BUILDING STOCK MODELLING

KEY ENABLER FOR DRIVING ENERGY EFFICIENCY AT NATIONAL LEVEL

BUILDING SECTOR IN INDIA

The building sector in India is experiencing an unprecedented growth. It has 38% (~208mtoe)[1] of the India's total primary annual energy consumption and 31% (296 TWh)[2] of the total annual electricity consumption with residential and commercial sector having 23% and 8% of total electricity consumption respectively. Buildings also represent a dominant share of India's overall cooling demand.

Under national missions like Housing for All, Smart Cities & Solar Cities, India is witnessing significant increase in commercial and residential building stock with lock-in period ranging from 30-50 years. The national missions and codes aligned to building energy efficiently and sustainably such as National Mission on Sustainable Habitat (NMSH), National Mission on Enhanced Energy Efficiency (NMEEE) now renamed ROSHANEE, Energy Conservation Building Code (ECBC – both for commercial and residential) focus on building design and construction practices but require to upscale implementation to fully realise their potential. The upcoming construction presents a unique opportunity to leapfrog into low carbon and resource-efficient future by building it responsibly. Incorporating energy efficient design and construction strategies, building can inherently have a reduced energy consumption footprint over its operating lifetime. Existing examples of high-performance buildings in India show that on an average the annual energy consumption of such buildings could reduce by 30-40%[3]. Further deployment of energy efficient appliances can significantly transform the energy consumption trajectory.

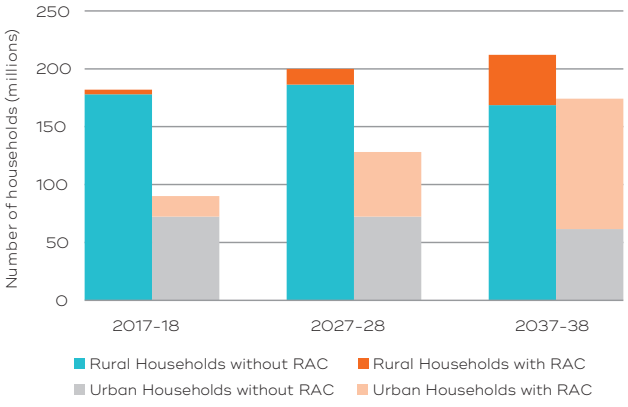
While, there are enough datasets available focusing on sustainable and energy-efficient building design and construction practices and energy-efficient appliances, the data gaps pertaining to current and future floor area within residential and commercial sector and the respective air-conditioned area/ air-conditioner penetration number is impeding efforts to address building sector holistically; which is imperative from data-driven and evidence based policy/ program development and implementation perspective and low carbon development.

RESIDENTIAL SECTOR BUILT-UP & AIR-CONDITIONED STOCK

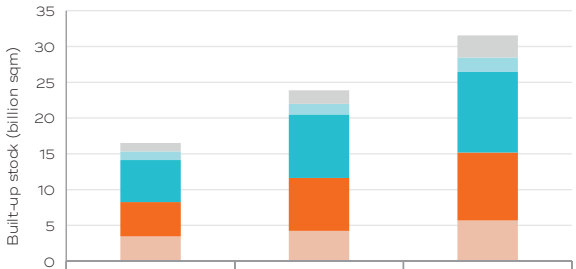
The fragmented character of the residential sector in India poses several challenges. From energy optimisation perspective, numerous guidelines/ codes/ programs have tried addressing the sector's sub-segments, comprehending energy efficiency parameters and highlighting the relevant energy savings; however, the dearth of sector specific floor area information belonging to various strata has impeded in addressing the sector holistically. AEEE, in one of its kind exercise, carried an exhaustive analysis and attempted to estimate the high-level stock number through a bottom-up approach. The overall methodology included data assembly from relevant Government of India (GoI) reports, data analysis and categorisation into groups of buildings of comparable segments and data modelling to arrive at the total floor area and number of air-conditioned households. The data analysis, categorisation and modelling included extensive discussions with experts and educated assumptions were substituted for absence of data.

