THERMAL COMFORT FOR ALL

Sustainable and Smart Space Cooling

Average temperatures across India have risen by more than 0.5°C in 1960-2009, with statistically significant increases in heat waves.

A recent study indicates that even moderate increases in mean temperatures from climate warming may cause great increases in heat-related mortality.

-Mazdiyasni et al., 2017

MULTIPLE DRIVERS UNDERSCORE THE NEED FOR SUSTAINABLE & SMART SPACE COOLING

HUMAN FACTORS
- Health and well-being
- Basic thermal comfort

GLOBAL COMMITMENTS
- COP21
- Montreal Protocol
- Sustainable Development Goals

NATIONAL INITIATIVES
- Power for All
- Housing for All
- Smart Cities

INDIA'S SPACE COOLING CONUNDRUM

India, with a population of 1.3 billion, national average cooling degree days (CDD) of approximately 3100, and a room air-conditioner (AC) penetration of less than 10%, is very vulnerable to the impacts of rising and extreme temperatures. Casualties due to extremely hot days often make news headlines in the summer months. This lays down the context for the overwhelming need for space cooling in India. The challenge for India is two-fold:

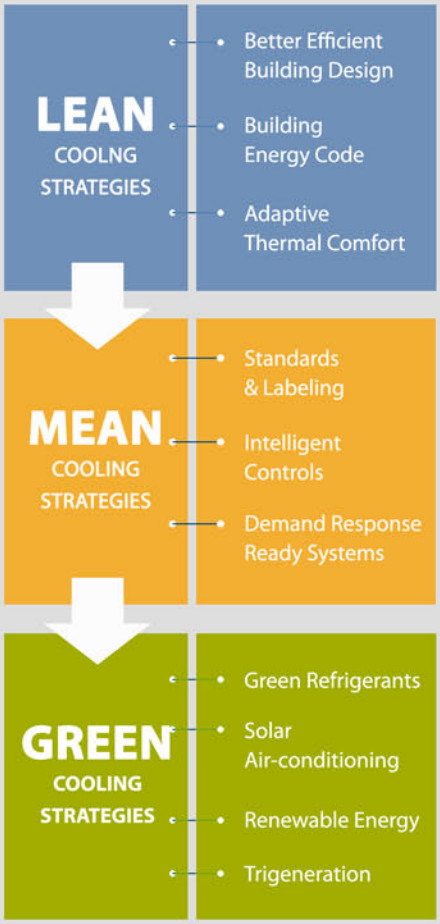
- A significant portion of the population has limited means or access to active space cooling. How does one provide thermal comfort to this stratum in an affordable manner, and uphold basic standards of well-being?
- India is at the cusp of an exponential growth in the air-conditioner market. Under a business as usual scenario, room AC penetration is expected to add approximately 150 GW to the peak demand by 2030, that is, nearly 30% of the total system load. This poses severe adverse impacts: significant additional power generation capacity, peak load impacts, and an enormous greenhouse gas footprint both direct, through refrigerants, and indirect, through electricity use. Notably, it also creates indefensible social inequity emerging from the asymmetrically distributed impacts of summertime power outages which deny even the basic thermal comfort available through fans to those sections of society that contribute least to AC-related peak demand.

MULTIPLE DRIVERS UNDERSCORE THE URGENCY

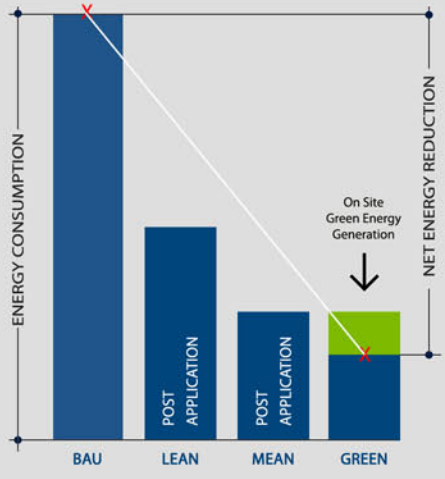
Indoor thermal comfort affects the physiological and psychological well-being and productivity of occupants under normal conditions and their health in extremely hot conditions (Shaikh et al., 2014). It is more imperative now than ever before to position thermal comfort as a basic human right available to all strata of society.

