

Space Cooling Appliances and Energy Usage in India

Sravanthi Choragudi¹

Highlights:

1. Space Cooling Appliances (SCAs)-air conditioners and coolers- are no longer a luxury but a necessary good, with wider adoption and higher energy consumption.
2. Rural-urban and rich-poor divide in adoption of SCA reflect unequal capabilities to adapt to climate change.
3. While longer summers increase the adoption of SCAs, warmer nights significantly lengthen their daily usage hours, both during the day and night.
4. Rising temperatures and increasing incomes will raise SCA ownership in the near future. We estimate that, by 2030-31, in areas with severe increase in heat stress, 70 percent of the households are going to own SCA.
5. If the share of AC in SCA adoption increases significantly by 2030-31, space cooling alone will demand 117-157 TWh of electricity. That accounts to 44 percent of the total electricity demanded by the households (by 2022-23 estimations).
6. Space cooling in India is a Climate Change Adaptation strategy that ought to take into consideration energy, equity and climate goals.
7. Stringent standards need to be combined with financial mechanism to make energy efficient SCAs affordable.
8. Consumer awareness and behaviour is key for demand side management.
9. The large informal component of India's SCA manufacturing/servicing need to be brought under the norms of standards and compliance.
10. To facilitate empirically supported policy prescription, large scale household surveys should collect data on the ownership, usage and energy demand of household appliances.

¹ Consultant Researcher, Divecha Centre for Climate Change, sravanthic@iisc.ac.in



I. Introduction

Intense and long summers in India are increasing the demand for Space Cooling Appliances (SCA) - air conditioners and coolers. This policy brief examines the adoption of SCA and energy consumption among Indian households. We also estimate, owing to high temperatures and long summers, how SCA adoption and energy used will escalate in the near future. The aim of this policy brief is to examine the extent to which the pull and push factors, income and heat, determine SCA ownership in Indian households. We also bring to light the inequalities that lie in its adoption.

II. Longer Summers:

Summers in India are getting longer, both in terms of the number of hot days in a year and the number of hours in a day exceeding the long-term average. In this study, using historical climate data from ERA-5 (Hersbach et. al., 2023), we highlight the increase in the heat stress between the base line summer of 1981-2011 and summer of 2021 (March, April, May and June). We use air temperature and dew point temperature to calculate the Wet Bulb Heat Index (WB-HI)² for major Indian states. We calculate WB-HI for the summer months of March, April, May and June, both the average monthly HI for twenty-four hours of the day and average monthly HI for the nights (20:00 to 7:00 hrs).

WB-HI is one of the indicators that highlights how the hot air feels on the skin when humidity is taken into account. High values of relative humidity lead to a slower evaporation rate thereby reducing the efficiency of the cooling mechanism of the body. Therefore, WB-HI is an appropriate indicator when assessing the demand for space cooling appliances. Further, number of hours exceeding the long term average is another indicator that highlights the intensity of heat stress. According to Indian Meteorological Department "If the minimum temperatures at night are warmer than normal then they also have a cascading effect on the next day maximum temperatures. The maximum temperatures may be attained the following day earlier and may also last for longer duration". This also determines for how long SCAs are in use during the night.

We observe that, first, WB-HI in the summer of

2021 is 0.3-0.9 degrees higher than the base line (1981-2011). Second, the beginning and the ending of summer i.e., March and June of 2021, is warmer than the baseline thus indicating at the lengthening intensity of the summer. Third, the nights are increasingly warmer in 2021 by 0.14-0.85 degrees compared to the baseline, suggesting the need for longer use of space cooling appliances.

III. Affordability and Ownership of Space Cooling Appliances

Household income and Heat Stress

SCA ownership was once associated with the affluent. Increase in the household income and falling prices has made owning them affordable. According to Household Consumption and Expenditure Survey (HCES) of 2022-23 (GOI, 2024b), 24 percent of the Indian households owned either a cooler or air conditioner by the time of the survey. In 2015-16, it was 17 percent³. In the year 2022-23 alone, 5.75 lakh ACs and 39 lakh coolers are purchased by Indian households (GOI, 2024b). We observed that, the relation between owning SCAs and economic status of the household is not as strong as one would expect. We examined SCA ownership against the average per-capita household income of the states-rural and urban areas separately. To a certain extent, we observed, a positive relation between the average household income and SCA among the rural households. But that is not the case among the urban households. (Figure 1) (Figures and Tables are at the end of the document). This is particularly true in the states that have experienced severe increase in the heat stress over time like Madhya Pradesh, Chhattisgarh, Rajasthan. It is also interesting to note that 11 percent of the households that own SCA do not own a fridge and 17 percent do not own a washing machine. This indicates how space cooling appliances are viewed from the consumer point of view, a necessity, not a luxury good.

Increase in the heat stress, on the other hand, is highly correlated to the average SCA ownership in the state. (Figure 3). Increase in the heat stress all the summer and beginning and the end of the summer is significantly correlated to the SCA ownership.

In the HCES survey, ownership of ACs and air coolers is clubbed together. This limits the estimation of

² We use Stull Wet-Bulb Temperature Formula to calculate WB-HI.

³ Based on National Family Health Survey-5 (2015-16) (IIPS and ICF, 2017).



electricity consumption and the impact of heat stress on the ownership of AC vs coolers. For example, at what heat stress level a lower middle-income household might shift from fan to cooler to AC. Among middle-income households, a one-time investment in high-cost household appliance like air conditioner is a rational economic choice considering the yearly increase in the heat stress. Also, the range of coolers available in the market made space cooling affordable among the low-income and lower-middle income classes.

