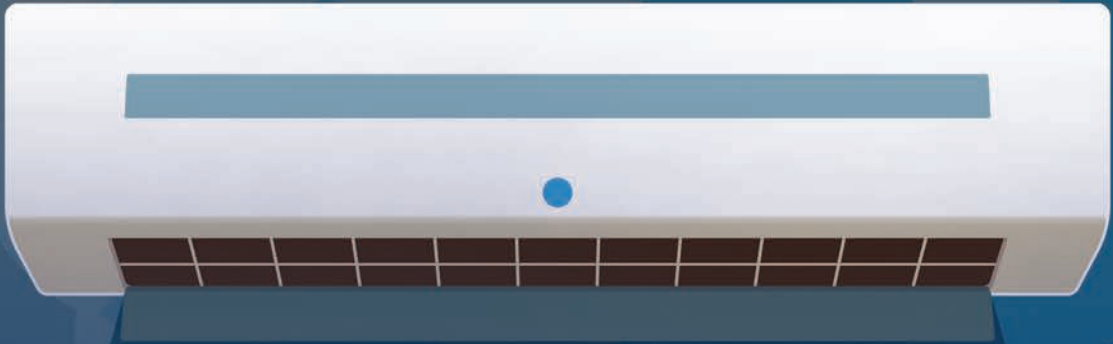

iFOREST INTERNATIONAL FORUM FOR ENVIRONMENT, SUSTAINABILITY & TECHNOLOGY

CLIMATE COST OF AIR CONDITIONING

National-Level Survey on Residential AC Usage, Refrigerant Leakage and Climate Risks

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Towards Effective Lifecycle Refrigerant Management (LRM) in India

CLIMATE COST OF AIR CONDITIONING

National-Level Survey on Residential AC Usage, Refrigerant Leakage and Climate Risks

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List of Abbreviations

AC	Air Conditioner
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
CAGR	Cumulative Annual Growth Rate
CEA	Central Electricity Authority
CO_2	Carbon Dioxide
CPCB	Central Pollution Control Board
EoL	End-of-Life
EPR	Extended Producer Responsibility
E-Waste	Electronic Waste
GHG	Green House Gases
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefins
ICAP	India Cooling Action Plan
LRM	Lifecycle Refrigerant Management
MoEFCC	Ministry of Environment, Forest and Climate Change
ODS	Ozone-Depleting Substances
RAC	Residential Air Conditioner
TR	Tonnes of Refrigeration

Executive summary

This report presents findings from a national survey on India's Residential Air Conditioning (RAC or AC) ownership, usage patterns, servicing practices, refrigerant leakage, and its climate impacts. Covering over 3,100 households across seven major cities – Delhi, Mumbai, Kolkata, Chennai, Ahmedabad, Pune, and Jaipur – the survey was conducted using stratified random sampling (95% confidence interval and 5% error) across three income groups (High, Middle, and Low). Cities were selected to ensure representation across hot climate zones (hot-dry, composite, and warm-humid).

The survey results highlight a rapid rise in AC ownership, a sub-optimal service sector, high refrigerant refilling rates that increase both household expenses and greenhouse gas emissions, and significant gaps in policy enforcement. These findings underscore the urgent need for comprehensive Lifecycle Refrigerant Management (LRM) regulations to control refrigerant release and ensure proper disposal at the end of life.

Rapidly expanding cooling demand

India's RAC market is growing rapidly, fuelled by urbanization, rising incomes, and intensifying heat stress. Around 80% of households have ACs less than 5 years old, and 40% of them are less than 2 years old—indicating an exponential rise in new AC ownership over the past five years.

ACs are now essential appliances

Of the households owning AC, nearly 87% own just one AC, while 13% own more than two. Air-conditioning is no longer a privilege of the rich but an essential appliance for all; lower-income groups are also buying ACs.

1.5 tonne AC dominates

The survey finds that ACs of 1.0–1.5 TR are the most preferred – they account for over 90% of total ACs in Indian households. 1.5 TR capacity ACs alone make up 74% of the total.

Energy efficiency awareness is high

Nearly 98% of households have 3-star to 5-star rated ACs, indicating strong awareness and preference for energy-efficient appliances. The 3-star category is dominant with a 60% share, while 5-star models account for 28%.

Households are keeping thermostats at optimum temperatures

Contrary to popular belief, the most preferred temperature setting nationally is 23–25°C. About 67% of households set their AC above 23°C. This trend was observed consistently across cities.

India's RAC stock will at least triple by 2035

The AC stock (total number of ACs installed) in 2025 is estimated to be 76 million, which will grow to at least 245 million by 2035, even at a modest sales growth rate of 10%. Notably, AC sales have grown 15–20% annually since 2020.

AC servicing is now synonymous with refrigerant refilling

In India, refrigerant refilling is far higher than global practices. About 80% of more than 5 years old ACs require refilling annually. Even one-third of newer ACs (less than 5 years old) are refilled every year. Effectively, about 40% of all ACs in India are refilled annually. Ideally, on average ACs should require refilling once in 5 years.

Refrigerant refilling has high costs for consumers and the climate

India's ACs required 32 million kg (32,000 tonnes) of refrigerant refills in 2024. With an average refilling cost of ₹2,200 per AC, consumers spent about ₹7,000 crore ($0.8 billion) in 2024. In a Business-as-Usual scenario, annual refilling costs will quadruple to ₹27,540 crore ($3.1 billion) by 2035.

As these refrigerants have hundreds of times more warming potential than CO_2 (HFC-32, the most commonly used refrigerant, has a global warming potential 675 times higher than CO_2), the equivalent GHG emissions from refrigerant release are estimated at 52 million tonnes of CO_2e in 2024. Emissions from refrigerant release are likely to increase to 84 million tonnes of CO_2e by 2035.

Mounting GHG burden of ACs

The climate impact of ACs is substantial and growing, owing to high refrigerant leakage and rapidly increasing electricity use.

Total GHG emissions from ACs (including refrigerant release and electricity consumption) in 2024 were 156 million tonnes CO_2e—equivalent to emissions from all passenger cars. In fact, an AC in India, refilled every two years, releases the same amount of GHGs as a passenger car.

Total GHG emissions from ACs will increase to 329 million tonnes CO_2e in 2035 under a Business-as-Usual scenario. By 2030, ACs will be the highest GHG-emitting appliance in the country.

Fragmented policy and weak enforcement

The India Cooling Action Plan (ICAP) targets a 25–30% reduction in refrigerant demand by 2037–38 but lacks regulations and enforcement mechanisms to prevent refrigerant leakage and ensure environmentally sound disposal. The E-Waste (Management) Rules, amended in 2023, include provisions for environmentally sound disposal of refrigerants from end-of-life ACs at CPCB-approved facilities. However, there is no information on implementation. Overall, India lacks adequate regulation and enforcement to manage climate-warming refrigerants.

EPR for refrigerants is a must

India needs comprehensive rules and enforcement mechanisms for Lifecycle Refrigerant Management – from filling in equipment to servicing and end-of-life disposal. This should include an Extended Producer Responsibility (EPR) obligation for AC manufacturers.

Refrigerant management will save costs and the climate

Lifecycle Refrigerant Management can avoid around 500–650 million tonnes of GHG emissions from refrigerant releases between 2025 and 2035 – equivalent to $25–33 billion in carbon credits over the next 10 years (at a moderate price of $50 per tonne of CO_2). It will also save consumers $10 billion in unnecessary refilling costs.

