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GOVERNMENT OF INDIA
MINISTRY OF POWER

Residential Energy Consumption Patterns and Appliance Ownership in India:

Insights from a 2024 Household Survey

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clasp

BEE@25

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CLASP's research aims to bridge the gap between analysis and action to hit net zero emissions in the appliances sector by 2050. Read ***Net Zero Heroes: Scaling Efficient Appliances for Climate Change Mitigation, Adaptation & Resilience*** to learn more about our net zero strategy.

कृष्ण चन्द्र पाणिग्राही
महानिदेशक
KRUSHNA CHANDRA PANIGRAHY
Director General

सत्यमेव जयते

Azadi Ka Amrit Mahotsav

ऊर्जा दक्षता ब्यूरो
(विद्युत मंत्रालय, भारत सरकार)
BUREAU OF ENERGY EFFICIENCY
(Ministry of Power, Government of India)

Message

India's residential sector is emerging as a central pillar of the country's energy transition. Rising electrification, growing appliance ownership, increasing heat stress, and changing lifestyles are reshaping household electricity demand and influencing the national load curve. Managing this transformation effectively is essential to ensure that India's power system remains reliable, affordable, and aligned with long-term climate and development goals.

The report *Residential Energy Consumption Patterns and Appliance Ownership in India: Insights from a 2024 Household Survey* provides timely and robust evidence to support this effort. By capturing how households across climatic regions and socio-economic segments consume electricity and adopt appliances, the study strengthens our understanding of present demand patterns and future trajectories.

For the Bureau of Energy Efficiency, such evidence is fundamental to advancing energy efficiency as a resource for the power system. Insights from this assessment will help inform the continued strengthening of appliance efficiency standards, the expansion of the Standards and Labelling programme, and the design of market transformation initiatives that make efficient technologies more accessible and affordable for consumers.

As India progresses towards its vision of a Viksit Bharat by 2047, energy efficiency will remain a cornerstone of energy security, emissions reduction, and household wellbeing. I commend the efforts of CLASP, the study team, and participating households for contributing to this important work. I am confident that this report will serve as a valuable reference for policymakers, utilities, researchers, and market actors shaping India's residential energy future.

K.C. Panigrahy

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Message

India stands at a critical juncture in its energy transition. Rising appliance ownership, accelerating cooling demand, increasing heat stress, and evolving household aspirations are reshaping electricity consumption and the everyday reality of affordability, comfort, and reliability for millions of families. As demand for electricity continues to grow, improving the efficiency of energy use is no longer optional; it is essential. The residential sector, is emerging as one of the largest and fastest-growing consumers of electricity.

A deeper understanding of how energy is consumed within homes presents a powerful opportunity to strengthen policy design and accelerate impact. Over the years, India has made significant progress through the Bureau of Energy Efficiency (BEE)'s Standards and Labelling Program. Building on this strong foundation, there is growing value in developing more granular, data-driven insights into end-use consumption. This report contributes to that effort.

This report, Residential Energy Consumption Patterns and Appliance Ownership in India, provides timely and relevant evidence. By capturing appliance ownership and electricity-use patterns; it strengthens understanding of what is happening in Indian homes today and what is likely to shape demand tomorrow. The findings reinforce a key insight: appliances will play a defining role in shaping India's energy future, and improving their efficiency can unlock significant economic and environmental benefits.

CLASP has been privileged to support India's appliance efficiency journey for many years, including earlier residential electricity end use research. This study builds on that foundation and responds to the need for contemporary and granular evidence.

We are grateful to the BEE for its leadership and partnership, and we thank the survey teams and participating households whose contributions made this research possible. We hope this report serves as a practical resource for policymakers, utilities, researchers, manufacturers, and development partners working to deliver lower bills, improved comfort, and a more resilient power system, while keeping India on track toward its long-term development and climate ambitions.

Neha Dhingra
Director, CLASP

Foreword

Evidencebased policymaking is increasingly critical as India's energy system becomes more complex and dataintensive. Recognising this need, the Bureau of Energy Efficiency established the Energy Data Management Unit (EDMU) to strengthen the collection, management, and application of highquality data across sectors. One of EDMU's core objectives is to bridge persistent data gaps in enduse energy consumption, particularly at consumption sectors, where rapid change is underway.

The residential sector has seen profound shifts over the past decade. Appliance ownership has expanded significantly, cooling demand is growing rapidly, and electricity consumption patterns are increasingly shaped by climate stress, income levels, and urbanisation. Yet much of the available data has struggled to keep pace with these changes. This study was initiated in response to a clear need identified through EDMU's work, namely the requirement for contemporary, granular, appliancespecific evidence to inform efficiency policy, demand planning, and future market interventions.

Conducted by CLASP in collaboration with BEE, this survey covers 4,321 households across 20 states, spanning climatic zones, income groups, and urban and rural contexts. It provides detailed insights into appliance ownership, usage patterns, efficiency awareness, and consumer decisionmaking. To the best of our knowledge, this is the first study of its kind undertaken by BEE at this scale and level of detail for the residential sector.

I would like to acknowledge CLASP for their technical partnership, the survey teams for their rigorous field work, and the households across the country who participated in this effort. It is our hope that this report will support a more responsive, datadriven, and futureready approach to residential energy policy in India.

Arijit Sengupta
Director, Bureau of Energy Efficiency

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Acronyms and Abbreviations

AC	Air Conditioner, Air Conditioning
BEE	Bureau of Energy Efficiency
BLDC	Brushless Direct Current
CAGR	Compound Annual Growth Rate
CEEW	Council on Energy, Environment, and Water
CFL	Compact Fluorescent Lamp
DC	Direct Current
DISCOM	Distribution Company
DSM	Demand-Side Management
EDA	Exploratory Data Analysis
GW	Gigawatts
ICAP	India Cooling Action Plan
INR	Indian Rupee
IRES	India Residential Energy Survey
kWh	Kilowatt Hour
LED	Light-Emitting Diode
LPG	Liquified Petroleum Gas
MNRE	Ministry of New and Renewable Energy
NFHS	National Family Health Survey
NSSO	National Sample Survey Office
OTG	Oven Toaster Griller
PNG	Piped Natural Gas
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan
PMUY	Pradhan Mantri Ujjwala Yojana
SEC	Socioeconomic Classification
S&L	Standards & Labelling
TWh	Terawatt Hour
UJALA	Unnat Jyoti By Affordable LEDs For All
W	Watt

Executive Summary

India's electricity consumption has surged in recent years, driven by economic growth, urbanization, rising living standards, and expanding electrification. As the world's third-largest energy consumer, India's residential sector now accounts for 25% of total electricity demand (FY 2024–25)[1] making it the second-largest electricity-consuming sector.

With climate change intensifying and the country progressing toward 100% household electrification, the use of appliances for cooling, heating, and cooking is expected to grow significantly. Without targeted interventions, this could strain power generation and distribution infrastructure, while also increasing carbon emissions and threatening energy security.

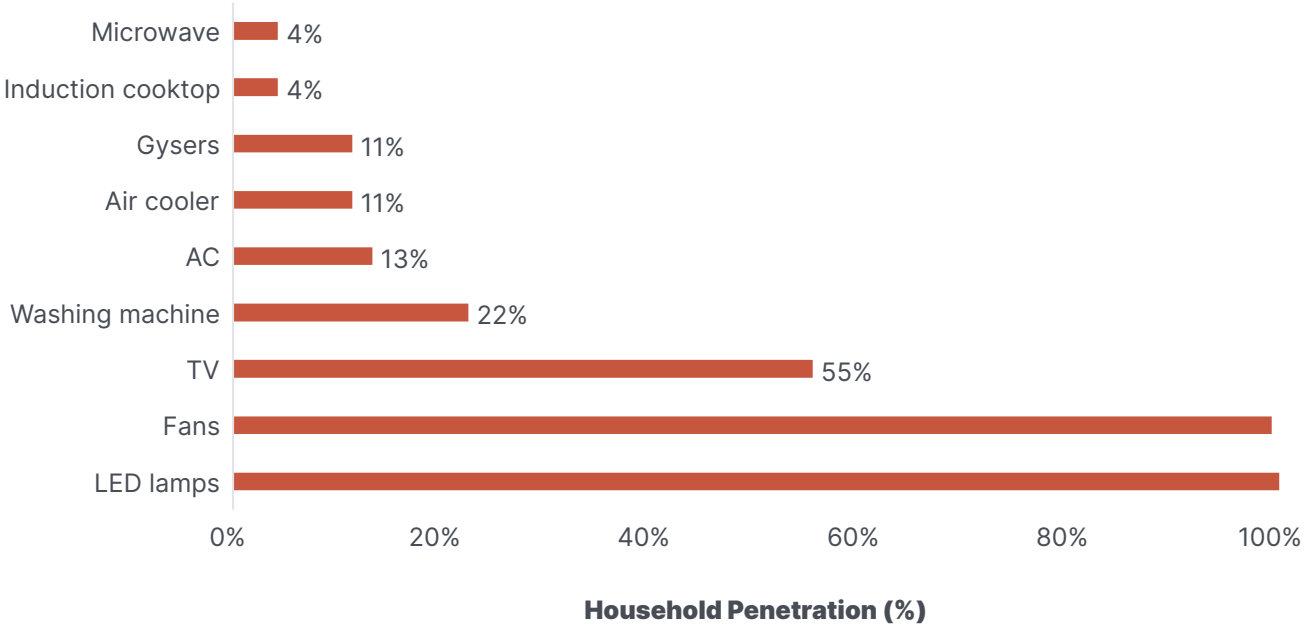
To inform future energy and appliance efficiency policies, CLASP, in collaboration with the Bureau of Energy Efficiency (BEE), conducted a household survey in 2024, covering 4,321 households across 20 states and major climate zones. The survey provides detailed insights into appliance penetration, electricity consumption patterns, and consumer behaviour among surveyed households.

1 Provisional data from CEA, accessed through BEE

Key Findings

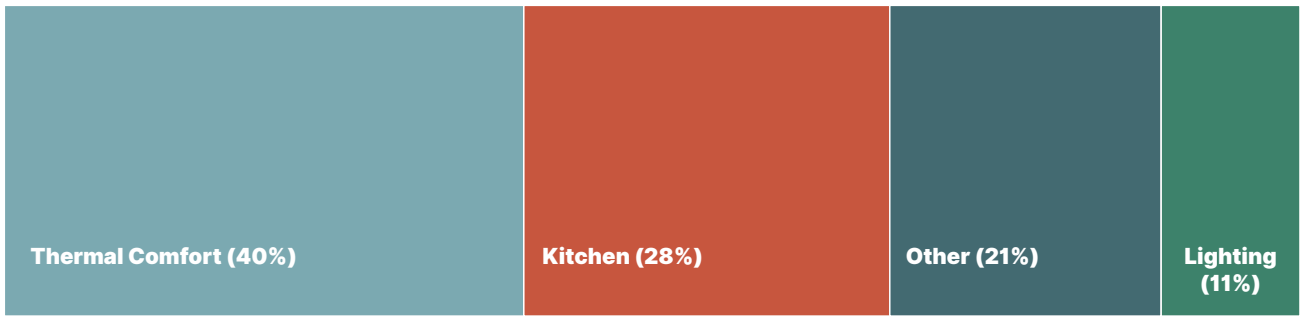
- Energy consumption in surveyed households is not uniform: Climatic conditions, socioeconomic status, awareness of energy efficiency strongly influence appliance use.

FIGURE 1: HOUSEHOLD APPLIANCE OWNERSHIP ACROSS SURVEYED HOUSEHOLDS



- Nearly all surveyed households own LED lamps (100%) and fans (99%), indicating widespread access to basic lighting and cooling. However, ownership of more advanced appliances like washing machines (22%) and air conditioners (13%) remains relatively low. Television is present in just over half of households (55%), suggesting moderate penetration of entertainment technology.

FIGURE 2: ANNUAL ELECTRICITY USE IN SURVEYED HOUSEHOLDS BY END USE



- Among surveyed households, electricity use is primarily driven by thermal comfort, which accounts for 40% of total consumption, reflecting the growing demand for cooling solutions. This trend is fueled by near-universal fan ownership and a noticeable rise in air conditioner adoption. Kitchen appliances contribute 28% to electricity use, while lighting accounts for 11%, and other miscellaneous uses make up the remaining 21%.

- Affordability is a decisive factor in appliance purchases, often outweighing energy efficiency considerations.
- Consumer behaviour around energy efficiency is inconsistent: All surveyed households reported using LED lighting, primarily due to the success of the UJALA programme. However, only 2 percent actively considered energy efficiency when purchasing lighting solutions. This contrast highlights the importance of market transformation initiatives in promoting the adoption of energy-efficient technologies.
- In the survey, electric cooking is currently being explored by early adopter households, particularly in urban areas.

POLICY RECOMMENDATIONS

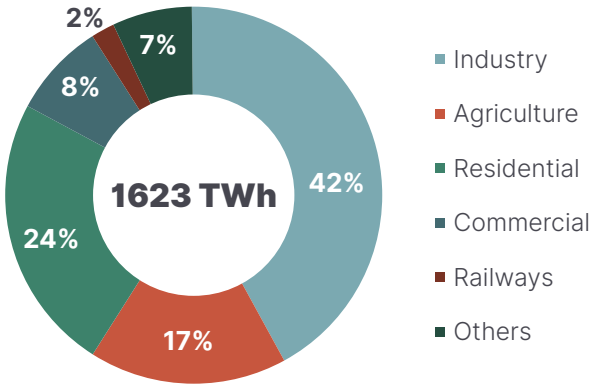
- Strengthen Appliance Efficiency Standards: Survey results and existing market studies indicate low ownership levels of many household appliances, with the exception of LED bulbs and fans. As urbanization progresses and household incomes rise, appliance adoption is expected to increase substantially. To manage the resulting growth in electricity demand, it is important to enhance energy efficiency standards, particularly by enforcing stricter Minimum Energy Performance Standards (MEPS) for high-impact appliances such as air conditioners, refrigerators, and other cooling devices.
- Promote Efficient Fan Technologies: Introduce targeted subsidies or rebates to accelerate the uptake of high efficiency (5 Star rated) fans, which offer substantial energy savings. As fans are the primary cooling solution for most Indian households, improving their efficiency can deliver widespread and immediate benefits in reducing residential electricity demand.
- Promote Exclusive Clean Cooking Fuel Use: Include refill-linked transfers and awareness campaigns, to encourage full transition away from traditional fuels.
- Bridge awareness-action gap: Better consumer education and stronger enforcement of efficiency standards can drive more conscious appliance choices.
- Leverage Market Transformation Strategies to Accelerate Adoption: Replicate successful models like the UJALA programme to drive uptake of super-efficient technologies across appliance categories through bulk procurement, partnerships, and public outreach. Building on these strategies, expand financial incentives such as preferential consumer financing, targeted subsidies, and trade-in programs to improve affordability and accessibility. Complement these measures with consumer awareness campaigns and initiatives that prioritize lower-income households and support the replacement of outdated, inefficient appliances.
- Assess the Impact of Electric Cooking and Increasing Adoption of Cooling Solutions on Power Systems: Initiate targeted studies to evaluate how the growing use of electric cooking and air-conditioning will affect electricity demand, peak load patterns, and grid infrastructure. As both e-cooking and cooling technologies gain traction, understanding their combined impact is essential for effective grid planning, load management, and ensuring reliable power supply, particularly during peak hours.

India stands at a pivotal moment in its energy transition, with residential electricity demand projected to rise steadily. Addressing this challenge requires a strategic shift toward energy-efficient technologies, deeper consumer engagement and smarter grid management. The findings of this survey offer a robust foundation for data-driven policymaking, infrastructure planning, and targeted demand-side interventions. By acting on these insights, India can ensure that its residential sector evolves in a sustainable, energy-efficient, and climate-resilient manner.