Inequality in SCA adoption

We observed significant rural-urban disparities in SCA adoption within the states. **Figure 2** shows the SCA ownership among the rural and urban households in relation to WB-HI. These disparities are more prominent in less developed but high heat stress states like Uttar Pradesh and Madhya Pradesh. Inequality in ownership of SCAs in extreme heat conditions is a reflection of *unequal capabilities* to adapt to climate change.

IV. Energy Consumption

Due to limitations in data, we relied on broad assumptions for assessing and predicting electricity demanded due to SCA usage. Three scenarios are assumed in calculating the average electricity demanded due to SCA usage. These scenarios are based on the composition of ACs and coolers in the total SCA adoption. The scenarios considered are: **1.** SCA ownership consists of 25% AC and 75% cooler, **2.** 50% AC and 50% cooler, and **3.** 75% AC and 25% cooler. According to our calculations, in 2022-23, 46-111 TWh of electricity are used in operating SCAs in the summer. This accounted for a significant share of electricity consumption in Indian households in 2022-23^{4,5}, ranging from 13-33 percent.

Rise in temperatures and sustained high heat conditions throughout the day and night keep the SCAs running for a long time, thereby increasing the energy demand. We examined hourly electricity demand met in the summer months of 2021 for a few major states⁶. To assess hourly demand in

typical days, we randomly picked two working days per week for the four months between March and June. We examined the hourly electricity demand against the night-time wet bulb heat index.

Typical demand for load increases as the day progresses (5:00am-6:00am), dips at the end of the working day (5:00pm-6:00pm) and rise again with the usage of lights and other household appliances. This rise is expected, in case of normal summers, to gradually subside in the early morning typically hitting the low point between by 1:00am - 2:00am. However, if the nights are not cool enough to wear-off the heat of the day, SCA usage will continue throughout the night into early in the mornings. The point of minimum electricity demanded in the night is shifting farther to the right, thereby sustained demand for electricity extends for longer hours. This results in a flatter electricity demand curve. We observed that electricity demand curve, of a state, gets flatter as the nights get warmer i.e., night time WB-HI increases. (**See figures 4a to 4h**). These observations make it clear that intense summers not only encourage more households to opt for SCAs but makes it necessary to use them for a longer period of time thereby significantly increasing the demand for electricity.

V. Demand for Space Cooling Appliances and Energy Consumption in the Future:

In this study, using 2022-23 as the base, we made projections for SCA adoption, and consequently, electricity demand for the years 2027-28 and 2030-31 in a few major states.

Adoption of SCAs: Projections of SCA ownership are based on the average household income of the state in the next five and ten years, and experienced heat stress WB-HI. For the sake of simplicity, we made two major assumptions. First, the average income of the household increases at the same rate as that of the state's net state domestic product (**RBI, 2025**) and the rate at which state's net domestic product grew in the past decade (2010-2011 to 2022-23⁷) would remain the same for the period between 2024-2031. Second, average increase in the WB-HI

⁴ Calculated using the annual demand for electricity by domestic sector as reported by CEA annual report 2022-23.

⁵ Here we assumed that the WB-HI remained the same between the year 2021 and 2022 when we assigned the average number of hours SCA is used. This in fact is a conservative estimate, given that in the year 2022, the temperatures rose significantly.

⁶ SCA adoption in these major states is more than 20 percent. Also, electricity demand in these states is free of competing peak demand in the night and early mornings in the form of irrigation pump sets during March-June.

⁷ Discounting 2020 and 2021 to account for the economic lull due to COVID-19.



among the states, observed in 2021, were assumed to remain the same for the next decade.

We observe that income elasticity of SCA falls significantly with the increase in the WB-HI. That is, as the summers get unbearable, a smaller increment in the income induces the household to own SCAs. See **figures 5 and 6** for the SCA ownership projections. Projections in **figure 5** are based on the WB-HI experienced throughout the summer, and **figure 6** is based on the WB-HI experienced in the beginning and the end of the summer. It is clear that in the next few years, the number of households that own SCAs is going to increase significantly. By 2030-31, 36 percentage of the households will own SCAs. Nearly 70 percent of the households in the areas that experienced high heat stress would own SCAs by 2030-31. More than a quarter of the households in the medium heat stress areas would own SCAs. This ownership projections are indeed based on conservative assumptions where household incomes are expected to grow at the past rate and WB-HI is assumed to be constant. Here, we also did not take into consideration the possibility of one household owning multiple SCAs, which is already a fact in upper middle-income and rich households in urban India.

Energy Consumption: Electricity demand for SCA is calculated after taking into account range of load differences in coolers and ACs, the average minimum and maximum number of hours SCAs would run is assumed based on the WB-HI of the day and night of the respective states. According to India Cooling Action Plan, total primary energy supply required for space cooling requirements in buildings is expected to grow four times between 2018-19 and 2037-38 (GOI, 2019). According to our calculations, for the year 2022-23, electricity used in operating SCAs in the summer accounted for 17-22% (based on scenario 2: SCA ownership composition is 50% ACs and 50% coolers) of electricity demanded by the Indian households that year⁸. However, this varied across states that experienced varying degrees of increment in the heat stress (see **table 1**).

Due to the increase in the SCA ownership, household demand for electricity would rise significantly by 2027-28 and 2030-31. According to 2022-23 projections, based on scenario 2, electricity

demand for SCA alone (*if everything else remains the same*) would account for 20-30% percent of households' demand for electricity in 2027-28 and 28-42 percent in 2030-31. If the household incomes increase significantly or heat stress increases severely, electricity consumption would increase at an even faster pace. Under scenario 3 (75% AC and 25% cooler), by 2030-31 117-157 TWh of electricity would be used for operating SCAs in the four summer months. See **figure 7**. This again is the factor of degree of heat stress (*difference between 2021 and base line*) (See **figures 7a, b and c**).