The criticality of addressing India's space cooling challenge cannot be overstated, particularly against the backdrop of recent international climate change agreements. First is the Paris Agreement (2015) wherein India, through its Nationally Determined Contribution (NDC), has committed to significantly reduce its emissions intensity. Second is the Kigali Amendment to the Montreal Protocol (2016) wherein India has committed to stop production of and freeze use of hydrofluorocarbons (HFCs) by 2028.

Per latest research, utilising a range of space cooling strategies has the potential



Typical Lean-Mean-Green space cooling strategies



Potential energy savings from a sequential Lean-Mean-Green approach

to reduce electricity used for space cooling in India by at least 50% by year 2030. This would save nearly INR 6,70,000 crore through avoided capacity (Kumar, 2016). This is a substantial outcome!

The reduced power demand and greenhouse gas emissions will contribute meaningfully to India's NDC goals as well as the HFC mitigation targets. The direct and indirect benefits also support several of the Sustainable Development Goals. Furthermore, the benefits align well with, and support the objectives of, key national initiatives undertaken by the Government of India, such as: Power for All, Housing for All, and Smart Cities, an initiative under Mission Innovation.

Recognizing the pressing need, and the urgency to act now, Alliance for an Energy Efficient Economy (AEEE), with support from Shakti Sustainable Energy Foundation (SSEF), took the initiative to bring together 12 research and academic institutions, industry associations, and not-for-profit organisations, to form the Sustainable and Smart Space Cooling Coalition in 2016. The Coalition's mission is to lead India's transition to a responsibly cooled built environment by advancing research and policy recommendations, and enabling market transformation.

As one of the initial tasks, the Coalition members have jointly prepared a report titled Thermal Comfort for All: Sustainable and Smart Space Cooling Strategies (TCA Report). The report has a twofold intent: (1) To bring together dispersed sustainable and smart space cooling strategies, as well as the independent initiatives from the government and the private sector; and (2) To propose a set of recommendations designed to promote the vision of thermal comfort for all through the use of energy efficient and environmentally sustainable cooling strategies and technologies.

LEAN - MEAN - GREEN: A HIERARCHICAL APPROACH TO SPACE COOLING

Foundational to the Coalition's space cooling approach is the Lean-Mean-Green construct popularised by building scientist Bill Bordass (Bordass et al., 2001). A hierarchical approach, Lean-Mean-Green as it applies to smart space cooling strategies advocates:

LEAN: First, reduce the cooling load by incorporating efficient building design and construction.

MEAN: Next, optimise energy use through energy efficient measures and efficient performance standards for appliances.

GREEN: Finally, reduce the carbon footprint to the extent possible through use of clean energy and low global warming potential (GWP) technologies.

For India, where the overall penetration of active space cooling technologies is modest, we believe that the biggest impact on addressing the space cooling needs will be through incorporating the lean cooling methods into building design and construction, and this impact can be leveraged most effectively during new construction! By utilising a combination of lean methods, energy efficient building design and construction, adoption of building energy code, and adaptive thermal comfort, the total energy

consumption of a new building could be reduced as significantly as up to 50% (Bordass et. al., 2001). It is imperative, and highly beneficial, to transfer this energy reduction through lean building approach to India's expanding future building stock.

The TCA Report elaborates on the various cooling strategies organised under the Lean - Mean - Green approaches respectively. It also discussing the current body of knowledge, potential challenges, and the wide-ranging benefits including indoor thermal comfort to a larger section of the Indian population, decreased energy consumption and peak demands, reduced stress on the grid, enhanced energy security, and reduction in carbon emissions.

India has a housing shortage of 1.9 crore units and 96% of it comprises the economically weaker sections of the society. In the wake of this housing crisis, the Government of India has announced its ambitious plan to provided 'Housing for All by 2020'. It is important to be mindful that this section of the Indian people will not have access to active air conditioning. Amid this discussion, now is the critical window to adopt and mainstream the Lean cooling strategies to make space cooling both sustainable and affordable in the upcoming housing stock.

