs (Gillingham, Newell, and Palmer 2009).

To overcome these challenges and to nudge the market towards higher efficiency products, BEE launched the standards & labelling (S&L) programme in May 2006. The programme aims to "provide the consumer an informed choice about the energy saving and thereby the cost saving potential of the relevant marketed product" (BEE 2020). Energy performance standards are defined in the programme, on the basis of which comparative energy (star) labels are displayed on appliances covered under the programme.[3] But the success of this programme crucially hinges on consumer awareness of these labels (Dhingra et al. 2016). In our survey, we elicited responses from households about their awareness of BEE star labels, which we elaborate in this chapter, along with its perceived benefits. We also explain where the lack of awareness arises from.

The success of BEE's S&L programme hinges on consumer awareness of these labels

3 While most appliances have comparative labels that allow consumers to compare energy performance across appliance models, some (e.g. laptops, printers) have endorsement labels, which provide a certification of energy efficiency to an appliance model.

3.1 Awareness levels about BEE star label

Our survey finds that awareness levels of the BEE star label at the population level are currently low.[4] At the national level, only one in four electrified households have heard about the programme despite the programme having been launched nearly a decade and a half ago.[5] Figure 5 shows that awareness is higher in urban areas than in rural areas.

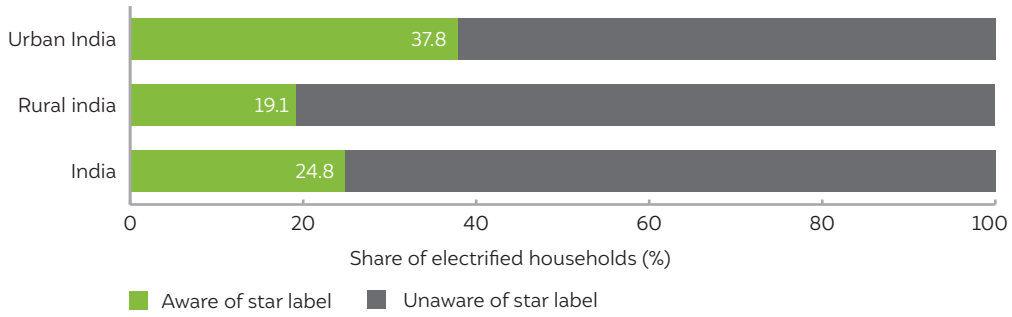


Figure 5
Only one-fourth of Indian households are aware of BEE star label

Source: Authors' analysis

Awareness levels vary across states (Figure 6). Six out of ten households in the NCT of Delhi were aware of star labels, as it is a fully urbanised area. Delhi is followed by Maharashtra, Kerala, and Himachal Pradesh, where more than 40 per cent of the households expressed awareness of the star label. In contrast, Chhattisgarh, Madhya Pradesh, and Haryana have less than 10 per cent households who are aware. State level averages are often brought down by the lower awareness among rural households.

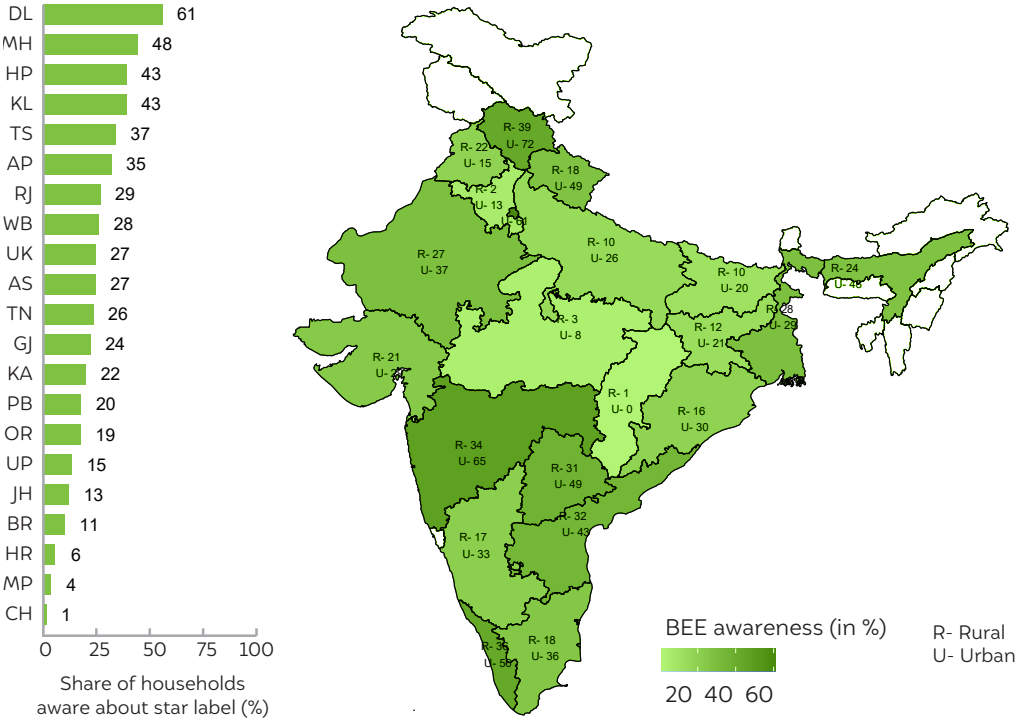


Figure 6
Awareness of BEE star label is highest in Delhi and lowest in Chhattisgarh

Source: Authors' analysis

4 After showing a typical BEE star label, we posed the following question to the respondents: 'Please see this picture. Have you heard of or seen the star rating or star labels on electric appliances?'

5 Ninety-five per cent confidence interval 95% (CI) for national level estimate is 24–25.5 per cent. For rural and urban households, the 95% CI is 18.3–20 per cent and 36.3–39.2 per cent, respectively.

Incidentally, our survey reports low overall awareness levels compared to those reported by earlier studies due to sampling differences. For instance, Dhingra et. al (2016) conducted a survey of 5,000 households in and around major cities and towns across four climatic zones in India, and found 63 per cent awareness among the surveyed households. The higher awareness levels reported in this study may be attributed to the following: (i) it included a higher proportion of urban households residing in major cities and (ii) it employed the method of quota sampling, wherein the share of households owning certain appliances was pre-defined.

As per IRES, awareness levels are higher in more urbanised districts and marginal in predominantly rural districts (Figure 7). Out of 152 districts surveyed, 28 districts have large urban agglomerations with a population of one million or more. Awareness levels in these districts are typically much higher than the national average. For example, in Mumbai and Mumbai Suburban districts, which are fully urbanised, more than three-fourths of the households are aware of star labels.

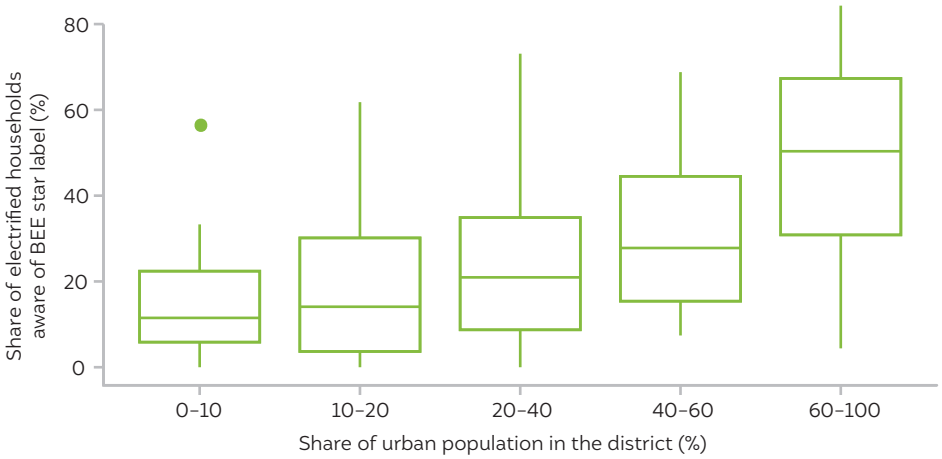


Figure 7
Awareness about the star label is higher in more urbanised districts

Source: Authors' analysis

Note: The share of urban population in the district is as per the Census of India 2011.

Perceived benefits of BEE star labels

The effectiveness of awareness about the star label lies in the benefits that consumers associate with it. We find that a vast majority of households that are aware of BEE star labels believe that labelled products yield 'lower electricity bills' and/or 'energy savings' (Figure 8). This implies the S&L programme's effectiveness in communicating the key benefit of using a rated appliance. A significant share of aware households also perceives star label as an indication of a good quality product with longer life. More than a quarter of the households also cited that the star label identifies an environment friendly product.[6]

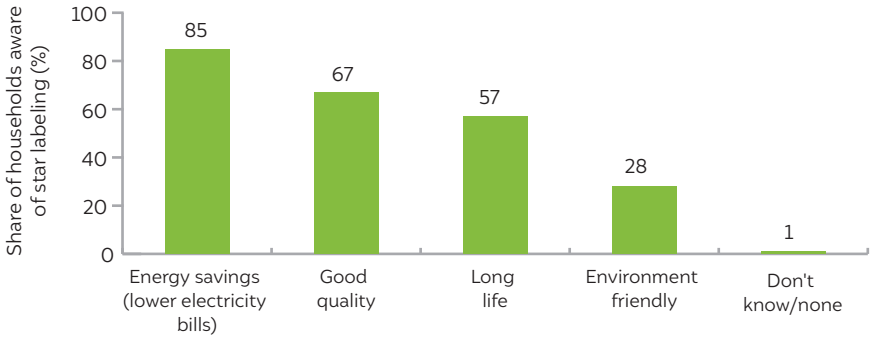


Figure 8
A majority of households associate the star label with energy savings

Source: Authors' analysis

6 We asked the respondents about the perceived benefits of using star-labelled appliances without giving any hints or options. Enumerators coded the multiple responses against the list of options in the questionnaire.

3.2 Understanding the variation in awareness levels

Figure 9a shows the variation in awareness of BEE star label across households/respondents with different socio-economic characteristics. We summarise our findings below:

- Awareness is higher among households with a more educated primary income earner[7] and younger survey respondents. This is because younger and more educated consumers are likelier to read and understand the star labels, which are in English. They are also more likely to buy a labelled appliance. Half of the households with a graduate primary income earner own an appliance covered under the labelling programme compared to only one-fifth of households having labelled appliances where the primary income earner was not a graduate.
- Awareness is higher among households with higher incomes and with ownership of at least one appliance covered under BEE's mandatory labelling scheme (Figure 9a)[8]. A recent survey in Uttar Pradesh found that awareness about the S&L programme varies from 2 per cent among low-income rural households to 21 per cent among high-income semi-urban households (Kaul et al. 2020).
- Rural households with similar socio-economic characteristics typically have lower awareness than their urban counterparts. This is likely due to lower appliance ownership among rural households as well as limited awareness efforts in rural areas. Lack of awareness among rural consumers is a major barrier to them not preferring energy-efficient appliances (Kumar et al. 2020).

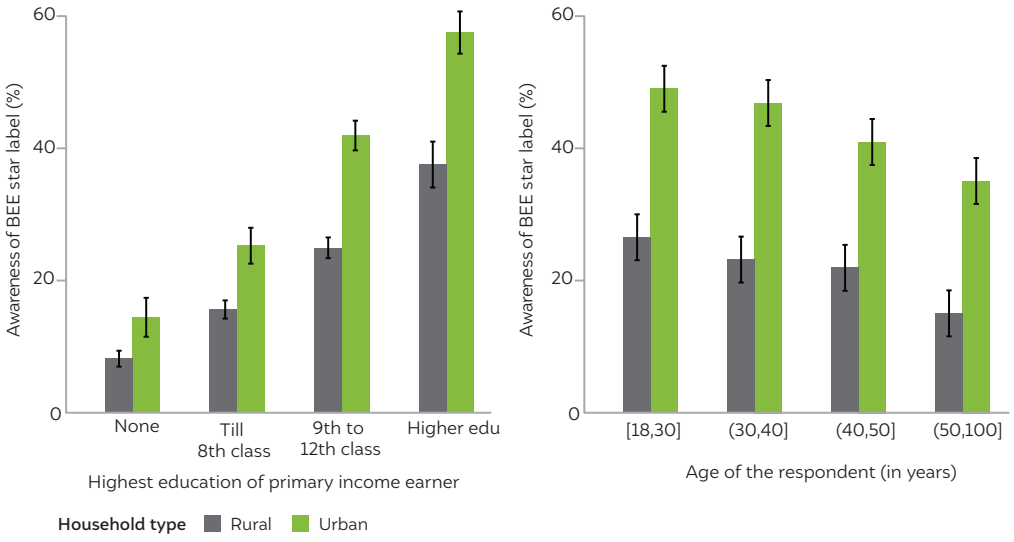


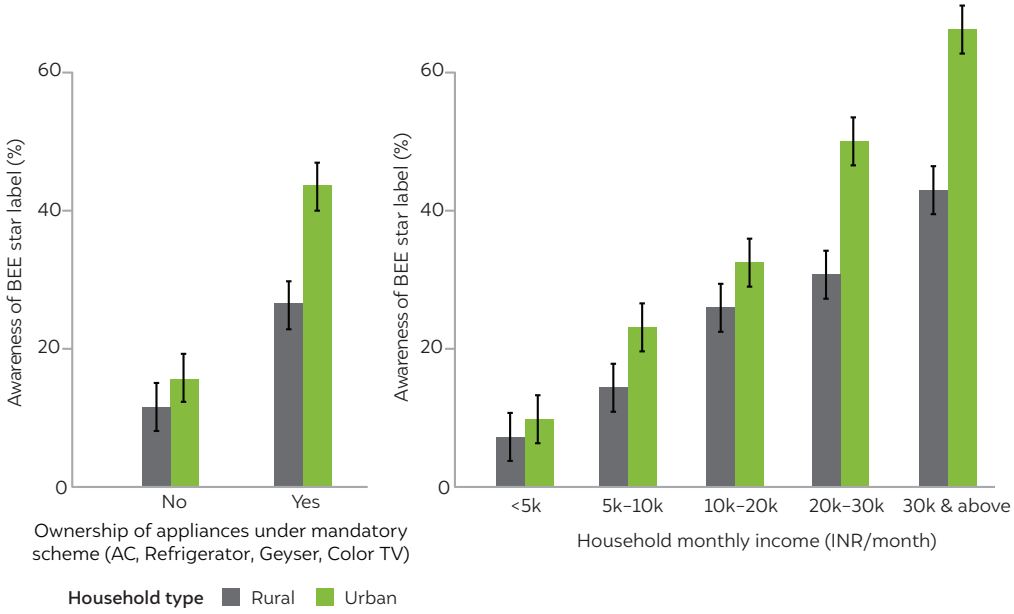
Figure 9a
Star label awareness varies with education levels, age, income, and appliance ownership

Source: Authors' analysis

Note: The error bars represent the 95 per cent confidence interval.