Objectives of the Survey

The primary objective of the survey was to identify and quantify the real-world scale and impact of refrigerant leakage from RACs by investigating:

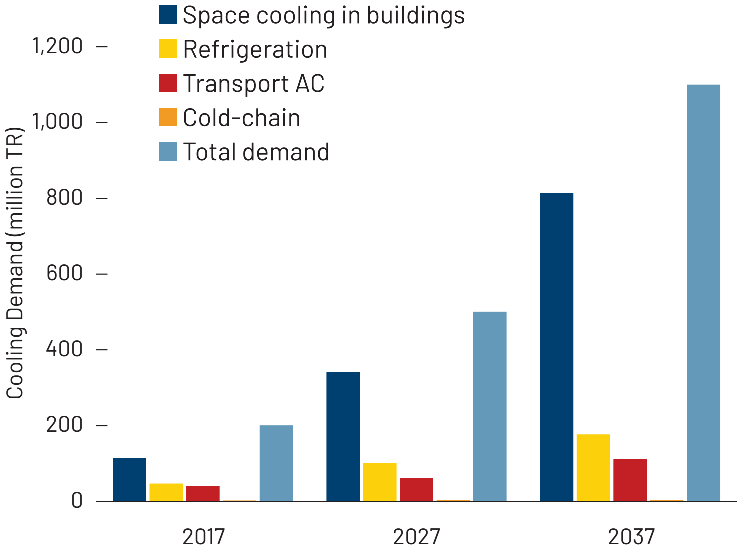
- RAC use scale, operation and maintenance practices in the Indian households across varying climatic conditions
- Refrigerant leakage and refill frequency and scale of the problem that needs to be addressed
- The scale of GHG emissions from RAC refrigerant leakages
- Financial implications of inadequate RAC refrigerant operation and management
- User awareness of climatic impact of RAC refrigerants and their climate-friendly alternatives.

The findings aim to provide the empirical evidence necessary to design a targeted, effective, and sustainable national refrigerant management strategy.

The research design and methodology for the survey were scientifically planned to accommodate a large population, ensuring a 95% confidence interval and 5% error in sampling design. For more details on the research design and sampling approach, please refer to Annexure A.

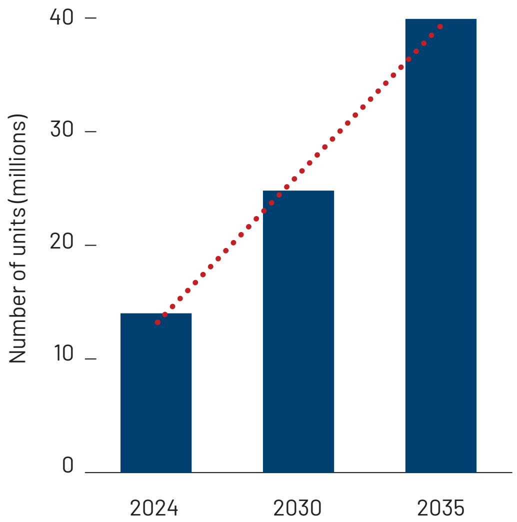
Introduction

Figure 1: Sector wise cooling demand (million TR)



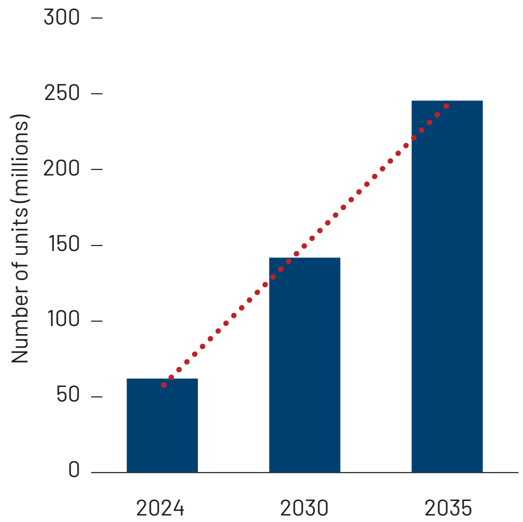
Source: (MoEFCC, 2019)

Figure 2: AC sale in India (millions)



Source: IFOREST Analysis

Figure 3: AC Stock in India (millions)



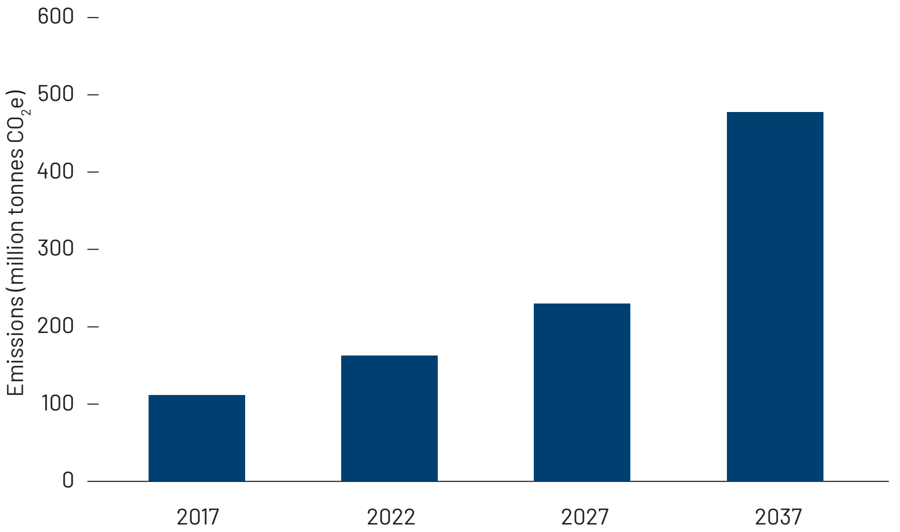
Source: IFOREST Analysis

- National cooling demand is projected to grow 2203 million TR by 2037 and Space cooling in buildings will share 74% of it. Emissions from space cooling in buildings will rise from 111 million tonnes in 2017 to 478 million tonnes by 2037 if no interventions are implemented (MoEFCC, 2019). This projected growth leads to a 5 to 8 times increase in the aggregated refrigerant demand.

- With rapid increase in sales from 14 million ACs in 2024 to 40 million in 2035, the India's AC stock is estimated to increase form 62 millions in 2024, this at the moderate 10% CAGR is expected to reach three-fold at 245 million in 2035. Notably, AC sales have grown 15–20% annually since 2020. This growth in AC use will increase refrigerant demand, making it important to manage refrigerant use and emissions carefully.

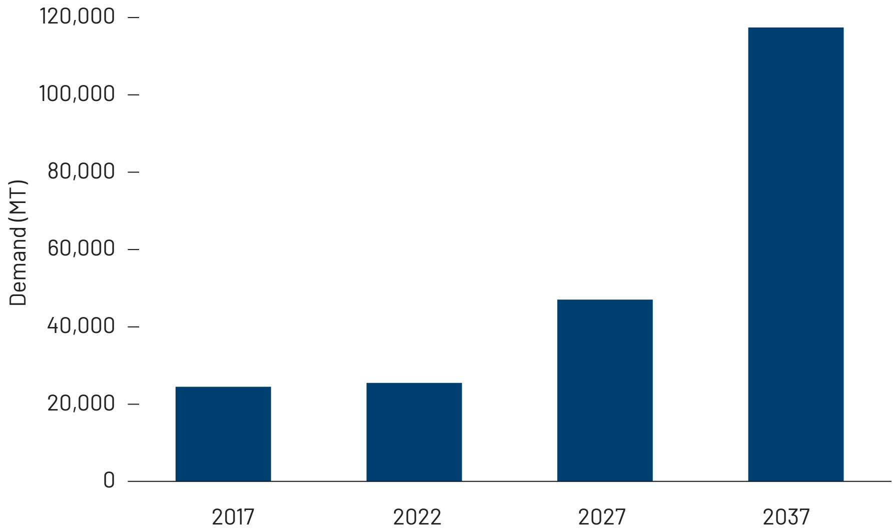
* For detailed references, please see the Annexure-A

Figure 4: Emissions (million tonnes CO_2e) cooling in Buildings - India



Source (MoEFCC, 2019)

Figure 5: Refrigerant demand in India (MT)



Source (MoEFCC, 2019)

- Annual refrigerant production in India was 24,300 MT in 2017 and is expected to reach 1,66,000 MT by 2037, with a large share used in room air-conditioners. The AC servicing sector consumes over 40% of this refrigerant and contributes about 20% of total emissions from air-conditioning (MoEFCC, 2019).