Introduction

India's energy landscape is undergoing rapid transformation, driven by a growing population, expanding economy, and increasing access to modern energy services. Over the past decade (2013–2024), the country's primary energy supply has increased by 54.5%, rising from 589 Mtoe to 910 Mtoe[2]. This is further reflected in electricity consumption, which nearly doubled from 874 TWh to 1,623 TWh during the same period, growing at an annual CAGR rate of 5.8%. Notably, peak electricity demand also surged by 79%, escalating from 136 GW in 2013–14 to 243 GW in 2023–24[2]. Looking ahead, peak demand is forecasted to exceed 300 GW by 2030[3], underscoring the need for expanded generation capacity, grid modernization, and clean energy integration.

FIGURE 3: SECTOR-WISE ELECTRICITY CONSUMPTION IN 2024-25



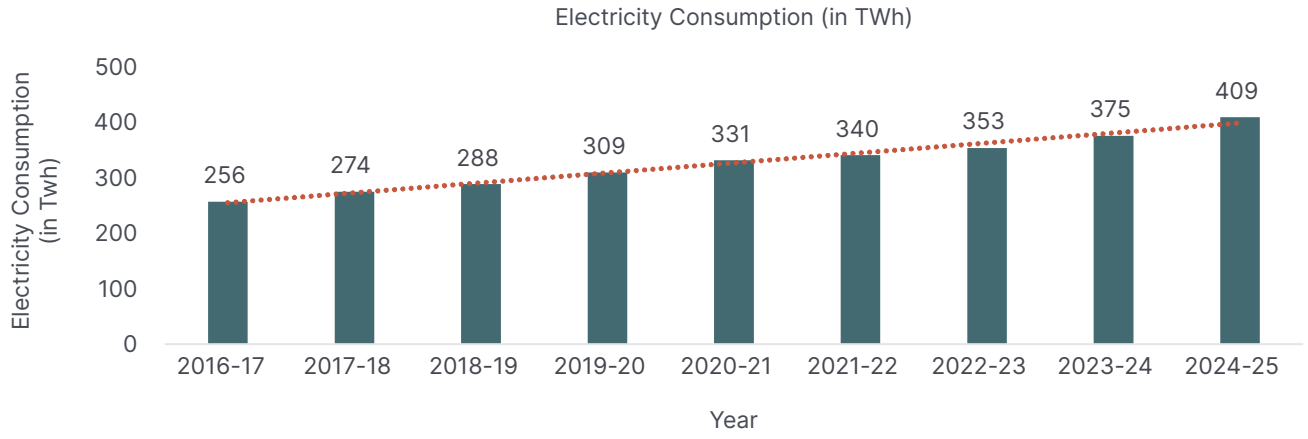
Source: CEA's provisional data for FY 2024-25

Within this context, the residential sector has emerged as one of the key contributor to overall electricity consumption. As of 2024–25, it accounts for approximately 25% of total electricity usage in the country[1], with an annual growth rate of 6%. Residential electricity consumption alone rose from 256 TWh to 409 TWh[2] over the last decade, making it the second-highest consumer after the industrial sector.

2 Bureau of Energy Efficiency (2024) India Energy Scenario for the Year 2023–24. 2nd ed., December. [link]

3 Central Electricity Authority (2023) Report on Optimal Generation Capacity Mix for 2029–30 (Version 2.0), April. [link]

FIGURE 4: ELECTRICITY CONSUMPTION IN THE RESIDENTIAL SECTOR



This can be attributed to growing population, rising household incomes, near-universal electrification, and a growing demand for space cooling in due to rising temperatures. Per-capita electricity consumption in India increased by ~46% over the past decade, from 957 kWh (2013–14) to 1,395 kWh (2023–24)[4]; while this marks significant progress, it remains below the global average of approximately 3,400 kWh[5], highlighting both the potential for further growth and the need for sustainable energy planning.

This evolving energy profile and growing demand highlights the need to better understand the drivers of residential energy consumption. As appliance ownership and usage patterns continue to change due to increasing heat stress and economic growth, there is a lack of recent representative data on household appliance ownership. To address this gap, the present study examines appliance ownership, energy consumption behaviors, and their contribution to residential energy demand. By identifying the key factors that influence energy use, the study aims to support the development of effective energy efficiency policies and help inform strategies to manage this growing demand efficiently in India's residential sector.

OBJECTIVES OF THE STUDY

This study analyzes appliance ownership, usage, and residential energy consumption patterns in India using data from a sample of 4,321 households across 20 states, covering major climatic zones. The sample reflects diverse climatic, socioeconomic, and urban–rural contexts but is not statistically representative of all Indian households. These households were part of a larger outreach effort that contacted over 26,000 households, with the final sample reflecting successful completions. The sample design captures variations in energy use across socio-economic groups and urban–rural settings.

The study focuses on the following key objectives:

- Examine appliance ownership and associated energy usage patterns, and assess their contribution to total residential energy demand across:
  - Climate zones
  - Urban and rural areas
  - Socio-economic classifications (SEC)
- Gather household-level electricity consumption
- Identify key drivers influencing residential energy demand, including income levels, climatic conditions, dwelling characteristics, and awareness of energy efficiency measures such as the Bureau of Energy Efficiency star label.

4 Press Information Bureau (2025) 'Year-End Review 2024: Ministry of Power', 1 January. [link]

5 World Bank Data, electric power consumption [link]

Methodology

This study follows a structured approach to capture residential energy consumption patterns across diverse household segments in India. The methodology ensures data-driven assessment of appliance ownership, usage behaviour, and electricity demand. A brief description of the survey design and data collection process is mentioned below.

SAMPLING

To ensure a statistically robust sample of 4,321 households, a stratified multistage sampling approach was adopted to capture regional, urban-rural, and socio-economic variability in household energy consumption. This method divides the population into subgroups or strata as follows:

Stage 1: the sample was stratified based on geographic characteristics, with states selected to represent different climatic zones.

India is divided into five climatic zones — Hot-Dry, Warm-Humid, Temperate, Cold and Composite, and sample was proportionately distributed across these climatic zones based on the population residing in each, ensuring the representation of varied energy usage patterns due to climatic diversity.

FIGURE 5: GEOGRAPHICAL COVERAGE OF SURVEY

Total Sample Survey Size = 4,300+

TABLE 1: STATES COVERED IN EACH CLIMATE ZONE

Composite	Warm & Humid	Hot & Dry	Temperate	Cold
Bihar	Andhra Pradesh	Gujarat	Karnataka	Uttarakhand
Chhattisgarh	Assam	Maharashtra		
Haryana	Karnataka	Rajasthan		
Jharkhand	Kerala			
Madhya Pradesh	Odisha			
New Delhi	Tamil Nadu			
Punjab	West Bengal			
Telangana				
Uttar Pradesh				

Stage 2: an urban–rural stratification was applied within the selected geographies to capture differences in energy access and consumption patterns.

Stage 3: sampling units (households) were selected using a Probability Proportional to Size (PPS) approach, ensuring that areas with larger populations had a higher probability of selection. Within selected clusters, households were then chosen using random sampling techniques to achieve better representation of the target population.

The sample included approximately 70% urban households (3,061) and 30% rural households (1,260). This distribution reflects the greater diversity in energy use, appliance ownership, and income levels typically found in urban areas. The 70:30 ratio is based on data from the National Family Health Survey (NFHS-5), which shows that 74% of the urban population and only 24% of the rural population fall within the top 50% of India's wealthiest individuals. Since wealth is closely linked to energy consumption and appliance ownership, this sampling approach helps capture those differences more accurately.

Probability Proportional to Size (PPS) is a sampling technique in which the probability of selecting a unit (such as a household or no. of surveys in this case) is proportional to its size (such as population). This method ensures that larger units have a higher chance of selection while maintaining statistical representation of smaller units

The study consisting of the final completed 4,321 households, covering various socio-economic strata, geographical regions, and climatic zones has been bifurcated as shown below:

FIGURE 6: SAMPLE DISTRIBUTION ACROSS INDIA

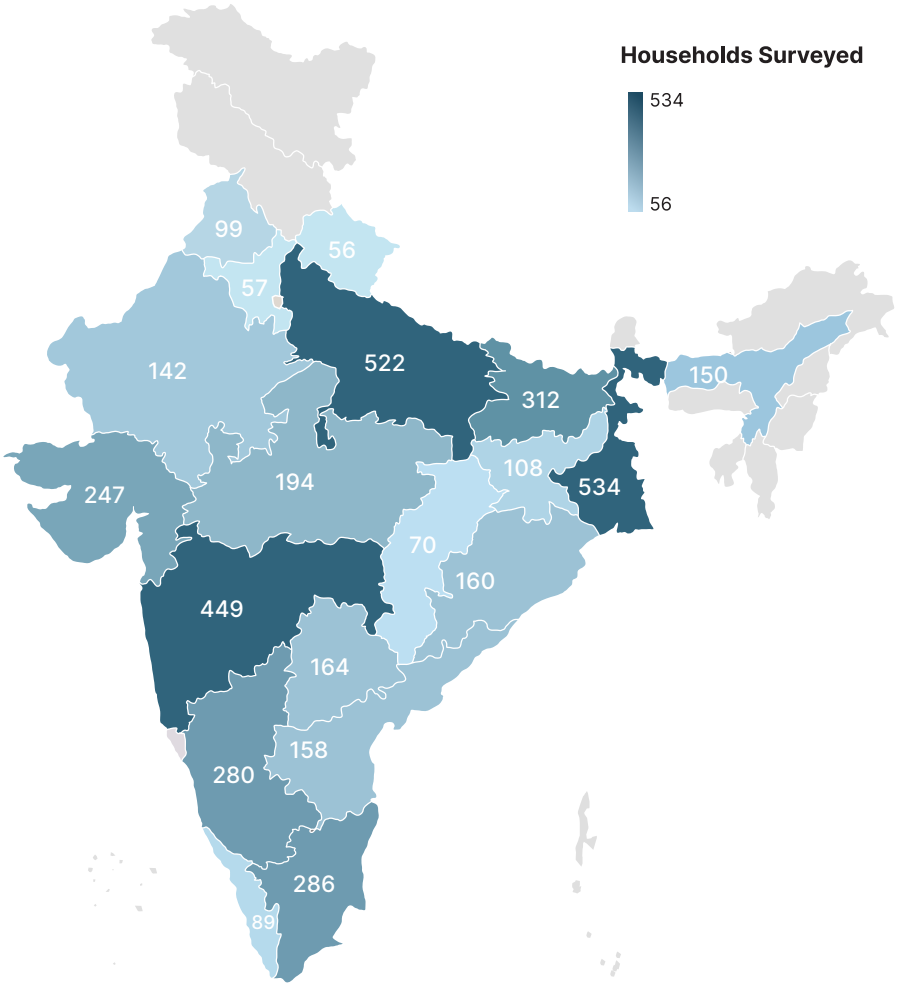
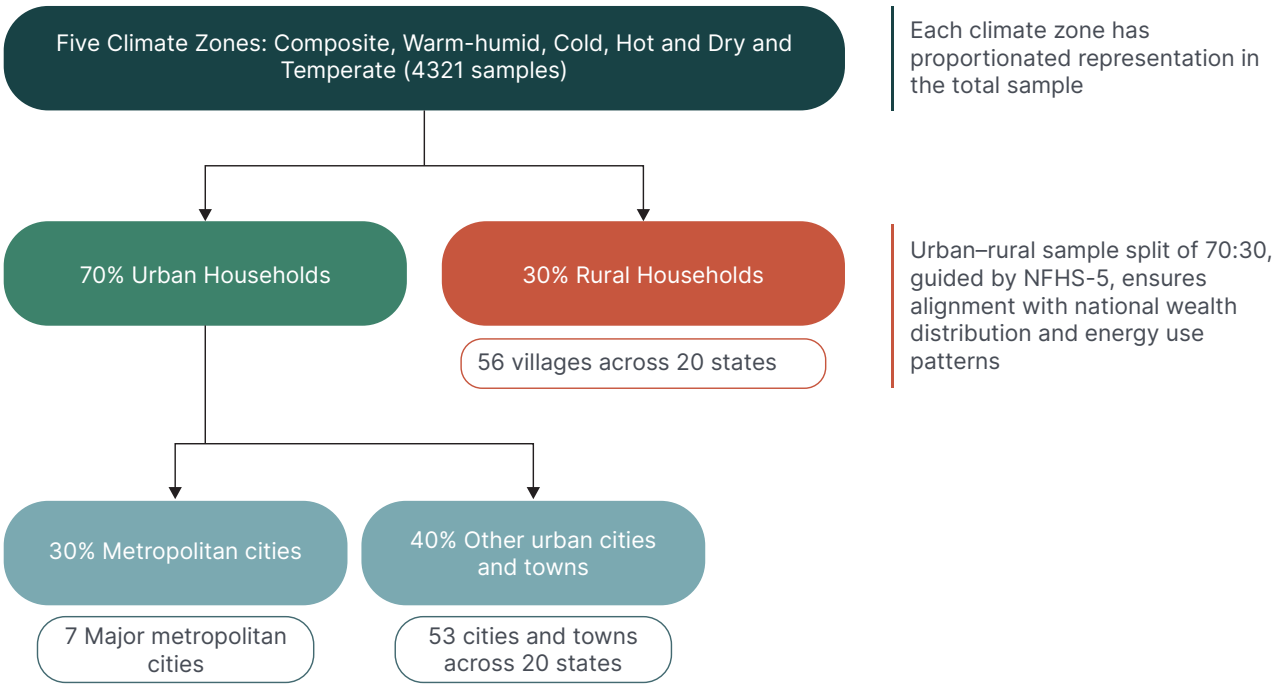


FIGURE 7: SAMPLING FLOWCHART



- **Urban Sampling:**
  1. Metropolitan Cities: 30% of the urban sample (1,285 households) is allocated to seven metropolitan cities, representing a significant proportion of the urban population and diverse socio-economic behaviours.
  2. Rest of Urban Areas: The remaining 40% of the urban sample (1,776 households) is distributed across 20 states using the Probability Proportional to Size (PPS) method. A minimum of 30 interviews is conducted in each of the 52 cities to ensure comprehensive participation, with a mix of tiered urban centers.

1. **Rural Sampling:** Rural households are distributed across 20 states, with a sample of 20 interviews per village. The PPS approach determines the number of villages per state, focusing on accessibility and logistical feasibility. States with extremely small proportions are excluded to ensure practical implementation. A total of 56 villages are covered, representing rural diversity.

Due to field logistics and response rates, no rural households were sampled in the Temperate zone. In the Cold zone, outcomes for certain appliance sub-categories (notably cooling appliance ownership) were based on small subsamples and are therefore suppressed to avoid misleading inferences.

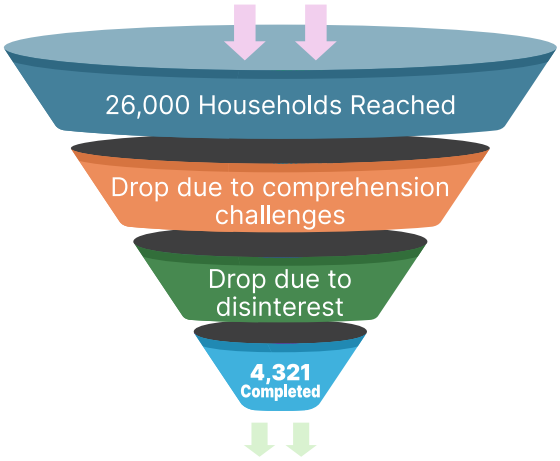
SURVEY PARTICIPATION TREND

The survey successfully completed 4,321 household interviews against a target of 4,000, which required outreach to approximately 26,000 households. The gap between outreach and completed interviews is primarily attributable to non-response factors such as occasional unavailability of residents during visits, disinterest, or survey fatigue.

In some cases, respondents faced challenges in comprehending the questionnaire, especially when technical details were involved. Additionally, there was limited awareness or recall of appliance-specific details such as type, capacity, or efficiency ratings of appliances like AC or fan types, which impacted data accuracy.