VI. Energy Efficiency

Usage of efficient SCAs will significantly reduce the household electricity consumption. Adoption of energy efficient ACs could be a game changer in managing AC load peak demand. In 2024, 1 Degree Celsius increment in heat was estimated to increase 7GW in electricity demand (IEA, 2025). It is estimated that if all the ACs manufactured between 2025-2030 are energy efficient then peak load could be reduced by 20 percent. However, adoption of efficient appliances is wrought with multiple problems, primarily high price and lack of awareness. Though, adoption of five star rated ACs have increased over years, their composition in the total ACs manufactured or adopted has not increased significantly (**Figure 8**). Between 2021-22 and 2022-23 four- and five-star ACs to the total ACs manufactured fell from 34.5 to 31 percent. Instead, the share of two-star ACs increased by 5 points. On an average three-star ACs are 20-25 percent cheaper than five-star ACs. While hotter summers drive Indian households to opt for ACs, middle class household prefer cheaper but energy inefficient options. In the light of revised and stringent BEE labelling standards for AC (BEE, 2025), applicable from January, 2026, they are likely to become more expensive, and understanding consumer behaviour is important.

In Indian households, upfront cost-energy efficiency trade-off and life-long savings are generally not considered while identifying AC models. Instead, frugality (thereby energy-saving) is usually attempted by running the AC for a shorter period of time at a significantly lower temperature (19-21 degrees) and turn the appliance off once the room gets cooler (Chunekar and Kulkarni, 2019). Unable

⁸ Calculated using the annual demand for electricity by domestic sector as reported by CEA annual report, 2024 (GOI, 2024a).



to identify the right tonnage, keeping in mind the coverage of space for ideal thermal comfort, is another aspect that results in energy inefficiency (**Chella et. al., 2021**).

Unlike ACs, a substantial percentage of coolers used in the Indian households are manufactured (and assembled) locally. Unorganised sector plays a significant role in manufacturing and maintaining coolers. This is specifically true and continues to be so in towns and rural areas. Local manufacturing and limited transaction costs makes coolers affordable to many. This also means that, one cannot ensure efficiency nor monitor the compliance norms.

VII. Implications for Policy

Summers in India are getting longer and hotter, thus increasing the risk of heat stress and related health problems- ranging from extreme discomfort to death. Children, elderly and people with pre-disposed illnesses are vulnerable to increasing heat stress, even indoors. This has led to an increasing demand for Space Cooling Appliances-air conditioners and coolers.

Adoption of SCAs in India, compared to the world average, is moderate. However, owing to rising temperatures and improved incomes, there is a notable increase over the years and is expected to grow in the near future. Increasing use of SCA not only escalates the demand for electricity but in-flexible nature of the demand makes its management a technical challenge. At the same time SCA adoption in India is inequitable. Rural-urban and poor-rich disparities are evident highlighting the unequal capabilities to adapt to climate change. Congested urban dwellings, poorly ventilated habitats, rural households amidst increasing deforestation adds to the rising temperatures making the poor more susceptible to heat stress but unable to tackle it.

Space cooling is a Climate Change Adaptation strategy, and not just a commercial opportunity or an individual household economic decision. At the same time, increasing cooling needs are to be addressed keeping in view broader energy and climate objectives, energy efficiency, and equity concerns.

Following are a few policy recommendations.

- Building norms, especially in urban areas, ought to take minimal thermal comfort

into consideration. There is significant scope for improvement in urban planning, building design and materials used. Financing such innovations could be integrated into the State driven housing schemes.

- A larger share of Indian households using SCAs rely on coolers, rather than ACs, for their space cooling requirements. Therefore, wider availability of energy efficient coolers in the market could have an impact on a larger scale. For example, ceiling fans have already been brought under BEE ratings scheme. Presently coolers are absent in the list of BEE mandatory Standards and Labelling programme. Adding coolers to this star rating programme would encourage both manufacturing of and adopting energy efficient coolers.

- BEE regulations and minimum efficiency standards can also play a role in bringing coolers from unorganised manufacturing to the formal manufacturing sector.

- Consumer awareness and behaviour is key to opting efficient appliances and demand side management. Ideal thermal comfort, AC tonnage to area coverage, relation between energy efficiency and life-long savings are a few components consumers need to be made aware of. For example, according to a study (**IEA, 2025**), setting AC at 26 degrees Celsius along with usage of fan would reduce electricity consumption by 420 kWh/year compared to using only AC set at 24 degrees Celsius, without compromising thermal comfort. BEE has already suggested such capping in hospitality industry and commercial buildings (**BEE, 2023**). This could be extended to residential usage provided the final consumers are adequately informed.

- Given the benefits of energy efficient appliances, adopting them should be made more affordable. To ensure higher adoption of efficient SCA, finance should be made affordable. The State and the market could make this possible via incremental payment with limited cost.

- Finally, empirically backed policy making calls for reliable data. Annually conducted Household Consumption Surveys are a major source of reliable information on household ownership of appliances. These surveys could make provisions to list appliances just not based on their broad final purpose like space cooling, transport but also based on their energy intensity.



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Figure 1: SCA Ownership and Household Income: Rural and Urban India.

