IETP
India Energy Transformation Platform
Decarbonising India

Developing cost-effective and low-carbon options to meet India's space cooling demand in urban residential buildings through 2050

This IETP study has been carried out by Greentech Knowledge Solutions Pvt. Ltd (GKSPL); Energe-se Research and Consulting, and Centre for Advanced Research in Building Science & Energy (CARBSE), CEPT University.

GKSPL is a research and advisory firm which offers services and solutions for improving energy efficiency in buildings, improving resource efficiency in the production of building materials and deployment of decentralized renewable energy systems.(www.gkspl.in)

Energe-se is a development research and consultancy organization providing knowledge-centric solutions for scaling energy efficiency practices and low carbon development in the built environment. (www.energese.in)

Centre for Advanced Research in Building Science and Energy (CARBSE) at CEPT University, carries out in- depth research in the fields of energy efficient building design, energy efficient building construction processes, environment friendly construction materials and resource audit & management. (www.carbse.org)

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India Energy Transformation Platform (IETP) is a multi-stakeholder group of experts in the field of energy, technology and policy. The Platform identifies crucial developments and technology solutions to look at long-term pathways for decarbonising India's energy sector up to 2050. In its first year, the Platform identified four themes - decentralised energy systems, renewable energy technologies, industrial process heating and urban space cooling - to look at non-linear, transformational technology and policy solutions for decarbonising India.

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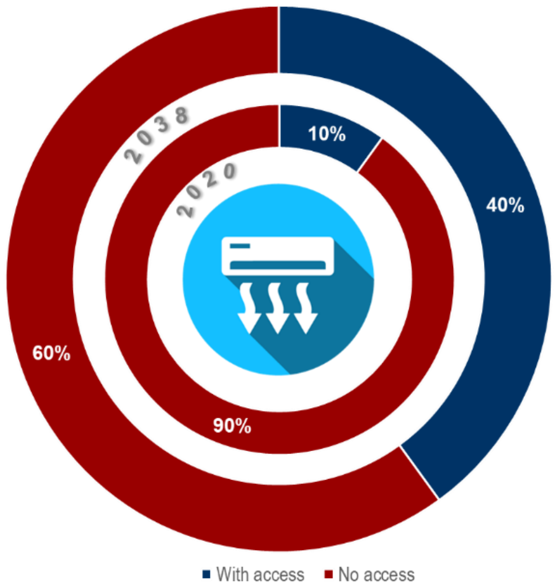
Executive Summary



Indian households with access to air-conditioning

There is a cooling access gap, which is not accounted for in long-term space cooling studies in India

Space cooling is the fastest growing energy use in buildings globally[1]. By 2050, 45% of India's peak electricity demand is expected to come from space cooling alone, of which a significant part is attributed to the adoption of room air conditioners in the residential sector[2]. Studies on calculating and reducing this cooling demand have mostly focussed on supply-side measures, specifically cooling technologies such as efficient room air-conditioners. However, this solution is limited to a segment of the population that has both reliable electricity access, and can also afford room air-conditioners.

Currently less than 10% of Indian households have access to air-conditioning. The India Cooling Action Plan estimates that this will increase to about 40% households by 2037-38. It does not specify how the thermal comfort requirements of the remaining 60% households are envisaged to be met. This reflects the *'cooling access gap'*, which is not accounted for in even long-term space cooling studies in India. The impact of overheating on health and productivity are widely known. Increasing heat waves and a warming world due to climate change will further exacerbate this divide amongst those who can, or cannot afford room air conditioners.

Optimising thermal comfort and well-being of occupants in residential buildings needs to be recognised as a development need in India, and should be incorporated in all housing policies particularly those concerning affordable housing. However, there has been no attempt at the policy-making level to visualize the quality of life and a decent standard of housing that would define this development paradigm.

Within this context, **this study assesses low-carbon and cost-effective solutions for enabling "*thermal comfort for all*" households, as a policy vision**. It recognises that in a residential building the cooling load primarily depends on the design and materials of the building envelope (external walls, roof and windows). This study includes the impact of both demand-side (building envelope optimisation) and supply-side (efficient cooling technologies) measures to meet the 2050 space cooling demand.

[1] IEA (2018). The Future of Cooling. International Energy Agency. Paris, France.

[2], MoEFCC (2019). India Cooling Action Plan. Ozone Cell, Ministry of Environment, Forest and Climate Change, Government of India, New Delhi.