To address these issues, appropriate data validation and cleaning procedures were undertaken, including consistency checks and logical imputation where feasible. These insights offer valuable opportunities to refine our outreach and improve engagement strategies in future rounds.

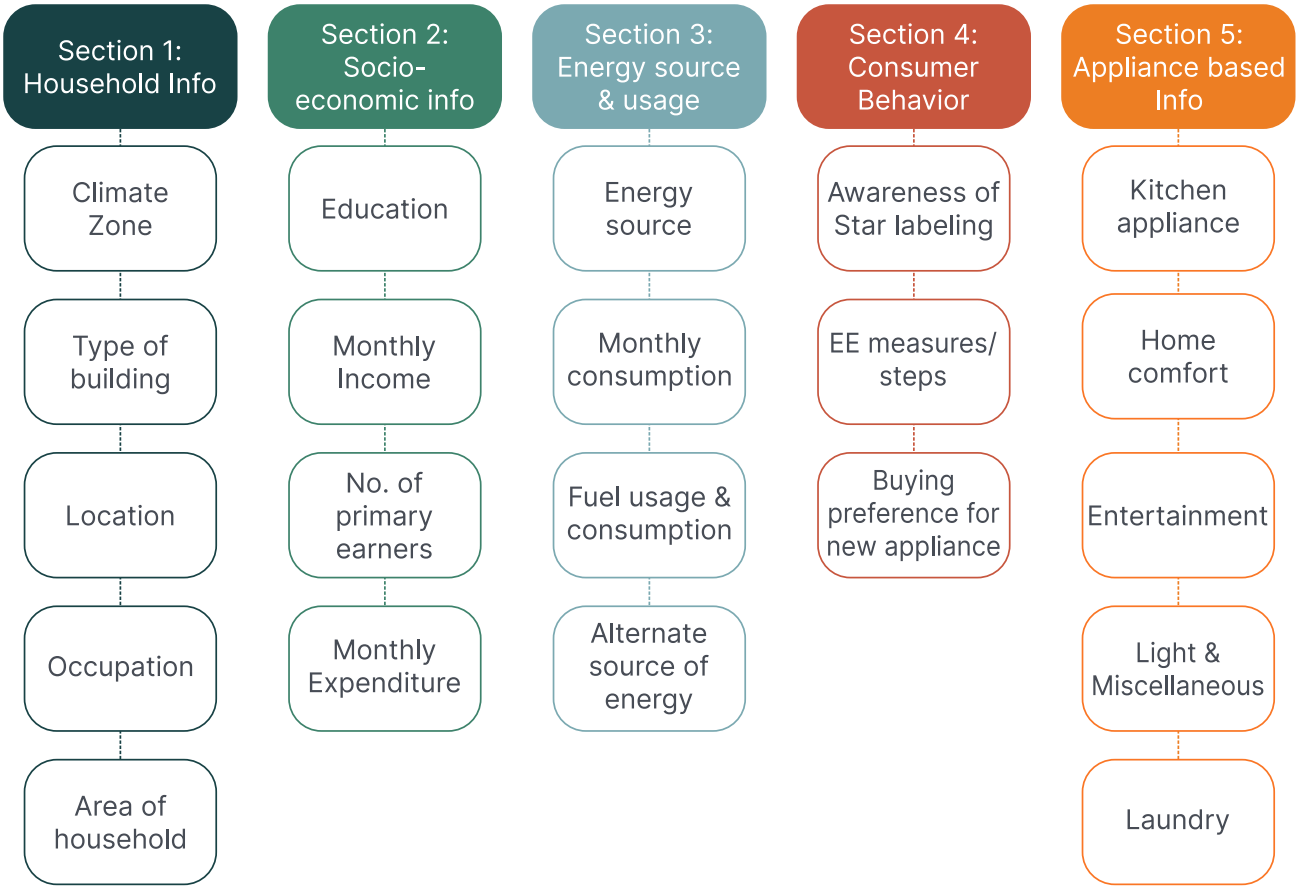
FIGURE 8: FACTORS AFFECTING SURVEY COMPLETION



Questionnaire Design

The questionnaire was designed to comprehensively assess residential energy consumption patterns and appliance usage. The survey instrument was structured into five thematic sections (Figure 8). The instrument was developed in a structured format. It was digitized and administered using **Computer-Assisted Personal Interviewing (CAPI)** to improve data accuracy, reduce manual errors, and enable real-time validation checks during data collection. Field teams gathered responses through door-to-door visits using handheld devices. Refer to Annexure 1 for complete questionnaire of the survey.

FIGURE 9: QUESTIONNAIRE FRAMEWORK



The survey covered following key parameters:

- Household Information: This included details such as the climate zone of the household, primary occupation of residents, house size, type of dwelling (e.g., independent house, apartment), and the number of occupants.

Socio-Economic Classification (SEC) Framework

Sampled households were segmented using the Socio-Economic Classification (SEC) system developed by the Market Research Society of India (MRSI). The SEC system differentiates urban and rural households based on key socio-economic indicators. In urban areas, classification is based on the education and occupation of the chief wage earner. In rural areas, it relies on the education level and type of housing. This segmentation enables a structured understanding of energy demand trends across lower-income and affluent households. For simplicity, the study groups SEC classes into three broad categories:

Class	Urban SEC	Rural SEC
Lower	D – E2	R4
Middle	B2 – C	R2 - R3
Upper	A1 - B1	R1

This standardized classification ensures consistency in analysis and interpretation. It avoids reliance on income data, which is often difficult to collect, and instead uses education, occupation, and housing as proxies for socio-economic status.

- Socioeconomic Profile: Captured information on the primary earner in the household, including monthly income and expenditure, as well as educational levels.
- Energy Sources and Consumption: Documented the types of fuels used in the household (such as electricity, wood, Liquid Petroleum Gas (LPG), biomass) and estimates of monthly consumption for each fuel type. It also collects data on monthly energy expenditures in Indian Rupees (INR), including seasonal variations in energy bills.
- Consumer Awareness and Behaviour: Investigated awareness levels regarding energy-efficient appliances and the BEE star labelling programme. Additional questions examine perceptions of the benefits of energy-efficient appliances and the household's stated willingness to invest in such technologies.
- Appliance Ownership and Usage Patterns: The questionnaire collected detailed, appliance-level data across major categories to understand ownership, age, star rating (where applicable), and usage frequency. This information helps estimate energy consumption and usage patterns across Indian households, segmented by socio-economic class. Appliances were grouped into following major categories:

    1. Thermal Comfort
    2. Kitchen
    3. Lighting
    4. Others

Data Collection & Analytical Approach

The dataset underpinning this study was collected through a comprehensive, six-month-long field survey conducted using a team of 60 trained field surveyors. To maintain data accuracy and consistency across such a large-scale operation, a digital data collection tool was employed. This not only minimized human error but also enabled real-time monitoring of survey progress and data quality checks throughout the data-gathering phase.

The survey successfully captured a total of 10.16 million data points, forming the foundation for all subsequent analysis. As mentioned above, these data points encompassed a wide range of variables related to household energy use, socio-economic characteristics, appliance ownership, and consumption patterns, providing a rich and detailed dataset for analytical exploration.

Data Cleaning

To ensure the integrity and usability of the dataset, a structured data cleaning process was implemented. Duplicate records were systematically identified and removed to prevent any bias in the subsequent analysis.

These steps were critical in preparing the dataset for rigorous analytical analysis while preserving its representativeness and reliability.

Data Validation

Validation was a multi-layered process designed to verify the accuracy and authenticity of reported energy consumption data. A logical and triangulated approach was adopted, combining three key sources of information:

- Electricity bills provided by respondents offering actual consumption figures.
- Estimated household electricity consumption calculated based on appliance usage patterns and well-defined assumptions.
- Self-reported consumption data collected directly during survey interviews.

By cross verifying these three independent data sources, we ensure that the reported consumption values were consistent and credible. This triangulation method significantly enhanced the validity of the dataset and reduced the likelihood of misreporting or inconsistencies. Detailed validation protocols and checks are outlined in Annexure III.

STUDY LIMITATIONS

While this study offers valuable insights into household energy consumption patterns across India, certain limitations must be acknowledged. The final sample of 4,321 households was drawn from an outreach effort that contacted over 26,000 households. Although the sample reflects diversity in regional variations, socio-economic conditions, lifestyle patterns, and cultural practices, it is not statistically representative of the entire Indian population.

Several factors contributed to the gap between outreach and completed interviews. These included the unavailability of residents during visits, lack of interest, survey fatigue, and difficulty in understanding technical aspects of the questionnaire. Many households were also unable to provide specific information on appliance parameters, which affected the completeness of the data.

Survey-based data collection is subject to potential sources of error such as recall bias, enumerator bias, and measurement inaccuracies. To reduce these risks, the study incorporated quality control measures including comprehensive training for enumerators, strict data validation protocols, and field audits. Despite these efforts, some residual biases or inaccuracies may still remain.

Survey Findings & Key Insights

As India's residential electricity demand continues to rise at 6% CAGR, understanding residential household energy consumption patterns, appliances that drive demand, and the factors that influence consumer decisions becomes increasingly crucial. The survey provides granular evidence on energy consumption patterns, appliances that drive demand, and factors influencing consumer decisions among the surveyed households.

KEY INFERENCES AND TAKEAWAYS

- Among surveyed households, energy consumption varies across climatic zone and socioeconomic class. Survey revealed that urban households in all climatic zones have higher energy consumption than their rural counterparts, largely due to higher appliance penetration, especially of cooling and heating devices.
- In the survey, urban households consume significantly more electricity than rural households, reflecting higher appliance penetration and income levels in urban settings.
- Thermal comfort appliances dominate domestic electricity use. Fans, air conditioners, and coolers collectively contribute about 40% of household electricity consumption overall, rising to 61% in rural homes.
- Ceiling fans and LED lighting have achieved near-universal penetration across surveyed households. However, ownership of other advanced appliances shows significant disparities. For instance, while almost all households report owning ceiling fans and LED lights, air conditioner ownership stands at 17% in urban areas compared to just 4% in rural areas.
- Adoption of clean cooking fuels has expanded, but traditional fuel use persists, especially in rural India.
- Energy efficiency awareness is relatively high, but influences purchasing behaviour for very few. While 65% report awareness of energy-saving appliances, only 2% say they consistently consider energy efficiency first when buying appliances, indicating a gap between awareness and action.
- Affordability remains a deciding factor in appliance purchases, particularly for lower-income households. Ensuring that energy-efficient appliances become more accessible can help bridge the gap in ownership, allowing more households to benefit from modern, efficient, and climate-responsive technologies.

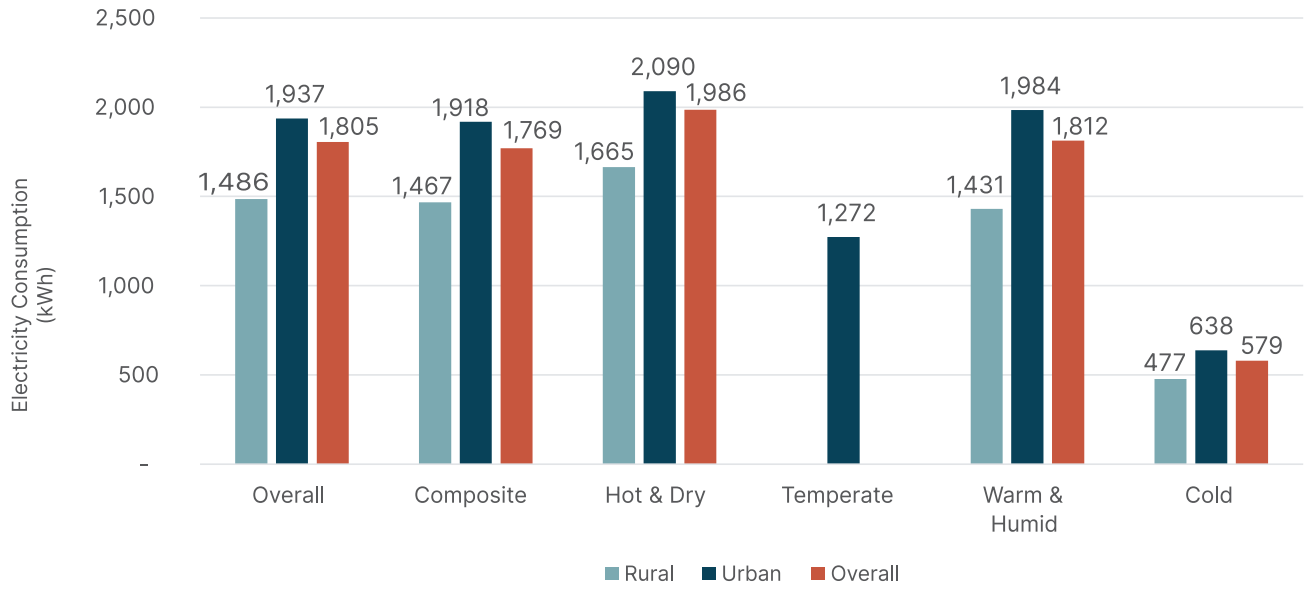
ELECTRICITY CONSUMPTION

Electricity consumption pattern across climatic conditions

We analyzed the average annual household electricity consumption using monthly electricity usage, cross-verified with electricity bills, and appliance usage data provided in the survey. Findings show electricity demand in Indian households is influenced by weather, geography, and adaptability, because heating, cooling, and ventilation requirements vary across regions.

Figure 9 presents electricity consumption across surveyed rural and urban households in different climatic zones. Urban households consistently show higher electricity usage than rural ones across climatic zones, driven by greater appliance penetration, higher living standards, and increased reliance on energy-intensive devices.

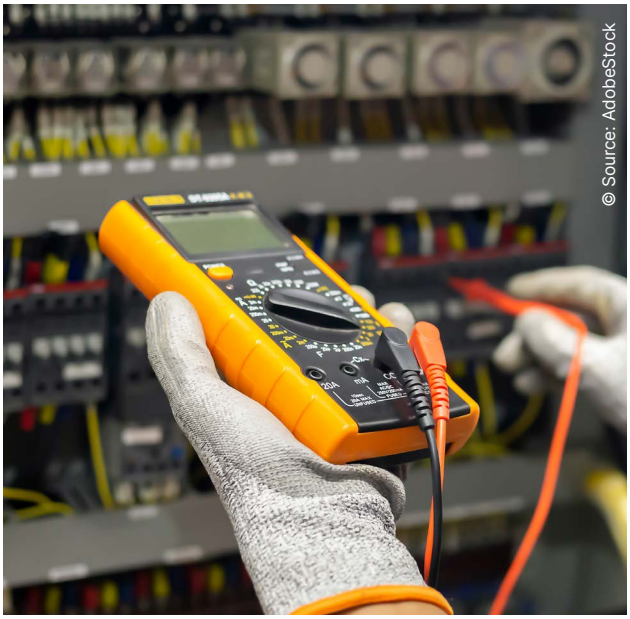
FIGURE 10: AVERAGE ANNUAL ELECTRICITY CONSUMPTION PER HOUSEHOLD



- Overall, urban households consume an average of 1,937 kWh/household-year, while rural households consume 1,486 kWh/household-year, resulting in a combined average of 1,805 kWh/household-year.
- Hot-Dry zones exhibit the highest electricity consumption, with urban households averaging 2,090 kWh/household-year and rural households 1,665 kWh/household-year.

Our survey estimates average household electricity consumption among the sampled households at ~1,805 kWh/household-year; the mode is 1,211 kWh/household-year, indicating that while a subset of homes consumes substantially more, a large share clusters around a lower annual use.

For orientation, an implied national average for the domestic consumer category (that is, per meter or connection, not per household) is about 1,160 to 1,200 kWh per consumer per year (about 97 to 100 kWh per month) in FY 2022–23, calculated by dividing electricity sold to the domestic sector by the number of domestic consumers or meters reported in MoSPI's Energy Statistics India 2024[6]. Further, findings from Household Consumer Expenditure Survey (HCES) 2022-23 by National Sample Survey Office (NSSO) also suggest about~97 kWh per month per household[7]. A domestic consumer refers to a meter or connection and may not correspond to a household.