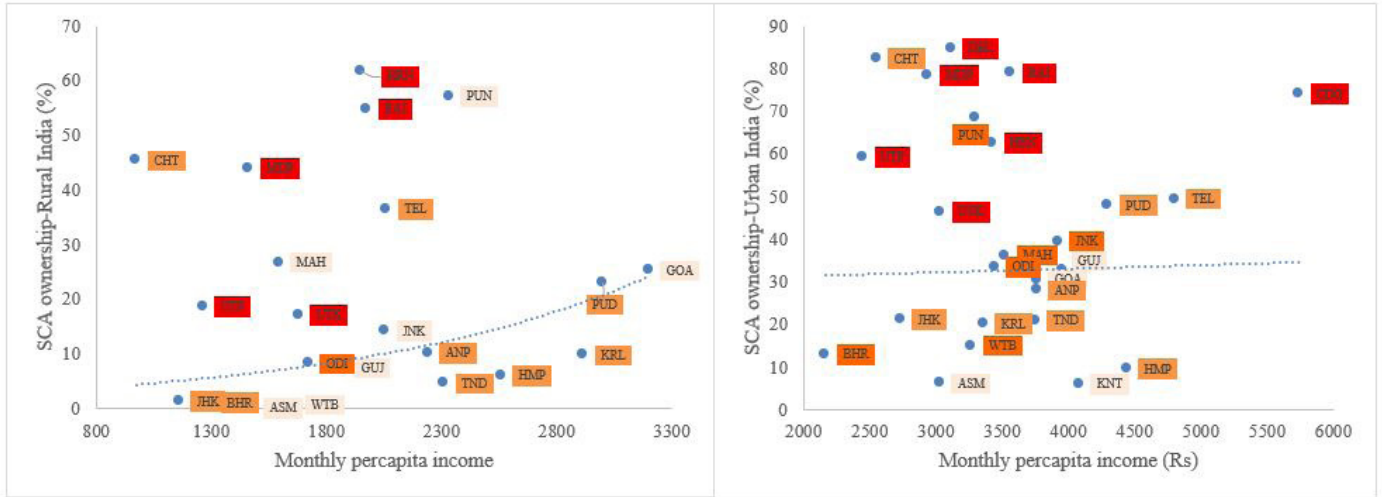


Figure 2: SCA ownership and WB-HI: Rural vs Urban Divide

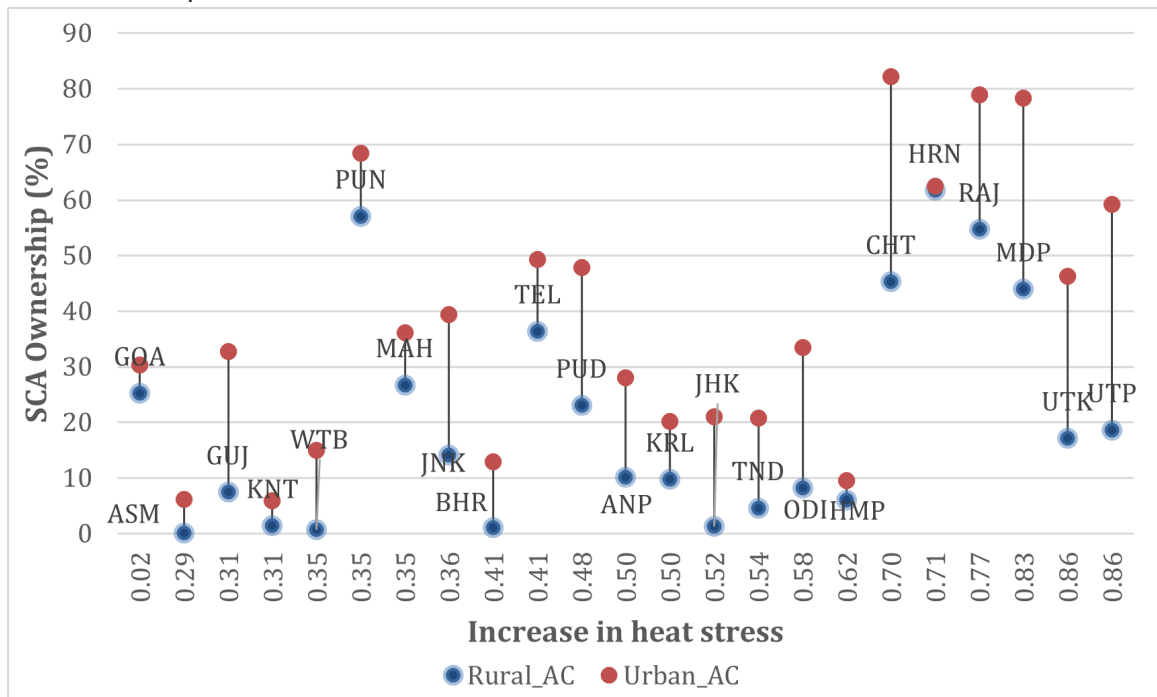
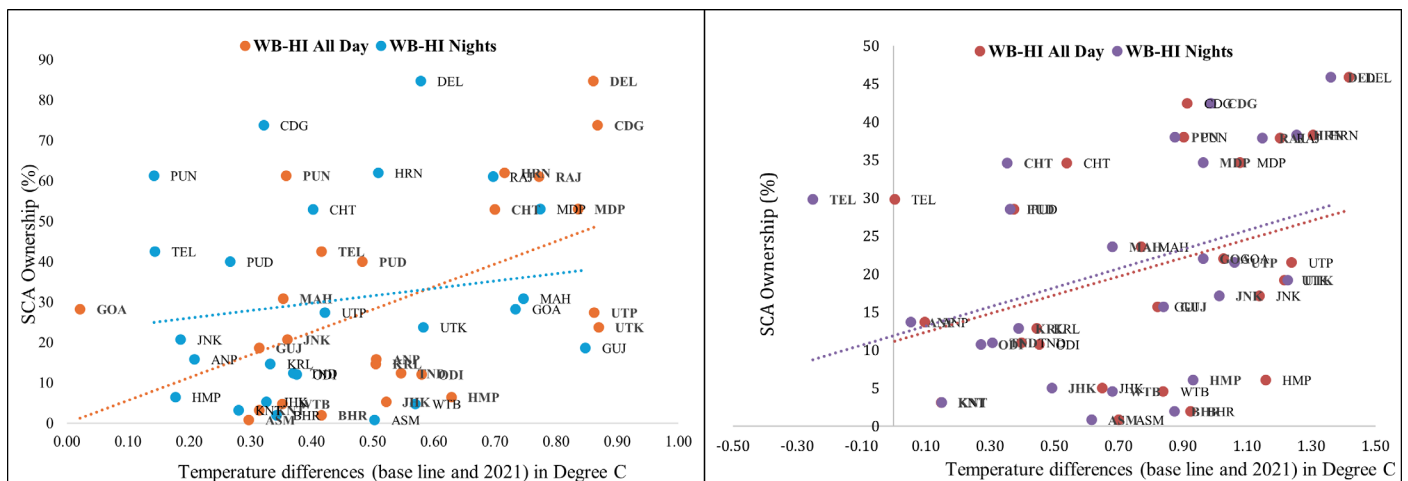