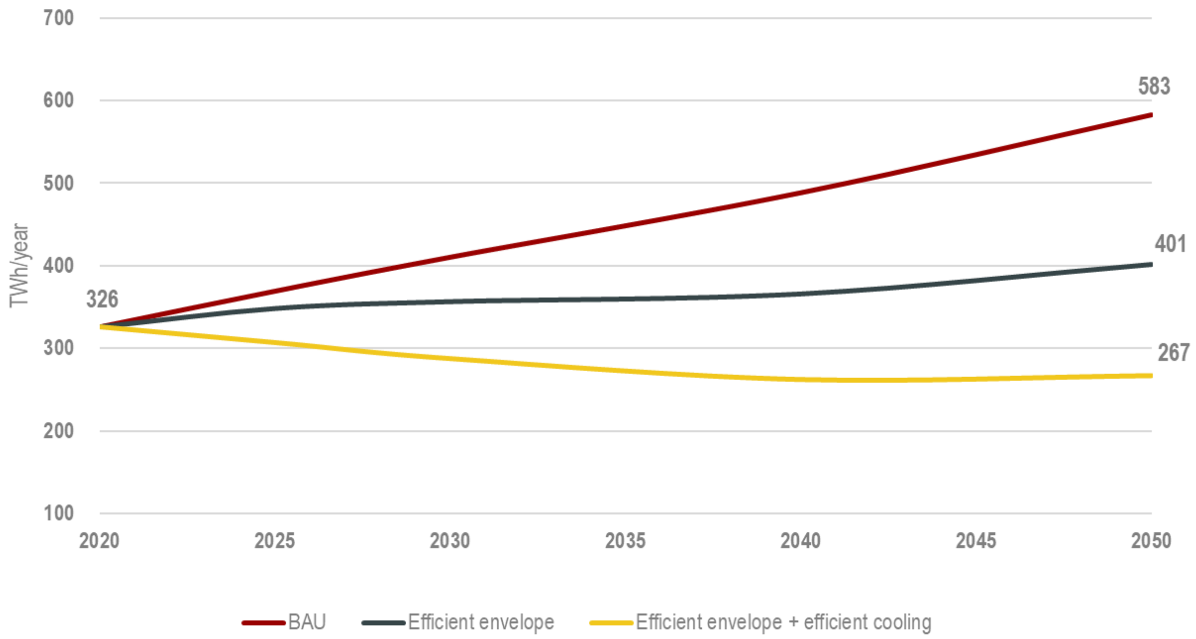
Granular, district-wise data on urban households and building stock, along with future population projections in India was used to develop a detailed bottom-up modelling framework. The results were then collated to estimate the cooling requirement and electricity demand at the state, climate zone, and country levels for the 2020-2050 period.

- The cooling electricity demand for providing thermal comfort for all in urban residential buildings is estimated at 326 TWh/year for the year 2020, which is almost 3.5 times the current electricity consumption for room air conditioners (around 90 TWh/year). This represents the currently existing cooling access gap.

- The energy-use and cost-benefit analyses show that significant reduction of 40-50% in discomfort degree hours[3] is possible (in different climate zones) by using appropriate building envelope materials and components, as compared to business as usual building envelope construction materials. This means that buildings can maintain thermally comfortable conditions in the cooling season for a much longer time period without relying on cooling technologies.

- In the *deep-cut* scenario, 30% reduction in cooling energy requirements is possible through use of efficient envelope measures alone. This reduction can save almost 190 TWh/year of electricity in 2050. The savings increase to around 316 TWh/year or 54%, if both efficient envelope measures along with efficient cooling technologies are given priority. This represents a considerably higher potential of savings as compared to studies where only efficient cooling technology options are considered.

Cooling energy demand (TWh/year) in urban residential buildings for providing thermal comfort for all



[3] *Discomfort Degree Hour (DDH)* is calculated for naturally ventilated spaces for the cooling period based on the Indian model for adaptive thermal comfort (IMAC).

Even though potential benefits of efficient building envelope are largely accepted, there has been a lack of quantification of the long-term benefits of this solution. Furthermore, due to challenges with implementation of building energy codes in India in the last decade, space-cooling policy focus has been on efficient cooling technology solutions instead of improving building envelope. The analysis in this study highlights two key reasons for this and suggests how these can be addressed.

Firstly, efficient building envelope measures comprise of both passive design measures such as orientation, window design, etc. as well as the use of efficient building materials and components. Passive design measures are considered to be subjective and difficult to regulate. A greater focus on mainstreaming the use of efficient building materials and components (low-density bricks, roof insulation systems, window shading systems, etc.) or in other words building envelope technologies can help in minimising the perceived implementation challenges for efficient building envelopes.

Additionally, building energy initiatives in India need to respond to India's unique context due to the large-scale, rapid urbanization-led construction, and a cooling-focused climate. These present a multitude of challenges with no precedence (in the largely heating-dominated climate of developed countries) in terms of policy implementation as well as the scale of the problem. Globally, building energy efficiency initiatives have been led by top-down mandatory public policies such as building energy codes, followed by a few and more recent market-based instruments such as incentives for building materials or financing programmes for retrofitting. However, in India, markets have been stronger in ushering energy efficiency innovations and system changes. Within market-based instruments also, building-level approaches such as building certification and labelling programmes have had limited impact in India, while, product-level market transformation for energy-efficient technologies (household appliances and more recently LED lamps), has been more successful. It is hence, recommended that market-based instruments for building materials and products are explored for accelerating the use of efficient building envelope technologies.

Key recommendations:

- *Mainstream "thermal comfort for all" as key criteria in affordable housing and space cooling policies*
- *Develop market transformation programmes to ensure adoption of commercially available efficient building materials and products*
- *Focused industry-led R&D initiative for next generation energy-efficient building envelope technologies*

The analysis in this report is based on efficient building envelope solutions such as Autoclaved Aerated Concrete (AAC) and hollow clay blocks, insulation materials, external movable shading systems and double-glazed windows, which are already available in the Indian market but need thoughtful policy support to be mainstreamed.

This, combined with a focused industry-led R&D initiative for next generation energy-efficient building envelope technologies such as smart windows, radiative cooling film, aerogel insulation, especially for retrofitting purposes (which has been evaluated for the first time in India's context), has the potential to transform the residential buildings sector with thermal comfort as a key indicator of housing design and construction quality.

The analysis clearly shows that meeting India's space cooling demand from urban residential buildings in 2050 requires accelerating the use of efficient building envelope technologies. Without it, the trajectory of meeting the cooling needs of India's population in 2050 will be highly energy and carbon intensive, while access to thermal comfort will remain limited to only part of the population that can afford cooling technologies.

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