Mainstreaming Thermal Comfort for All and Resource Efficiency in Affordable Housing

Affordable housing is broadly defined as housing adequate in quality and location and does not cost so much that it prohibits its occupants in meeting other basic living costs or threatens their enjoyment of basic human rights (UN-Habitat, 2011). In the Indian context, affordable housing refers largely to *low cost housing* built for economically weaker sections (EWS) or lower income group (LIG) and has a specified built up area in relation to the income parameters that define EWS and LIG (MoHUPA, 2012a) (MoHUPA, 2012c) (MoHUPA, 2013).

Several policies and missions have been launched to provide for appropriate affordable housing to address India's housing shortage, the most recent of which is the Pradhan Mantri Awas Yojana (PMAY), Government of India's flagship program aiming to provide affordable housing to urban and rural poor. Launched in 2015, the PMAY - U (urban) initial target was to construct 20 million units by 2022 against the 18.78 million housing demand (MoHUPA, 2012b). The target has been recently revised to 12 million against the revised housing demand of 10 million units (MoHUA, 2017a) (MoHUA, 2017). Under PMAU-U, each dwelling unit built/ to be built will be atleast 30 m^2 in area (MoHUPA, 2016). As a result, the expected addition to the building footprint by 2022 will be at least 360 million m^2. This is equivalent to 32% of the existing commercial building footprint (Kumar et al., 2018).

The significant amount of upcoming affordable housing construction will generate high carbon footprint, posing adverse environmental impacts. While, current affordable housing units have low electricity consumption, with rising incomes and comfort aspirations, energy use and associated costs in these houses is expected to rise. The housing sector lies at the intersection of the government's plan to meet both its sustainable development goals (SDG 7- Affordable and Clean Energy; SDG 11- Sustainable and Clean Cities) as well as climate change mitigation goals. Large-scale construction of affordable housing provides an opportunity to evaluate, demonstrate and build housing that also focuses on providing thermal comfort hence, minimising future energy and resource use, in line with India's climate change targets. Building thermally comfortable housing is also important from a resilience perspective. Urban poor are most vulnerable to climate change impacts such as increased temperature and urban heat island effects due to their lack of access to proper housing and common services. Building climate resilient housing will reduce these vulnerabilities from both a health and energy perspective (ACCCRN, 2013).

Status of PMAY (Urban) mission and its implications on energy demand

The Missions requires each state/ UT to understand and validate their housing demand by carrying out a demand survey. The estimated housing shortage of 18.76 million and the total Mission target of 20 Million was revised in 2017 to 10 million and 12 million respectively (MoHUA, 2017). As per the previous target of 20 million dwelling units by 2022, demand for 15.7 million dwelling units was confirmed by the states/ UTs. A total of 4317 cities (472 class I cities) were targeted to estimate the total housing demand. The data analysed includes information about dwelling units that have been sanctioned/constructed till December 2017 and indicates that the top 10 states constitute 88% of the total demand. Figure 1 shows the sanctioned stock in the states having maximum demand, which includes projects which are approved, but have yet not started construction. Approximately 3.8 million of the total 12 million housing stock has been sanctioned so far. Figure 2 shows the status of the top 10 states with maximum sanctioned stock and the respective construction status. While stock corresponding to 32% of the total housing demand is sanctioned, only 6% and 2% of the total required stock is under construction and constructed, indicating a significant amount of upcoming construction activity and consequent energy impacts for the country.

Figure 1: States having highest housing demand and its corresponding sanctioned stock

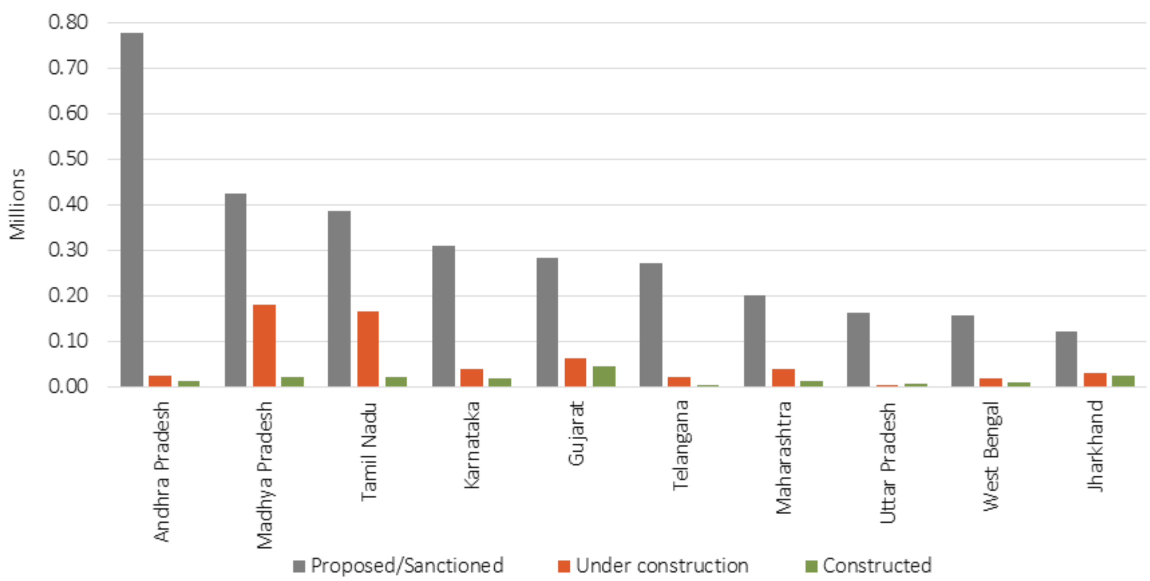

Figure 2: States having maximum number of stock sanctioned and its construction status

Embodied and operational energy impacts of design and construction

The large scale of construction of affordable housing as part of the mission will significantly add to the embodied and operational energy consumption from the residential sector. Embodied energy is the energy required for extraction, manufacture and transportation of building materials as well as the energy required for construction, maintenance, refurbishment and demolition. Operational energy is the energy required to maintain comfort by space cooling/ heating, lighting, and for running equipment and appliances operating at dwelling level and building level (common services).