Figure 3: Heat Stress All Summer, Beginning and End of the Summer and SCA ownership.

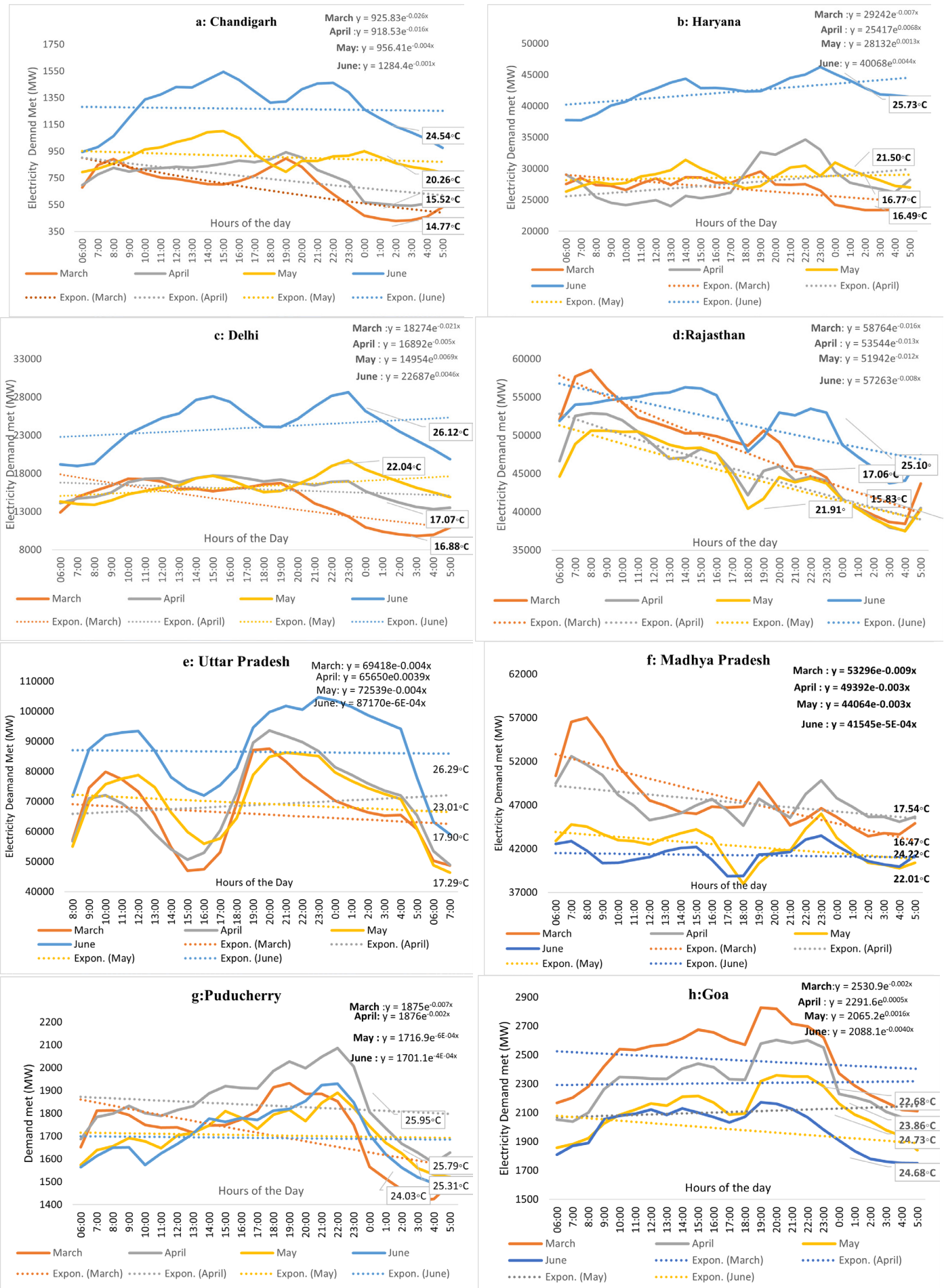


Source: Author's calculations based on HCES (2022-23) and ERA-5 data

Figure 1 Note: Red: Severe increase; Orange: Moderate increase and Light Orange: Slight increase in the heat stress



Figure 4: Hourly Electricity Demand in Summers and Warm Nights.



Source: Indian Climate and Energy Dashboard (2025)



Figure 5: Heat Stress (All Summer) and SCA ownership: 2022-23, 2027-28 and 2030-31 (percentage).