© Source: AdobeStock

However, electricity consumption also varies within urban and rural areas based on socioeconomic (SEC) data (figure 10 and figure 11).

6 Ministry of Statistics and Programme Implementation (2024) Energy Statistics India 2024. [link]

7 Our World in Data (2026) 'Per capita electricity generation' dataset. [link]

FIGURE 11: RURAL ELECTRICITY CONSUMPTION BY SEC CLASS

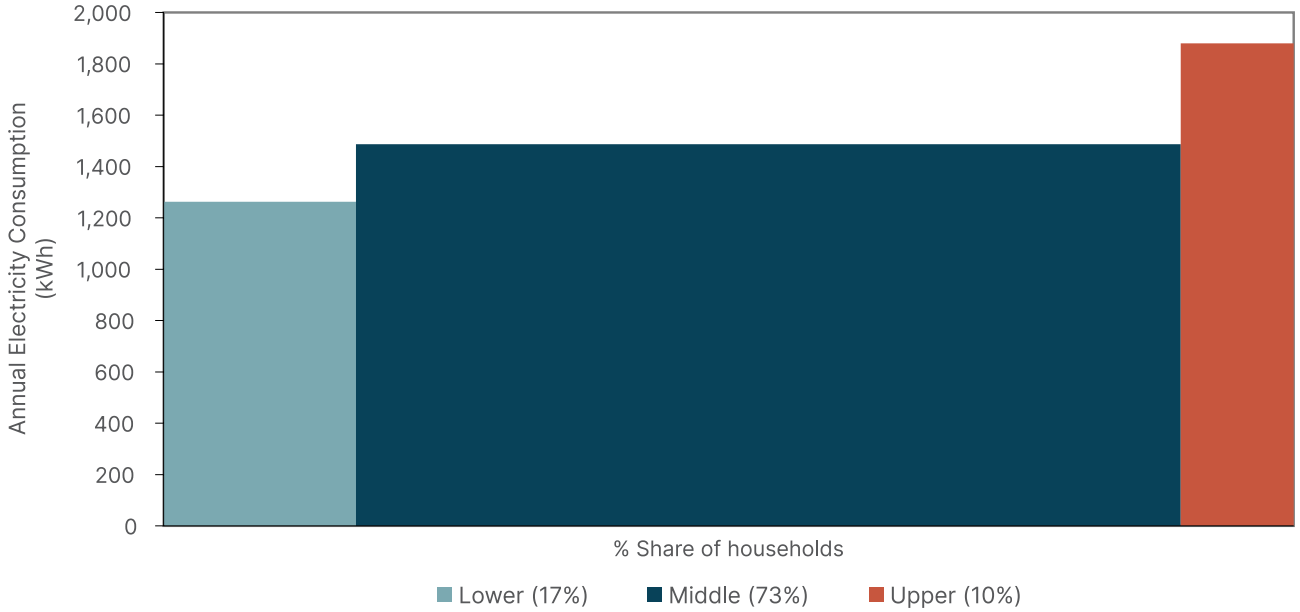
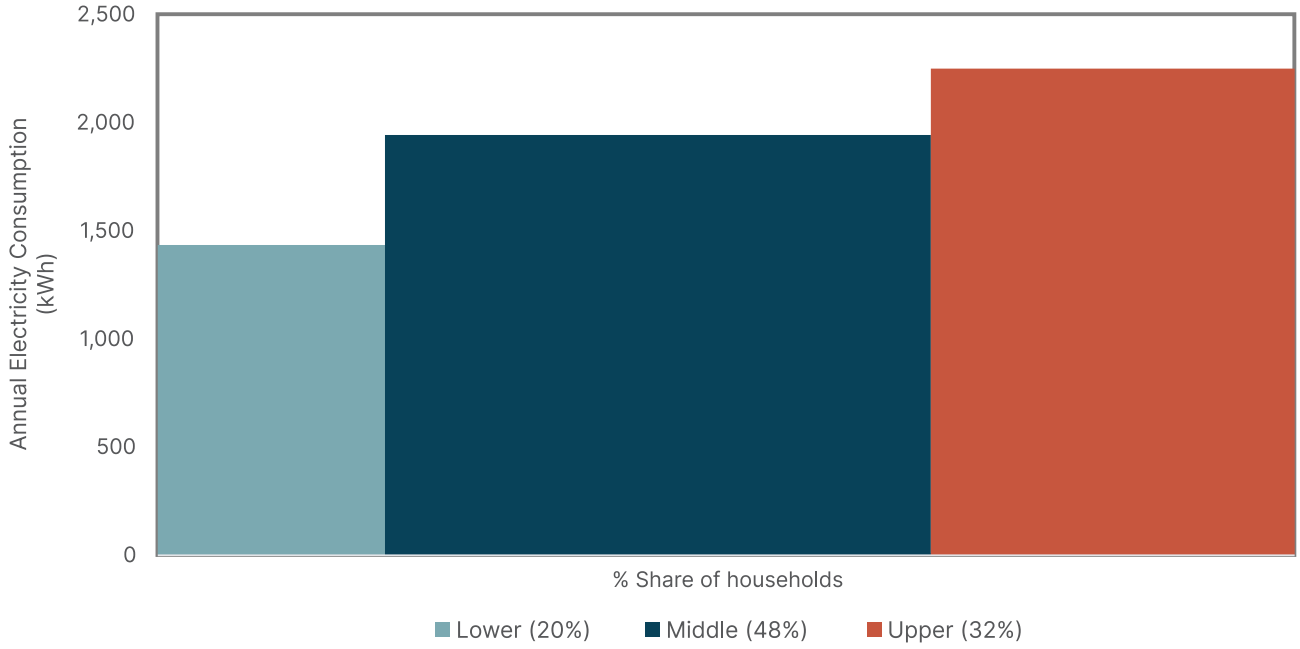


FIGURE 12: URBAN ELECTRICITY CONSUMPTION BY SEC CLASS



In urban areas, the majority of households (48.2%) fell into the Middle-income category, followed by 31.7% in the Upper segment. Upper category recorded the highest average annual electricity consumption at 2,249 kWh, indicating a strong link between income level and energy usage. Figure 12 illustrates that both Middle- and Upper-income households in urban settings contribute significantly to overall electricity demand, likely due to higher ownership of electrical appliances.

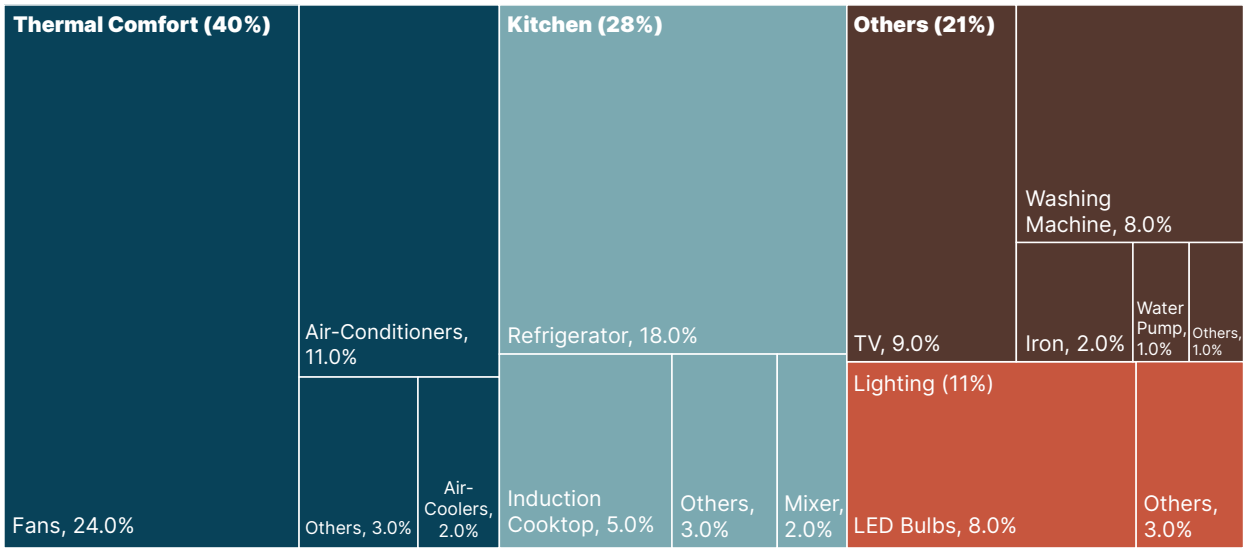
In rural areas, although only 9.5% of households were classified as Upper income, they had the highest average electricity consumption at 1,880 kWh annually. This suggests that wealthier rural households have greater appliance penetration and usage, which drives up energy demand. Additionally, the use of older or less energy-efficient appliances may further contribute to elevated consumption. The Middle-income group, comprising 73.2% of rural households, also showed substantial energy use, reinforcing the trend that electricity consumption increases with income level.

HOUSEHOLD ELECTRICITY CONSUMPTION BY END USE

We analyzed the average annual household electricity consumption using appliance ownership and usage information provided in the survey, cross-validated by monthly electricity usage data and electricity bills. The findings were categorized by appliance groups to understand their contribution to overall residential electricity demand.

The results show that across surveyed households, thermal comfort appliances account for the largest share of household electricity use at 40%. This includes fans at 24%, air conditioners at 11%, and air-coolers at 2%. Kitchen appliances follow closely, consuming 28% of electricity, with refrigerators alone contributing 18%. Lighting accounts for 11%, primarily driven by LED bulbs at 8%. The remaining 21% is attributed to other appliances such as televisions (9%), washing machines and others.

FIGURE 13: SHARE OF APPLIANCES IN ELECTRICITY CONSUMPTION ACROSS SURVEYED HOUSEHOLDS

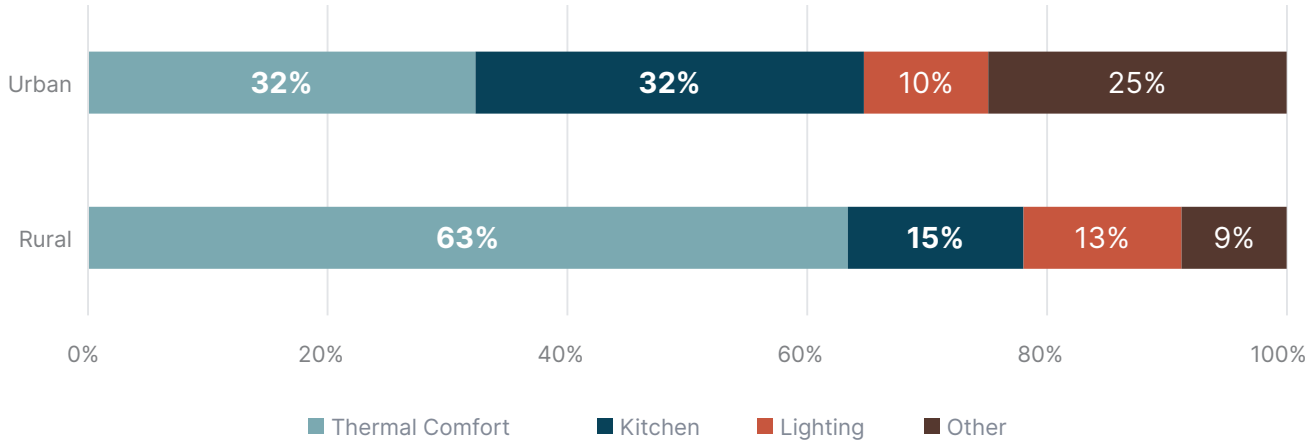


The distribution of electricity consumption by end use reveals distinct patterns between rural and urban households. In rural areas, thermal comfort appliances dominate electricity use, accounting for 63% of total consumption. It has to be noted that majority of this cooling consumption is contributed by fans (48%), followed by ACs and air coolers. This is followed by kitchen appliances at 16%, lighting at 13%, and other uses at 10%.

In contrast, surveyed urban households show a more balanced distribution. Kitchen appliances and cooling appliances each contribute the highest share at 32%, followed by lighting and others. Lighting accounts for 10% of urban electricity consumption. Within cooling segment, key contributors are fans 16% and ACs at 12%.

These differences reflect variations in appliance ownership, usage behaviour, and possibly climatic conditions and housing infrastructure across rural and urban settings.

FIGURE 14: RELATIVE CONTRIBUTION OF ELECTRICITY CONSUMPTION BY END USE



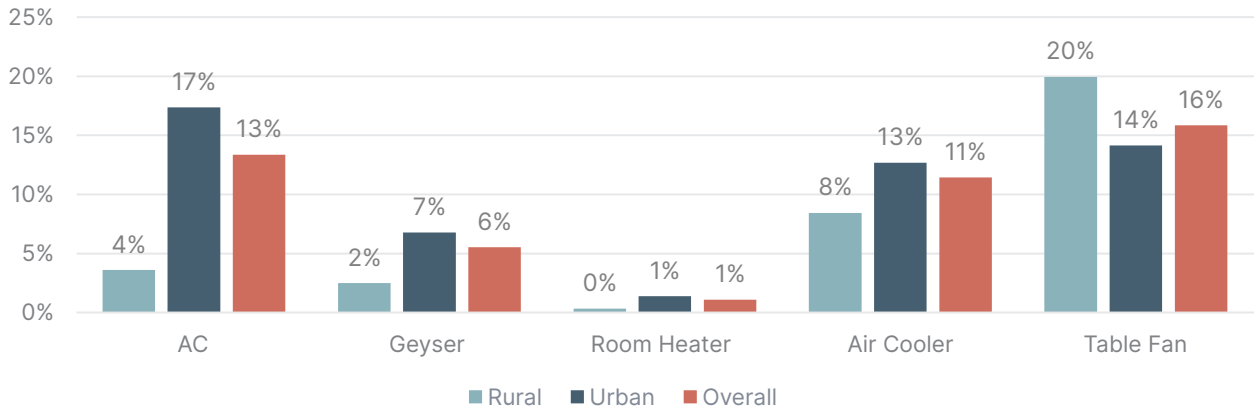
APPLIANCE OWNERSHIP

India's rising electrification, urbanization, and income levels have significantly increased demand for appliances, influencing energy consumption trends. Urban households exhibit higher ownership of appliances across categories, influenced not just by access to a wide range of appliances, but also by higher disposable incomes and more reliable electricity supply.

THERMAL COMFORT APPLIANCES

Maintaining comfortable indoor environments is a growing priority for Indian households, driven by the country's diverse climatic conditions. This pursuit of comfort relies on appliances, broadly categorized into cooling appliances like air conditioners, fans, and air coolers, and heating appliances such as room heaters and geysers.

FIGURE 15: HOUSEHOLD LEVEL OWNERSHIP OF THERMAL COMFORT APPLIANCES



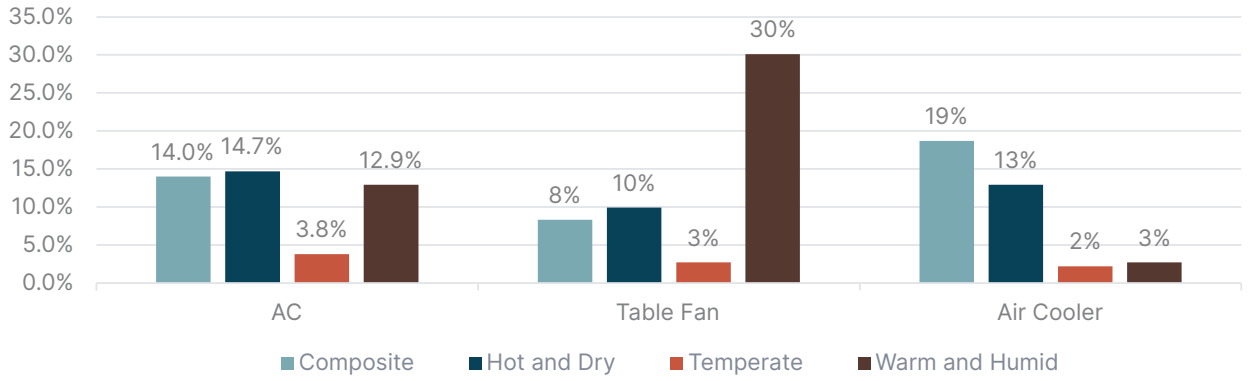
Survey data shows clear differences in the ownership of thermal comfort appliances between rural and urban households. Ceiling fans are nearly universal, with 97% of rural and 100% of urban households reporting ownership. Table fans are more common in rural areas (20%) than urban ones (14%).