- The current AC market is growing rapidly and, in response to the Kigali Amendment, is transitioning towards R32, other low-GWP HFCs, and Hydrofluoroolefins (HFOs). However, a large share of the existing AC stock still relies on high-GWP refrigerants such as R410A. Since nearly 40% of refrigerants are used in servicing, posing the risk of huge GHG emissions in next 10 years.

- Efforts to quantify leakages, refilling rates, and GHG emissions from the servicing sector form the first step towards systematic refrigerant lifecycle management. Assessing existing regulations and identifying gaps based on ground realities will provide a realistic picture of the effectiveness of current laws and governance structures. This survey, through structured questions, documents AC ownership and stock profile, usage and consumer behavior, servicing and refilling costs, and GHG emissions, and provides recommendations to minimize refrigerant leakage and strengthen lifecycle refrigerant management.

* For detailed country-specific references, please see the Annexure-A

01 Ownership & Stock Profile

1.1 AC Ownership

Table 1: Percentage of households with AC ownership - City, National

City	Households with 1 AC	Households with 2 and more ACs
Ahmedabad	95	5
Chennai	77	23
Delhi	94	6
Jaipur	82	18
Kolkata	83	17
Mumbai	96	4
Pune	83	16
National	**87**	**13**

Figure 6: Percentage of households with AC ownership - City

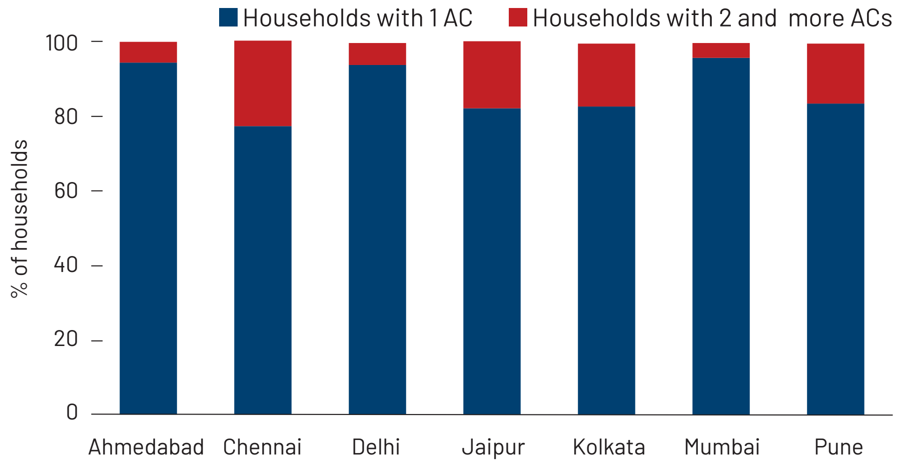
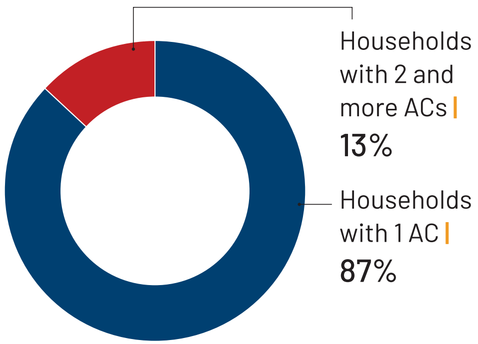


Figure 7: Percentage of household with AC ownership – National



- 87% households has at least one AC- indicating building space cooling is a necessity, contesting the affordability.

- 13% of households own 2 ACs and more. City-wise, Chennai, Jaipur, Kolkata, and Pune show higher ownership of 2 ACs per household, ranging from 13% to 20%.

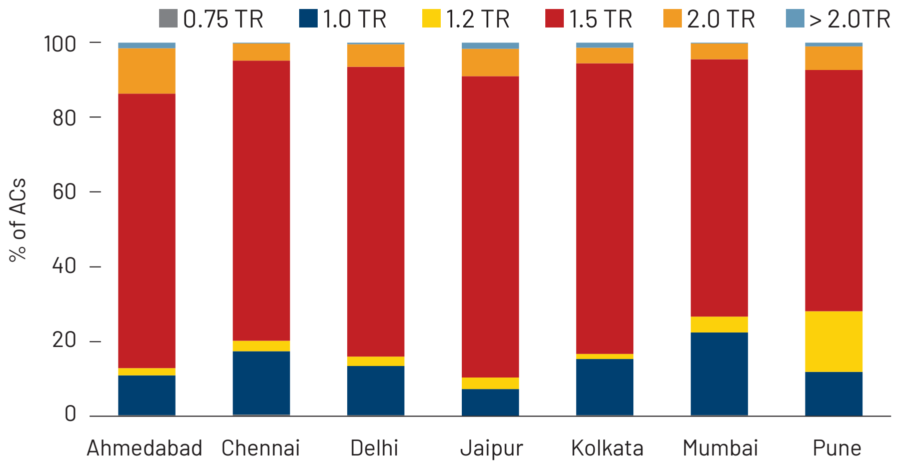
- The AC stock (total number of ACs installed) in 2025 is estimated to be 76 million, which will grow to at least 245 million by 2035, even at a modest sales growth rate of 10%. Notably, AC sales have grown 15–20% annually since 2020.

1.2 Cooling Capacity Tonnage Distribution

Table 2: AC Capacity (TR) Distribution – City, National

City	0.75 TR	1.0 TR	1.2 TR	1.5 TR	2.0 TR	More than 2.0 TR
Ahmedabad	0.2	10.6	1.9	73.6	12.1	1.5
Chennai	0.4	17	2.8	75.1	4.6	0.2
Delhi	0.2	13.1	2.6	77.6	6	0.4
Jaipur	0	7.2	3.1	80.7	7.3	1.7
Kolkata	0.2	15.1	1.3	77.9	4.2	1.3
Mumbai	0.2	22.2	4.2	69	4.2	0.2
Pune	0	11.8	16.2	64.6	6.4	1
National	**0.2**	**13.8**	**4.6**	**74.2**	**6.3**	**0.9**

Figure 8: AC capacity (TR) distribution – City



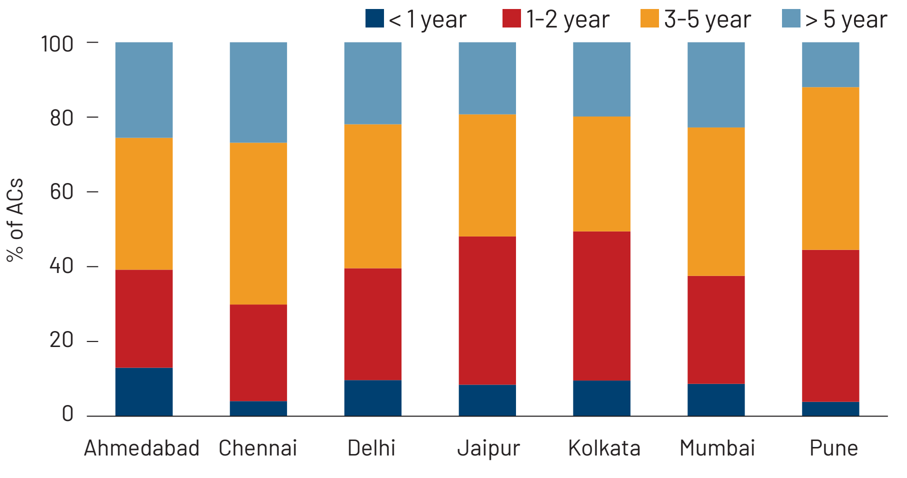
- Lower capacity AC dominates are common in the Indian households. Over 90% Indian households owns 1 TR - 1.5TR capacity ACs to meet their cooling demand. 1.5 tonne AC capacity is most common among the households- 74% of all household prefers it.
- 1.0 TR capacity ACs have 14% share, highlighting a substantial segment of smaller homes or single rooms' necessary cooling demand.
- 2.0TR AC capacity requirement- mainly for large room sizes, shares 6% of the national distribution- higher in non-metro cities especially in Ahmedabad and Jaipur.
- Smaller capacity- 0.75TR is least preferred, nationally.
- Pune is an exception, where 1.2 TR units account for 16.2% of the market, over three times the national average.