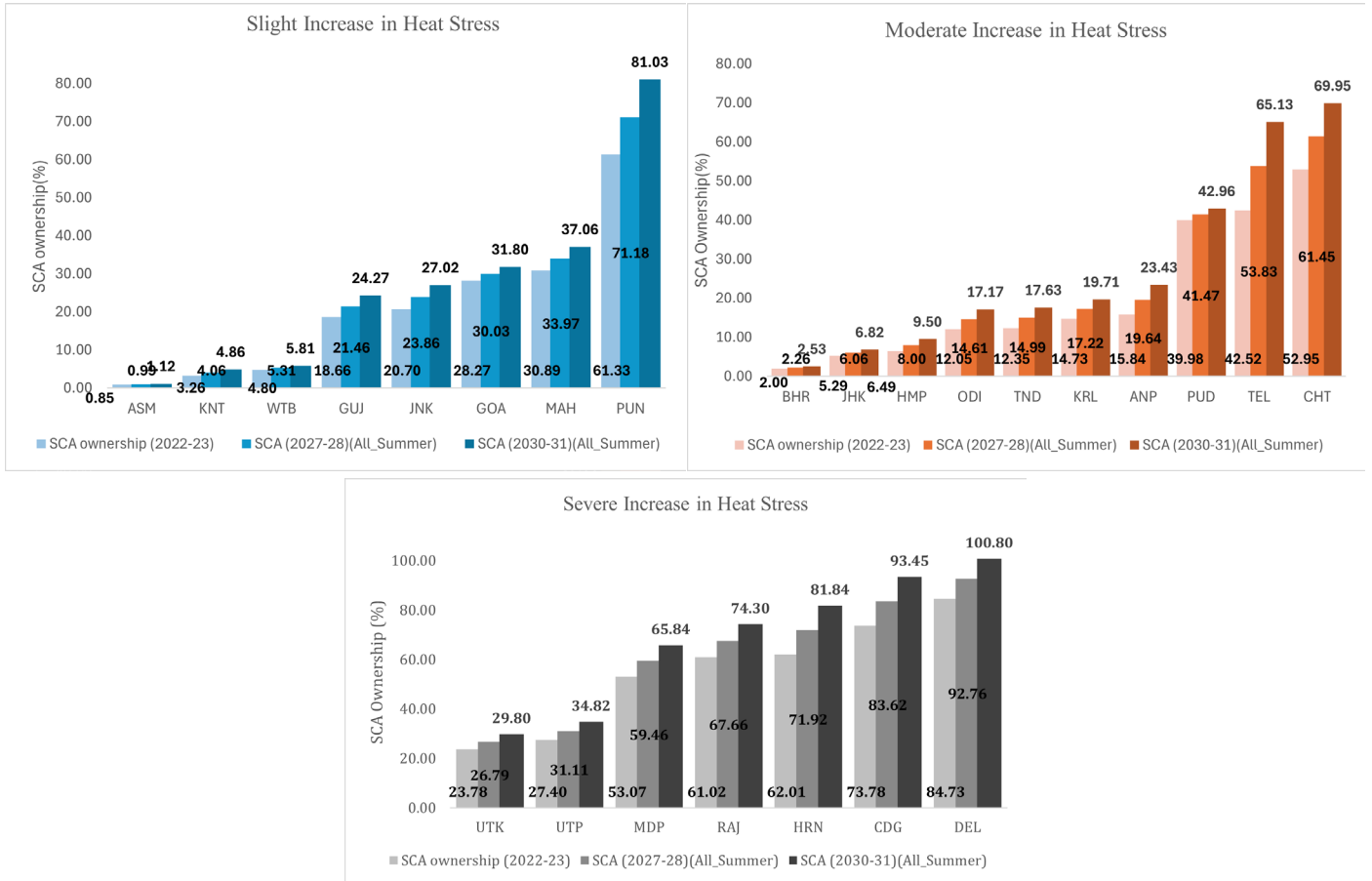
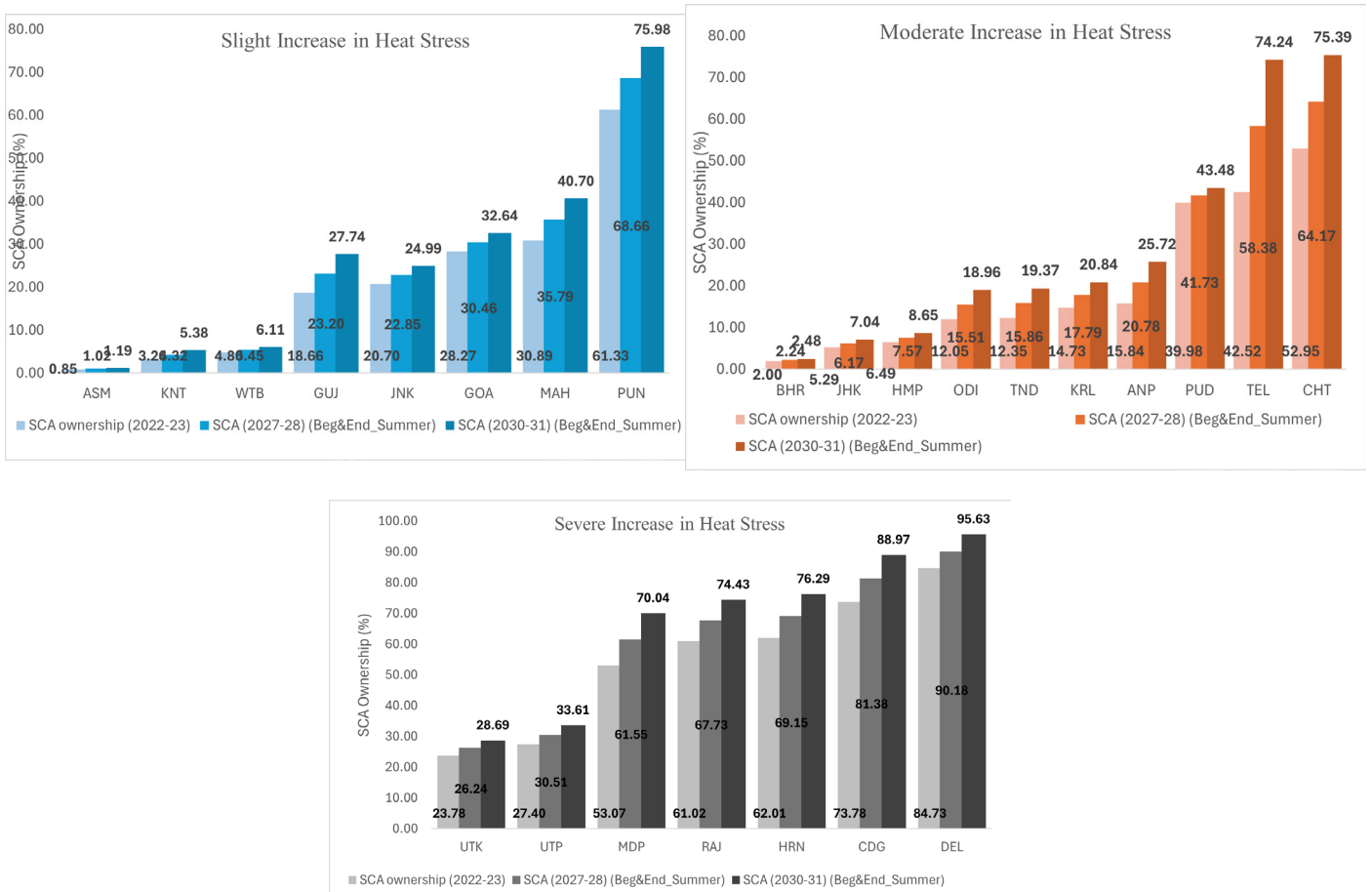