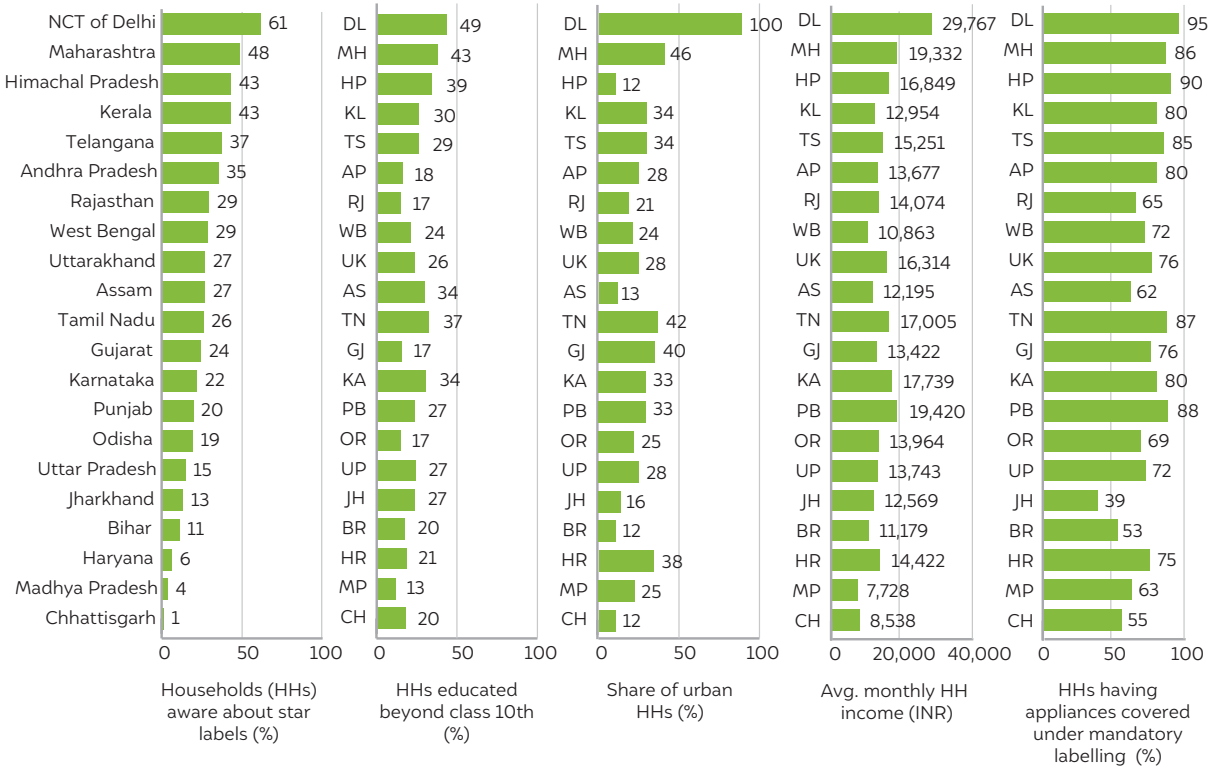
7 Two-thirds of the survey respondents were primary income earners.

8 Initially, a voluntary labelling programme was introduced for refrigerators and ACs, which was later on expanded to 10 appliances, including ceiling fans and washing machines. In 2009, BEE made star labelling mandatory for four appliances, including refrigerators and ACs. As of June 2020, obtaining and displaying the label is mandatory for 10 appliances and voluntary for 16 (see Annexure 1 for details).



These indicators also explain the variation observed across states (Figure 9b). States which have higher average household income, more primary income earners educated beyond class 10, more urban households, and higher ownership of appliances covered under the mandatory scheme typically have higher awareness levels. The mentioned factors are strongly correlated (0.6–0.7) with the share of aware households in a state.

Figure 9b State-wise variation in awareness of star label is linked to household characteristics



Source: Authors' analysis

Note: HH = household

3.3 Evaluating the past awareness efforts

Besides designating a star label to provide a simple visualisation of energy performance and potential energy savings from appliances, BEE is also engaged in increasing awareness and understanding of labels among users of appliances through consumer education and information campaigns (Dhingra et al. 2016). BEE leverages several channels for the awareness campaigns as discussed below.

- BEE has made use of print media, radio, television, digital channels, and more recently social media platforms for ensuring a wider reach of its information campaigns (BEE 2019a). For example, 156 episodes of a radio programme called *Bachat ke Sitaare Dost Hamare* (Energy efficiency star labels, our friends) have been aired on the All India Radio in 20 languages in 30 cities. BEE also launched a mobile application in 2015, in which a list of appliances in each scheme and a calculator for potential energy bill savings from rated appliances are provided.
- The SDAs, encouraged by BEE, periodically conduct painting competitions on energy conservation in schools and colleges (BEE 2013). Recently, energy efficiency has been included in school curricula of classes VI to X, and Energy Clubs have been inaugurated in schools in various states through the SDAs (BEE 2018).
- To involve relevant stakeholders, BEE also conducts training programmes for retailers periodically. So far, the Bureau has conducted training sessions across 34 cities and nearly 7,500 retailers have been trained on the star labelling programme (BEE 2018, 2019, 2020). Previous studies clearly indicate the role of retailers in influencing consumer decisions during appliance purchase (Dhingra et al. 2016).

Though these efforts are commendable, our data suggests that their impact has been limited and much more needs to be done. We interviewed officials at BEE's SDAs from a few states such as Haryana, Punjab, Madhya Pradesh, and Uttar Pradesh. Two key issues emerged from these interviews:

- ***Low frequency and limited geographic coverage of awareness campaigns.***

  Our interviewees revealed that advertisements in print media are typically issued on select days, such as on the World Environment Day (June 5) or the Energy Conservation Day (December 14). Similarly, the painting competitions in schools/colleges are mostly limited to urban areas and are organised once or twice in a year. Even the retailer training programme is limited to predominantly urban areas.

- ***Gaps in institutional capacity.***

  The *Energy Conservation Act* of 2001, under which the BEE was formed, provided for state governments to "designate any agency as designated agency to coordinate, regulate and enforce provisions of this Act within the State" (Government of India 2001). It does not provision for SDAs to be offices dedicated to energy efficiency activities. Consequently, out of 35 SDAs notified, only two are "stand-alone" offices (in Kerala and Andhra Pradesh), whereas 16 are the renewable energy development agencies, which were set up to oversee renewable energy projects at the state level; 11 are electrical inspectorates or state power departments, whose primary function is to maintain and operate the states' electric infrastructure; and six are discoms (BEE 2018).

Thus, most SDAs are typically agencies or departments that have been given the additional responsibility of energy efficiency. SDA personnel informed us that renewable energy deployment has increasingly assumed centre stage since 2011, due to which SDAs often face difficulty in balancing the competing priorities. The resulting constraints are exacerbated in SDAs that are understaffed and have limited resources at their disposal.

Competing priorities and human resources crunch limit SDAs' capacity to promote energy-efficiency in states

Further, the Act provisions for SDAs to carry out inspections of retail/distribution outlets and warehouses for compliance with S&L regulations (via an externally appointed inspection officer), report breaches to BEE and the SERC, and inform the public about the findings (BEE 2019b). The Act does not mandate SDAs to create awareness of S&L. This coupled with competing priorities and human resources crunch limit SDAs' capacity to design context-specific strategies to promote energy efficiency in states.

In 60% of Indian homes, the purchase decision is taken by the male head of the family

Besides filling the institutional gaps and investing in capacity building of the SDAs, there is a need to rethink the outreach strategy for generating mass awareness among households from diverse socio-economic backgrounds and geography. Past efforts have focussed on targeting and educating school students, the thinking behind which was that it may deliver long-term benefits as they become independent consumers. However, their capacity to influence family purchase decisions in the medium term may be limited. Our analysis shows that in 60 per cent of electrified households, the purchase decision is taken by the male head of the family; in less than 15 per cent of the households, all members of the family contribute to decision-making. Influencing the key decision makers of the family should be incorporated into the outreach efforts of BEE.

To gain an idea about purchase influencers, we asked the household decision-makers whom they consult when buying a new appliance. We find that 75 per cent of consumers (rural and urban) consult their friends or family when making an appliance purchase decision (Figure 10). Nearly 17 per cent do not consult anyone, while 40 per cent rely either on vendors' advice, TV advertisements, or online reviews; only 6 per cent rely on radio advertisements. Though Indian consumers prefer different modes for gathering information, we infer that an overwhelming number of them rely on word-of-mouth—through friends/family. It also highlights the need for innovative and cost-effective ways of reaching out to masses.

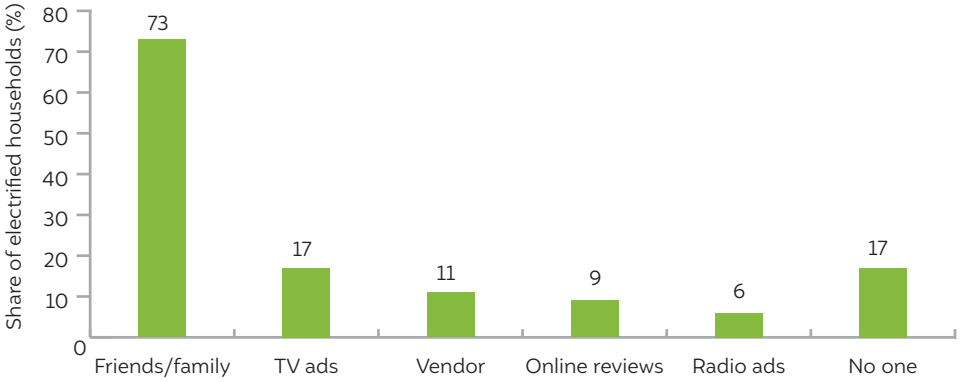


Figure 10
Most people consult friends/family when purchasing an appliance

Source: Authors' analysis

Way forward

Over the past decade and a half, since the launch of the S&L programme, BEE has spearheaded efforts to spread awareness about energy efficiency through star labels. The results of these efforts are more apparent in urban, more educated and high-income households than otherwise. BEE's information, education, and communication (IEC) strategy in future should endeavour to popularise the BEE star labels across the length and breadth of the country. We place the following recommendations for the attention of policymakers to create better awareness of BEE's star rating programme:

- *Design an aggressive, consumer-centric, and localised consumer awareness strategy.* Low awareness levels about star labels highlight the need for year-round and sustained awareness campaigns, in regional languages and through diverse media, instead of sporadic mass media campaigns. Outreach should be targeted to reach households in small towns and rural areas, where awareness is poor at present.
- *Leverage multiple stakeholders for reaching all consumers.* At present, SDAs are responsible for implementing BEE's state-level IEC campaigns. However, given the constraints SDAs face, there is a need to rope in other relevant stakeholders.
  - Studies evaluating the implementation of S&L programmes show that civil society organisations (CSOs) can help build trust and awareness among consumers (Jairaj, Martin, and Singh 2013). Institutions like gram panchayats in rural areas, residents' welfare associations and municipal councils in urban areas, and other grassroots organisations could be called in and incentivised for conducting awareness programmes in their jurisdiction. We recommend this approach, as it has been leveraged under *Swachh Bharat Mission* and for promotion of rooftop solar in certain cities (Trivedi 2019).
  - BEE could consider a pilot programme to identify influencers of local community to become local 'champions of energy efficiency'. These could lead the discourse on energy efficiency among local community and make it aspirational. As discussed in Box 1, this could help leverage the powerful effects of social norms in shaping individual behaviour (Prabhu et al. 2013; Rathi and Chunekar 2015).
  - Given their widespread on-ground presence, discoms should lead initiatives on creating consumer awareness of energy savings, including instilling in consumers a preference to buy energy efficient appliances. For instance, discoms in Maharashtra provide energy-saving tips on their bills, which can be emulated by other discoms. BSES Rajdhani Power Limited (BRPL), a private discom in Delhi, in partnership with Oracle Utilities, is running a behavioural energy efficiency pilot with 0.26 million consumers (Sachar et al. 2019). Under this programme, the discom sends personalised home energy reports (HERs) to consumers, which contain information about their historical electricity use, normative comparison of one's consumption with that of neighbours, and suggestions to reduce bill amounts through energy-saving measures.

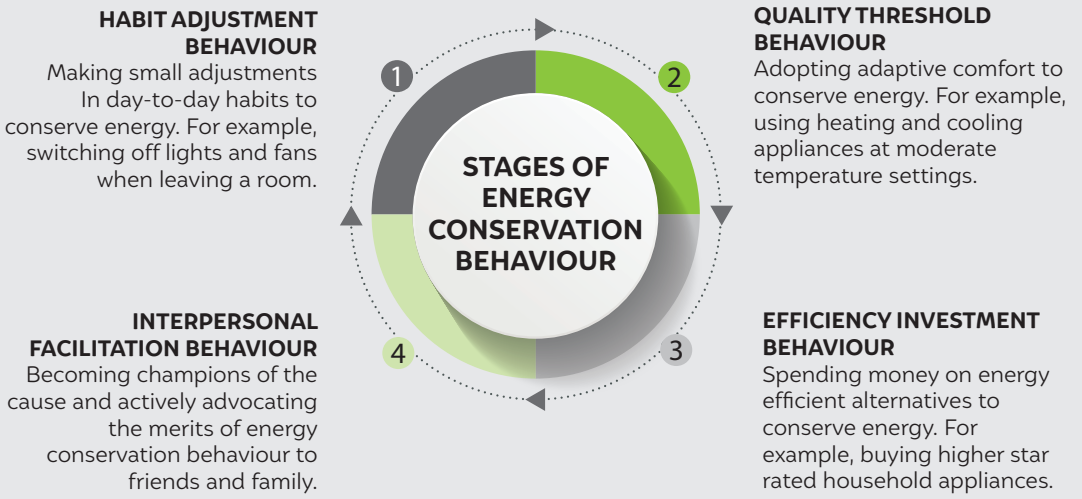
Our analysis suggests that low awareness levels are also linked to lower ownership of high-cost appliances, such as air conditioners (ACs) and refrigerators, that were mandated to have the star label early on. In contrast, essential appliances, such as ceiling fans, have remained in the voluntary scheme since 2010. Star labels for light-emitting diodes (LEDs), which are now ubiquitous, were mandated only in 2018.[9] Widely used appliances with high energy saving potential need to be brought within the fold of the mandatory scheme, which would expose more consumers to star labels. However, implementing the mandatory scheme is not easy and raises many questions. With several household appliances presently covered under the star labelling programme, what is the level of penetration of energy-efficient appliances in Indian homes? And to what extent does the mandatory or voluntary labelling for an appliance influence the adoption of efficient products? We answer these questions in the next chapter.

9 In case of lighting appliances, the switch to the compact fluorescent lamp (CFL) spiked following the launch of the *Bachat Lamp Yojana* in 2009. However, they were never part of the S&L programme. Sales of tubular fluorescent lamps (TFLs), part of the mandatory programme since 2009, on the other hand, had peaked by 2014 and were surpassed by LED sales by 2016 (Chunekar, Mulay, and Kelkar, 2017). Thus, a majority of households may not have been exposed to the star labels on LEDs as they shifted from ICLs to CFLs and then to LEDs.

Box 1: The four stages of energy conservation behaviour (ECB)

The most efficient unit of energy is the unit that is never consumed. Energy conservation at the consumer level, therefore, is an integral piece of the energy efficiency puzzle. Yue et al. (2019) divide energy conservation behaviour (ECB) into four types, based on which we propose a four-stage process (Figure 11). The first two stages—habit adjustment behaviour and quality threshold behaviour—require small to moderate adjustment in appliance use on a day-to-day basis. Many of the current awareness campaigns stress on these behavioural changes through messages on electricity bills, radio jingles, or TV advertisements. Achieving the third stage of efficiency investment behaviour is harder, as interventions are required to offset the higher upfront costs that consumers pay to acquire energy-efficient appliances and reducing information asymmetry. BEE's S&L programme and EESL's *UJALA* scheme focus on this stage. In the last stage—interpersonal facilitation behaviour—a consumer becomes the local champion of ECB and advocates its benefits to friends and family, bringing others into the ECB fold. India's energy efficiency policy could be designed to test various interventions, especially the last stage on a pilot basis.

Figure 11 The four stages of energy conservation behaviour



Source: Author's adaption from Yue, Ting, Ruyin Long, Junli Liu, Haiwen Liu, and Hong Chen. 2019. "Empirical Study on Households' Energy-Conservation Behavior of Jiangsu Province in China: The Role of Policies and Behavior Results." International Journal of Environmental Research and Public Health 16 (939): 1–16.