1.3 Age Profile

Table 3: AC Age profile (%) – City, National

City	less than 1 year	1- 2 years	3-5 years	More than 5 years
Ahmedabad	13	26	35	26
Chennai	4	26	43	27
Delhi	10	30	38	22
Jaipur	8	40	33	19
Kolkata	10	40	31	20
Mumbai	9	29	40	23
Pune	4	41	44	12
National	**8**	**33**	**38**	**21**

Figure 9: AC Age profile (%) – City



- Survey finds- around 80% of the ACs are less than 5 years old- indicating increased AC ownership over the last five years.

- Over 40% of ACs are less than two years old, indicating a significant rise in new AC ownership in India, with Jaipur, Kolkata, and Pune leading this trend.

- Kolkata, Jaipur and Pune lead in newer AC ownership, less than 2 years old, well above the national average.

- One-fifth of the total ACs in India are more than 5 years old.

1.4 Distribution of Energy Efficiency Preferences

Table 4: Energy efficiency preferences (%) – City, National

City	1 star	2 star	3 star	4 star	5 star
Pune	0	1	56	20	23
Ahmedabad	1	3	67	7	21
Mumbai	2	1	55	7	35
Delhi	2	2	68	5	24
Chennai	1	1	62	16	21
Kolkata	0	0	53	4	42
Jaipur	1	3	61	5	31
National	**1**	**1**	**60**	**9**	**28**

Figure 10: Energy efficiency preferences (%) – City

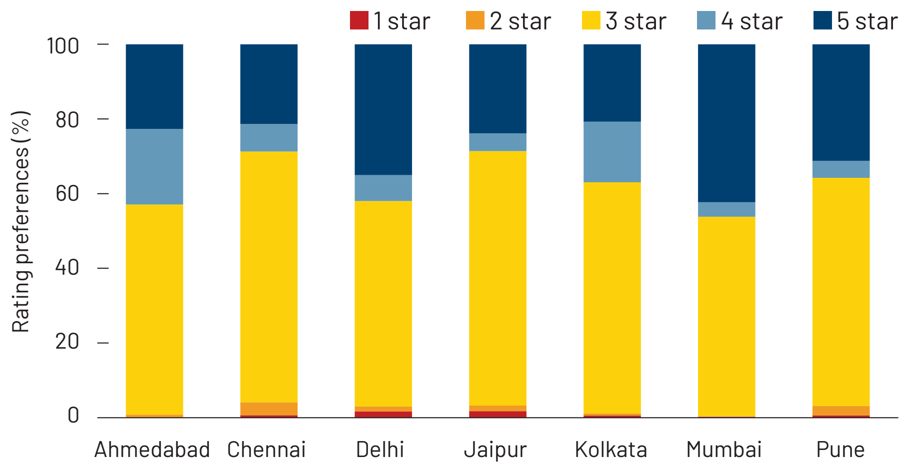
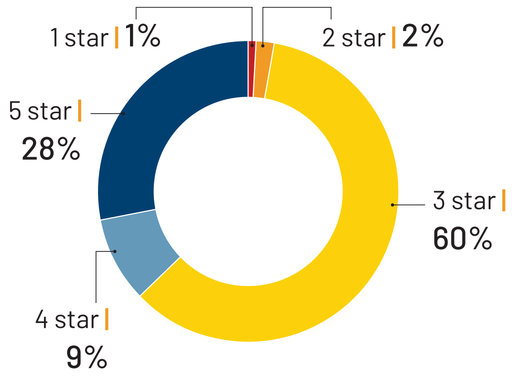


Figure 11: Energy efficiency preferences (%) – National



- Nearly 98% of the household have 3-star to 5-star rated ACs- indicating awareness and preference for energy efficient ACs in Indian households is well-established. The government's effort to promote energy efficiency in AC segment has been very successful.
- 3-star and 5-star rating ACs are common in India.
- The 3-star category is dominant (average 60%) across all cities, ranging from 53% in Kolkata to 68% in Delhi.
- Kolkata (42.3%) and Jaipur (31.2%) have the highest share of 5-star ACs, significantly exceeding the national average of 28%.
- The 3-star category is dominant (average 60%) across all cities, ranging from 53% in Kolkata to 68% in Delhi.

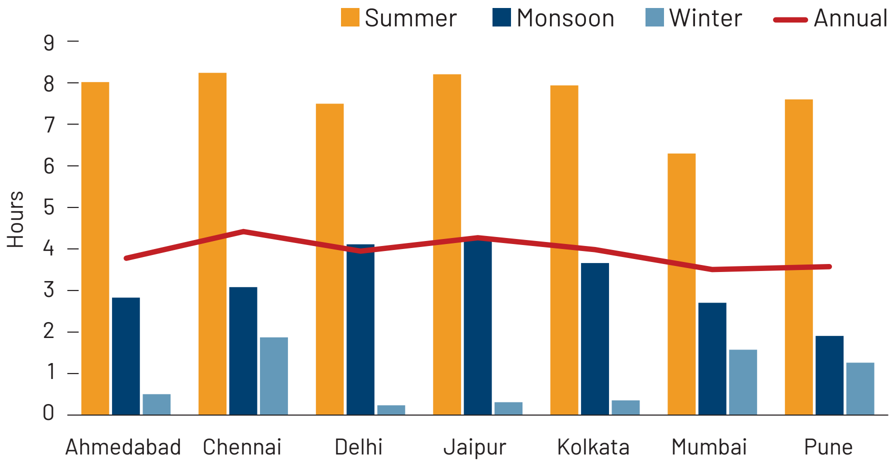
02 Usage & Household Behavior

2.1 Daily Usage Hours

Table 5: AC usage (Hours) – City, National, Seasonal

City	Summer Average	Monsoon Average	Winter Average	Annual Average
Ahmedabad	8.0	2.8	0.5	3.8
Chennai	8.2	3.1	1.9	4.4
Delhi	7.5	4.1	0.2	3.9
Jaipur	8.2	4.2	0.3	4.3
Kolkata	7.9	3.7	0.4	4
Mumbai	6.3	2.7	1.6	3.5
Pune	7.6	1.9	1.3	3.6
National	**7.7**	**3.2**	**0.9**	**3.9**

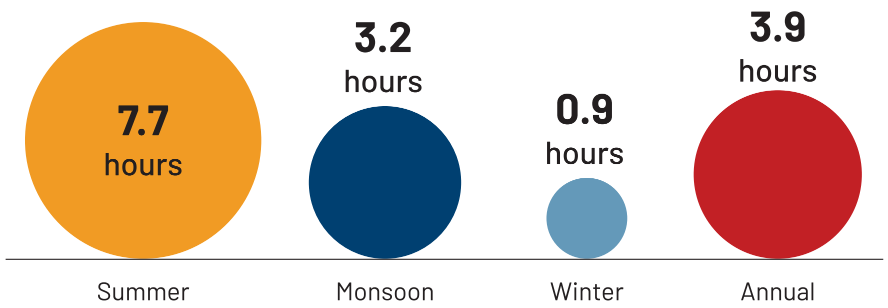
Figure 12: Average AC usage per day (Hours) – City, Seasonal



- Indian households use AC for 4.0 hours per day on an average in a year. The annual average daily usage across most cities falls within a relatively narrow range of 3.5 to 4.4 hours.

- AC usage in summer season is more than double (7.7 hours per day) of the monsoon season (3.2 hours per day)- reflecting a strong correlation between usage and peak temperatures. Summer is consistently the period of highest demand across all cities.