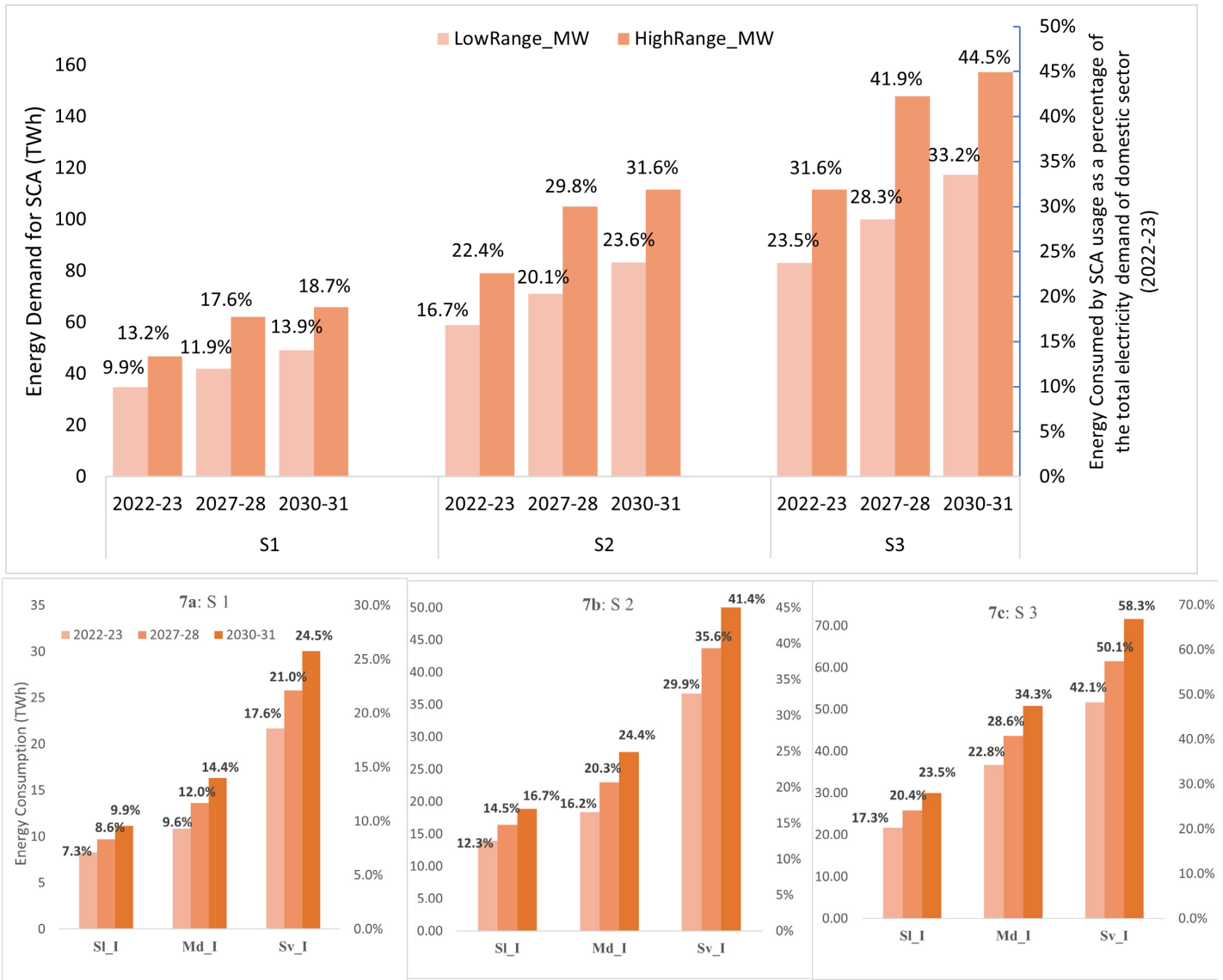
Figure 6: Heat Stress (Beginning and end of summer) and SCA ownership: 2022-23, 2027-28 and 2030-31(percentage).



Source: Author's calculation based on HCES (2022-23) and ERA-5 data



Figure 7: Energy Usage and Space Cooling Appliances under Different Scenarios and Heat Stress Locations.