Indian consumers have warmed up to the energy-efficient LED lamps. A customer buying LED lamps in Pali district, Rajasthan.

Image: Shalu Agrawal/CEEW

4. How energy efficient are Indian homes?

As India is close to achieving universal electrification of homes, it becomes important to gauge how access to electricity is enabling access to basic services and comfort in homes. But with greater *power* comes greater responsibility – that of using electricity wisely and efficiently. To what extent have Indian households taken to energy-efficient appliances to meet their domestic needs? In this chapter, we discuss the various end-uses of electricity in Indian homes, the extent to which the residential appliance stock is efficient, and the hits and misses of past efforts in pushing for energy efficiency in the country.

4.1 Lighting

Space lighting is the most common end-use of electricity. Energy-inefficient incandescent lamps (ICLs)[10] were widely used at homes for lighting until recently and replacing them was the focus of government efforts in the last decade. In 2009, BEE launched *Bachat Lamp Yojana* (*BLY*) to support the adoption of compact fluorescent lamps (CFLs). Then, in 2015, the Government of India launched the *Unnat Jyoti by Affordable LEDs for All* (*UJALA*) scheme. Under UJALA, EESL significantly brought down the cost of LED lamps through demand-aggregation and bulk procurement and distributed them to households at a discounted price. As of 16 September 2020, nearly 366 million LED lamps have been distributed under *UJALA* scheme (MoP 2020a).

The government's efforts have yielded very encouraging results on the lighting front. Nearly 90 per cent of electrified households have LED lamps or tubes in their house, as per our survey findings, with high penetration levels in both urban and rural areas (Figure 12). Apart from LEDs, we find that less than half of the households use CFLs and tubular fluorescent lamps (TFLs), while one-third continue to use ICLs.[11] While use of ICLs is lower among urban households (25 per cent, compared to 34 per cent among rural households), use of all other lighting fixtures is higher among urban households.

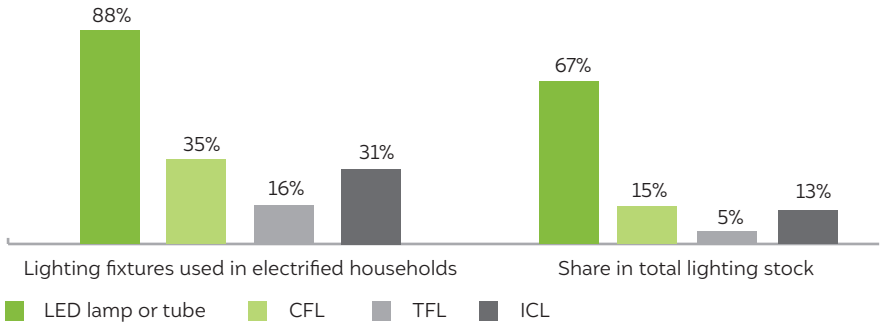


Figure 12
After the *UJALA* scheme was launched, LEDs have made massive inroads into Indian homes

Source: Authors' analysis

Note: Sum of shares in the left graph is more than 100 due to mix of LEDs/CFLs or ICLs in some cases.

10 Also referred to as GLS (general light service bulbs) or ILBs (incandescent light bulbs).

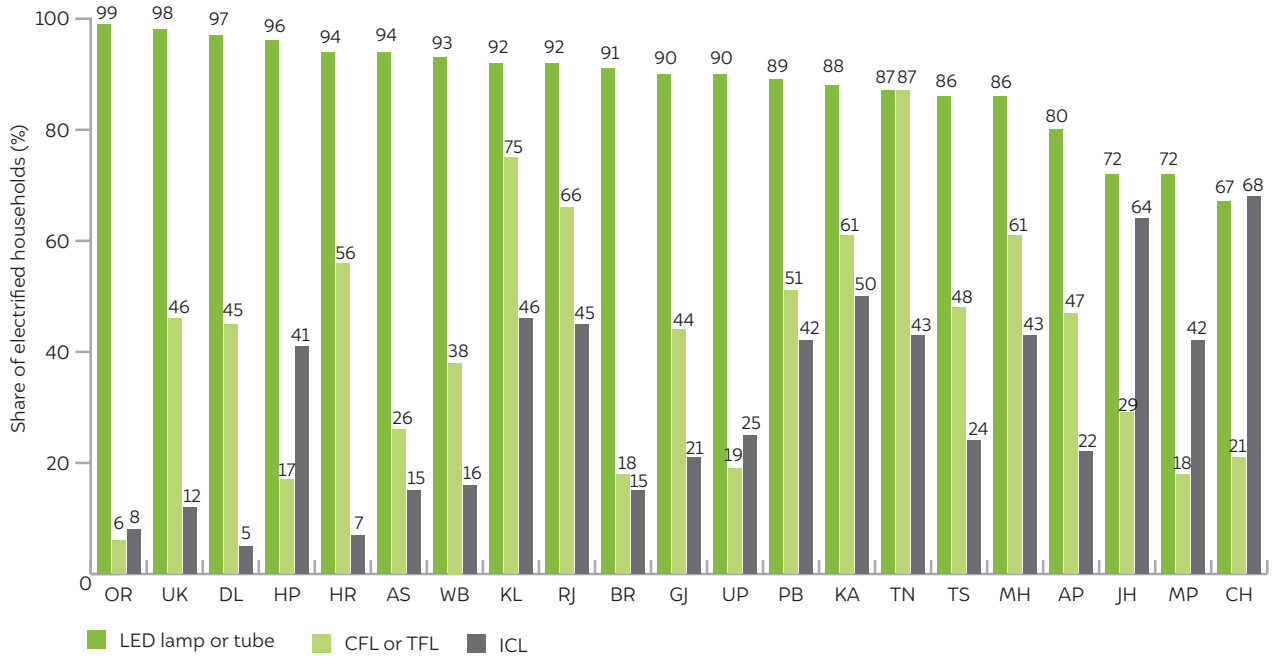
11 During the survey, enumerators used images to help the households correctly identify different lighting equipment in the house. However, some measurement error is likely in these estimates, as some households may have confused between different lighting types.

Our survey reveals that Indian homes have a stock of 1.09 billion light lamps and tubes, of which 67 per cent (721 million) are LED lamps and tubes.[12] The annual sale of LED appliances in India has gone up 100 times in four years, from 4.86 million in 2014 to 520 million in 2018 (ELCOMA 2019). The *UJALA* scheme has been instrumental in bringing in a market transformation by bringing down the retail price of LED lamps and making it affordable for a large number of households. Around 30 per cent of the users cited LED availability at low cost (under the government scheme) as the reason for its purchase; other reasons include lower electricity bill, better quality product, and longer life. Nearly all LED users (97 per cent) expressed satisfaction with their LED lights.

Indian homes have a stock of 1.09 billion light lamps and tubes, of which 721 million are LEDs

Household preferences concerning lighting appliances vary across states (Figure 13). For instance, more than 95 per cent of the households in states like Odisha, Delhi, Uttarakhand, and Himachal Pradesh have LED lamps. The share of ICLs in the lighting stock is low in these states, implying very high levels of energy efficiency in lighting use (Figure 14). However, in states like Madhya Pradesh, Chhattisgarh, and Jharkhand, nearly one-third of the households do not use any LED lights and rely primarily on ICLs for their lighting needs. In states such as Kerala, Maharashtra, Karnataka, and Tamil Nadu, the share of LED in lighting stock is less than 60 per cent due to higher stock of CFLs that were promoted under the *BLY* scheme (Figure 14).

Figure 13 More than 80 per cent households use LEDs for lighting in all except three central states

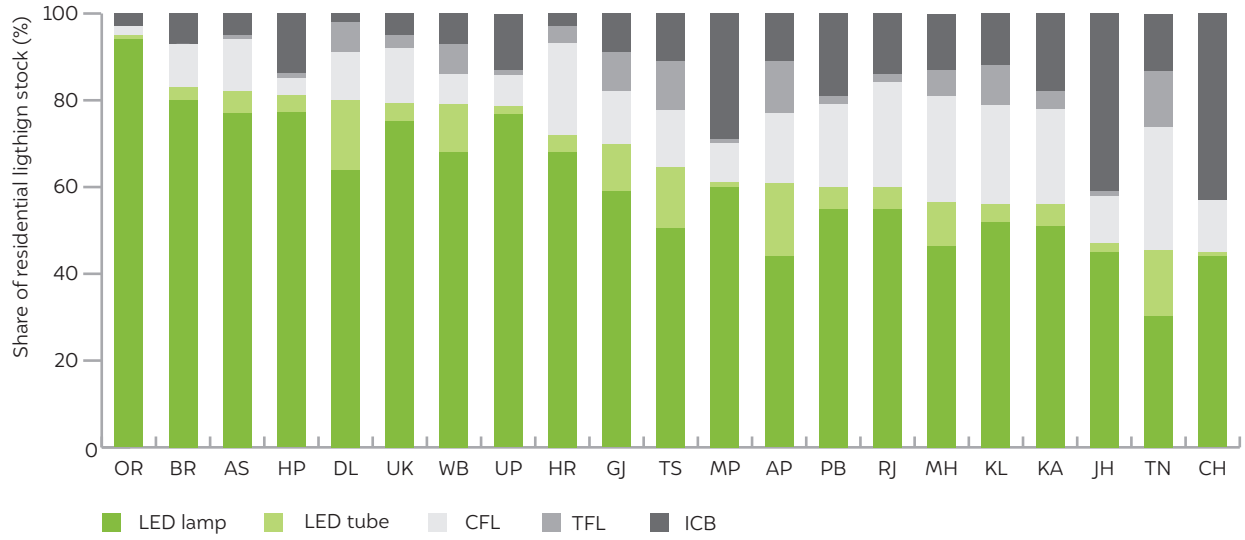


Source: Authors' analysis

Note: The numbers sum up to more than 100 per cent as some households have a mix of LEDs, CFLs, and ICLs.

12 Ninety-five per cent confidence interval for lighting stock is 1.08–1.1 billion, and that for LED lamps and tubes is 711–731 million. On average, an Indian household has 4.6 lighting lamps, comprising 3.1 LEDs, 1 CFL/TFL, and 0.6 ICLs. Average lighting stock per household is 4.4 in rural areas (2.9 LEDs, 0.9 CFL/TFL, 0.6 ICLs) and 5.2 in urban areas (3.4 LEDs, 1.4 CFL/TFL, 0.4 ICLs).

Figure 14 Odisha, Bihar, and Assam have the highest share of LEDs in total lighting stock



Source: Authors' analysis

High penetration of LEDs in some states can be traced to implementation of government schemes. In January 2019, Odisha government launched a scheme to distribute four LEDs free of cost to all households in the state, which may explain its highest share of LEDs in lighting stock (PTI 2019). Even in Delhi, Uttarakhand, and Himachal Pradesh, the total number of LEDs distributed so far is nearly four times the total number of households in the state.[13] The ratio of LEDs distributed to total households in the lagging states is relatively much lower. Recent electrification under the *Pradhan Mantri Sahaj Bijli Har Ghar Yojana* (*Saubhagya*) scheme could have led to high share of LED in lighting stock in Bihar, Assam, and Uttar Pradesh, as it is mandatory for discoms to distribute LEDs along with the connection under the scheme (REC 2020).

The timing of LED lamp distribution may also explain the variation of LED stock in lighting across states. Under the *UJALA* scheme, 280 million LED lamps (out of the total of 366 million) were distributed between 2015 and 2017 (India.com 2017). In the intervening period, some LEDs may have become dysfunctional, following which some households, particularly those in rural areas, may not have purchased LEDs due to cost or availability barriers (see Figure 15). Odisha, on the other hand, witnessed a recent LED distribution drive covering all households. However, to identify best practices in the states with a high share of LEDs in stock, further research is necessary.

Overcoming the barriers to uptake of LED lights

In order to displace traditional lighting solutions with LED lights in Indian homes, it is important to understand the reasons which have kept some households away from LEDs. As per our survey, 9 per cent of urban and 14 per cent of rural households in India do not use any LED light. We asked each of these households the primary reason for not using LED lights. Two key reasons stand out: lack of awareness and high cost of LED lights.[14] When we dipped in further, we find that awareness is the primary concern in urban areas whereas affordability is the key constraint in rural areas. The *UJALA* scheme may not have covered the entire population as yet. Limited availability of LED lights in local shops emerged as the third important barrier, mainly in rural areas (Figure 15).

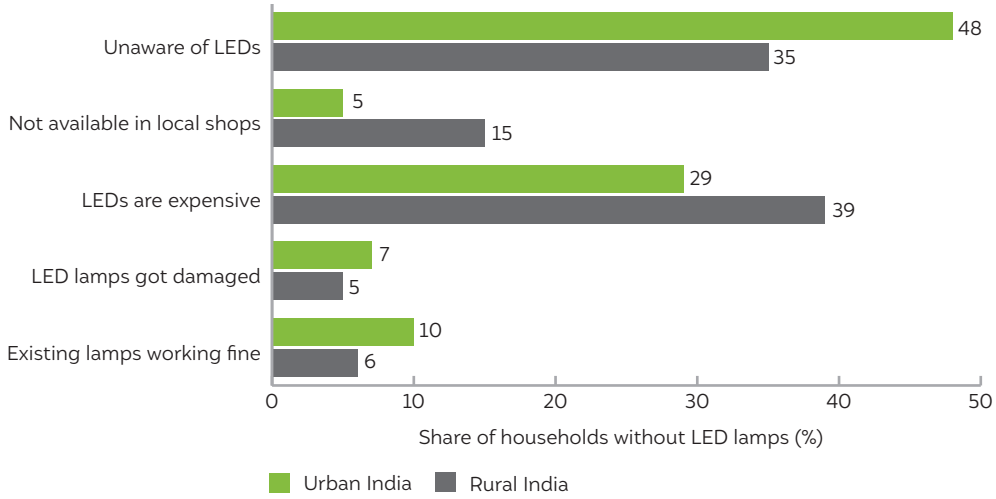


Figure 15
Limited awareness and higher cost are the key reasons behind households not using LED lamps

Source: Authors' analysis

LED lamps or tubes are absent in households that lie on the lower end of the socio-economic spectrum; these were typically *kuchha* or semi-*pucca* houses and their residents had low education attainment. LED lights would be a boon to these low-income households as their electricity bills would drastically come down. Targeted interventions are necessary to reach out to such households by addressing awareness, affordability, and availability constraints. For instance, power utilities could consider distributing two free LED lamps every year to low-income households.

4.2 Ventilation and space cooling

After lighting, ventilation and/or space cooling is the second most common end-use of electricity in Indian homes, as per our survey. While 93 per cent of the electrified households across India use fans, more than 99 per cent of urban households have fans (Figure 16).[15] The use of fans in Indian homes has consistently increased over the past decade from 72 per cent in 2011 (68th round of National Sample Survey Organisation [NSSO]) to 78 per cent in 2015 (4th round of National Family Health Survey [NFHS]) to 93 per cent in 2020, thanks to the intensive household electrification (Paswan et al. 2017). At an average ownership of two fans per household observed in our survey, the total fan stock (ceiling and other types) in Indian homes is about 450 million (95 per cent CI: 444–456 million).