Ownership of more energy-intensive appliances such as air conditioners and geysers is significantly higher in urban households. Air conditioners are present in 17% of urban homes compared to just 4% in rural areas. Similarly, geysers are owned by 7% of urban households and only 2% of rural ones. Room heaters remain rare across both segments, with negligible ownership. Air coolers show moderate penetration, with 13% of urban and 8% of rural households reporting ownership.

These findings are consistent with the CEEW-IRES 2020 report[8], which provides appliance-level ownership data and confirms that ceiling fans are the most widely owned appliance across Indian households.

Figure 16 highlights ownership trends of cooling and heating appliances across different climatic zones. Air conditioners are most common in hot and dry (14.7%) and composite (14%) zones, reflecting high cooling needs. Air coolers are more popular in composite zones (19%) and hot and dry zones (13%), while table fans dominate in warm and humid areas (30%), where simpler cooling solutions are preferred. Ownership of all cooling appliances is lowest in temperate zones, indicating limited demand due to milder weather.

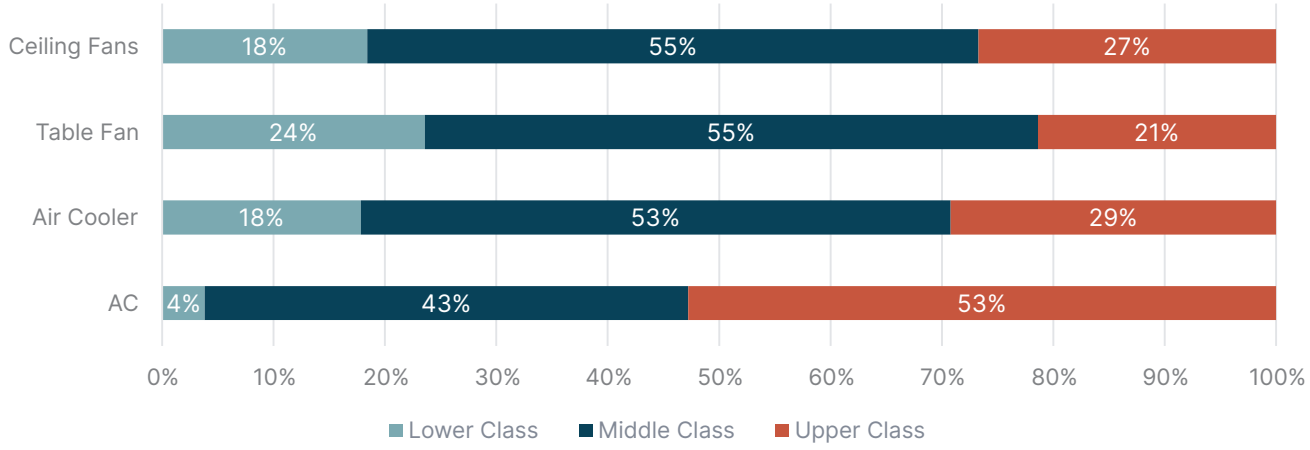
FIGURE 16: HOUSEHOLD LEVEL THERMAL COMFORT APPLIANCE OWNERSHIP ACROSS CLIMATE ZONES



Note: Ceiling fans demonstrate near-universal ownership across all surveyed households and are therefore not explicitly depicted in this figure for enhanced clarity.

Ownership of cooling appliances rises sharply with household socio-economic class. Air conditioners are owned by 53% of upper-class households, compared to just 4% in the lower class, indicating a strong link between income and access to high-energy appliances. Air coolers and table fans are more common among middle-class households (53% and 55%, respectively), suggesting a preference for moderately priced cooling options. Interestingly, lower-class households show notable ownership of table fans (24%) and air coolers (18%), reflecting reliance on affordable solutions for thermal comfort.

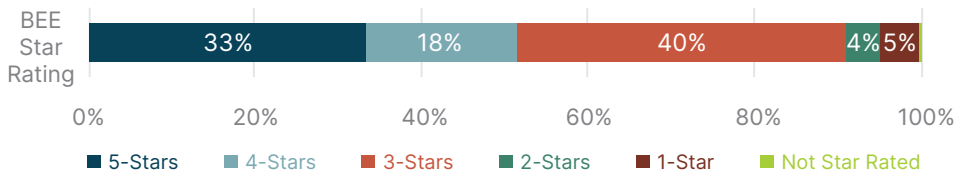
FIGURE 17: THERMAL COMFORT APPLIANCE OWNERSHIP BY SEC CLASS



8 Council on Energy, Environment and Water (2020) Awareness and Adoption of Energy Efficiency in Indian Homes: Insights from the India Residential Energy Survey (IRES) 2020, October. [link]

AIR CONDITIONERS AND FANS

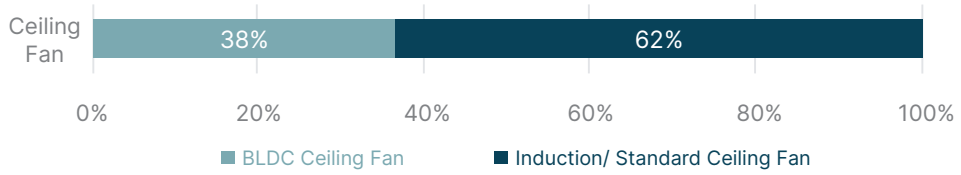
FIGURE 18: OWNERSHIP OF STAR-RATED ACS IN THE HOUSEHOLDS



Approx. **one-third** of ACs are 5-star rated in surveyed households.

As per survey data, 13.3 percent of households own ACs. This figure is higher than the 10 percent AC ownership reported in 2022 for Indian households. Of the total ACs owned by surveyed households, 33 percent are 5-star rated, 18 percent are 4-star rated, while 40 percent are 3-star rated ACs (Figure 18). Notably, only 0.2 percent of the ACs in the surveyed households were found to be non-star rated. The relatively high share of 4-star ACs, compared to historical market trends, may indicate either a recent shift in consumer preferences while providing responses or possible misreporting and misinterpretation of information by respondents. Further, fifty-five percent of all ACs in the households surveyed were purchased in the last five years. As per AC registration data available with BEE for 2023–24, Room AC market stood at 11.47 million.

FIGURE 19: OWNERSHIP OF THE FANS IN THE HOUSEHOLDS



38% of fans were reported as BLDC in surveyed households.

In the case of fans, while existing market studies suggest low penetration of BLDC technology, our survey data presents a contrasting picture. Among respondents, BLDC fans account for 38% of owned units (Figure 19), indicating potentially accelerated adoption in certain demographics or regions. This could be attributed to increased consumer awareness or targeted marketing efforts. However, it's also possible that some respondents may not clearly distinguish between BLDC and induction technologies, which warrants further investigation. Despite the notable share of BLDC fans, induction-based models still dominate with 62% ownership, highlighting a significant opportunity to promote energy-efficient alternatives to curb the anticipated rise in cooling-related electricity demand.

The escalating demand for space cooling in India necessitates a strong focus on energy-efficient solutions. ICAP projects national cooling demand to grow eightfold by 2037–2038 from the 2017–2018 baseline[9]. Promoting 5 star cooling appliances which are significantly more efficient than conventional alternatives, can play a key role in managing this surge. This calls for a multi-pronged approach, including:

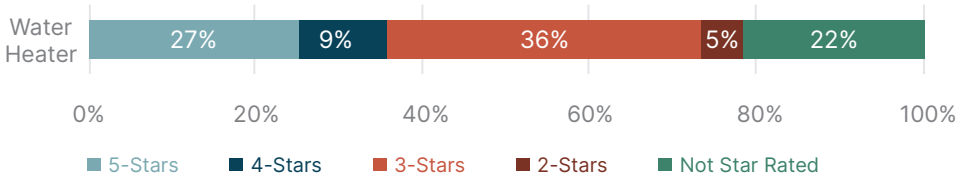
9 India Cooling Action Plan, Ozone Cell, MoEFCC, [link]

- Market transformation programs: Implement bulk procurement initiatives targeting government and private sector buildings to drive demand for energy-efficient appliances.
- Procurement guidelines: Mandate the adoption of 5-star rated appliances in institutional and commercial procurement processes.
- Stricter standards and labelling regulations: Raise minimum energy performance standards to push the market toward more efficient models.
- Consumer awareness campaigns: Educate consumers about the benefits of energy-efficient appliances through targeted outreach and information dissemination.
- Financial incentives: Offer rebates, subsidies, or other monetary benefits to encourage the purchase of higher-rated appliances.
- Applicability across appliances: These strategies are not limited to cooling devices like fans and air conditioners; they can be effectively applied to a wide range of household and commercial appliances.

HEATING APPLIANCES

WATER HEATERS

FIGURE 20: OWNERSHIP OF STAR-RATED GEYSERS IN HOUSEHOLDS



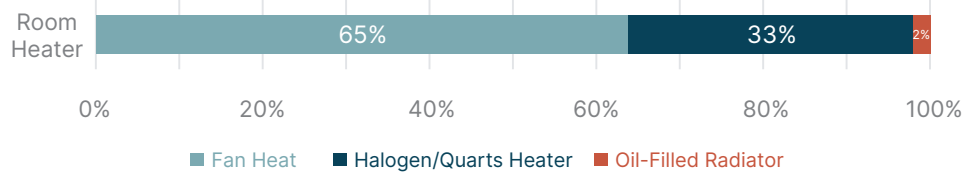
27% of total geysers are 5-star rated, own by surveyed households.

Across surveyed households, only 6% own water heaters, indicating limited adoption. Of the total geysers owned by surveyed households, 27% are 5-star-rated, 50% are 4-star and lower star rated, whereas the remaining 22% of geysers owned by households are non-star rated water heaters (figure 20). The survey primarily analyzed electrical geyser – type of water heaters, which are most commonly used in Indian households and are popular in urban areas due to convenience and availability. However, other water heating methods, such as immersion rods and solar water heaters, are also particularly prevalent in regions with limited access to electrical geysers. Geysers are becoming increasingly common, but they remain a luxury for lower class households. Survey data shows that 97% of water heater ownership comes from middle and upper class.

Space heaters

Among the 4,321 households surveyed, only 46 reported owning room heaters. Within this small group, fan heaters were the most common. Their popularity is likely due to affordability and quick heating, although they are generally less energy-efficient and result in higher electricity consumption.

FIGURE 21: DENSITY OF ROOM HEATERS IN THE HOUSEHOLDS

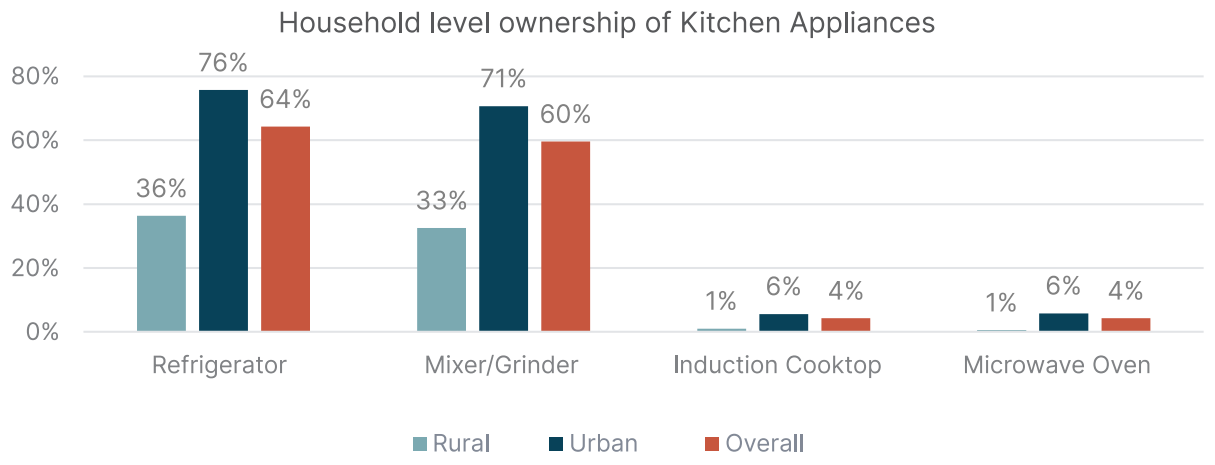


Room heaters are predominantly concentrated in urban areas, with higher ownership observed among the upper class.

KITCHEN APPLIANCES

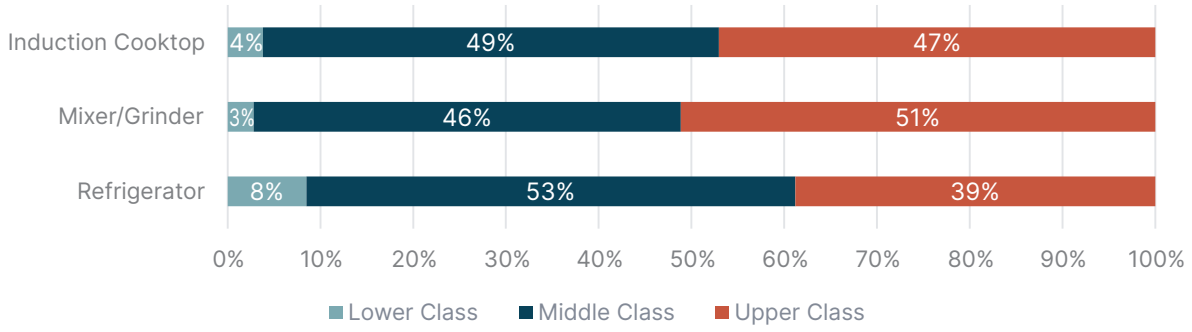
Survey findings reveal a clear urban–rural divide in kitchen appliance ownership. Refrigerators and mixer/grinders are the most commonly owned appliances overall, with 64% and 60% ownership respectively. Urban households show significantly higher adoption across all categories, especially refrigerators (76%) and mixer/grinders (71%), compared to just 36% and 33% in rural areas. Ownership of other appliances such as electric kettles, electric rice cookers, and microwave ovens remains low across both segments. Notably, urban ownership of induction cooktops stands at 6% in this survey, slightly lower than the 10% reported in the CEEW-IRES 2020 study, indicating a possible stagnation or slower-than-expected growth in adoption.

FIGURE 22: HOUSEHOLD LEVEL OWNERSHIP OF KITCHEN APPLIANCES



Within households owning each respective appliance, lower-class households show limited ownership across key kitchen products. Their share ranges from just 3% for mixer/grinders to 8% for refrigerators. In contrast, middle- and upper-class households dominate ownership across all categories.