Source: Author's calculation based on HCES (2022-23), ERA-5 data and CEA (2022-23)

Note: power consumption range: AC-1.5kW-2.2 kW, Cooler-0.12-0.25kW, number of hours are particular to each state depending on the increase in the degree of heat stress.

Scenarios: S1: 25% AC- 75% cooler ownership, S2- 50%-50% and S3: 75%-25%. SI_I: Slight increase, Md_I: Moderate increase and Sv_I: Severe increase in heat stress (between 2021 and base line).

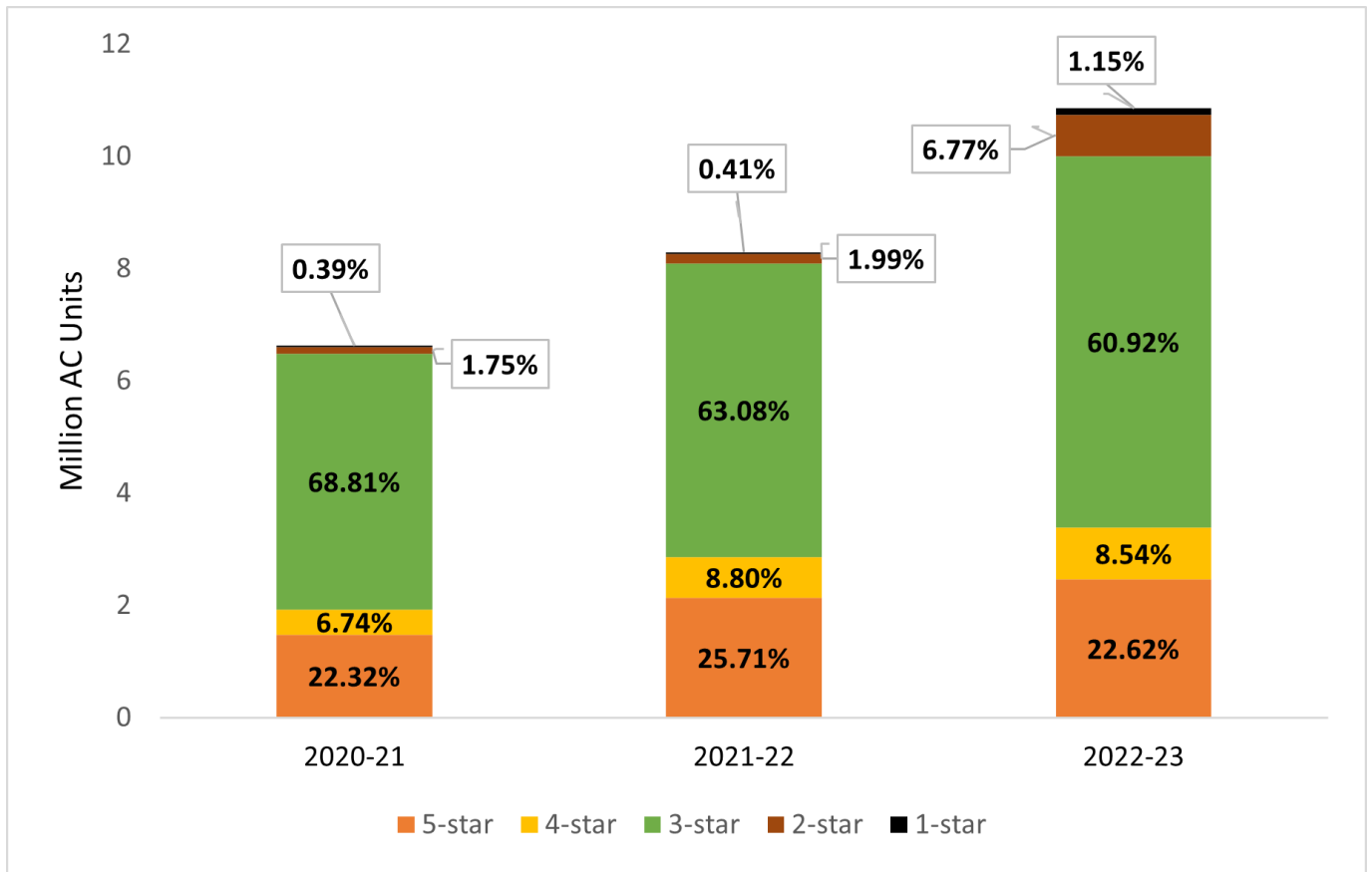
**Table 1:** Energy Consumed using SCA compared with Total Demand for Electricity (2022-23).

Degree of change in heat stress between baseline (1981-2011) and 2021	States	Electricity Demand due to SCA usage (%)
Slight increase in the heat stress	Assam	0.67%
	Karnataka	1.41%
	Jammu & Kashmir	3.20%
	West Bengal	4.42%
	Goa	5.09%
	Gujarat	8.85%
	Punjab	9.61%
	Maharashtra	18.17%
Moderate increase in the heat stress	Bihar	1.71%
	Himachal Pradesh	1.81%
	Jharkhand	3.58%
	Tamil Nadu	4.35%
	Andhra Pradesh	5.31%
	Kerala	5.58%
	Puducherry	6.95%
	Odisha	8.17%
	Telangana	15.16%
	Chhattisgarh	30.07%
Severe increase in the heat stress	Uttarakhand	11.09%
	Uttar Pradesh	13.98%
	Chandigarh	15.98%
	Haryana	18.22%
	Delhi	23.78%
	Rajasthan	33.79%
	Madhya Pradesh	39.54%

Source: Author's calculations based on HCES (2022-23) data (based on scenario1).



Figure 8: Annual Air Conditioner Production Volumes in India by Efficiency Rating.



Source: Annual Reports on Impact of Energy Efficiency Measures by Bureau of Energy Efficiency (2026).