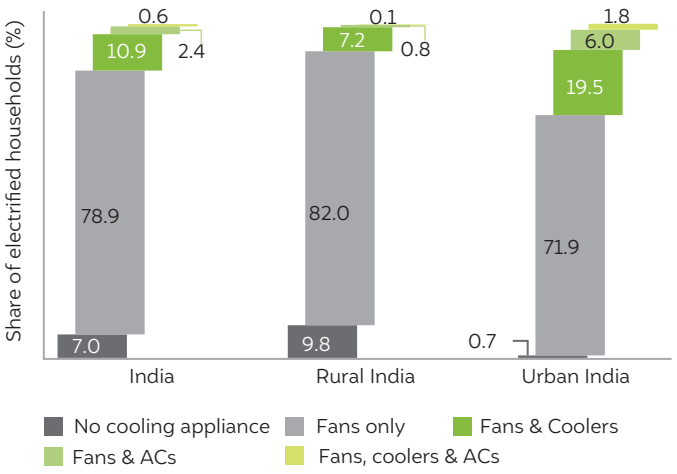


Figure 16
More than 90 per cent of Indian households use fans for ventilation

Source: Authors' analysis

15 While almost all households use ceiling fans, nearly 15 per cent also use table/pedestal/wall-mounted fans.

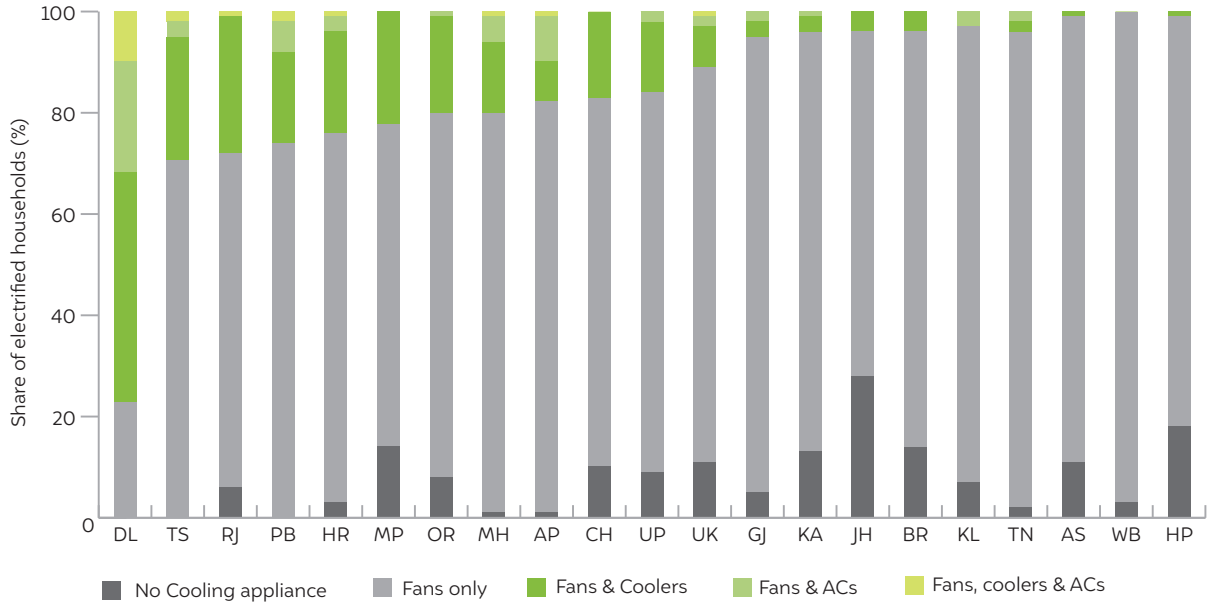
However, only 12 per cent of households have desert coolers and 3 per cent have room ACs. Figure 16 shows the combination of cooling appliances used in Indian homes. Around one in four urban households use a cooler or/and an AC, but in rural areas, just 8 per cent households have these spacing cooling appliances. Around 60 per cent of the AC-owning households have fixed-speed split ACs of 1.5-ton capacity. As many as 80 per cent of AC users reportedly bought their first AC in the past five years.

80% of households owning ACs bought their first AC in the past five years

AC and cooler ownership are an under-estimation on account of high non-response rates in more urban and economically better-off districts and potentially also due to non-sampling errors. As per NHFS-4, the ownership of ACs or coolers in Indian homes stood at 18 per cent in 2016 (Paswan et al. 2017). *India's Cooling Action Plan* (*ICAP*) estimates AC ownership to be around 9 per cent (MoEFCC 2019), but these figures are based on sales/stock data. A survey conducted with government backing and allowing stratification to adequately cover all consumer segments can yield a robust estimate of AC and/or cooler ownership in the country.

The choice of cooling equipment also varies widely across the states (Figure 17), which may be due to variations in climatic conditions. Nearly three-fourths of all Delhi households have a cooler or an AC, whereas less than 30 per cent of households in other states had these space cooling appliances. The eastern states of Assam, Bihar, Jharkhand, and West Bengal have the lowest shares of AC or cooler using households. Limited use of coolers in eastern India may be attributed to the region's humid weather in which coolers are not effective. Our state-wise figures of AC and/or cooler ownership are lower than the estimates from NFHS-4 for all states, because of higher non-response in prosperous neighbourhoods, as discussed earlier.

Figure 17 Delhi leads the Indian states in terms of AC and cooler use in homes



Source: Authors' analysis

Lack of access to cooling appliance

Our survey also shows that nearly seven per cent of electrified households, most of them in rural areas, do not have any cooling appliance, including fans.[16] Households in parts of Himachal Pradesh, Uttarakhand, and Assam, where relatively cold weather prevails through most part of the year, may not feel a need for a cooling equipment. However, two-thirds of non-cooling-appliance-owning households are in five states—Uttar Pradesh, Bihar, Madhya Pradesh, Karnataka, and Jharkhand—that experience scorching summers.

7% of electrified households lack access to even basic cooling appliances like fans

Further, half of the households without access to cooling got connected to the grid only in the past five years, and more than 80 per cent of them survive in poor economic conditions such as living in *kuccha* or mixed houses and not owning a motorised vehicle. It would be important to devise strategies to enable access to cooling solutions for such households, particularly in view of rising temperatures and heat stress events (SEforAll and Heriot-Watt University 2019). Apart from access to cooling devices, it would be equally beneficial to promote passive cooling techniques to provide thermal comfort as the houses get built, particularly under social housing schemes (MoEFCC 2019).

Energy-efficient cooling appliances

Since 2010, BEE's S&L programme is mandatory for ACs and voluntary for ceiling fans. Other space cooling appliances, such as table/pedestal/wall-mounted fans and desert coolers are currently out of the purview of the S&L programme. In our survey, more than 75 per cent of AC-owning households have reported owning a BEE star rated model (Figure 18). Of these, 50 per cent have 4-star or 5-star ACs. And the remaining half have 3-star models,[17] the proportion of which is even higher in rural households. Around one-sixth of AC users didn't know the star rating of their AC, and a majority of these were also unaware of the BEE star label. About 7 per cent of AC users have unlabelled ACs, which in a majority of the cases are older than 10 years when the star labelling for ACs was voluntary.

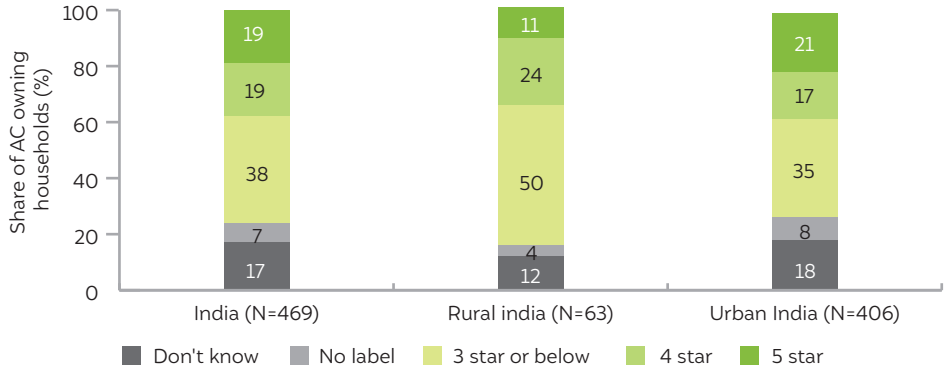


Figure 18
A majority of the ACs used in Indian homes are star rated

Source: Authors' analysis

We specifically asked households owning ACs with a rating of 3-star and below why they didn't choose higher efficiency models. The most cited reason was cost of higher rated models (46 per cent) followed by lack of awareness or interest to inquire about star labels. Some households (7–13 per cent) also reported reasons such as vendor's advice, unavailability at the shop, low usage, and uncertainty about benefits of higher rated models for not purchasing higher rated models.

16 Ninety-five per cent confidence interval is 6.6–7.5 per cent.

17 These estimates are subject to errors due to social desirability bias: some households may have stated a higher star rating than that on their label.

18 Only two per cent households had a 2-star AC and no household reported having a 1-star AC. This is why we have created a category of 3-star to refer to all the low-efficiency ACs.

In contrast to the 'high' user awareness of star-rated ACs, only eight per cent of households using ceiling fans are aware of BEE star-rated fans.[19] The low consumer awareness of energy-efficient fans can be attributed to the voluntary labelling for ceiling fans. Further, only three per cent of ceiling fan users have star-rated fans, among which a majority belong to richer and urban households. The low adoption of energy-efficient fans could be because of their high cost.

Only 8% of households using ceiling fans are aware of BEE star-rated fans

Even limited availability (because of lower demand) could be an important reason for low penetration, as only nine per cent of the ceiling fan market in 2017–18 was made up of star-rated ceiling fans (Mathew et al. 2019),[20] possibly because star-rated fans fell under the voluntary labelling scheme of S&L. This shows that the voluntary labelling scheme for fans, in place for a decade now, has been unsuccessful in nudging the manufacturers and the market towards higher efficiency fans. As fans and coolers account for nearly 40 per cent of India's cooling energy demand in the buildings sector (MoEFCC 2019), the sale of energy-inefficient fans and coolers is a concern that policymakers should suitably address in future.

As a step in the right direction, BEE plans to make S&L mandatory for ceiling fans from January 2022 (New Indian Express 2020). However, India's fans market is made up of a high proportion of unorganised manufacturers and therefore enforcing a mandatory labelling scheme would pose a big challenge (Box 2). As per our survey, around 40 per cent of the fan users (both ceiling and table fan) and half of the desert cooler users own locally manufactured fans and coolers, respectively.[21,22]

Box 2: Supply-side bottlenecks to energy-efficient fans

BEE's S&L programme aims to transform the market by reducing information asymmetry on energy efficient appliances through a demand-side intervention. However, evidence suggests that lower capital costs contribute to increased diffusion of energy-efficient technology (Bhattacharya and Cropper 2010). Thus, along with creating a demand pull, removing supply-side barriers in production and sale of energy-efficient appliances would be imperative. We interviewed eight small-scale fan manufacturers from different states to understand their awareness of the planned mandatory labelling for fans and perceived challenges in its implementation. The following issues emerged:

- *Low awareness:* Most manufacturers were not aware that S&L programme would soon become mandatory for fans. Some were not even aware of even the existing voluntary labelling for fans.
- *High cost of inputs and price-sensitive consumers:* Only two of the eight manufacturers currently produce energy-efficient appliances, while rest produce the popular 70–75 W variants. Due to expensive components, the cost of energy-efficient fans would tend to be high, which deters customers from buying them.[23] For example, brushless DC (BLDC) motors and components such as controllers and magnets make energy efficient fans expensive. There is also lack of domestic supply chain providing these components at competitive prices.
- *Gaps in standards enforcement:* All manufacturers agreed that some minimum standards would be good for the market and help weed out spurious quality products. Even larger brands sell low-quality products to tap the low-income market (Consumer Voice, 2019), which puts pressure on local manufacturers to compete using low-cost components. However, all of them expressed concern about BEE's ability to enforce mandatory standards and labelling given the huge presence of unorganised and unregistered market (due to consumer demand for cheaper fans).

19 We asked the respondents using ceiling fans: 'Have you heard about energy-efficient (BEE star rated) fans?' As of now, there is no labelling for table/pedestal/wall-mounted fans.

20 In 2018, 99 per cent of star-rated ceiling fans available in Indian market fell in 5-star category.

21 We asked respondents: 'The ceiling fan that you use the most, is it from a local company or a reputed brand?'

22 About 10 per cent of fan and cooler using households did not know whether their appliance is branded or local.

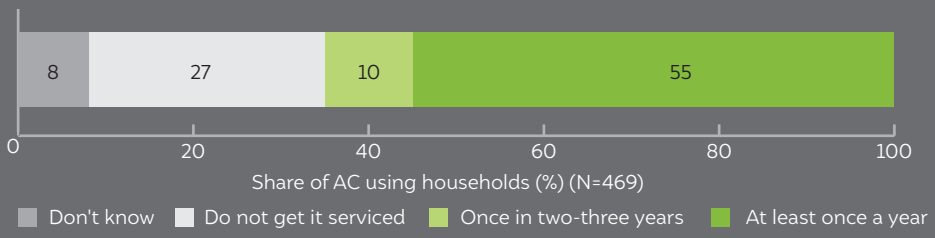
23 BLDC fans cost around INR 3,000 (USD 40). Average price for 70–75 W fans is INR 1,000–1,100 (USD 15).

Spotlight 1: AC usage behaviour with implications for energy savings

While adoption of energy-efficient appliance is the crucial first step, it does not automatically ensure energy savings, for which usage behaviour is essential as well. We analysed household behaviour concerning AC use and focus on three key parameters, as discussed below.

- ***Temperature setting***: As per BEE, using AC at a temperature setting of 24 degrees Celsius is ideal for both health and energy saving (MoP 2018). As per our survey, 60 per cent of the AC users preferred to keep their ACs running at 23 degrees or below. In order to nudge consumers towards adopting higher temperature setting, from 1 January 2020, BEE mandated the default temperature to be 24 degrees Celsius for all new ACs (MoP 2020b). This is a welcome move, but consumers can always change the default settings. BEE has also undertaken several initiatives to educate consumers about the benefits of higher temperature setting and must continue these efforts on a sustained basis as more households become first-time AC users.
- ***Use of fans with ACs***: Studies have shown that use of a fan along with AC, set at a higher temperature, can provide similar thermal comfort, compared to using only AC, which can also drastically bring down energy consumption (Virginia Cooperative Extension 2020). As per our survey, only 20 per cent of AC-owning households reported *always* using ceiling fans with ACs; 46 per cent *sometimes* use fans with ACs and one-third never use fans with ACs.
- ***Frequency of AC servicing***: We also asked households about their AC servicing practices and found that more than one-fourth of the AC users do not get their AC serviced by a technician unless the AC stops functioning. Another 10 per cent get it serviced only once in two to three years (Figure 19). Such poor servicing practices can have adverse implications on energy consumed by AC (Sridhar and Chaturvedi 2017).

Figure 19 More than one-fourth of AC users do not get their AC serviced at all



Source: Authors' analysis

Nearly 2.2 per cent of the non-AC households reported that they plan to buy an AC in the next two years, indicating five million potential new purchases. Though demand for ACs may get subdued due to the economic impact of the COVID-19 crisis, the findings still highlight the increasing AC adoption in India. Therefore, sustained efforts are needed to educate consumers about practices to optimise AC energy use, such as periodic servicing, optimal temperature setting, and use of fan with ACs.

4.3 Space and water heating

The use of electricity for warming homes is quite low in India. Unlike household energy demand for cooling, we find that a mere 2.3 per cent of Indian households use some form of energy to keep their houses warm during winters. Himachal Pradesh, which experiences extreme winters, has the highest share of households using space heating for thermal comfort (85 per cent).[24] It is followed by other northern states of Delhi, Punjab, and Uttarakhand, where only 12—14 per cent households use space heating appliances, and

24 Our survey did not cover Jammu & Kashmir, Sikkim, Arunachal Pradesh, and other mountainous territories.

most of them are economically well-off. In the remaining states, less than three per cent of electrified households reportedly use space heating.

As regards space heating, we find that nearly 60 per cent of these households rely on electric room heaters (predominantly halogen), while one-fifth make use of gas heaters and one-fourth use traditional *chulha* (powered by firewood, coal, and other traditional biomass). The use of solid fuels for space heating is higher among rural households, particularly in Himachal Pradesh and Uttarakhand, where two-thirds of the area are covered by forests. In contrast, nearly 90 per cent of those actively using space heating solutions in Delhi use electric equipment (Figure 20). On average, households use electric room heaters for three hours a day during winter months.