Figure 13: Average AC usage per day – National, Seasonal (Hours)

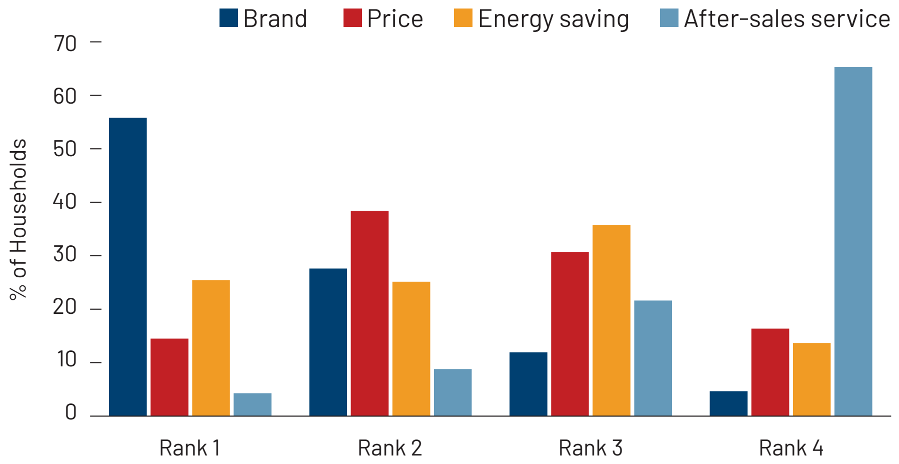


2.2 Buying Preferences

Table 6: AC Buying preference (%) – National

Preference	Rank1	Rank2	Rank3	Rank4
Brand	56	28	12	5
Price	15	38	31	16
Energy Saving	25	25	36	14
After-sales service	4	9	22	65

Figure 14: AC Buying preference – National



- The brand (56%), followed by price (38%), is the top preference for purchasing ACs in Indian households—indicating that companies have high potential to drive constructive policy implementation in this segment.

- Energy saving is a significant factor, with 50% of consumers ranking it within their top two priorities (combined percentage of Rank 1 and Rank 2).

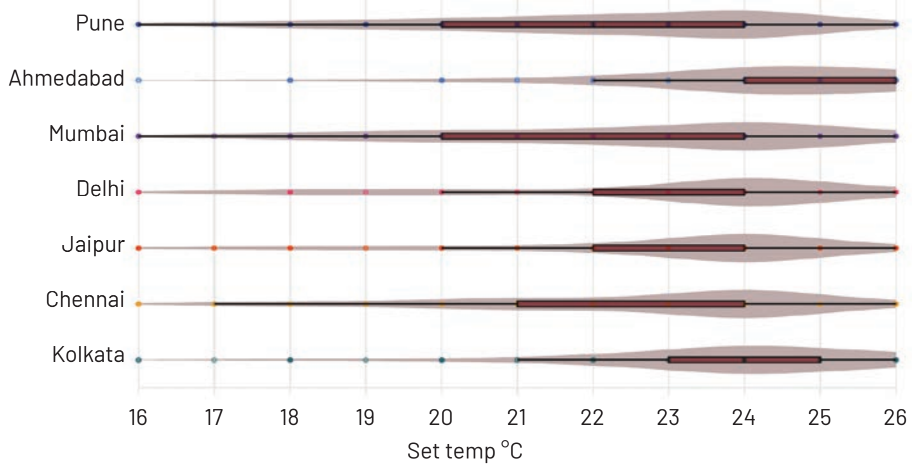
- After-sales service is not an important criterion at the time of purchase, with 65% of consumers ranking it as their last priority (Rank 4).

2.3 Temperature Setting Preferences

Table 7: Household temperature setting preferences (°C)

City	Less than 20°C	20-22°C	23-24°C	25 and above°C
Ahmedabad	2	16	40	43
Chennai	10	29	49	11
Delhi	13	18	51	18
Jaipur	9	20	59	12
Kolkata	4	17	49	30
Mumbai	12	32	37	18
Pune	15	37	39	9
National	**9**	**24**	**47**	**20**

Figure 15: AC Temperature settings by households - City



- Indian households are keeping thermostats at optimum temperatures. Contrary to popular belief, the most preferred temperature setting nationally is 23–25°C. About 67% of households set their AC above 23°C. This trend was observed consistently across cities.
- The most preferred temperature setting nationally is 23–24°C. In comparison, 24% of households prefer relatively lower settings of 20–22°C.
- Overall, about one-third of households set temperatures below 22°C, indicating a considerably higher cooling preference for indoor environments. There are also visible variations across cities, with households in Delhi, Mumbai, and Pune showing a stronger preference for lower temperature settings.

03 Servicing and Cost

3.1 Frequency of Refrigerant Refills

Table 8: Age of ACs - Vs - frequency of refrigerant refills – National

AC category	% of total ACs	Refill frequency
ACs (less than 5 years old)*	33%	Annual
ACs (5 years and above)	80%	Annual
	20%	Once in a 2 years

- In India, refrigerant refilling is far higher than global practices. About 80% of ACs older than 5 years require refilling annually. Even one-third of newer ACs (less than 5 years old) are refilled every year.

- Effectively, about 40% of all ACs in India are refilled annually. Ideally, on average, ACs should require refilling once in 5 years.

- Frequent refrigerant refills raise critical questions about the quality of RACs and the services in the Indian market, in addition to user operation and maintenance practices.

- Manufacturers in the Indian market give one year in-warranty coverage and 2-5 years of extended-warranties on ACs. But these warranties don't include refrigerant refills- that means the cost of such frequent refilling is only borne by the consumer alone.

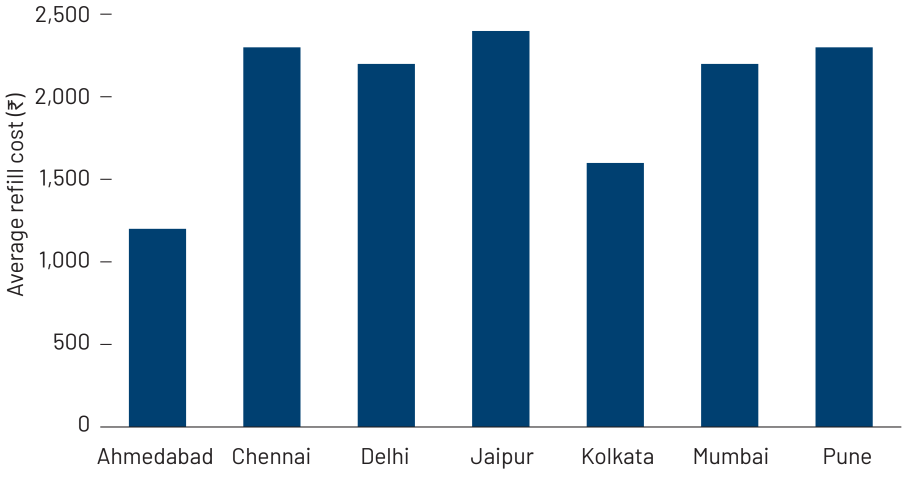
* Two-third of ACs less than 5 years old, have not experienced refrigerant refill being new ACs.

3.2 Cost of Refrigerant Refilling

Table 9: Cost of refrigerant refilling per AC per year (₹) – City, National

City	Average refill cost (₹)
Ahmedabad	1,200
Chennai	2,300
Delhi	2,200
Jaipur	2,400
Kolkata	1,600
Mumbai	2,200
Pune	2,300
National	**2,200**

Figure 16: Cost of refrigerant refill per AC per year (₹)



- An Indian household, on an average, pays ₹2,200 for refrigerant refilling per AC per per year. The cost varies between ₹1,200 to ₹2,400 across cities.

- There is significant regional variation: refill costs in Chennai and Jaipur are the highest compared to the national average, while in Kolkata they are considerably lower than the national average.

- It is important to note that, refrigerant charging is rarely offered as a full warranty benefit. Most brands either exclude it altogether or allow coverage only under specific conditions. Adding to the complexity, many brands keep their first-year warranty terms vague, which means, ultimately, consumers have to pay.