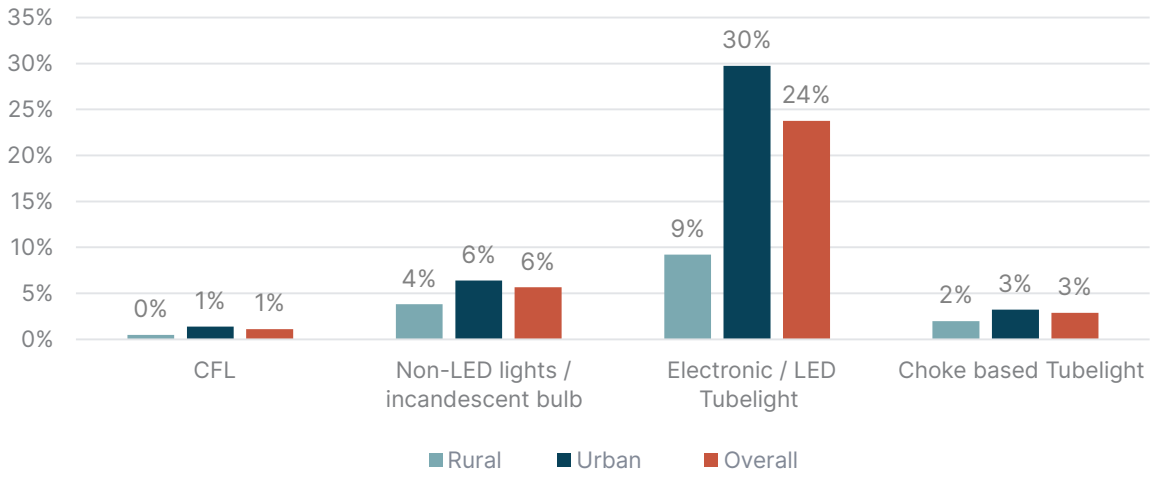
FIGURE 23: KITCHEN APPLIANCE OWNERSHIP BY SEC CLASS



LIGHTING

Survey data indicates near-universal adoption of LED bulbs and ceiling-mounted LED lights across all climatic zones, largely driven by government initiatives such as the UJALA (Unnat Jyoti by Affordable LEDs for All) scheme, which aimed to make energy-efficient lighting accessible and affordable. However, when it comes to tube lights, the picture is more nuanced. The term "electronic or LED tube lights" refers to newer, more efficient alternatives to traditional fluorescent tubes—either using electronic ballasts or LED technology. These formats are more prevalent in urban areas (30%) compared to rural regions (9%), suggesting uneven adoption of newer lighting technologies. For many consumers, the distinction between conventional electronic tube lights and LED tube lights may not be clear, which could affect reporting accuracy. Despite the high overall penetration of LED lighting, a small but notable share of households continues to use legacy lighting technologies, indicating room for further transition and awareness efforts.

FIGURE 24: HOUSEHOLD LEVEL OWNERSHIP OF LIGHTING APPLIANCES

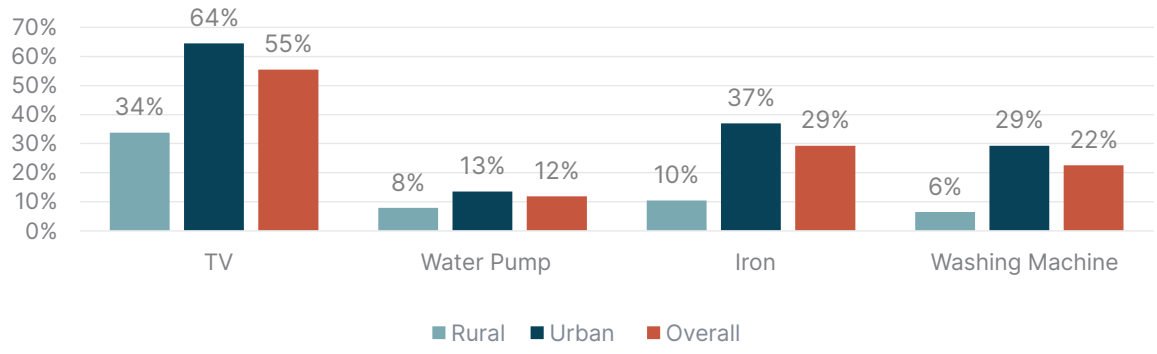


Note: LED Bulbs / Ceiling mounted LED lights demonstrate 100% ownership across all surveyed households and are therefore not explicitly depicted in this figure for enhanced clarity.

OTHER APPLIANCES

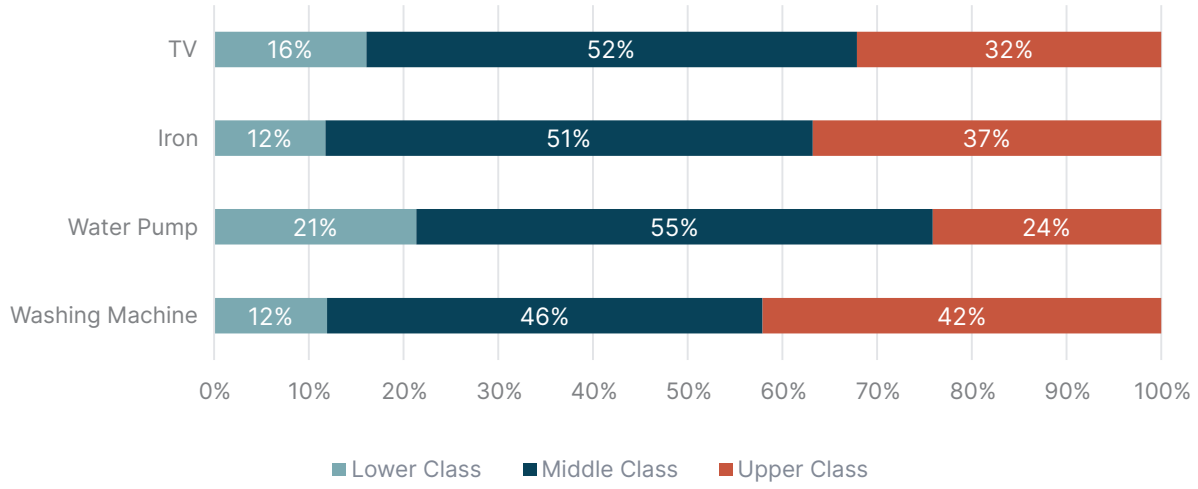
Television ownership is the most widespread, with 55% of households owning one—urban areas dominate this category with 64% ownership compared to 34% in rural areas. Similarly, washing machines show significant urban penetration (29%) versus rural (6%), indicating a strong correlation with infrastructure and income levels.

FIGURE 25: HOUSEHOLD LEVEL OWNERSHIP OF OTHER APPLIANCES



When viewed through the lens of socioeconomic class, middle-class households lead appliance ownership across all categories, accounting for over half of the ownership in TVs, irons, washing machines, and water pumps. Interestingly, lower-class households show relatively higher ownership of water pumps (21%), possibly reflecting agricultural or utility needs rather than lifestyle preferences. Irons are another moderately adopted appliance, with 29% overall ownership—urban households again dominate (37%) compared to rural (10%).

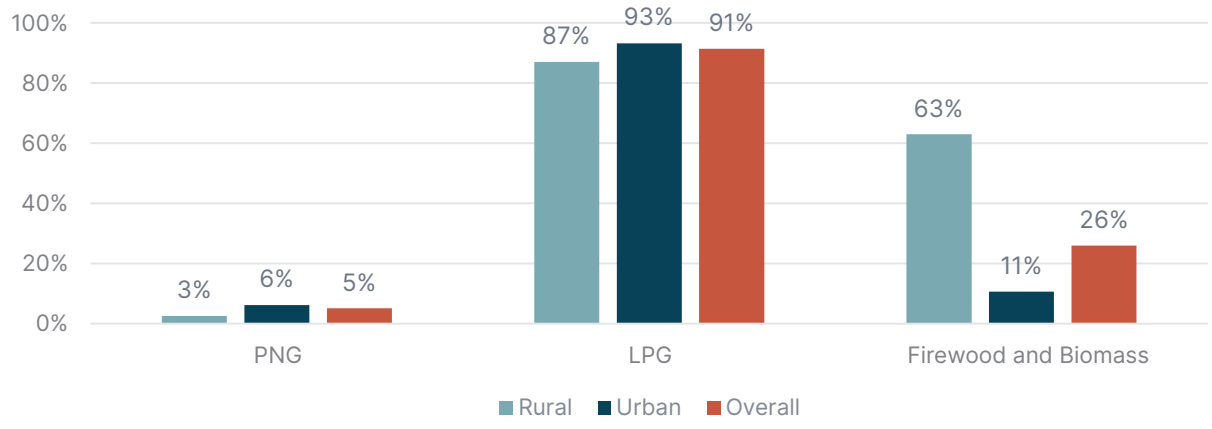
FIGURE 26: OTHER APPLIANCE OWNERSHIP BY SEC CLASS



COOKING FUELS

The data highlights widespread access to LPG, with 91.4% of households reporting usage. Urban areas show slightly higher adoption at 93.3%, while rural areas follow closely at 87%, indicating successful penetration of clean cooking fuel across geographies.

FIGURE 27: FUEL ACCESS ACROSS HOUSEHOLDS



Despite this, traditional fuels like firewood and cow dung remain significant in rural areas. Firewood is used by 44.9% of rural households, compared to just 5.5% in urban areas, and cow dung usage stands at 16.4% in rural versus 2.4% in urban areas. This suggests that while modern fuels are dominant, many rural households continue to rely on biomass fuels, likely due to factors such as affordability, availability, and cultural practices.

This pattern also reflects the fuel stacking behaviour observed in the CEEW IRES study, where households use multiple fuel sources simultaneously. The continued use of traditional fuels, even where clean options are available, indicates that access alone does not guarantee complete transition. Moreover, these fuels may serve additional household needs beyond cooking, such as space heating or water heating, further reinforcing their persistence.

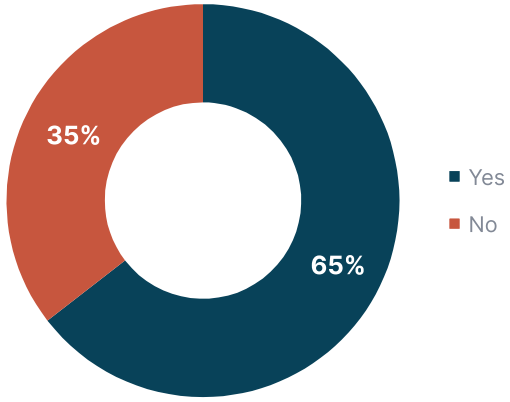
Consumer Awareness and Purchase Behaviour

While energy efficiency awareness has grown due to government initiatives (including labelling programs) and rising electricity costs, its impact on purchase behaviour, appliance usage, and energy-saving practices varies across households. This section explores multiple aspects of consumer engagement with energy efficiency, including awareness levels, energy-saving habits, purchasing priorities, and future appliance adoption trends.

Respondent awareness levels

Findings such as appliance ownership trends, energy consumption patterns, and climatic influences provide essential context for interpreting awareness levels and energy-saving practices. The survey finds that while 65% of respondents are aware of energy efficiency, actual behavioral shift remains limited, with only 2% actively selecting energy-efficient appliances.

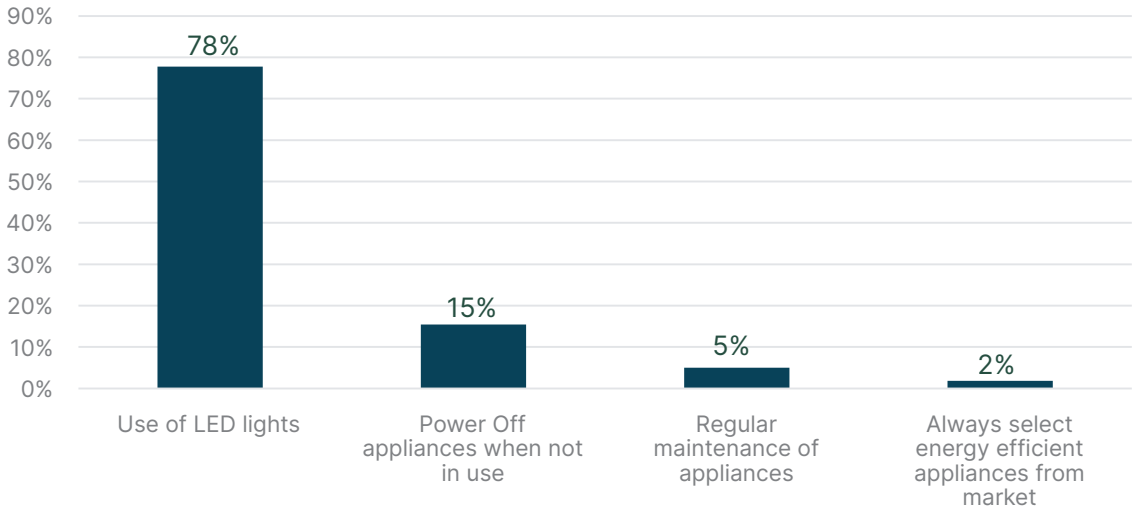
FIGURE 28: QUESTION: ARE YOU AWARE OF THE BENEFITS OF THE ENERGY EFFICIENT APPLIANCES?



Household Awareness of the Benefits of Energy-Efficient Appliances

Most of respondents use LED lights, showing the success of programs like UJALA, but few respondents practice energy-saving habits, such as powering off unused appliances (15%) or opting for regular appliance maintenance (5%). This suggests that while government-led initiatives have improved specific behaviors, broader consumer habits and market choices still require stronger policy interventions, financial incentives, and behavioral nudges.

FIGURE 29: EE MEASURES PRACTICED BY HOUSEHOLDS



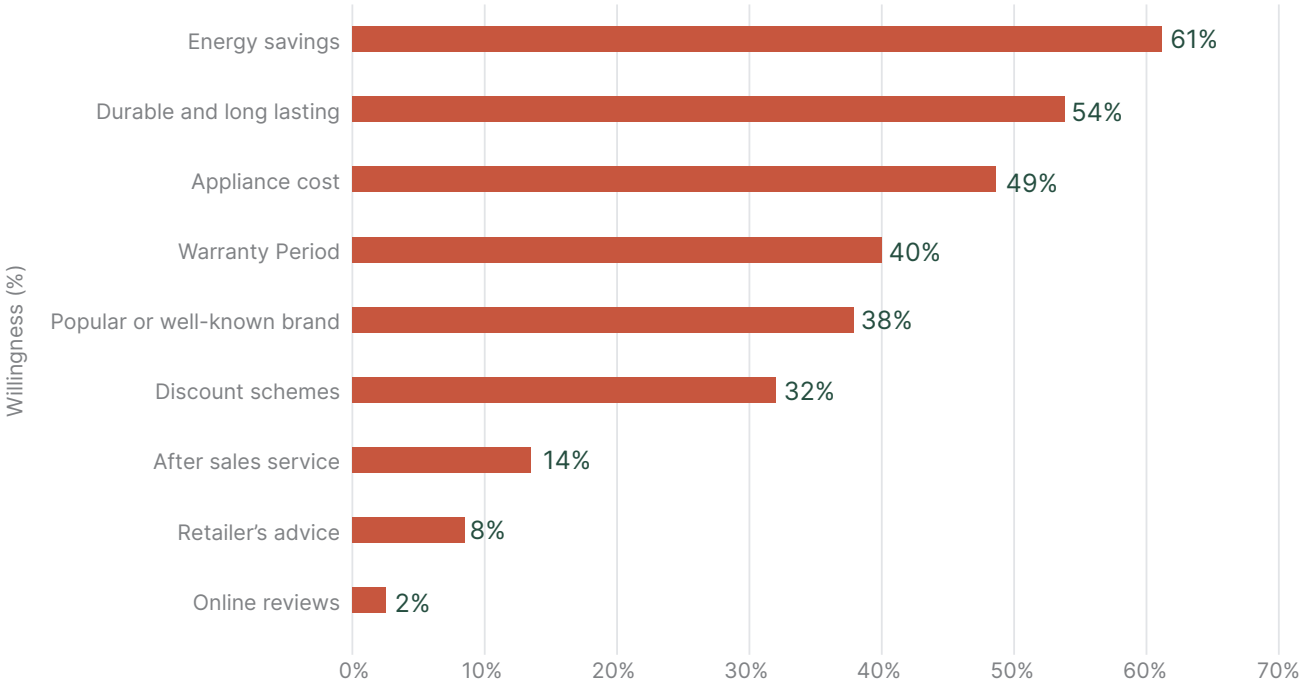
Appliance purchase behaviour

Factors influencing appliance Purchase Behaviour

The figure below illustrates the key factors influencing consumer decisions when purchasing new appliances.