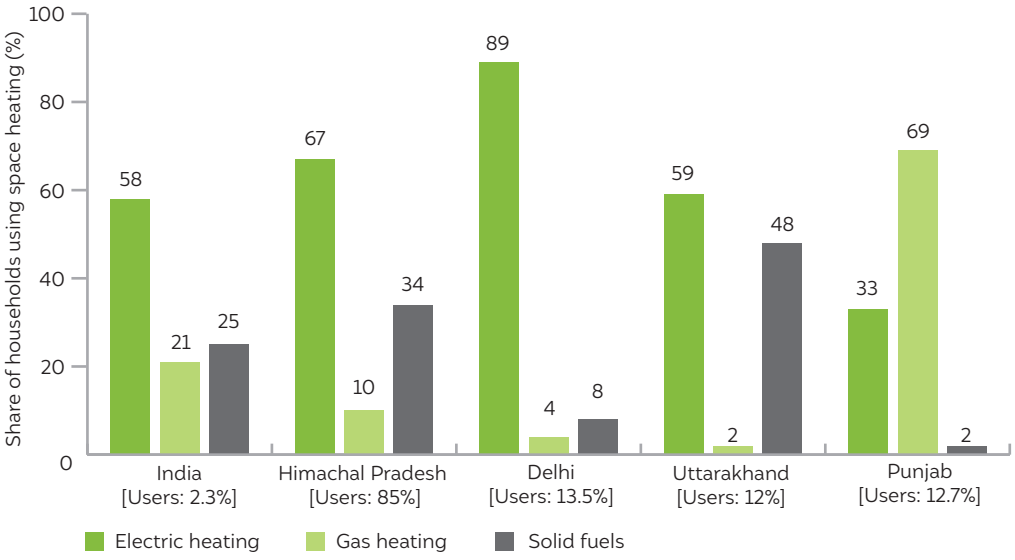


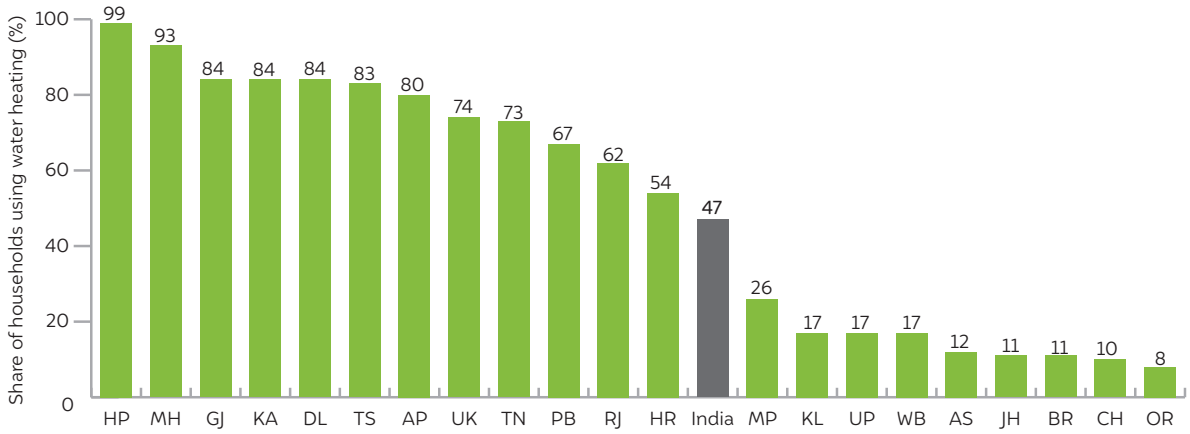
Figure 20
For space heating, majority of households in Delhi and Himachal Pradesh use electric heating

Source: Authors' analysis

Note: The shares sum up to more than 100 as some households use multiple sources.

Unlike space heating, use of energy for heating water for bathing purposes is quite prevalent in Indian homes. We observe that half of Indian households use hot water for bathing and this practice is higher in urban areas (58 per cent) than in rural areas (43 per cent). Except the eastern and the central states, water heating is prevalent in most homes in all other states (Figure 21). As per our data, average household income in a district moderately correlates (correlation coefficient of 0.45) with the share of households using water heating.

Figure 21 **A majority of Indian households in most Indian states use hot water for bathing**



Source: Authors' analysis

Most Indian households heat water for bathing on their cookstoves, with liquefied petroleum gas (LPG) and firewood as the preferred fuels in urban and rural areas, respectively (Figure 22). Less than one-sixth of users have electric equipment—geysers or immersion rod—and most of these are urban households. Around 12 per cent households reportedly use LPG based instant geysers, and just half a per cent use solar water heaters.

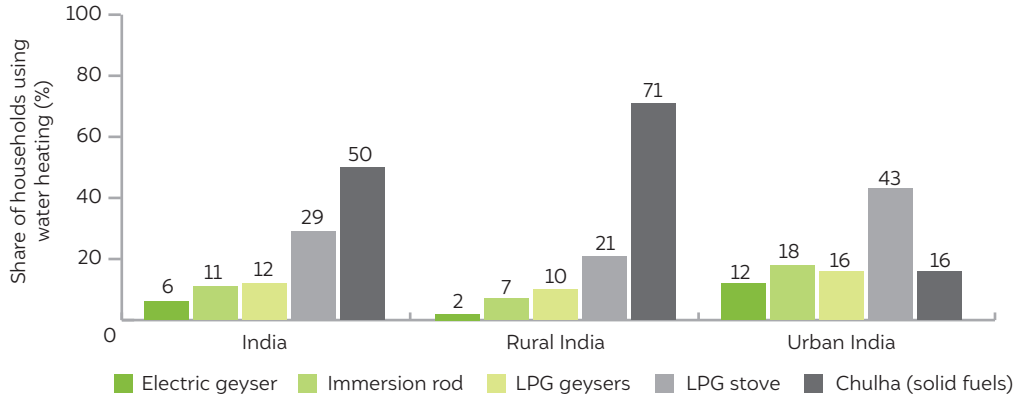


Figure 22
A majority of Indians heat water for bathing on cookstoves

Source: Authors' analysis

Note: The shares sum up to more than 100 as some households cited multiple options.

Himachal Pradesh, Delhi, and Uttarakhand have the highest users of electric water heating appliances, evidently because of the extreme cold weather prevailing in these states during winter. Tamil Nadu and Maharashtra lead the states on the use of LPG cookstoves, while Jharkhand has the highest share of households using solid fuels for water heating. The use of electricity for water heating is also associated with the household's economic status, evidently as appliances like geysers need an upfront investment and also entail recurring electricity consumption charges.[25] We find that households using geyser typically earn twice than those using *chulha*. Further, both *chulha* users and non-users have equally low awareness (30 per cent) of the negative health impacts of using solid fuels.

Energy-efficient heating appliances

Among the space and water heating equipment, electric geysers are covered under BEE's mandatory S&L programme since 2016. Of the six per cent of geyser users in the country, we find that more than half have star-labelled geysers, while one-third were unaware of energy-efficiency label on their geyser (Figure 23). Comparing these results with those of ACs, we find AC stock in Indian households is relatively more efficient than the geyser stock, and that AC users are more aware of their equipment labelling than geyser users. This may be attributed to mandatory labelling for ACs since 2010 or increased awareness campaigns focussed on ACs. We also observe that one-sixth of all geyser users have purchased an unlabelled product, and one-third of them bought geysers after 2016. This points towards the presence of local and unlabelled geysers in the market, and the need for stricter enforcement of S&L regime.

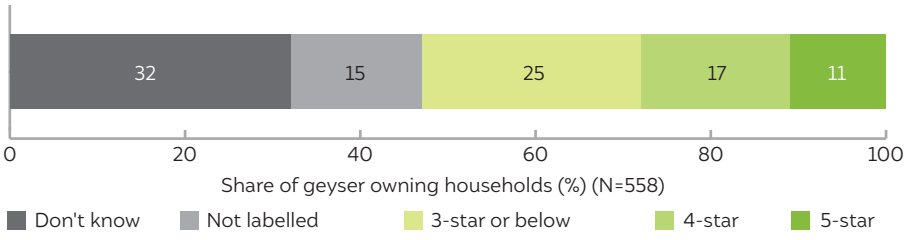


Figure 23
Only 60 per cent of electric geyser users reportedly have star labelled models

Source: Authors' analysis

25 Electric geysers with 10–25 litre storage consume 2–3 kW power and cost between INR 3,000 and 7,000 (USD 40–90, at USD 1 = INR 75), depending upon the brand and star rating. In contrast, immersion rods consume 1–1.5 kW power and cost around INR 500/unit (~USD 7/unit).

There is an urgent need to wean the population away from solid fuels, which causes indoor and outdoor air pollution. Poorer households rely on traditional solid fuel sources (relatively cheaper and easily available) to meet their heating needs despite having an electricity connection. The use of LPG for water heating raises the question of whether policymakers should consider LPG as a strategic intermediate option to facilitate households' transition away from solid fuels. We found that households that use LPG for both cooking and heating needs used a higher number of LPG refills annually, despite having a lower average family size.[26] This would entail assessing the LPG required to meet both cooking and heating needs, and revisiting the quota for the subsidised fuel. Further, a full transition to cleaner sources would require creation of opportunity cost for freely available traditional fuels (Mani et al. 2020).

4.4 Infotainment

In Indian homes, television (TV) occupies an important slot as a provider of information and entertainment (infotainment), followed by smartphones, computers, and music systems (Figure 24).[27] Our survey shows that around three-fourths of Indian households have TVs and smartphones, while the ownership of computers, laptops, and audio/music system is less than five per cent.[28] Given that colour TV market is one of the fastest growing segments among consumer electronics (IBEF 2020).

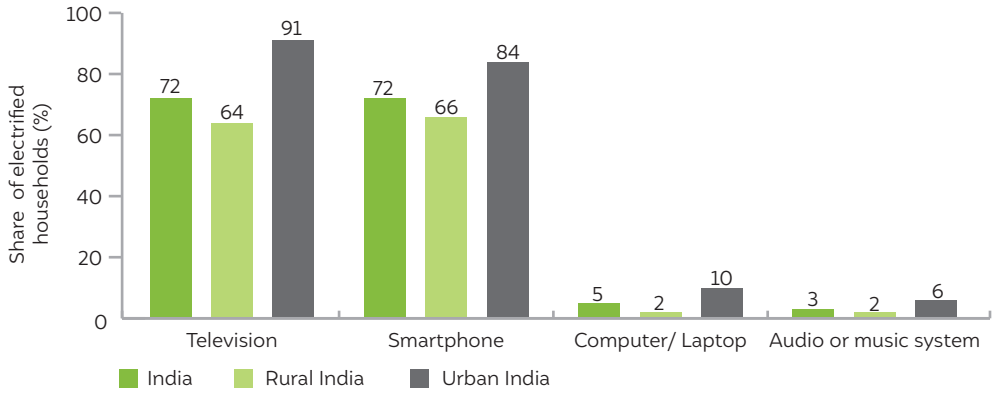


Figure 24
Around three-fourths of Indian households own televisions and smartphones

Source: Authors' analysis

While 72 per cent of all surveyed Indian households own a TV, its ownership is higher among urban households (91 per cent) in comparison to rural households (64 per cent). But despite being a very common electronic device, most homes still have energy-intensive TV sets. Though the current TV market is dominated by LED and liquid crystal display (LCD) TV sets, nearly 60 per cent of TV stock in Indian homes are the old-generation cathode ray tube (CRT) models, which are energy-intensive.[29] Obviously, rural households (67 per cent of the TV users) retain more CRT TVs than urban homes (50 per cent).

Households, predominantly urban households, have shown a preference for LED-LCD TVs in their recent purchases (Figure 25). Thus, the share of energy-efficient TVs in the residential stock is gradually rising. However, many rural households still hold on to CRT models for

26 Households that use LPG for both cooking and heating needs use an average of 7.7 large cylinders annually (or 109.34 kg LPG), compared to 6.5 large LPG cylinders annually for households that use it only for cooking needs (92.3 kg LPG). They use 17 kg more LPG annually, despite having a lower family size of 4.6, compared to an average household size of 5.1 for those that only use it for cooking.

27 As shown in Annexure 2, our survey estimates on ownership of high-end appliances like computer/laptop could be underestimated due to higher rate of non-response to our questionnaire by economically richer neighbourhoods.

28 More than 98 per cent of Indian homes have at least one phone.

29 Around one per cent of TVs are CRT black-and-white models and another one per cent are plasma models.

many reasons such as ease of repair, lower prices, easy availability in the secondary market, and lower repair cost.

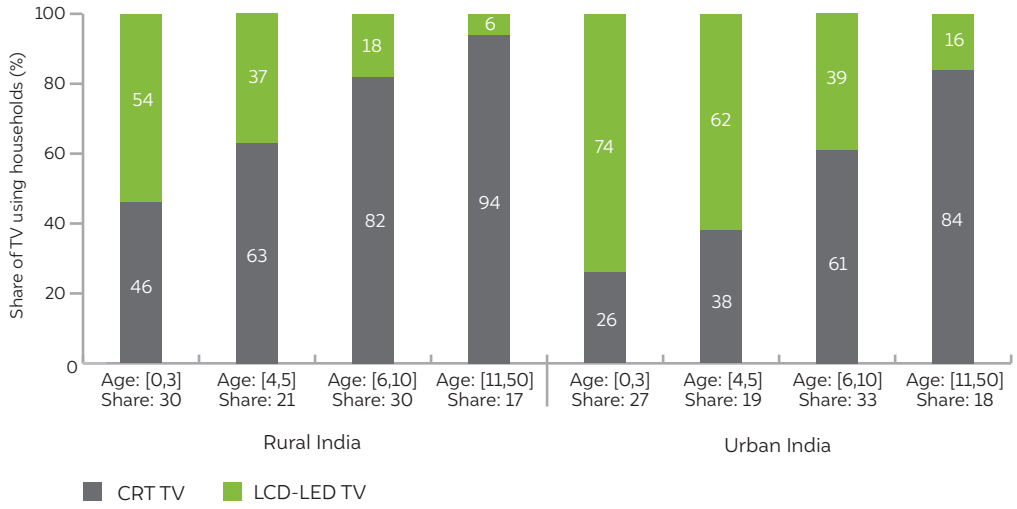


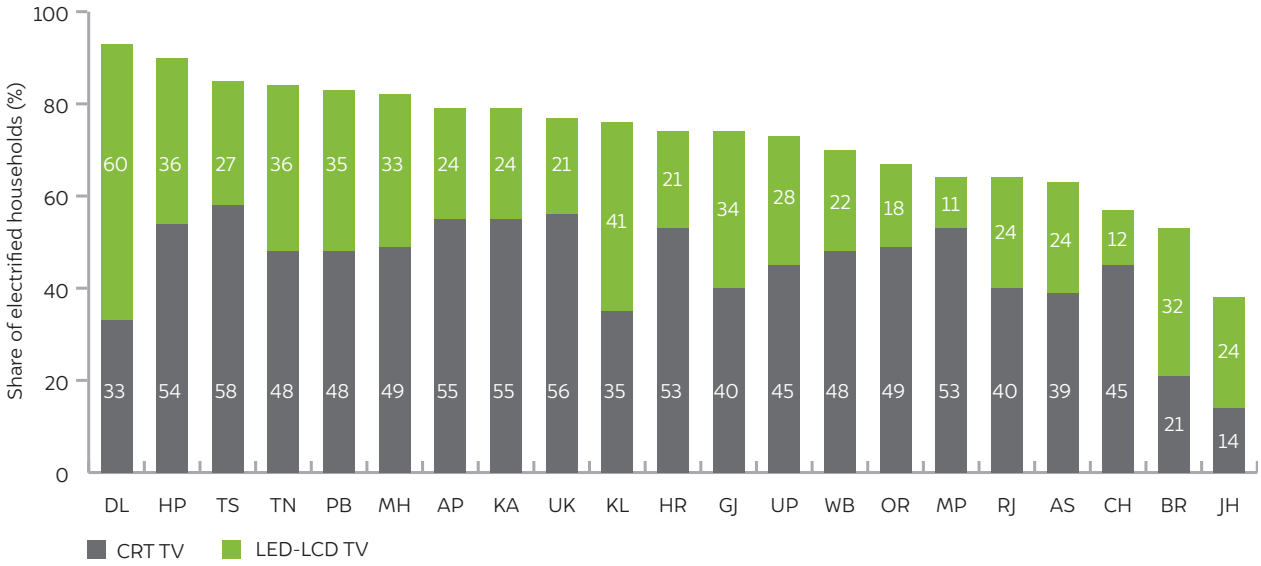
Figure 25
Indian households are increasingly turning toward more efficient LCD/LED TVs

Source: Authors' analysis

Note: Some households were unaware about their TV's age

TV ownership and household preferences for TV models also vary widely across Indian states (Figure 26). Delhi, followed by Himachal Pradesh, Telangana, and Tamil Nadu boast of the highest TV ownership in the country. The share of LCD-LED TVs is highest in Delhi but lowest among Odisha, Chhattisgarh and Madhya Pradesh. Although Bihar and Jharkhand display the lowest TV ownership, most households have LED-LCD models as they bought TVs the past five years. Even though star labelling is mandatory for all colour TVs, unlabelled TVs are found in most Indian homes. States with lower TV ownership present a strong opportunity for TV retailers to push for the sales of more efficient LED-LCD models, with an active promotion of appliance financing for efficient TVs.