In 2017, approximately 272 million households were estimated in India which will rise to 328 and 386 million in 2027 and 2037 respectively[4]. The Census 2011[5] of India breaks down the number of households in the following segments: non-exclusive room, one room, two rooms, three rooms, four rooms and five rooms and above. Approximately 60%-70% of all the households fall in one room and two room categories. According to the NCAER[6] 2010 estimates, 56.3%, 29.6%, 12.9% and 1.3% of the households fall under the Economically Weaker Section (EWS), Low Income Group (LIG), Medium Income Group (MIG) and High Income Group (HIG) respectively. National Building Code[7] and various housing policies/ missions/ reports[8,9,10] provide a range of built area (similar to floor area) for EWS, LIG, MIG & HIG. Floor area for each household segment is estimated based on the aforementioned data and extensive discussions with experts and in the working group. The available data is extrapolated to arrive at the current and future floor area within each income group. MIG segment covers approximately 38% of the total floor area followed by LIG, EWS and HIG at 23%, 31% and 8% respectively in 2017 and it is assumed that the similar trend follows for next ten years. Residential built-area CAGR (Compound Annual Growth Rate) from IESS (India Energy Security Scenarios) 2047 is also referred to align the medium and long-term built-area for the residential sector.

Rural and Urban households with AC penetration



Residential & Commercial sector floor area (billion sqm)



	2017-18	2027-28 Medium-term	2037-38 Long-term
Commercial	1.16	1.88	3.09
HIG	1.2	1.49	2
MIG	5.87	8.87	11.24
LIG	4.79	7.38	9.51
EWS	3.48	4.25	5.69

For the current analysis, the share of the total households for each income group that have room air conditioners were estimated using short expert surveys from building design and construction industry professionals and by reviewing AEEE study[11] and trends for other appliances. As per the analysis, at present approximately 8% of the total household have Room Air-conditioner. This is anticipated to rise to 21% and 40% in 2027-28 and 2037-38. As per NSSO 2011, there were approximately 1.2 room air conditioners per household. The present analysis indicates approximately 1.25 room air conditioners per household in 2017-18 which will rise to 1.5 and 2 room air conditioners per household in 2027-28 and 2037-38 respectively. It is anticipated that from 2001 till 2017, the majority of room air conditioner penetration was occurring within households without air conditioner (first air conditioner); however, based on the AEEE research[12] and our interactions with various stakeholders, it is likely that in next 10 & 20 years significant penetration will take place in households already having

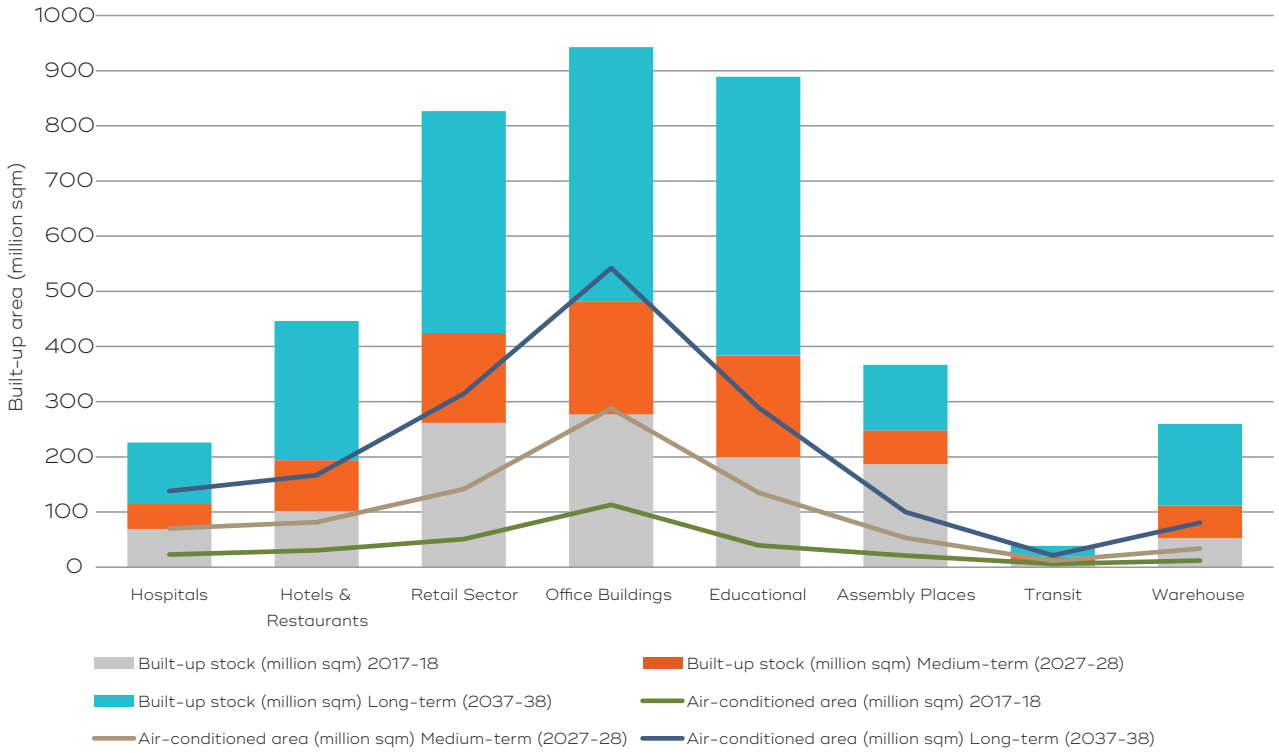
air conditioners (households will opt for second/third air conditioner).