According to the survey, the top three considerations are energy efficiency (61%), durability (54%), and appliance cost (49%). Notably, energy savings emerged as the most prioritized factor among respondents.

FIGURE 30: PRIORITY OF RESPONDERS WHILE MAKING NEW PURCHASE OF APPLIANCES



While 61% of responders consider energy savings a primary factor in their purchase decisions, this preference is especially concentrated among specific demographics. More than half of these respondents reside in urban areas, and approximately 40% possess higher education qualifications. This suggests that awareness and prioritization of energy efficiency may be stronger among urban and more educated segments of the population.

Beyond energy efficiency, the survey highlights several other factors shaping consumer decisions when purchasing new appliances. Durability ranks as the second most important consideration, with 54% of respondents emphasizing the need for long-lasting products. Affordability also plays a critical role, with 49% of respondents identifying appliance cost as a key factor. This high level of price sensitivity suggests that many consumers (particularly those from lower-income segments), may face barriers to accessing energy-efficient appliances. To address this, there is a clear need for market transformation interventions, such as financing options, subsidies, or incentive programs, that can help make efficient appliances more accessible and affordable.

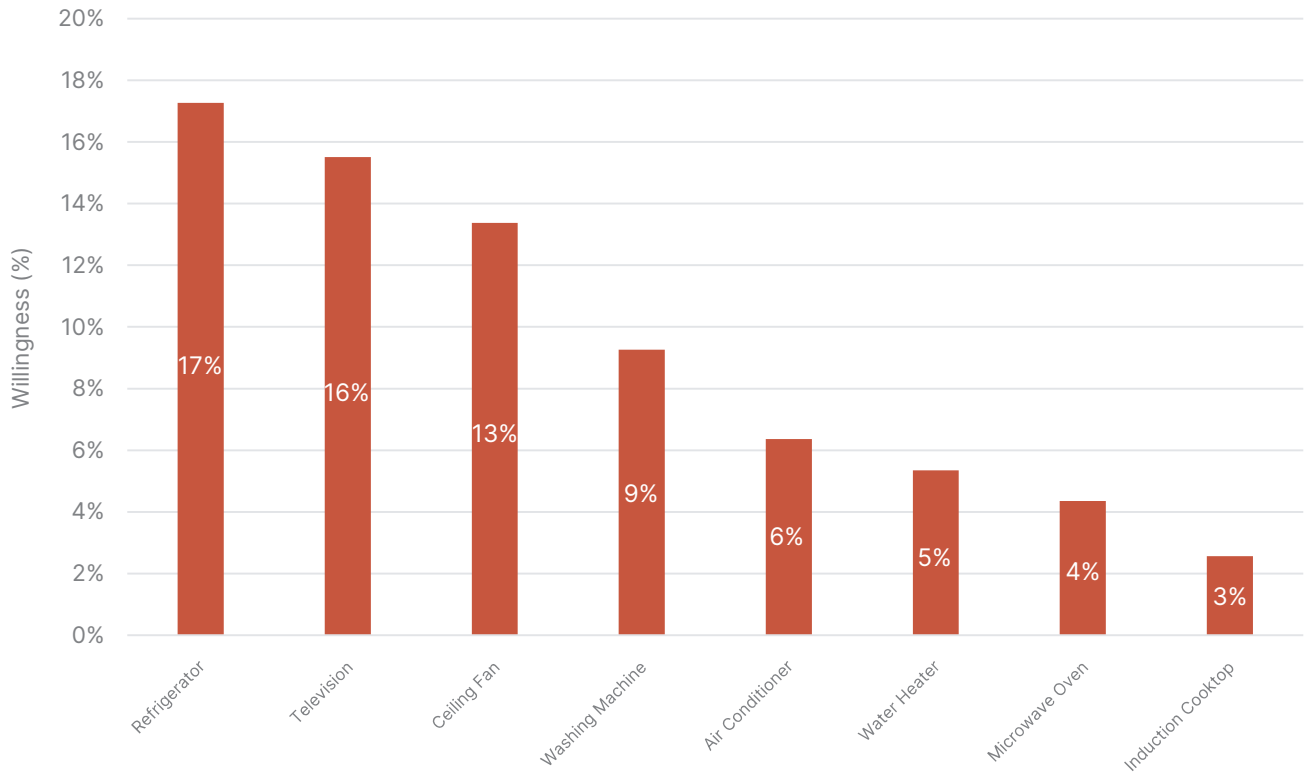
Interestingly, retailers' advice (8%) and online reviews (2%) are the least influential factors in consumer decision-making, according to the survey. This finding appears counterintuitive, however, these may reflect the nature of evolving appliance purchases in India, where consumers often rely on personal experience, brand familiarity, and word-of-mouth within trusted circles, rather than formal retail or online sources.

Importantly, these insights are consistent with findings from the CEEW IRES survey, which similarly explores how consumers rank appliance characteristics and how these preferences vary across urban and rural settings. Together, the evidence underscores the importance of tailored outreach strategies and policy interventions that address the diverse needs and constraints of different consumer segments.

Future willingness to purchase new appliances

Figure 31 highlights the willingness of respondents to purchase appliances within the next 12 months, with refrigerators leading at 17%, followed by televisions (16%) and ceiling fans (13%). Approximately 17% of refrigerators in surveyed households are older than 10 years, likely less efficient and consume significantly more electricity than newer models.

FIGURE 31: WILLINGNESS OF RESPONDENTS FOR BUYING NEW APPLIANCES



There are significant opportunities to reduce refrigerator electricity consumption and increase efficiency:

- Incentivizing energy-efficient replacements: Appliance replacement programs with incentives, exchange offers, or zero-interest financing can encourage consumers to upgrade to higher star-rated, energy-efficient models.
- Manufacturing and market opportunities: High appliance demand signals growth potential for manufacturers to expand production and innovation in efficient technologies, including models optimized for Indian climatic conditions

Additionally, more than half of all ACs owned by survey respondents were purchased in the last five years— these have a lifespan of 10–12 years, and a significant number of households will replace or upgrade or purchase a new ACs in the coming years.

Conclusion and Recommendation

India's residential energy landscape is undergoing a rapid transformation, driven by rising incomes, urbanization, and near-universal electrification. The survey reveals that, within the sampled households, access to electricity and modern appliances has expanded significantly, and energy consumption patterns remain deeply influenced by climate, income, and awareness levels. Key findings highlight that:

- Appliance penetration varies widely: While basic appliances like ceiling fans and LED lights are nearly universal, ownership of energy-intensive devices such as air conditioners and washing machines is concentrated among urban, middle, and upper-class households. Awareness of energy efficiency labelling (BEE star ratings) exists, but it does not significantly translate into purchase decisions.
- Energy consumption is shaped by multiple factors: Income class, education level, building type, regional climate, and household demographics all influence electricity usage. The survey's socio-economic classification (SEC) framework enables targeted analysis, identifying areas where energy poverty is most acute and where interventions could be most effective. While many regions are transitioning away from solid fuels, traditional sources like firewood and cow dung remain prevalent in rural, lower-income households.
- The survey shows that cooling demand is a major driver of electricity use, particularly in urban and affluent households. However, the widespread use of inefficient models highlights the need for stronger efficiency standards and consumer awareness.
- Disparities in appliance ownership persist: Urban and upper-class households report higher penetration of high-energy consuming appliances, while rural and lower-income groups rely more on basic or traditional solutions.
- Fuel stacking is common, especially in rural areas, where traditional fuels continue to be used alongside LPG.
- Energy efficiency awareness is growing, but behaviour change is limited, indicating a gap between knowledge and action.
- Electric cooking is currently being explored by early adopter households, particularly in urban areas. However, before developing a broader strategy for large-scale adoption, its potential impact on grid stability and peak load demands must be carefully assessed and addressed through proactive planning and infrastructure readiness.

These surveybased insights, together with existing national data, call for a multi-pronged policy approach that not only promotes energy-efficient technologies but also addresses affordability, behavioral change, and regional disparities. To accelerate India's transition toward energy-efficient household appliances, the following policy actions are recommended:

1. Expand and Enhance Appliance Efficiency Standards
    - Revising India's energy labelling programme for energy-intensive appliances that contribute to both base load and peak load should evolve into a continuous process. Appliances such as refrigerators and fans, which operate year-round, significantly impact base load, while seasonal and time-specific appliances like air conditioners add to peak load stress in addition to their base load contribution. Although India's current Minimum Energy Performance Standards (MEPS) may be aligned with global benchmarks, these international standards continue to evolve. Therefore, it is essential for India to regularly update and strengthen its MEPS to ensure comprehensive and future-ready energy performance regulation across diverse appliance usage patterns.

- Transitioning energy-intensive appliances from voluntary to mandatory energy labelling under the Standards and Labelling (S&L) programme remains an important policy recommendation. For example, the Bureau of Energy Efficiency (BEE) is actively working to expand mandatory labelling to include appliances such as LPG cookstoves, induction cooktops, and pumps, with the objective of strengthening energy performance standards and promoting informed consumer choices. This effort should be continued in the future to cover other appliances currently under the voluntary labelling regime, thereby broadening the impact of the programme and accelerating the shift toward energy-efficient technologies.

2. Promote Efficient Technologies Through Incentives and tailored programs for middle and lower consumer segments
   - Energy efficiency programs should prioritize middle-class households, who are the primary adopters of appliances, while also tailoring interventions to meet the specific needs of rural and lower socioeconomic segments, particularly for essential appliances like fans and refrigerators.
   - Provide financial mechanisms such as easy financing and targeted incentives to support adoption.
   - Encourage adoption of 5 star appliances through targeted state-level programs including rebates, bulk procurement, and performance-linked incentives.
3. Enhance Consumer Awareness and Behavioral Change
   - Launch focused outreach campaigns to communicate the cost savings and reliability of energy-efficient appliances.
   - Promote Exclusive Clean Cooking Fuel Use: Include refill-linked transfers and awareness campaigns, to encourage full transition away from traditional fuels.
4. Facilitate Appliance Replacement Programs
   - Introduce trade-in schemes and zero-interest financing to replace older appliances, especially refrigerators, air conditioners, and fans with newer, high-efficiency models.
5. Strengthen Data-Driven Policy Design
   - Institutionalize regular household energy surveys to monitor appliance penetration and usage patterns. Integrate SEC-based analytics into programme design and evaluation to improve targeting and impact assessment.
   - Assess the Impact of Electric Cooking on Power Systems: Initiate targeted studies to evaluate the implications of increased electric cooking on electricity demand, peak load patterns, and grid infrastructure. As e-cooking gains traction, understanding its impact is essential for effective grid planning, load management, and ensuring reliable power supply, especially during peak hours.

FURTHER RESEARCH

Further research is needed to deepen the understanding of residential energy consumption patterns in India, enabling more precise policy interventions and future projections.

Data and measurement improvements

- ☐ Establish a periodic household energy survey to track appliance ownership, usage patterns, and fuel choices over time, ensuring continuity and comparability across survey rounds.
- ☐ Integrate advanced measurement tools such as smart meters, smart plugs, and IoT-based monitoring to capture real-time appliance usage, moving beyond recall-based responses and improving the accuracy of end-use load estimates.
- ☐ Collaborate with DISCOMs to access anonymized billing and load-curve data, allowing cross-validation of survey-based estimates and more robust modelling of household demand profiles.

Regional and end-use focused analysis

- ☐ Expand the sample in future studies to enable more granular analysis by state, DISCOM area, and climatic zone, with particular focus on cooling and heating needs in temperature-extreme regions.
- ☐ Deepen analysis of specific end-uses, especially space cooling, water heating, and cooking; to understand how appliance choices, efficiency levels, and usage behaviours vary across income groups and urban–rural segments.

Fuels, demand flexibility, and system linkages

- ☐ Develop hybrid approaches for fuel-use estimation, combining survey data with energy diaries, direct metering, or loggers to improve estimates of LPG, PNG, biomass, and emerging electric cooking loads.
- ☐ Explore the potential for demand flexibility and demand response in households by analysing when and how key appliances (ACs, geysers, pumps, electric cooking) are used, and how this could interact with TOU tariffs or utility-led DR programmes.

Policy, market, and behavioural insights

- ☐ Assess the impact of existing policies—such as the Standards & Labelling programme, UJALA, and state schemes—on appliance ownership, efficiency levels, and consumer decision-making in different socio-economic segments.
- ☐ Investigate market and behavioural barriers, including affordability constraints, access to finance, information gaps, and trust in efficiency labels, to inform the design of targeted incentives and communication strategies that accelerate adoption of efficient appliances.

Annexes

Annex 1: Survey Questionnaire

Section 1: Household Information

1.1 Climate Zone: Select the zone where the household is located.

- ☐ Hot and Dry
- ☐ Warm and Humid
- ☐ Composite
- ☐ Cold
- ☐ Temperate

1.2 State where the house is located._____.

1.3 District where the house is located. _____.

1.4 Category

- ☐ Metropolitan
- ☐ Town
- ☐ Village

1.5 City/ Village where the house is located _____.

1.6 Address _____.

1.7 Pin Code _____.

1.8 Type of Building

- ☐ Apartment Independent
- ☐ House

1.9 If the residence is an apartment, how many stories/levels does the building have?

- ☐ Basement
- ☐ Ground Floor
- ☐ 1-3
- ☐ 4-7
- ☐ 8-11
- ☐ 12-15
- ☐ 15+

1.10 Floor at which the family is residing _____.

1.11 Is the residence rented or owned?

- ☐ Rented
- ☐ Owned

1.12 How many years has the family been living in the house?

- ☐ 1-3 years
- ☐ 4-6 years
- ☐ 7- 10 years
- ☐ 11-15 years
- ☐ 16-20 years
- ☐ 21-25 years

- ☐ 26-30 years
- ☐ 30+ years

1.13 Number of Dwelling Units/Building area

☐ Bedrooms	
☐ Halls/Drawing rooms	
☐ Kitchen	
☐ Bathrooms/Toilets	

1.14 Record the estimated carpet/built-up area occupied by the resident excluding any tenant if the resident cannot tell exact appliance details used by tenant. Include this if the resident can provide exact details of appliances used by tenant and electricity connection is common. (sq.ft., sq.mt., gaj, beegha, etc.)