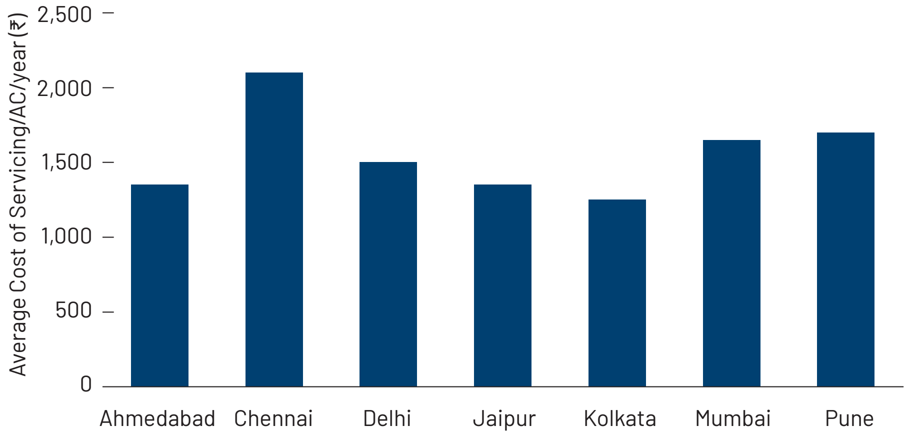
- In India, ACs required 32 million kg (32,000 tonnes) of refrigerant refills in 2024. With an average refilling cost of ₹2,200 per AC, consumers spent about ₹7,000 crore ($0.8 billion) in 2024. In a Business-as-Usual scenario, annual refilling costs will quadruple to ₹27,540 crore ($3.1 billion) by 2035.

3.3 Cost of Servicing

Table 10: Cost of AC servicing to consumer (₹) – City, National

City	Average Cost of Servicing per AC per year (₹)
Ahmadabad	1,350
Chennai	2,100
Delhi	1,500
Jaipur	1,350
Kolkata	1,250
Mumbai	1,650
Pune	1,700
National	**1,500**

Figure 17: Cost of AC servicing to consumer (₹) – City



- The overall AC servicing cost range is significant, with the most expensive city—Chennai (₹2,100 per AC)—costing 66% more per year for AC servicing than the least expensive city, Kolkata (₹1,250 per AC). Chennai's annual servicing cost is approximately 30% higher than the national average of ₹1,500.

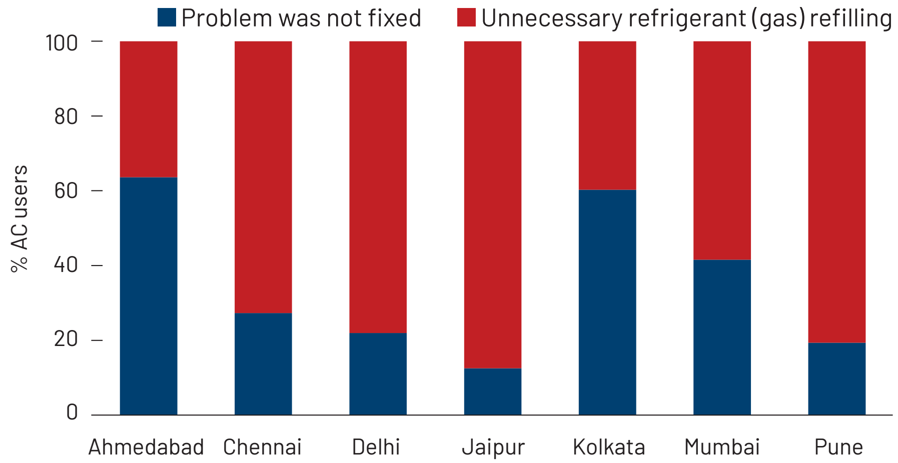
- Servicing costs in Chennai, Pune, and Mumbai are higher than the national average, whereas they are lower in Kolkata, Ahmedabad, and Jaipur.

3.4 Service Complaint Types

Table 11: Reported AC service complaints (%) – City, National

City	Problem was not fixed	Unnecessary refrigerant (gas) refilling
Ahmedabad	64	36
Chennai	27	73
Delhi	22	78
Jaipur	13	88
Kolkata	60	40
Mumbai	42	58
Pune	19	81
National	**32**	**68**

Figure 18: Reported AC service complaints (%) - City



- Unnecessary refrigerant refilling is the dominant service complaint across Indian households. Average, 68% of consumers shared this issue. Nearly 7 out of 10 service complaints are for unnecessary gas refilling, indicating a quality service issues that not only costs to the consumer, but, significantly, to the climate through refrigerant leakage and release.

- The problem is particularly high in major cities- Jaipur (88%), Delhi (78%), Pune (81%), and Chennai (73%),

- A consumer trust deficit is apparent in after-sales service. For majority of AC owners, the primary service experience is not about repair but being upsold an unneeded service, eroding confidence in technicians.

3.5 Technician Preferences

Table 12: Preferences for AC technician (%) – City, National

City	Company technician	Local technician	Online servicing platforms
Ahmedabad	35	63	1
Chennai	39	54	7
Delhi	59	39	2
Jaipur	69	31	1
Kolkata	63	34	2
Mumbai	53	45	2
Pune	67	33	0
National	**55**	**43**	**2**

Figure 19: Preferences for AC technician (%) – City

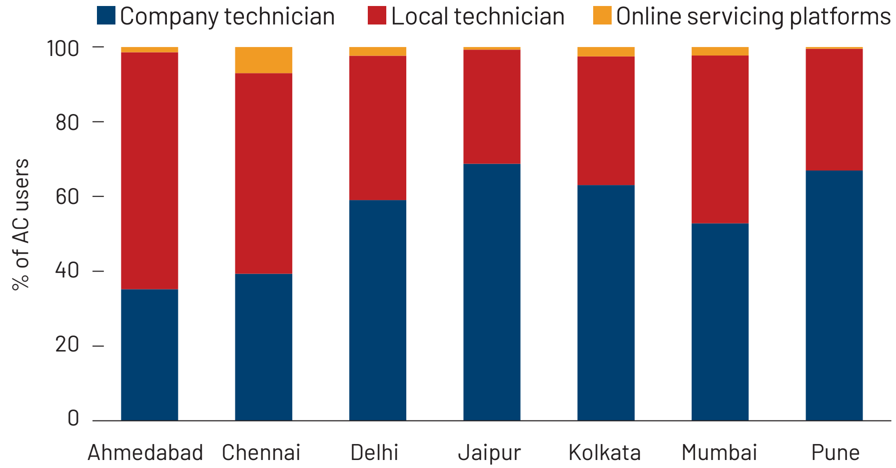
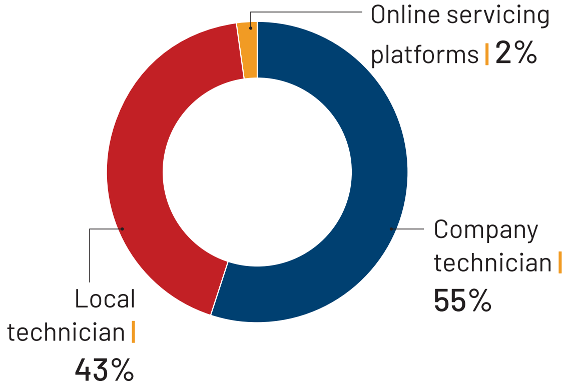


Figure 20: Preferences for AC Technician – National



- Across the country, 42% of all consumers rely on local technicians, proving they are a huge and important part of the service sector that cannot be ignored. Very few are choosing online platforms.

- Households in Jaipur, Delhi, Mumbai, Pune and Kolkata have higher preference for company technicians, which also reflected in national level choices. With the survey, there is no specific relationship observed in city, age of ACs and the choice of technician.

- Only Ahmedabad and Chennai households prefer local technicians.