COMMERCIAL SECTOR BUILT-UP & AIR-CONDITIONED STOCK

The commercial sector has been a priority sector for Bureau of Energy Efficiency (BEE), GoI since BEE's inception to promote building energy efficiency. GoI prioritized commercial sector due to the fragmented character of the residential sector. The focus was on developing and launching Energy Conservation Building Code (ECBC) with the objective to make a difference in the commercial building sector that was projected to grow rapidly over the next 2-3 decades. However; the lack of floor area and air conditioned area in the sector has stretched the implementation for long as it is foundational to any building energy efficiency policy formulation, implementation and update. AEEE[13] carried an extensive bottom-up commercial building stock modelling exercise which analysed the various commercial segments to understand the current and upcoming commercial stock. These six stages which includes: Building Data Assembly, Parametrisation and Segmentation, Characterisation, Calculation and Outputs; and Quality Assurance and Validation, were followed individually for each of the building segments. The outputs obtained from modelling were validated with the help of data assembled in earlier stages of the methodology. Inter category comparisons were also drawn to review the assumptions and outputs in each sector. Based on this study on India's commercial building stock, its subsequent refinements based on other model and publications and extensive stakeholder consultations, the current and future floor area for the commercial building sector has been estimated.[5, 14].

The commercial sector floor area in 2017-18 is estimated to be 1160 million m^2 and is expected to grow 1.6x in the next decade to 1880 million m^2, and 2.7 times the size of 2017-18 to 3090 million m^2 by 2037-38. The percent air-conditioned area is expected to increase from approximately 26% in 2017-18 to 43% in 2027-28 and around 54% by 2037-38.

Commercial Sector-Built-up and air-conditioned stock (million sqm)



EXPECTED OUTCOMES

This exercise shall provide-

- ***Stock projections*** – Promote data driven, evidence based policies and programs; Closer link between energy efficiency policies and other flagship programs of GOI
- ***Determining energy consumption –*** The national level energy consumption/ EPI numbers can promote:
  - ***PAT*** – Greatly helps in identifying the energy-intensive commercial building segments leading to ease in DC notification
  - ***ECBC*** – Helps in determining connected load thresholds, applicability, strengthening the code periodically and ensure effective enforcement
  - ***Star Labeling*** – Encourage energy efficiency in building stock through adoption of star labelling program/ other rating systems. Mandatory labelling of appliances such as fans and air-conditioner which have higher penetration/ energy consumption
  - ***Energy use data disclosure*** – Promote data disclosure within different segments of building stock, pushing for standard energy data framework
  - ***Promote and support ESCO model*** – Helps in targeting energy-intensive (segments with higher EPI or poor efficiencies) segments
- ***Determining air-conditioning demand –*** Space cooling in the building sector represents a bulk (around 50%) of India's overall cooling demand. This sector is also unique in that it offers the highest potential for optimization and efficiencies to positively impact India's growing cooling demand. National level air-conditioned area, air-conditioner stock and corresponding energy consumption can promote:
  - ***Resource efficient and low carbon future –*** By adopting Lean, Mean and Green, a hierarchical approach which underscore low-cost, energy-efficient and sustainable construction by first targeting the building design and construction, followed by installation of energy-efficient appliances/systems coupled with smart controls and finally the deployment renewable energy to meet the electricity demand.
  - ***Efficient cooling appliances –*** Ratcheting up cooling appliance efficiency such as fans and air-conditioner
  - Championing "Thermal Comfort for All"

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