☐ Total Number of People living in the house	
☐ Number of Adults (18 years and above)	
☐ Number of Children (Under 18 years)	

Section 2: Socioeconomic Information

2.1 Gender of primary earner _____ .

2.2 What is the highest level of education completed by the primary earner in the household?

- ☐ No Schooling
- ☐ Literate or schooling up to 4 years
- ☐ Schooling (5-9 years)
- ☐ SSC/HSC (10-12 years)
- ☐ Some college but not graduate (drop out, ITI, computer course like typing)
- ☐ Graduate/Post Graduate General (15+ years)
- ☐ Post Graduates (Ph.D./ Advanced medical degree (MD, MS)

2.3 Monthly Income Level of a household

- ☐ Up to Rs. 5000
- ☐ Rs. 5,001 - Rs. 10,000
- ☐ Rs. 10,001 to 20,000
- ☐ Rs. 20,000 – Rs. 30,000
- ☐ Rs, 30,001 to 40,000
- ☐ Rs. 40,001 – Rs. 50,000
- ☐ Rs. 50,001 to 75,000
- ☐ Rs. 75,001 – Rs. 1,00,000
- ☐ Rs. 1,00,000 – Rs. 1,50,000
- ☐ Rs. 1,00,000 – Rs. 1,50,000

2.4 Occupation of the primary earner in the household.

- ☐ Unskilled worker/Fresher
- ☐ Skilled worker

- ☐ Petty traders
- ☐ Shop owners
- ☐ Entrepreneurs with no employees
- ☐ Entrepreneurs with less than 10 employees
- ☐ Entrepreneurs with more than 10 employees
- ☐ Self-employed professional
- ☐ Clerical/Salesman
- ☐ Supervisory level
- ☐ Officers/Executives-Junior
- ☐ Officers/Executives-Mid/Senior
- ☐ Farmer
- ☐ Teaching
- ☐ Agriculture
- ☐ Others, please specify

2.5 Total earning members

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 5+

2.6 Monthly expenses in the household (in Rupees)

_____.

2.7 Vehicle Details

Vehicle Details	Type (2 Wheeler /4 Wheeler / Others)	Type of fuel (petrol/ diesel/CNG/EV)	If EV vehicle owned, installed charging station capacity
Vehicle 1			
Vehicle 2			
Vehicle 3			
Vehicle 4			
Vehicle 5			
Vehicle 6			

Section 3: Energy Sources and Usage

3.1 What are the primary sources of energy used in your household? (You may select more than one)

- ☐ Electricity Grid
- ☐ Renewable Energy (please specify):.....
- ☐ LPG (Liquefied Petroleum Gas)
- ☐ PNG (Piped Natural Gas)

- ☐ Diesel Generator
- ☐ Coal

3.2 Average monthly electricity expense in (in ₹):

- ☐ March – June (Summer)_____
- ☐ July – October (Autumn) _____
- ☐ November – February (Winter) _____

3.3 Monthly fuel usage:

- ☐ PNG (Piped Natural Gas)_____(cubic feet/cubic metre)
- ☐ LPG (Liquefied Petroleum Gas) cylinders _____ Nos.
- ☐ Firewood _____kg
- ☐ Cow dung _____kg
- ☐ Charcoal _____kg
- ☐ Kerosene_____ ltr.
- ☐ Other (Specify)

3.4 Typical monthly bill cost on cooking fuel (in ₹):

- ☐ PNG (Piped Natural Gas)_____
- ☐ LPG (Liquefied Petroleum Gas) _____
- ☐ Solid Fuel_____
- ☐ Liquid Fuel _____

3.5 Does your household use electricity from a diesel generator? If yes, what is the capacity? _____

3.6 How much money do you spend on diesel back-up for electricity per month? _____

3.7 Does your households have a solar rooftop system? If yes, what is the size of the system?_____

3.8 Is it connected to the grid? (Yes/No) _____

3.9 Do you use solar home system for electricity in your house? If yes, what is the capacity?_____

3.10 Will you ever consider installing solar home system? If no, why? _____

3.11 Are you aware about solar rooftop subsidy/PM surya ghar Yojana?_____

3.12 Do you have an electricity meter? If yes, is it working? _____

3.13 Do you face blackouts in summer? If yes, frequency of blackouts in summer in a week _____

Section 4: Consumer Behaviour and Willingness to Upgrade

4.1 Are you aware of the benefits of energy-efficient appliances? Can you tell any._____

4.2 Are you aware about BEE star rating system? (Yes/No)

4.3 Do you use practice any energy-saving technique for appliances?

- ☐ Use of LED lights
- ☐ Power Off appliances when not in use
- ☐ Regular maintenance of appliances
- ☐ Always select energy efficient appliances from market (Yes/No)

4.4 Do you use AC in your home? If yes, what is the average temperature setting of your air conditioner? _____

4.5 If LED lights are not installed, what is the reason?

- ☐ Costly
- ☐ Not easily available
- ☐ Old are working fine

- ☐ LED bulb quality issue

4.6 Whenever you have to buy a new appliance for your house then what matters the most for that buying decision? Of these options, choose & rate 3 most important things (1 is most important, 2 is important and 3rd is relevant)

- ☐ 1. Appliance cost
- ☐ 2. Popular or well-known brand
- ☐ 3. Durable and long lasting
- ☐ 4. Energy savings
- ☐ 5. Discount schemes
- ☐ 6. Warranty period
- ☐ 7. After sales service
- ☐ 8. Retailer's advice
- ☐ 9. Online Reviews

Section 5: Household Appliance Information

Category 1: Kitchen Appliances				
Baseline Appliances - For each unique appliances row would be added				
S.No.	Kitchen Appliances	Capacity as per Specified units	Age (Years)	BEE Star Rating (record as per provision)
1	Refrigerator			
1.1	Single Door Refrigerator	Liters (L)		1-5 Star
1.2	Double Door Refrigerator	Liters (L)		1-5 Star
1.3	Side-by-Side Refrigerator	Liters (L)		Yes/NO
1.4	Mini Refrigerator	Liters (L)		1-5 Star

S.No.	Kitchen Appliances	Capacity as per Specified units	Age (Years)	Usage Frequency	BEE Star Rating (record as per provision)
				Hours/Day	
2	Induction Cooktop	Watts (W)			Yes/No

Category 2: Home Comfort Appliances						
Baseline Appliances - For each unique appliances row would be added						
S.No.	Home Comfort Appliances	Capacity as per Specified units	Age (Years)	BEE Star Rating (record as per provision)	Usage Frequency	
					Hours/Day	Months/Year
1	Air Conditioner					
1.1	Split Air Conditioner	Tons, ISEER and Variable or Fixed Speed		1-5 Star		
1.2	Window Air Conditioner	Tons, ISEER and Variable or Fixed Speed		1-5 Star		
2	Room Heater					
2.1	Fan Heater	Watts (W)		NA		
2.2	Halogen/Quartz Heater	Watts (W)		NA		
2.3	Oil-Filled Radiator	Watts (W)		NA		
3	Water Heater (Geyser)					
3.1	Instant Water Heaters (Tankless)	Liters (L), Watts (W)		NA		
3.2	Storage Water Heaters (Tank)	Liters (L), Watts (W)		1-5 Star		
3.3	Gas (LPG) Water Heaters	Liters (L), Watts (W)		NA		
3.4	Solar Water Heaters	Liters (L)		1-5 Star		
4	Immersion rod	Watts (W)		NA		

Category1: Kitchen Appliances			
Occasionally used Appliances			
S.Nos.	Kitchen Appliances	Average Usage Frequency	BEE Star Rating (record as per provision)
		Hours/Day	
1	Microwave Oven		Yes/No
2	OTG (Oven Toaster Griller)		Yes/No
3	Electric Water Purifier		NA
4	Mixer/Grinder		NA
5	Toaster		NA
6	Electric/Rice Cooker		NA
7	Air Fryer		NA

Category 2: Home Comfort Appliances

S.No.	Home Comfort Appliances	Brand/Non-Branded/Both	Number of units	Average Usage Frequency		BEE Star Rating (record as per provision)
				Hours/Day	Months/ Year	
1	Ceiling Fan					
1.1	Induction/Standard Ceiling Fan					Yes/NO
1.2	BLDC Ceiling Fan					Yes/NO
2	Table/Wall/Pedestal Fan					Yes/NO

Category 2: Home Comfort Appliances					
S.No.	Home Comfort Appliances	Number of units	Average Usage Frequency		BEE Star Rating (record as per provision)
			Hours/Day	Months/Year	
3	Air Cooler				NA

Category 2: Home Comfort Appliances				
S.No.	Home Comfort Appliances	Average Usage Frequency		BEE Star Rating (record as per provision)
		Hours/Day	Days/Week	
4	Computer			Yes/NO

Category 3: Entertainment Appliances			
S.No.	Home Comfort Appliances	Average Usage Frequency	BEE Star Rating (record as per provision)
		Hours/Day	
1	Television		
1.1	LED		Yes/NO
1.2	CRT		NA

Category 3: Entertainment Appliances				
S.No.	Home Comfort Appliances	Average Usage Frequency		BEE Star Rating (record as per provision)
		Hours/Day	Days/Week	
2	Home Theater System/Audio System			NA

Category 4: Laundry Appliances				
S.No.	Home Comfort Appliances	Average Usage Frequency		BEE Star Rating (record as per provision)
		Hours/Day	Days/Week	
1	Washing Machine			
1.1	Semi-Automatic			Yes/NO
1.2	Fully Automatic Top Load			Yes/NO
1.3	Fully Automatic Front Load			Yes/NO
2	Iron			
2.1	Steam Iron			NA
2.2	Dry Iron			NA

Category 4: Laundry Appliances			
S.No.	Home Comfort Appliances	Average Usage Frequency	BEE Star Rating (record as per provision)
		Hours/Day	
3	Water Pump		
3.1	Centrifugal/Standard Water Pump		NA
3.2	Submersible Water Pump		NA

Category 5: Lighting and Other Miscellaneous Appliances					
S.No.	Lighting and Other Miscellaneous Appliances	Brand/Non-Branded/Both	Number of units	Average Usage Frequency	BEE Star Rating (record as per provision)
				Hours/Day	
1	LED Bulbs / Ceiling mounted LED lights				Yes/NO
2	CFL				NA
3	Tubular Fluorescent Lamps				NA
4	Incandescent bulb				NA
5	Electronic / LED Tubelight				NA
6	Choke based Tubelight				NA

Annex 2: Detailed Methodology Adopted

This annex documents the sampling design, field execution, and data-handling steps that directly inform interpretation of the results. Detailed validation checks are summarized in Annex 3.

Survey frame and scope. We surveyed 4,321 households across 20 states, covering India's five ECBC climatic zones—Hot-Dry, Warm-Humid, Temperate, Cold, and Composite, with an urban–rural split of about 70% (3,061) and about 30% (1,260). Fieldwork spanned six months using trained teams and a digital data-capture tool.

A. Sampling approach

- Design: Stratified multistage probability sampling by climatic zone and settlement type (metropolitan / other urban / rural).
- Allocation: Targeted proportional coverage by population and field feasibility. Temperate rural was not sampled; Cold has smaller subsamples for some sub-category analyses (reflected in figure notes).
- Urban segmentation: About 30% metros; about 40% other urban towns and cities.
- Footprint: 7 metropolitan cities, 52 towns and cities, and 56 villages.

Note on SEC. We use the Market Research Society of India (MRSI) classification, aggregated into three analysis buckets: Lower (Urban D–E2; Rural R4), Middle (Urban B2–C; Rural R2–R3), Upper (Urban A1–B1; Rural R1). Full matrices are available on request.

B. Selection & in-field procedures

- Primary selection: Locations chosen using Probability Proportional to Size (PPS) within zone–state strata.
- Starting points: 3–4 random starts per location to spread coverage.
- Route & skips: Right-hand rule with 5–6 household skips between completes; refusals replaced using the same rule within the enumeration area.
- Minimum completes per site: Metros and Tier-2/3 towns followed preset targets; villages aimed for ~20 interviews each, subject to access/logistics.
- Supervision & QA: Random back-checks and GPS spot-verifications; daily interviewer dashboards.

C. Questionnaire and data capture

- Instrument: Structured questionnaire covering Household info, SEC, energy sources/bills, appliance ownership & use (thermal comfort, kitchen, lighting, others), and awareness/behaviour (BEE star label, practices).
- Digitization: Device-based entry with in-form validations and required-field checks; photo capture of bills where available.

D. Data cleaning & validation (pointer)

- De-duplication, standardization, and basic range checks were applied before analysis.
- Consumption triangulation used billed kWh, appliance-based estimates, and self-reports; reconciliation and suppression thresholds are provided in Annex 3 (not repeated here).

E. Interpretation notes (for figures/tables)

- Temperate–rural: not sampled; charts show "No rural sample" or omit the split.
- Cold zone: valid overall results, but some sub-category estimates may be suppressed or flagged due to small n.
- Zone naming is standardized as Hot-Dry, Warm-Humid, Temperate, Cold, Composite across figures, tables, and captions.

Annex 3: Validation Points

ENERGY CONSUMPTION

1. Energy Consumption vs. Appliance Count (IQR Method)

Validation Point: Calculate the Interquartile Range (IQR) for energy consumption within each climate zone. If a household's energy consumption falls outside the IQR and total appliance count is below weighted average for that zone, mark as invalid.

Logic:

- Spotting Unusual Values: Helps find outliers by looking at central range of energy use, preventing extreme values from skewing results
- Local Fit: Allows for setting energy use standards based on local climate zones, ensuring benchmarks work for different areas

IQR=Q3−Q1.

Identify valid ranges:

Lower bound: Q1−1.5×IQR

Upper bound: Q3+1.5×IQR

2. Appliance Density vs. Number of Rooms

Validation Point: If appliance density is significantly lower than average density for respective income slab and climate zone (e.g., more than one standard deviation below), mark as invalid.

Logic:

- Expected density: Income slabs and climate zones have expected range of appliance density. If a household's density falls significantly below this range, it suggests an inconsistency that may indicate underreporting or misclassification of appliances.

3. Monthly Expenditure vs. Energy Consumption, and Income Slab

Validation Point: If a household's total monthly expenditure is less than the average, but their energy consumption is higher than average, mark as invalid.

Logic:

- Economic viability: Higher energy consumption with lower expenditure may imply that the household is not accurately reflecting its energy costs, which could lead to unrealistic assumptions about its financial situation.

4. Income Slab vs. Appliance Ownership

Validation Point: For households within higher income slabs, if the total appliance count is significantly lower than the expected count (e.g., less than the 25th percentile of appliance ownership for that income slab), mark as invalid.

Logic:

- Expected Ownership: Higher-income households typically have more resources to invest in appliances, leading to higher expected appliance ownership.
- Threshold for Invalidity: If a household in a higher income slab has an appliance count below the 25th percentile, it suggests an unusual situation that may indicate underreporting or issues with household needs.

5. Correlation Between Home Comfort Appliances and Energy Consumption

Validation Point: In a linear regression model to predict energy consumption based on the number of home comfort appliances, if the actual energy consumption deviates significantly (e.g., more than two standard deviations) from the predicted value, mark as invalid.

Logic:

- Expected energy consumption: Likely inaccurate reporting, as patterns are established.

6. Validation of Energy Consumption for Refrigerators and Air Conditioners

This check verifies the energy usage of refrigerators and air conditioners by considering their age and Energy Star ratings.

- Age Limit: Refrigerators should be no more than 15 years old, and air conditioners should be no more than 10 years old. Older appliances are likely to be less efficient and consume more energy, which can indicate potential issues
- Energy Consumption Standards: The energy consumption of these appliances is compared to average consumption rates for their specific age groups

7. Home Comfort vs. Essential Appliances

Validation Point: If a household owns any home comfort appliance but lacks essential appliances like lights, fans, or

refrigerators, and they live in a metro city with an average income, mark as invalid.

Logic

- Necessities: Households in metro cities prioritize daily essential appliances. Comfort appliances without basics indicates imbalance in appliance ownership.
- Financial Feasibility: If a household can afford home comfort appliances, investment in essential appliances is expected. Inconsistency raises concerns about finances.

8. Cluster-Based Validation Using K-Means and Silhouette Scores

Validation Point: Using K-means clustering on variables like energy consumption, appliance count, and income to form groups of similar households. For each household, calculate silhouette score to see how well it fits within its cluster. If silhouette score is low (e.g., <0.1), indicating poor alignment with any cluster, flag as potentially invalid.

Statistical Method: K-Means Clustering with Silhouette Analysis, which measures how similar a point is to its cluster compared to other clusters.

Logic: Households with unusual combinations of attributes will have low silhouette scores, indicating that they do not align well with typical household profiles within their group, suggesting possible data issues.

Cooking Fuel Validation

This checks the availability and cost of cooking fuel:

1. Availability of Cooking Fuel

Each household must have at least one cooking fuel source available. If a household lacks a cooking fuel source, mark as invalid.

Logic:

- Basic Necessity: Access to cooking fuel is essential for meal preparation and overall daily functioning. Households without a cooking fuel source may face significant challenges in managing their daily lives.

2. Solid Fuel Usage and Household Size

If a household uses solid fuel, has more people living in it than average, and the monthly cost of solid fuel is less than the average, mark as invalid.

Logic:

Cost Discrepancy: A lower expenditure on solid fuel for a larger household raises concerns about accuracy of fuel consumption reporting. Larger households typically require more fuel, thus lower cost may suggest underreporting or misuse.

Notes

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