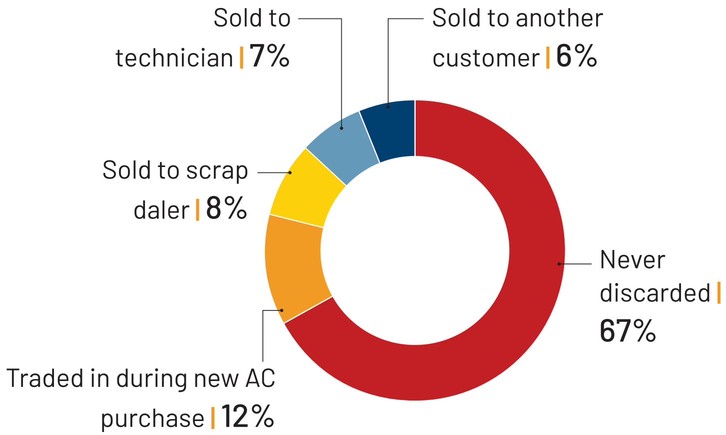
04 Climate Impact & GHG Emissions

4.1 End-of-Life Disposal

Table 13: End-of-Life disposal of AC (%) - National

Response on AC Discarded (EoL)	Households(%)
Never discarded	67
Traded in during new AC purchase	12
Sold to scrap dealer	8
Sold to technician	7
Sold to another customer	6

Figure 21: End-of-Life disposal of AC (%) - National



- Survey finds that 67% of households have never discarded an AC- indicates new ownership. This aligns with the previous finding that new AC ownership is growing rapidly with rising ambient temperature.

- Among the discarded a ACs, a significant 45% went to informal channels like scrap dealers and technicians, demonstrating that these pathways are already a dominant force in end-of-life management which is not covered under EPR.

- The existing reliance on informal collection networks presents an important opportunity.

4.2 Consumer Readiness for Climate-Friendly Refrigerant

Table 14: Willingness to buy AC with climate-friendly refrigerant (%) – City, National

Preference	Ahmedabad	Chennai	Delhi	Jaipur	Kolkata	Mumbai	Pune	National
Unaware	42	64	34	20	69	47	22	43
Yes, and I'd switch	24	20	42	36	13	25	51	30
Yes, but only if affordable	33	16	24	44	18	28	26	27

Figure 22: Willingness to buy AC with climate friendly refrigerant (%) - City

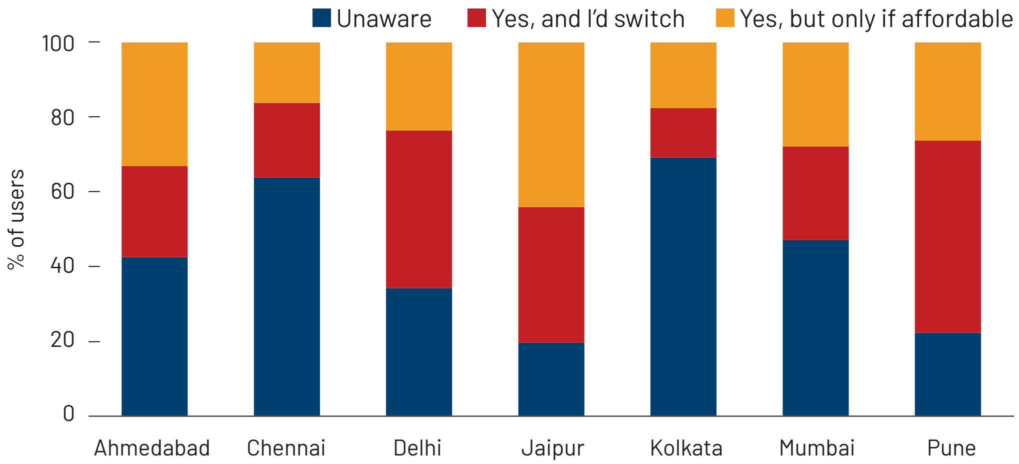
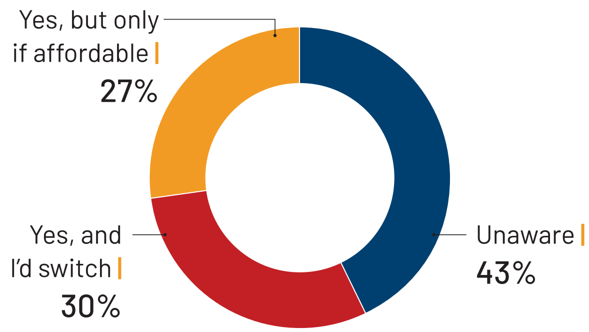


Figure 23: Willingness To Buy AC With Climate Friendly Refrigerant (%) - National



- Indian household show good awareness on energy efficiency of ACs, but awareness on climate-friendly or natural refrigerant-based ACs is very low- 43% households are unaware of it.
- Kolkata (69%) and Chennai (64%) households are the most unaware ones.
- Overall, one-third of total households shows willingness to shift to climate-friendly options, and another one-third wishes if it is affordable- highlighting that cost is a key consideration alongside awareness.
- Pune (51%), Delhi (42%) and Jaipur (36%) show the highest willingness to switch to climate-friendly based ACs.
- Jaipur appeared the most price-conscious city- 44% households wished to choose natural refrigerant if it is affordable.

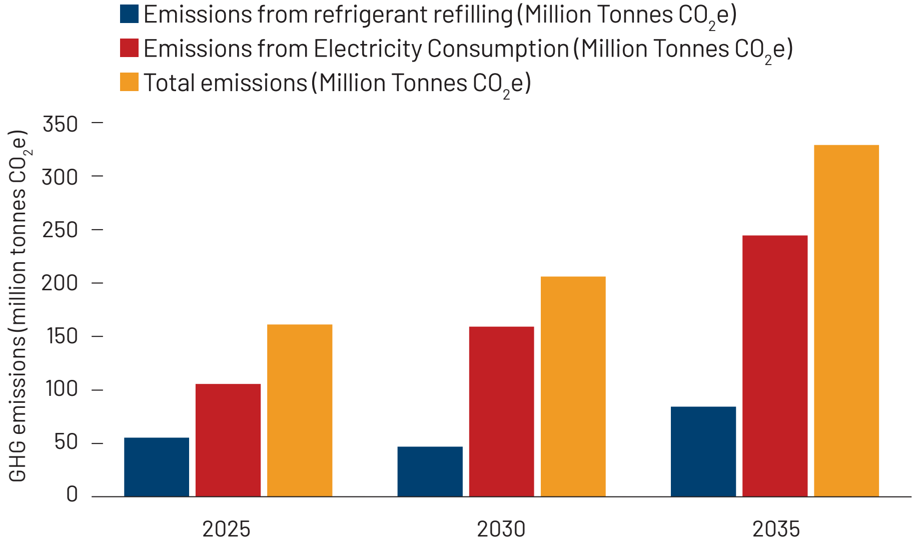
4.3 GHG Emissions from AC

Table 15: Annual Greenhouse Gas Emissions (Million Tonnes CO_2e) for AC stock

	2025	2030	2035
Emissions from refrigerant refilling (Million Tonnes CO_2e)	55	47	84
Emissions from Electricity Consumption (Million Tonnes CO_2e)	106	159	245
Total emissions (Million Tonnes CO_2e)	161	206	329

- AC sales CAGR for 2014-2024 calculated at 13.30%, and for 2025-2035 assumed at 10%.
- Annual AC sales for 2024 calculated from AC manufacturers sales data in India.
- As per AC market transition, till 2019, refrigerant R-410A (GWP=2088) and 2020 onwards, R-32 (GWP=675) considered.
- Average 1kg refrigerant charge estimated for all AC capacities.
- Annual electricity consumption per AC calculated as weighted average for 0.75TR to 2TR ACs for average 1460 annual operating hours (survey finding).
- Emission factor for electricity consumption estimated as a ratio of total emissions from electricity generation and total electricity generation.
- Cost of refrigerant refilling is ₹2200/refill/AC (from survey finding).
- Carbon price of $50 / tonne CO_2e
- Currency conversion at 88 Rupees=$1

Figure 24: Annual Greenhouse Gas Emissions (Million Tonnes CO_2e) for AC stock



- India's ACs required 32 million kg (32,000 tonnes) of refrigerant refills in 2024, which is expected to increase with AC stock to 125,000 tonnes by 2035.
- The current AC stock (2025) in India is 76 million ACs and with 10% Cumulative Annual Growth Rate (CAGR), it is estimated to increase at to 245 million ACs in 2035. This requires around 38,000 tonnes refrigerant in 2025 , increasing to 125, 000 tonnes in 2035.
- Emissions from refrigerant refilling will marginally decrease from 34% to 26% owing to complete transition to lower GWP refrigerant and reduction in electricity-emission factor.
- Refrigerant-related GHG emission is estimated around 55 million tonnes in 2025, increasing to 84 million tonnes in 2035.
- A proper Life-cycle Refrigerant Management (LRM) in the place can save around 650 million tonnes GHG emission in next 10 year (by 2035). This equals nearly $33 billion saving in the carbon market in next 10 years (at a moderate price of $50 price per tonne of CO_2).
- Overall GHG emission of AC use (including electricity consumption) will increase from 161 million tonnes (2025) to 329 million tonnes per year in 2035. It implies we may need 4 billion tress in 2025 and nearly 15 billion trees in 2025 to absorb all the GHG emission from AC use.