Figure 26: TV ownership and type vary widely across Indian states



Source: Authors' analysis

4.5 Household utility appliances

Besides lighting, ventilation, space cooling/heating, and infotainment, households use electricity for several other end-uses and day-to-day chores, including refrigerators, washing machines, electric irons, and water pumps.

As per IRES, more than one-third of the Indian households own a refrigerator. This is a marked increase from 20 per cent ownership in 2011, as per 68th round of NSSO. Closely followed by refrigerators, Indian households possess other white goods, such as mixers/ grinders for food processing and electric irons for ironing clothes. Ownership of washing machines is still quite limited (Figure 27).[30] As with other appliances, these consumer durables have a higher penetration in urban households than in rural homes. However, with rising incomes, rural India is likely to follow the same trajectory.

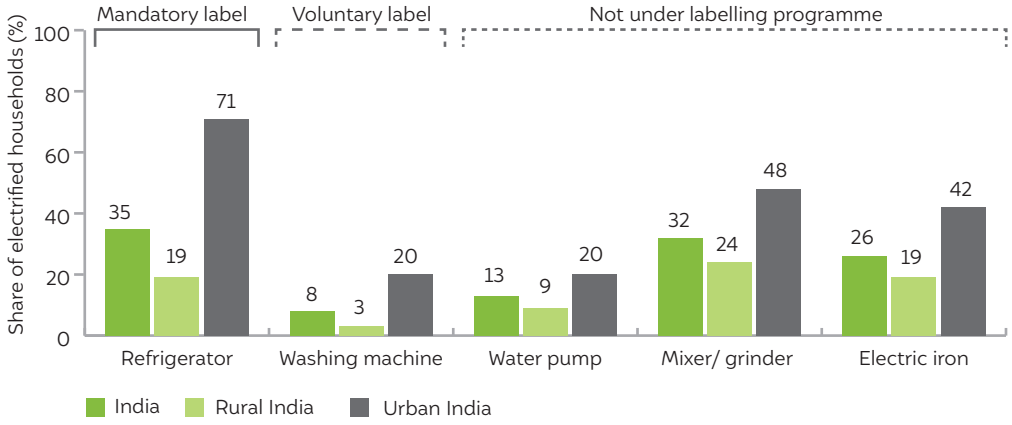


Figure 27
White goods including refrigerators are becoming common in urban India

Source: Authors' analysis

Of these appliances, only refrigerators and washing machines are currently covered under BEE's S&L programme. Delhi, which has the highest per capita income among the states covered in the study, has the highest ownership of both refrigerators and washing machines, followed by Maharashtra, Kerala, Tamil Nadu, and Punjab (Figure 28). These states have more than 50 per cent refrigerator ownership and they also lead on washing machine use in the country (12–15 per cent uptake) along with Himachal Pradesh. States in eastern India have the lowest uptake of both these appliances.

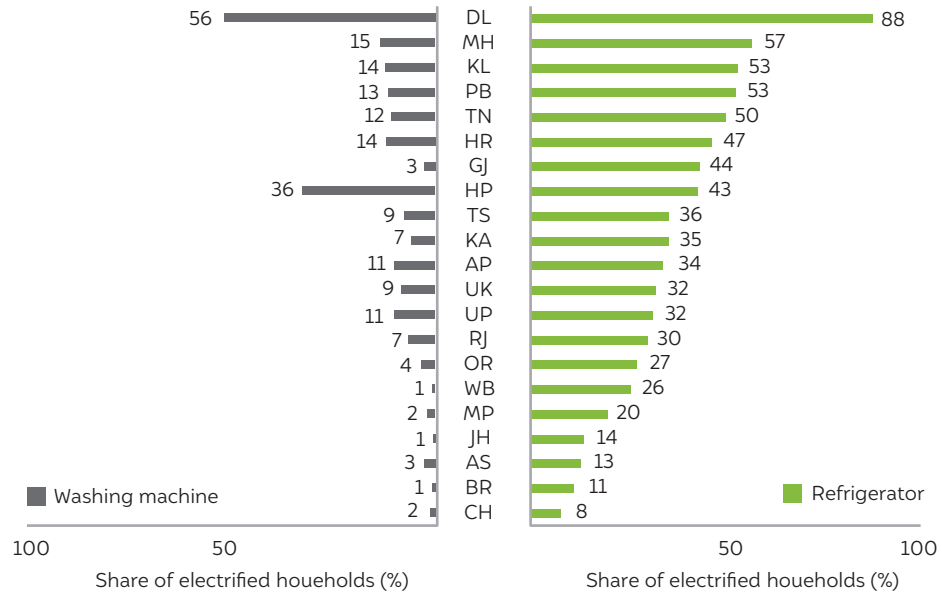


Figure 28
Ownership of refrigerators and washing machines is lowest in eastern states of India

Source: Authors' analysis

30 As shown in Annexure 2, our estimates of washing machine ownership much lower than the estimates from NFHS-4 (14 per cent) on account of higher non-response in economically better off districts.

Energy-efficient refrigerators and washing machines

We find that the share of star-labelled units, particularly 4- or 5-star labelled appliances, is higher in case of refrigerators than washing machines (Figure 29). We also observe a higher share of unlabelled appliances and less aware households in case of washing machines. These differences could be attributed to the difference in labelling mandates for the two products. Since 2009, BEE's S&L programme is mandatory for frost-free refrigerators and was made mandatory for direct cool models as well in 2016. Washing machines, however, are under the voluntary scheme since 2018.

We also observe that the share of labelled products is higher among newer purchases (made over the past four years) than older appliances, for both refrigerators and washing machines (Figure 29). These findings indicate that the refrigerator and washing machine stock in India is becoming more efficient over time due to the star labelling scheme, with a stronger impact of the mandatory scheme. Nearly 40 per cent of the unlabelled refrigerators are more than 10 years old, i.e., bought before the launch of labelling scheme for refrigerators. However, the presence of unlabelled refrigerators among newer purchases may reflect lack of consumer awareness about the labels on their refrigerator, second-hand buys or availability of unlabelled products in some markets. BEE should focus on increased consumer education and also think of incentivising users who report unlabelled products in the market. The lower penetration of washing machines calls for bringing it under the mandatory scheme at the earliest.

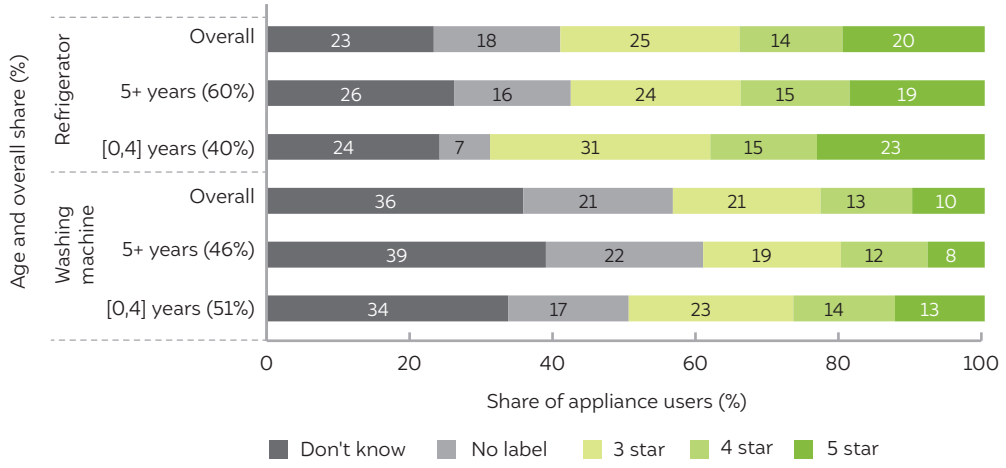


Figure 29
Uptake of star-labelled products and consumer awareness of labels is higher in case of refrigerators than washing machines

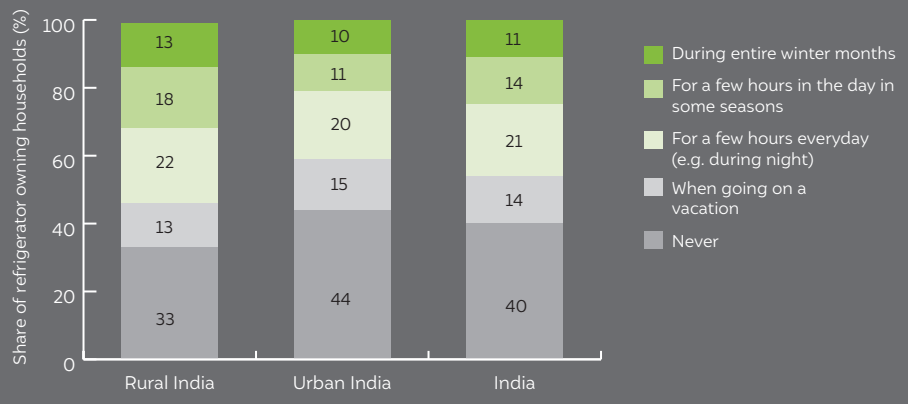
Source: Authors' analysis

Note: Around 2 per cent of refrigerator and 3 per cent of washing machine owners were unaware of the age of the appliance

Spotlight 2: Household behaviour concerning refrigerator and washing machine use

While estimating energy and emission savings from the use of higher efficiency refrigerators, it is generally assumed that these appliances would run 24×7 throughout the year. However, our survey suggests that only 40 per cent of refrigerator users operate it through the day. More than 45 per cent users turn off their refrigerators for a substantial amount of time (Figure 30a).

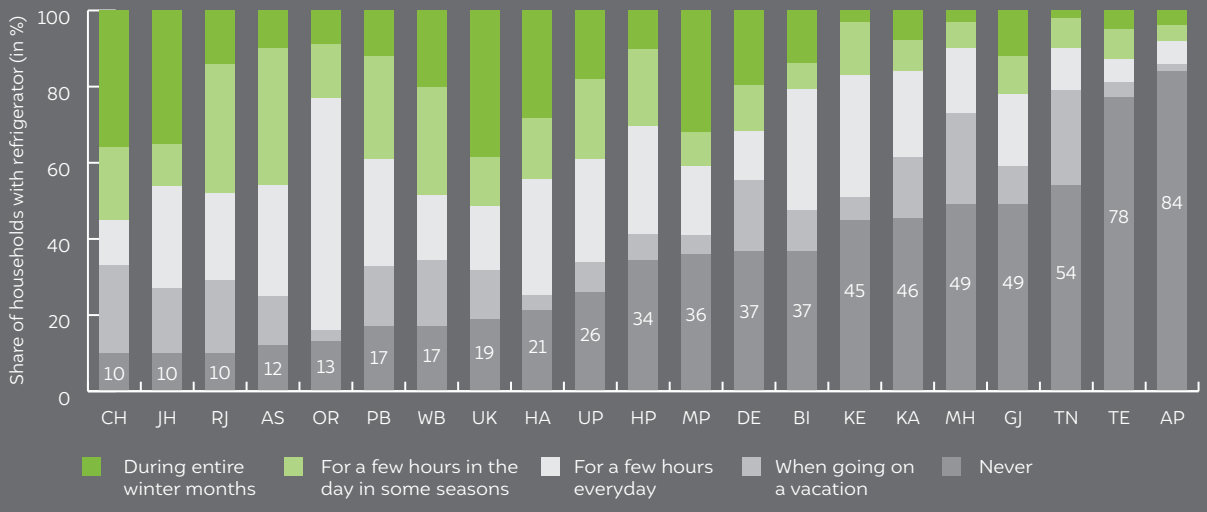
Figure 30a More than 10 per cent households turn off their refrigerators during the winter months



Source: Authors' analysis

Households may be switching off their refrigerators to reduce their electricity consumption and bills, or due to limited storage requirements (Chunekar and Kulkarni 2019). This partly reflects the tendency of Indian consumers to find ways to maximise energy and thereby cost savings in the use of electric appliances. Such usage behaviour should be accounted for while estimating savings from efficiency interventions. The seasonal switching-off behaviour is more prevalent in northern Indian states, which experience harsher winters, than in the more tropical southern states (Figure 30b).

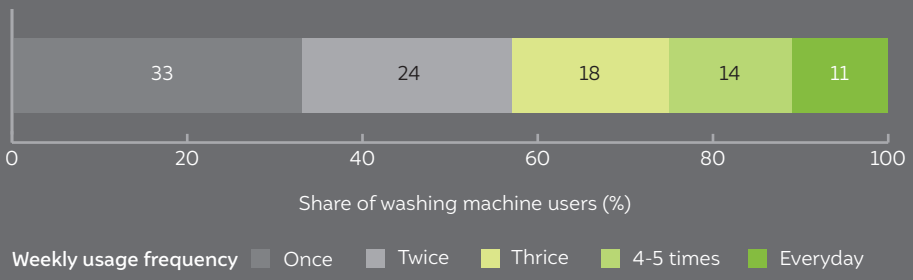
Figure 30b Refrigerator switching off frequency is lower in south Indian states



Source: Authors' analysis

Unlike refrigerators, washing machines are used much less frequently. For instance, one-third of the washing machine owning households use it only once a week, while just 11 per cent use it every day (Figure 31). As energy consumption and therefore savings from a more efficient model are closely tied to the usage frequency, it would be necessary to educate users to give due weightage to this factor in their purchase decisions. This is because currently there is no significant variation in star rating of washing machines across households with high or low washing frequency.

Figure 31: A majority of consumers use washing machines just once or twice every week



Source: Authors' analysis

4.6 Cooking

Cooking accounts for a major share of energy use in Indian homes (Kaul et al. 2020). We found that households primarily rely on non-electric cooking energy sources, such as LPG, piped natural gas (PNG), firewood, dung cakes and other traditional fuels. However, there are early signs of Indian households gradually adding electric appliances to their cooking devices stock.