The balance of embodied and operational energy in a building's lifecycle varies greatly. While a large part of the embodied energy of the building is during the construction phase and remains constant through the building's life, the operational energy continues to be added annually. In buildings that are expected to maintain internal comfort conditions through active space cooling or heating such as energy intensive air conditioning, the operational energy is significantly higher than the embodied energy. A study in 2011 (EDS, 2011) analysed the long-term energy impact of affordable housing to understand how embodied and operational energy is likely to change over a 20 year period for a typical low cost housing unit, depending on if the housing remains unconditioned or shifts to using air-conditioning. The results (figure 3) are based on simulation analysis of a typical affordable housing block in composite and warm and humid climate.

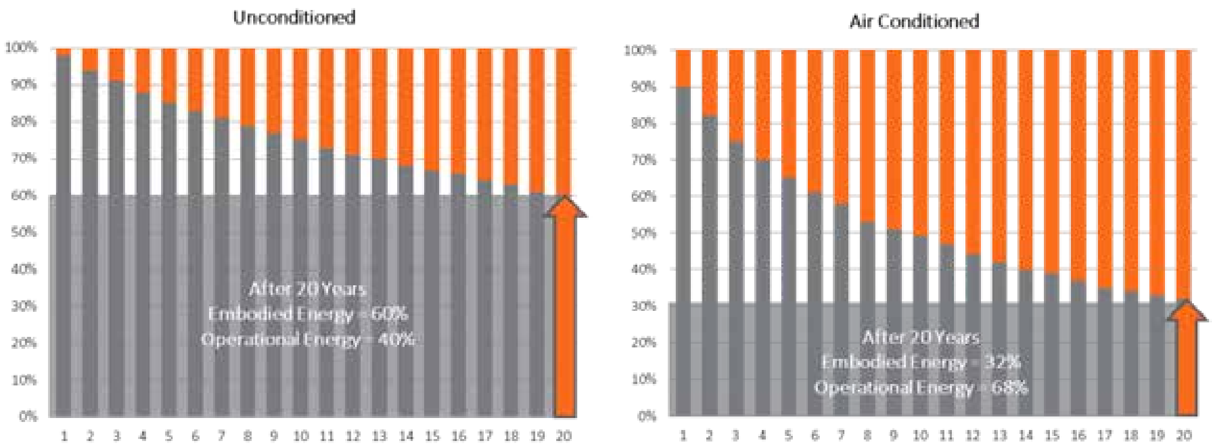

Figure 3: Embodied and Operational energy consumption pattern over 20 years (EDS, 2011)

Within the larger context of energy efficiency in the building sector and associated carbon emissions from the large scale construction expected due to urbanisation, it becomes important to account for strategies that can help in reducing embodied energy and operational energy in buildings without compromising the comfort levels. Building codes, energy regulations and other building rating systems majorly focus on reducing operational energy use and shifting to decarbonised electricity provision either through onsite or offsite generation; however, reduction of embodied energy has not been an explicit mandate due to inherent complexities in calculating it.

Key strategies to reduce embodied energy	Key strategies to reduce operational energy
• Balance between the thermal performance and embodied energy properties while selecting materials • Reduction in the use of high embodied energy materials - steel, glass, aluminium, or their replacement with materials • Replace materials which are used in larger quantities by mass (such as in walls) with lower embodied energy materials or with higher recycled content • Assess the design and construction technology/ structure for impact on embodied energy.	• Integrating passive cooling and daylight strategies at dwelling and building level to enhance comfort levels such as optimum cross ventilation, window shading, cool roof, building orientation and WWR • Integration of energy-efficient (star labelled appliances) at household level • Optimum building height to minimise common services operational energy and maintenance cost and enhanced RE integration potential • Targeting low life-cycle operational cost rather the low initial building cost for affordable operation and maintenance

Key findings

Affordable housing narrative is currently driven by the link between *income and built space provisions* and the *cost* of the dwelling unit, as the determining criteria of affordable housing. The scale of the challenge in meeting the affordable housing demand and the Mission targets necessitates that energy impacts of housing construction are evaluated to avoid lock-in of a large inefficient housing stock. Building to optimise energy use and provide thermally comfortable housing can significantly reduce the energy impacts from the affordable housing sector. Substantial research on thermally comfortable design and construction practices exists; however, it has not been mainstreamed into the policy and the development of housing projects. Most of these measures have no significant cost associated with them.

1 The mission has a diverse range of housing and project types and any one solution will not be universally applicable.

2 The rate of project approval and construction is slow. This provides a window of opportunity to incorporate thermal comfort criteria and energy optimisation strategies in the design and construction of affordable housing.

3 Mainstreaming energy optimisation requires a stronger link between research, practice and policy design.

4 A large proportion of the mission target is likely to be self-build housing. Innovative approaches are needed to mainstream energy optimisation in this segment.

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Alliance for an Energy Efficient Economy™

Saira Tower, 4th Floor, N-161A,
Gulmohar Enclave, Yusuf Sarai, New Delhi 110049
info@aeee.in | +91-11-40567344