05 Current Regulations on Refrigerant Management

5.1 Current Regulations on Refrigerant Management

- India ratified Kigali Amendment to the Montreal Protocol in 2023, on substances that deplete the ozone layer (ODS) for phase down of HFC in India. It will complete its phase down of HFCs in 4 steps from 2032 onwards with cumulative reduction of 10% in 2032, 20% in 2037, 30% in 2042 and 85% in 2047. This phase-down is expected to prevent the emission up to 105 million tonnes of CO_2e (Press Information Bureau, 2021).

- India's E-waste rules-amendment 2023, added specific duties for refrigerant management. Companies that make, repair, or recycle refrigerators and ACs must safely recover the refrigerant when handling old or scrapped units. The recovered gas has to be destroyed only at CPCB-approved facilities using approved methods. These rules work alongside the online Extended Producer Responsibility (EPR) system for electronic products, but refrigerants are not included in the tradable e-waste certificates. Importantly, these regulations do not cover refrigerant leakage during AC operation and maintenance, which is a major source of emissions (Central Pollution Control Board, 2023).

- India Cooling Action Plan (ICAP) launched in 2019, to achieve sustainable cooling and thermal comfort securing environmental protection. This plan aligns with global commitments including Kigali Amendment. ICAP addresses RAC servicing, refrigerant demand, and domestic production. It targets a 25–30% reduction in refrigerant demand by 2037–38 and emphasizes training and certifying servicing sector technicians.

- Other regulations in India also manage HFCs production and use, including the Ozone Depleting Substances Rules, 2000 (Ozone Cell, n.d.), (These rules are amended under the Montreal Protocol ((Ministry of Environment, Forest and Climate Change, 2020) and Kigali Amendment, and the Environment Protection Act (1986), which regulates the import, production, and use of fluorocarbons like Hydrofluoroolefins (HFOs) (MoEFCC. (2019).

- Globally, demonstrated legal and governance structures exist to manage refrigerant leakages at the household level and mandate manufacturers to take full responsibility for refrigerant collection, reclamation, and destruction. For instance, Norway, Japan, and China have strong laws, licensing, and data registries, while Australia has a robust governance structure and incentive mechanisms. (See - Annexure B- References for Country Data on Global LRM Practices)

Overall, India lacks adequate regulation and enforcement to manage climate-warming refrigerants.

06 Recommendations

6.1 Recommendations for an Effective Refrigerant Management System in India

India needs comprehensive rules and enforcement mechanisms for Lifecycle Refrigerant Management – from filling in equipment to servicing and end-of-life disposal. This should include an EPR obligation for AC manufacturers. It should:

01

- Enact dedicated Refrigerant Management Law similar to EPR, covering the entire life-cycle of refrigerants (production, use, recovery, and destruction) that ensures legal accountability across sectors and prevents emissions at all stages.

02

- Establish an effective enforcement mechanism to ensure strong monitoring, reporting, and compliance structures and penal provisions to deter non-compliance and ensure industry-wide adherence.

03

- Implement a Real-Time Refrigerant Data Management System that tracks refrigerant use, leakage, recovery, and destruction at national and local levels and enables data-driven policymaking and transparent reporting.

04

- Launch a comprehensive Technician Training & Certification Program to standardize servicing practices to reduce leakages and equip technicians with skills in handling climate-friendly refrigerants safely and efficiently.

05

- Drive consumer awareness on Sustainable Cooling by promoting responsible refrigerant use and disposal practices and educate about climate-friendly refrigerants.

India can also learn from the Global Best Practices. Norway, Japan, and China have strong laws, licensing, and data registries, while Australia has a robust governance structure and incentive mechanisms. A robust Life-cycle Refrigerant Management framework will reduce emissions, enhance compliance, and contribute to India's climate commitments.

Annexures

Annexure A- Research Design and Sampling Approach

Purpose:

- The purpose of this survey is to understand household ownership, usage patterns, servicing practices, and awareness levels related to residential air conditioners in India. It seeks to capture information on how socio-economic factors influence AC adoption, the role of seasonal usage in energy consumption, consumer priorities in purchasing decisions, and experiences with servicing, refrigerant refilling, and disposal of old units. The findings, along with global best-suited practices, will inform the development of a lifecycle refrigerant management policy roadmap for India to promote sustainable cooling and climate-friendly transitions.

Design:

- Cross-sectional, survey-based research integrating demographic, climatic, and behavioral variables.

Sampling Method:

- Stratified random sampling across three income groups (High, Middle, Low).
- Ensured representation across climate zones (hot-dry, composite, humid, coastal).
- Randomized household selection within localities.

Sample Size determination:

- For a large population, the sample size (n) for a proportion is calculated as:

$$n = \frac{Z^2 \times p \times (1-p)}{e^2}$$

Where: Z is z-score (1.96 for a 95% confidence level); p = estimated proportion (0.5 for maximum variability); e = margin of error (0.05)

- 384 is rounded up to 430 households per city to account for potential design effects from stratification and to ensure robust analysis for city-level insights.
- Total: 3,100 households across 7 cities (Delhi, Mumbai, Kolkata, Chennai, Ahmedabad, Pune, Jaipur).
- This sample size provides a 95% Confidence Level with a 5% Margin of Error for the overall national estimates, assuming a conservative response distribution of 50%.

Selected cities for Survey Sample

Respondents:

- Primary household decision-makers and AC users.

Key Variables Considered:

- Household RAC ownership & penetration; City population & urban growth projections; Temperature; Heatwave exposure (thermal stress)

Composite Index:

- Normalized (0–1) scores applied across variables.
- Combined to capture heat-vulnerability, market depth, and refrigerant demand pressure.
- Min-Max Normalization (for each variable x) (Krejcie & Morgan, 1970)

$$X_{normalised} = \frac{X - X_{min}}{X_{Max} - X_{min}}$$ (Krejcie & Morgan, 1970)

Where:

- *X is the original value for a city.*
- *X_{min} is the minimum value of that variable across all candidate cities*
- *X_{Max} is the maximum value of that variable across all candidate cities.*

This formula scales each value to a range between 0 (worst) and 1 (best).

- Composite Index Score (for each city) (Han et al., 2012).:

$$Composite\ score = w_1(X_{1-norm}) + w_2(X_{2-norm}) + w_3(X_{3-norm}) + \ldots\ldots + w_n(X_{n-norm})$$

Where:

- *$w_1, w_2, w_3, \ldots, w_n$ are the weights assigned to each normalized variable, reflecting their relative importance in the overall index.*
- *$X_{1-norm}, X_{2-norm}, X_{3-norm}, \ldots, X_{1-norm}$ are the normalized values for each variable.*

City Selection:

- Final 7 cities chosen based on high composite scores representing climatic, demographic, and ownership diversity.
- Covers India's major urban cooling hotspots across North, West, East, and South regions.

Outcome:

- Methodology ensures external validity and provides a reliable foundation for policy-relevant insights.

* For detailed references, please see the Annexute-B

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