As per our survey, five per cent of the electrified households use electricity for cooking in some form or the other. Cooking using electrical equipment is common in urban kitchens (10 per cent) than in rural households (3 per cent). Figure 32 shows that induction cookstoves and rice cookers are the most commonly used cooking appliances, followed by microwave ovens. However, only microwave ovens are covered under voluntary labelling programme. A majority of households practising electric cooking belong to higher income categories. So, we are inclined to think that with rise in incomes, more households may include electric cooking to their mode of preparing food, which in turn would necessitate bringing in measures to ensure availability of energy-efficient cooking appliances for domestic use in the market.

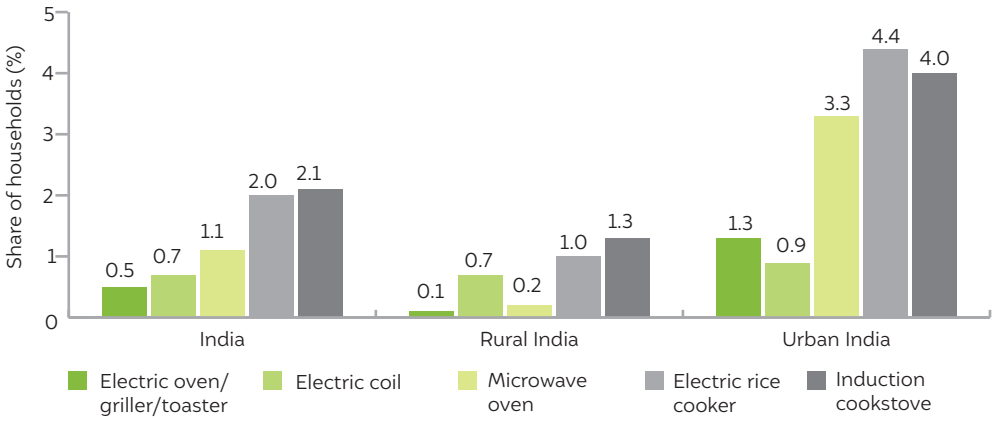


Figure 32
Induction cookstove and rice cooker are the most commonly used electrical devices for cooking

Source: Authors' analysis

Way forward

Our analysis shows mixed results of the efforts on promoting energy efficient appliances. One of the great successes of the energy conservation campaigns, coupled with mandatory labelling, in India has been adoption of LED lamps and energy-efficient ACs and refrigerators. Nearly 90 per cent of Indian homes have LED lamps, which now comprise two-thirds of the total lighting stock. More than 75 per cent of users have star-labelled ACs. Adoption of energy-efficient geysers and washing machines appears to be moderate, because these were only recently brought under mandatory and voluntary labelling from 2016 and 2018, respectively. Two-thirds of TV users still own old-generation, energy-intensive CRT models, but there is an increasing shift of new buyers towards energy-efficient LCD-LED TVs.

Consumers still have not shown an inclination for energy-efficient ceiling fans, because of their relatively higher cost and limited availability in the market. This is despite the fact that ceiling fans, which are the major driver of residential electricity use, are under voluntary programme since 2009. Coolers, immersion rods, mixers/grinders, electric irons, and induction cookstoves are other key appliances used in Indian homes, which are likely to see higher levels of adoption with rise in incomes but are currently out of the purview of the S&L programme.

For achieving an optimum balance between surging demand and supplying electricity of an optimum quality to all households, Indian consumers need to shift towards using energy-efficient appliances. The current levels of adoption of energy-efficient appliances have to improve by leaps and bounds for which sustained and more intensive supply-side interventions are needed, as discussed below.

- **Bring more appliances driving residential electricity consumption within the fold of mandatory scheme.** Our study confirms the stronger influence of mandatory labelling programme in ensuring uptake of energy-efficient appliances by Indian consumers. However, we are also aware that development and enforcement of mandatory labelling programmes is a resource-intensive exercise. Therefore, BEE needs to continuously evaluate and identify key appliances driving residential electricity demand through a robust mechanism. Ceiling fans consume a very large share of household power and, quite appropriately, BEE has planned to bring them under mandatory labelling from January 2022. Going forward, there is a need to assess the utility of bringing other appliances such as desert coolers, immersion rods, induction cookstoves, and other appliances under the S&L programme.
- **Educating and supporting small-scale manufacturers to improve availability of efficient products in the market.** Nearly 40 per cent of consumers use non-branded locally manufactured fans and coolers. Our conversation with a few small-scale fan manufacturers from different parts of the country suggest that many are not even aware of voluntary labelling scheme for fans or even new technologies, such as BLDC fans. Awareness campaigns are required to educate all manufacturers about the benefits and process of participating in the labelling scheme. Besides awareness, small-scale manufacturers would require adequate time to adapt to the new standards and access to components of more-efficient technologies at competitive prices. These factors should be considered before mandatory labelling scheme is implemented for appliances and small-scale manufacturers should be made an inclusive part of the programme. These efforts would be needed to be coupled by a strict enforcement of performance standards to weed out malpractices like fake labels and use of low-quality components.

Several factors – cost, brand, durability, aesthetics, energy efficiency - influence consumer purchase decision.

Image: Shalu Agrawal/CEEW

5. What determines appliance purchase decisions of Indian households?

The recent advances in household electricity access and currently low ownership of key appliances, is likely to result in an increased uptake of electric home appliances in India. But we have observed the trend of households settling for locally manufactured, inefficient appliances, as discussed in the previous chapter. Changing consumer behaviour towards purchasing energy-efficient appliances is an effective avenue to avoid residential consumption taking an energy-inefficient pathway. This is particularly important as most high-consumption appliances are bought infrequently and replaced slowly (Gaspar and Antunes 2011). In this chapter, we discuss the key factors that households consider while buying new appliances, the extent to which campaigns for energy conservation have played in buying decisions, and the strategies that could nudge consumers towards energy efficiency.

5.1 Consumer preferences regarding appliance characteristics

We asked all the electrified households to choose and rank the parameters that they consider important while buying new appliances.[31] Figure 33 shows that appliance cost, brand popularity, and product durability are the most preferred characteristics. Nearly 40 per cent of households rank appliance cost as the most important parameter (rank 1), validating the common opinion about the price-sensitivity of Indian consumers.

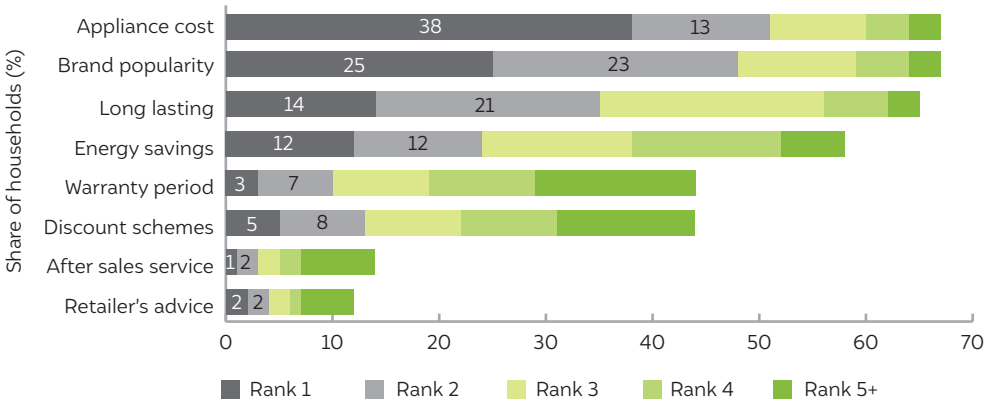


Figure 33
Most households consider appliance cost as the most important parameter, but some also value energy savings

Source: Author's analysis

31 We asked the households to choose parameters they consider important (up to a maximum of eight) out of the options highlighted in Figure 33. Thereafter, we asked them to rank these parameters by their relative importance. These are stated preferences and may differ from revealed (actual) preferences.

Interestingly though, more than half of the households also identified energy savings as part of their decision-making while buying new appliances, though only one-fourth of the households rank it among the top two criteria. Most consumers (paying their electricity bills) would prefer appliances with lower power consumption to save on recurring expenditure. However, being price-sensitive, they are likely to deterred by the need to pay a higher upfront cost to buy such appliances. A higher share of households in rural areas value appliance cost among the top three criteria, while more urban households value product branding, durability, and energy savings (Figure 34a).

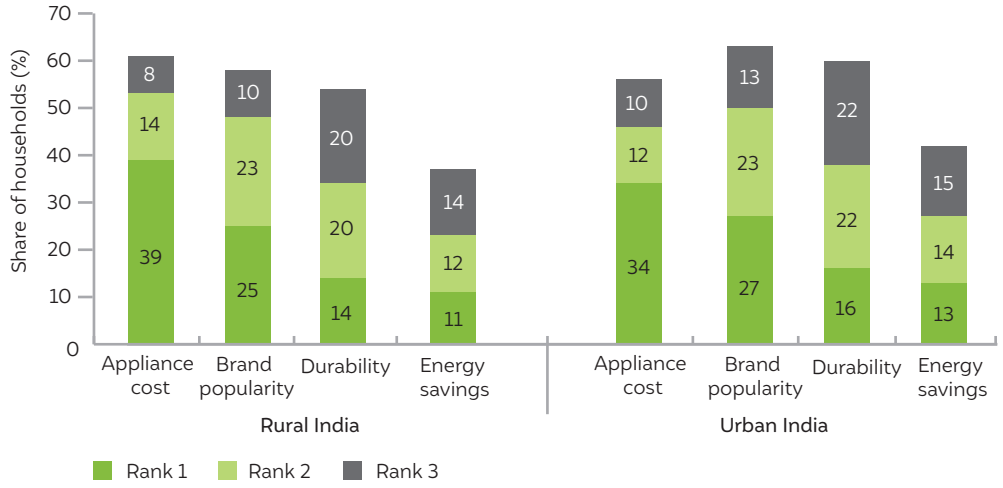
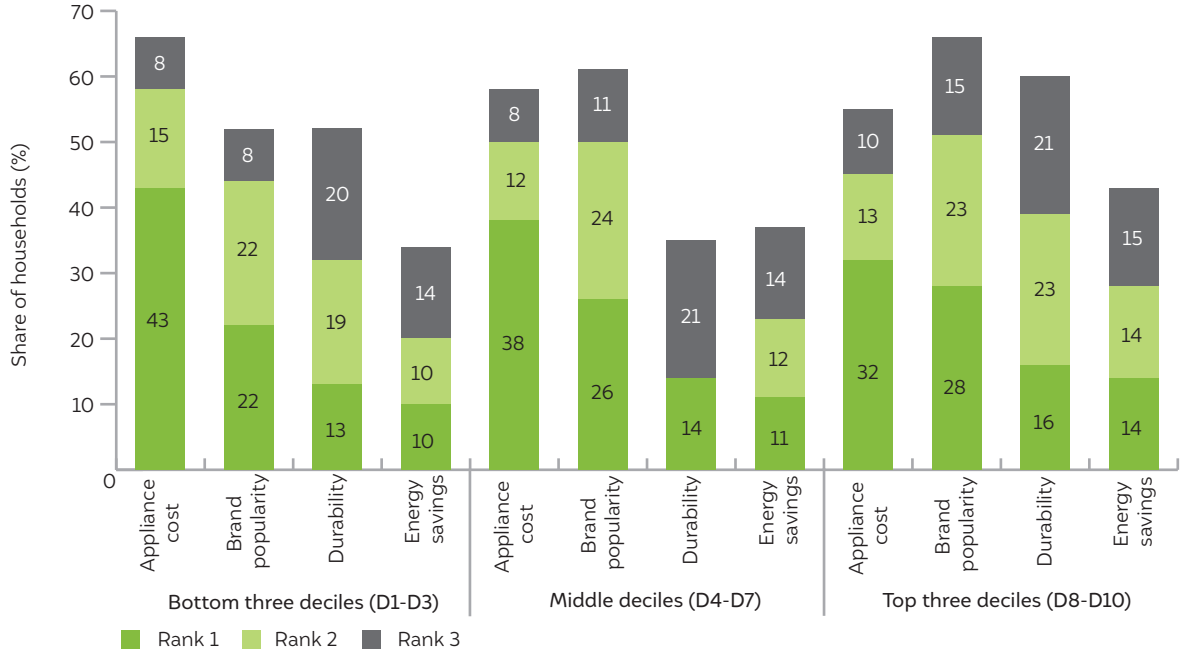


Figure 34a
A higher share of rural households value appliance cost as the important criteria

Source: Authors' analysis

We also find that a higher share of households from lower economic strata consider appliance cost as the clinching factor to decide whether to buy or not whereas consumers with higher economic status do not give such a heavy weightage to cost (Figure 34b). Even though the recurring electricity bills may be prohibitive for poorer households, few among them consider energy savings as important enough.

Figure 34b Poorer households are more sensitive to appliance cost, while more among richer households value product brand and durability



Source: Authors' analysis

Note: We divided households into wealth deciles by using a wealth index. Wealth index is created using principal component analysis on select 12 indicators that together indicate the long run economic status of a household. Please refer to technical documentation for details.

The cost differential between energy-efficient appliance and unlabelled product can sometimes be quite substantial, which is only offset by electricity bill savings over time. Consumers generally perceive such investments to be risky, and so are reluctant to pay the higher upfront cost (Qiu, Colson, and Grebitus 2014). Low awareness of BEE star label, particularly among rural and low-income households, is another barrier.

Nearly 4% of electrified households in India have purchased a home appliance on loan

In view of the consumer preferences and the gaps in awareness, interventions that make efficient appliances affordable, easily available, and identifiable can shift the market towards efficient appliances. Creating demand for such products has to be accomplished by awareness drives. The government has acted with foresight in this regard first by bringing in *Energy Conservation Act* and has initiated several schemes and interventions, targeted at all levels of the supply chain—production, distribution, and consumption. While BEE's S&L programme aims to improve availability and identifiability of efficient products, EESL's *UJALA* scheme made LEDs affordable for all households through demand aggregation and bulk procurement. However, similar efforts at a larger scale are required to make a larger array of efficient appliances affordable.

5.2 Role of consumer financing in influencing adoption of efficient appliances

Consumer financing could be effectively leveraged to attract price-sensitive households towards buying energy-efficient products (Kelly 2012; Parikh and Parikh 2016; Singh and Phore 2020). As per our survey, nearly four per cent of electrified households have purchased a home appliance on equated monthly instalment (EMI), that is, through a consumer durables loan. More urban households have opted for loans than their rural counterparts (Figure 35). It is likely due to the availability of point-of-sales financing in urban retail stores or online market places coupled with faster approval of such loans, as credit history of the urban consumers is easily available to the financing institution. Further, 17 per cent of the households who have never availed loans for buying appliances expressed interest in doing so if given the option. These point to a large untapped demand for financing of home appliance purchase in the country.

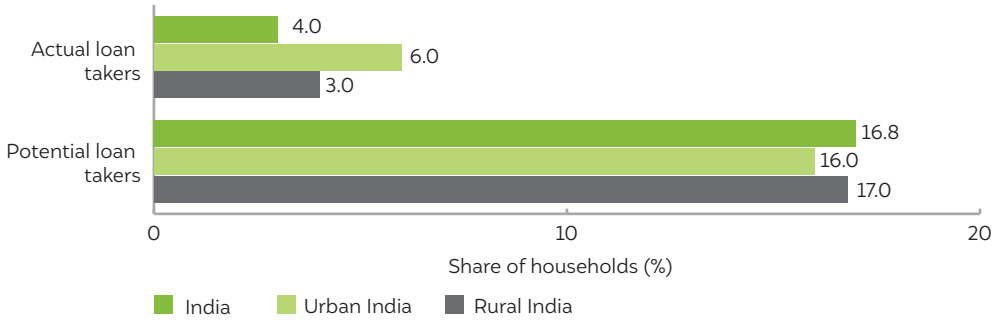


Figure 35
More urban households avail appliance loans, but more rural households aspire to do so

Source: Authors' analysis

We also observe that the share of loan-availing households is higher in higher income categories (Figure 36). However, a greater share of low-income households aspire to purchase appliances on credit. Interestingly, around one-fourth of these low-income homes received a grid connection in the past three years. A greater desire for availing appliance-related credit among poorer households could be due to their aspiration to enjoy comforts of recent electrification.

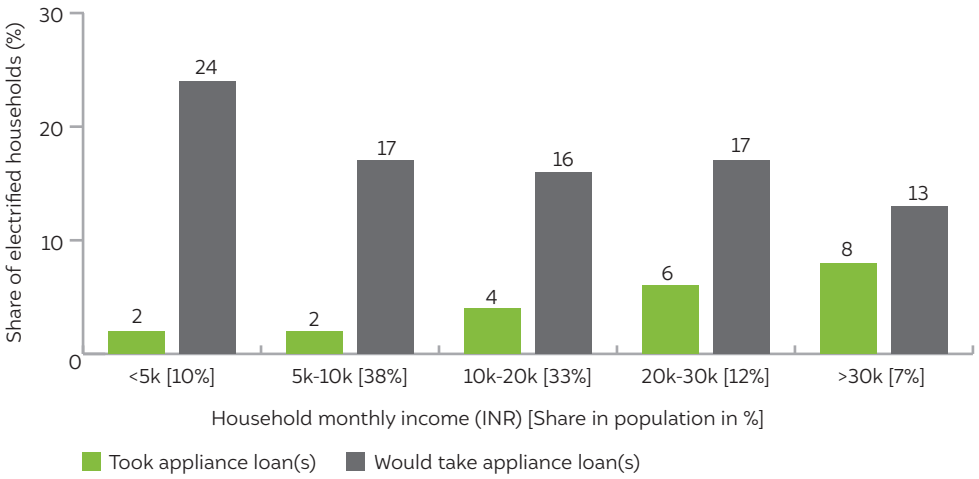


Figure 36
Aspiration for appliance-related credit is higher among lower income households

Source: Authors' analysis

We observe that one-tenth of all ACs were bought with the help of loans, but availing loans for other appliances was less common. However, aspiring households expressed interest in a wide variety of appliances for availing credit (Figure 37). Refrigerators and TVs are most popular consumer durables that people would like to buy with appliance financing, followed by space cooling appliances. While the demand for appliances requiring small-ticket loans like fans and coolers is higher among low-income households, relatively richer households are more interested in buying medium-ticket items like refrigerators, washing machines, and ACs.

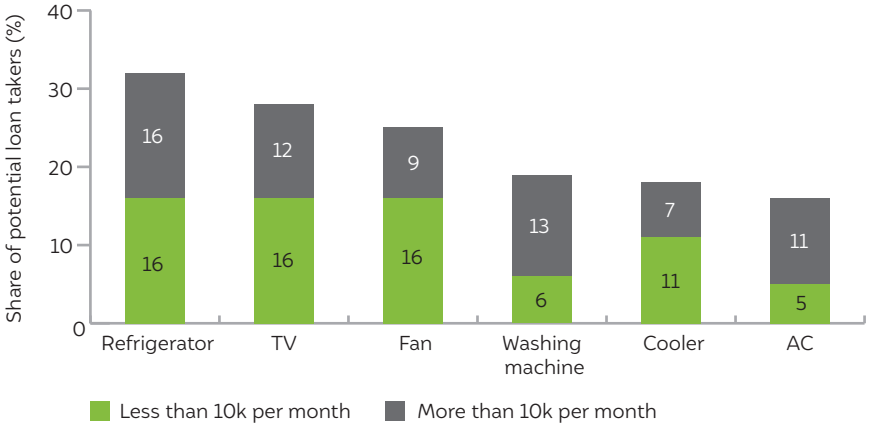


Figure 37
A majority of consumer finance aspirants expressed interest in refrigerators and TVs

Source: Authors' analysis

Way forward

Our analysis suggests that most Indian consumers are price-sensitive and rank appliance cost as the most important factor in their purchase decision, followed by other characteristics. This underscores the need for interventions that could make energy-efficient appliances affordable.

- One approach could be to employ *demand aggregation and bulk procurement* to bring down the costs of efficient appliances with currently low market share, like BLDC fans. EESL has recently partnered with discoms in Delhi to leverage demand aggregation for energy-efficient ACs and is facilitating their uptake through a dedicated e-commerce platform (EESL mart) (MoP 2019). More discoms could consider leveraging this approach for diverse products as part of their demand-side management strategy.
- Another option could include *discoms running on-bill financing (OBF) programmes* under which consumers can pay for the energy-efficient appliance purchase through their utility bills. Under the *UJALA* programme, consumers had the option of paying for LED lamps in small instalments of INR 10 per month as part of their electricity bills (EESL 2017). Adopting OBF for other energy-efficient appliances, particularly fans, can be used as a low-cost method to promote their uptake. Pilot studies need to be done to design suitable business models and test the consumer response to such interventions.
- *Consumer financing could be yet another approach* to incentivise adoption of energy-efficient appliances. As product brand is also a key determinant of consumer choice, industry leaders must leverage this opportunity to shift the market towards efficient and affordable appliances by coordinating with key stakeholders. Further, non-banking financial institutions (NBFCs) like Home Credit are increasingly extending loans for both offline and online purchases for a wide range of appliances, to even first-time borrowers (Menon 2019). As the need for appliance financing goes up in rural areas, microfinance institutions (MFIs) and small finance banks (SFBs) could play an important role in meeting the credit demand. BEE could incentivise such institutions extending loans on consumer appliances to provide more favourable loan terms—such as longer tenure or lower interest rate—on purchase of energy efficient products.

The current low penetration of high-power appliances like ACs and washing machines presents an opportunity to promote a higher efficiency stock in future.

Image: Shalu Agrawal/CEEW

6. Conclusion

Energy efficiency has often been anointed the cheapest form of energy – saving a unit is more prudent than generating another unit even with the most sustainable technology. In the Indian context, energy efficiency assumes high importance as there are significant losses in downstream distribution and highly inefficient generation from older thermal assets. Thus, every unit not needed to be delivered has a multiplier effect on savings through the value chain. In a very large country with several million consumers connected to the grid, saving electricity would lead to a large number of benefits.

On energy efficiency awareness, it is a case of 'well-begun' but sustained efforts are needed

Recognising the importance of energy efficiency, India was an early mover in bringing energy efficiency through a legislative mandate by enacting the *Energy Conservation Act* as early as 2001. BEE, which was born out of this legislation, has been driving energy efficiency at scale for various sectors of the economy. We set out to understand three aspects of energy efficiency: (i) awareness of the marquee programme on appliance energy labelling, (ii) the penetration of energy-efficient appliances within households, and (iii) factors influencing the decisions of households to purchase (or not) efficient appliances.

What does our assessment reveal?

BEE has done a commendable job of identifying and certifying home appliances covered under the labelling programme. It has been gradually adding one appliance after the other in the mandatory and voluntary S&L programme. India has seen an increase in adoption of efficient technologies. This apart, its awareness drives have resulted in Indian homes adopting efficient technologies for certain appliances. We further ask: have these measures been effective and if so, what is their impact?

On the awareness front, we conclude that it is a case of 'well-begun'. Only one-fourth of the households are able to relate to the iconic (to some of us) 'star rating' that categorises the efficiency of appliances. Higher awareness levels are observed in households with higher incomes and in urban areas. However, many households own appliances that fall under the mandatory labelling category (refrigerators, TVs, and LED lamps, for instance) and yet are unaware of the star labelling on the product.

Appliances under mandatory labelling show higher uptake of star-labelled products

Lighting finds universal coverage and efficient LED lights now have been adopted in 90 per cent of Indian households. A fan in each house is still not the norm (90 per cent of households have a fan). Many poorer and more recently electrified households do not have access to any cooling appliances. As many as 72 per cent of the households possess a TV set. Then comes the great divide. The ownership of ACs, refrigerators, geysers, and washing machines is limited, but this is also where the need for efficient appliances is the highest (as they consume more power to run). We find that appliances that were brought under mandatory labelling very early do show higher levels of penetration of star-labelled appliances. ACs have benefited in a big way with more than three-quarters of the current

stock being BEE-labelled products. However, we notice that only a few consumers display an optimum behaviour, such as use of fans along with ACs, periodic servicing, or running AC at a temperature setting of 24 degrees Celsius or higher.

Higher upfront cost is the biggest barrier to purchase of efficient appliances

Unsurprisingly, we find that the biggest barrier for especially customers from the lower strata of society is the high upfront cost they have to incur to procure efficient appliances. In an economy with a high discount rate, saving now is better than saving later. However, low electricity prices presumably deter consumers from valuing energy savings from buying costly but energy-efficient appliances. As a result, the concomitant environmental benefits are also foregone. Interestingly, 'brand value' influences appliance choice (second only to the cost of appliances). In such a scenario, innovation is needed in bringing down effective prices of branded appliances through large-scale procurements and suitable financing mechanisms. We find that few consumers have availed of financing options to purchase efficient appliances, but many households expressed their willingness to try such solutions, but they have limited options now. This demand for financing appliance purchase is an opportunity for the industry leaders to coordinate with key stakeholders like electricity utilities and other demand aggregators to shift the market towards efficient and affordable appliances and garner market share.

What should be prioritised in new efforts?

There is a need for a concerted mechanism that communicates the benefits to manufacturers, retailers, and consumers so that a seamless transition to the energy-efficient product happens. When any one part of the value chain is not convinced of the benefits, say retailers plugging an appliance of a specific rating and thereby sending signals to both manufacturers and consumers, we remain at a low-level equilibrium. Given the poor penetration of high-power appliances, it still presents an opportune path to deepen energy efficiency for India. Power distribution companies and grassroots entities must be at the forefront of this renewed effort and provide region- and context-specific information to new consumers. Currently, the communication is urban-centric and targeted at young users, while the older consumers and rural users have been left out of the awareness campaigns. New information campaigns that promote energy-efficient products should aim to reach new audiences and appeal to decision-makers in households across the country.

Equally, the need of the hour is to educate consumers on appropriate use of appliances (e.g. temperature setting in ACs) and the trade-off between upfront cost of buying appliances versus electricity bill savings for an array of home appliances. The reality is that the purchase of the most energy-efficient appliance may not necessarily be an economically sound decision for all appliances and certainly not for all consumers.

Energy efficiency in home appliances has firmly taken root at the policy level of the government. The fruits of early legislation are there to see after nearly two decades. Like all other economic sectors, the pandemic could make the pursuit of 'costlier technology' a lower priority. However, there are opportunities to build new domestic supply chains for components used in energy-efficient appliances (BLDC motors for fans, for instance), given the large base of consumers who are yet to adopt these appliances. Most importantly, implementing minimum performance standards across the remaining set of household appliances in a gradual manner and enabling smaller manufacturers to shift to supply chains of efficient components would be crucial in firmly lodging the concept of energy efficiency throughout the value chain.

Bulk procurement and consumer financing solutions can make energy-efficient appliances affordable

Finally, innovative models to finance the purchase and use of energy-efficient appliances need to be tested and implemented for benefiting a large number of consumers. Bulk

procurement and demand aggregation to drive down prices worked well for mass-market products like lighting. However, the administration costs of such an approach for larger appliances are high. We recommend that this model could be explored in specific geographies. We also suggest that the on-bill financing model needs to be tested at scale. For first convincing consumers to buy these appliances, it is first important to establish a robust measurement of savings by fixing baselines and demonstrating to consumers the value that they are likely to derive through the use of efficient appliances.

Future areas for investigation

We can start with the last of our recommendations. Instead of pronouncing deemed savings associated with energy-efficient devices, efforts should be directed to identify mechanisms and modalities to quantify and establish savings. The mechanisms for designing a quantifiable cost savings model in a robust manner need to be identified. Here, we must leverage technology for the measurement of electricity consumption at a high temporal resolution and establishing baseline use of appliances under various conditions. Then cost savings can be calculated based on baseline consumption values. Use of social surveys to establish hours of use across households is not efficient. We propose something ambitious and larger in scope but accurate and unambiguous in outcome—undertaking a large nationally representative study through an anonymised assessment of consumption patterns across incomes, seasons, and climatic zones using technology and appropriate data privacy and sharing protocols.

From a policy perspective, two important aspects of the energy efficiency value chain require further investigation. The prevalence of small and medium enterprises (SMEs) in value chain of all forms of manufacturing of lights implies that they need support in shifting their production chains to supply energy-efficient products. The Government of India's *Atmanirbhar* programme seeks to promote Indian enterprises in the manufacturing space. Understanding their barriers and addressing them categorically will ensure that the sector thrives and that livelihoods in the informal sector are not affected. The other issue that needs to be explored is the business models that will actually deliver the potential that energy efficiency holds. We briefly discussed utility-led models, but private sector led models that leverage the entrepreneurial spirit of individuals at a local level are needed to truly scale up energy efficiency initiatives in India.

Support for SMEs would be critical to shift production chains to supply energy-efficient products

Annexures

Annexure 1
List of appliances under the BEE Star labelling scheme

S. No.	Mandatory	Year included in scheme
1.	Frost-free refrigerators	2009
2.	Tubular fluorescent lamps	
3.	Room ACs	
4.	Distribution transformer	
5.	RAC (Cassette, floors standing tower, ceiling, corner ACs)	2016
6.	Direct cool refrigerators	
7.	Electric geysers	
8.	Colour TVs	
9.	Variable capacity ACs	2017
10.	LED lamps	2018

Table A1
Appliances under the mandatory BEE star labelling scheme

Source: Adapted from BEE website and AEEE (2015). Evaluating Market Response to the Appliance Standards and Labelling Programme—A Status Report. New Delhi: Alliance for an Energy Efficient Economy

S. No.	Voluntary	Year included in scheme
1.	Induction motors	2009
2.	Agricultural pump sets	
3.	Ceiling fans	
4.	Domestic LPG stoves	
5.	Washing machines	
6.	Ballast (electronic/magnetic)	
7.	Diesel engine driven monoset pumps for agriculture	
8.	Solid state inverters	
9.	Diesel generators	
10.	Computers (notebooks/laptops)	2011
11.	Office equipment (printer, copier, scanner, MFDs)	
12.	Chillers	2018
13.	Solar water heaters	2019
14.	Microwave ovens	2019
15.	Light commercial ACs	2020
16.	Deep freezers	

Table A2
Appliances under the voluntary BEE star labelling scheme

Source: Adapted from BEE website and AEEE (2015). Evaluating Market Response to the Appliance Standards and Labelling Programme—A Status Report. New Delhi: Alliance for an Energy Efficient Economy

Annexure 2
Comparing appliance ownership rates with past surveys

For validating the robustness of our survey estimates, we compared the appliance ownership rates for key appliances with those from the latest (fourth) round of the National Family Health Survey (NFHS-4), which was conducted in 2015–16 (Paswan et al. 2017). Table A3 shows the comparison for all Indian households as well as for urban-rural categories.

Appliance	NFHS-4 (2015–16)			IRES (2019–20)		
	Rural India	Urban India	India	Rural India	Urban India	India
Phone	87	96	90	98	99	98
Fan	69	95	78	86	98	90
TV	54	87	65	61	90	70
Refrigerator	16	54	30	18	71	33
AC or cooler	10	33	18	8	27	13
Washing machine	6	29	14	3	20	8
Computer	4	19	9	2	10	4

Table A3
As compared to NFHS-4, IRES underestimates the ownership rates of ACs or coolers, washing machines, and computers

Source: Authors' analysis

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Nationally representative consumer surveys can help assess awareness levels and behaviour about adoption and use of energy efficient appliances and practices.

Image: CEEW/Market Xcel

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