CASE SUDY 1: ARANYA BHAWAN, JAIPUR

Aranya Bhawan, the 14,000 m^2 new office building of the Rajasthan Forest Department in Jaipur, applied the Lean-Mean-Green cooling strategy to enhance thermal comfort and reduce cooling demand. A combination of roof and wall insulation, low glazing ratio and double-glazed window reduced the cooling system size by 28%. This was met by a water-cooled energy efficient chiller. The building is supported by a 45 kW_p grid-connected rooftop solar PV. After applying all the measures, the EPI reduced from 77 kWh/m^2 to 43 kWh/m^2 with 44% energy saving (BEEP, 2016).

CASE STUDY 2: INFOSYS, HYDERABAD

Utilizing a combination of Lean-Men-Green building strategies, and an enterprise level approach to sustainability, Infosys has achieved enhanced human comfort, and significantly reduced the cooling load and environmental footprint of their building portfolio. The key outcomes (Infosys, 2017), using 2008 as the baseline year, are:

- 51% reduction in the average per capita energy consumption across their campuses; this is well over $100 Million savings in electricity bills.
- 53% reduction in air-conditioning load, without compromising on thermal comfort.
- 62% improvement in campus-wide building energy performance index.

Infosys incorporated several smart cooling strategies such as: radiant cooling, highly efficient building envelope, and high-efficiency HVAC system with smart automation. After retrofitting and re-engineering 31 chiller plants, Infosys has reduced the number of chiller plants from 54 to 41. The steps taken have freed up almost a third of the space that was previously occupied in the plant room. Retrofits in air conditioning systems have helped Infosys achieve about 15 MW connected load reduction in the last four years.

THE WAY FORWARD

A concerted effort is needed through government support, market enablement, and consumer awareness to bring about a transformative change to address India's escalating cooling energy demand. Listed below are the Coalition's recommendations to promote smart cooling strategies, overcome potential challenges and advance the vision of thermal comfort for all. For each of the recommendations, the TCA Report also identifies supporting actions and tactics that will help facilitate the requisite changes.

- Leverage ongoing government initiatives and integrate smart cooling strategies to maximize potential benefits
- Institute comprehensive legislation as a cornerstone to achieve a viable market for smart cooling
- Generate market momentum towards smart cooling through awareness campaigns, access to information and technical assistance
- Drive adoption of energy efficient building materials and equipment into mainstream through consistent testing and rating protocols, and market transformation strategies
- Undertake bold actions to phase out HFCs and drive the industry towards green refrigerants

CALL TO ACTION

The Coalition's drive for sustainable and smart space cooling is envisioned as, and would be most effective as, a component that is integrated within several of the ongoing government initiatives to maximise their potential benefits. For example, the energy efficient building design and construction strategies, energy conserving technologies, and clean energy alternatives proposed in this report would be very relevant to the following Government of India initiatives:

- Mission Innovation under which India will see growth of 109 smart cities that provide improved core infrastructure, enhanced quality of life to its citizens, and a clean and sustainable environment,
- Housing for All that is poised to build 2 crore houses for the economically weaker sections in urban areas by 2022,
- National Mission on Sustainable Habitat that envisages a framework to build urban resilience to climate change and
- National Mission for Enhanced Energy Efficiency that aims to strengthen the market for energy efficiency by conducive regulatory and policy regime and innovative business models.

The Coalition strongly believes that timely and bold interventions to adopt smart cooling strategies into the mainstream will lead us towards significant societal, national and environmental benefits. While the path to get there may be challenging, it is one that must be embraced with conviction. The Coalition has laid down the first steps, and urges the policy-making entities at the centre – such as Ministry of Power, Bureau of Energy Efficiency, Department of Science & Technology, Ministry of Environment, Forest & Climate Change, Ministry of Housing & Urban Poverty Alleviation, and Ministry of Urban Development – and relevant state level departments, to embrace the drive for *Thermal Comfort for All* and marshal their resources and policies to lead us towards this vision. In this drive, all the Coalition member organisations stand committed to offer any support per their respective areas of expertise.

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COALITION MEMBERS

SHAKTI SUSTAINABLE ENERGY FOUNDATION · CEPT UNIVERSITY · clasp · EEW · I.C.L.E.I Local Governments for Sustainability · NRDC NATURAL RESOURCES DEFENSE COUNCIL · Prayas (Energy Group) · fAIR CONDITIONING · SMART JOULES · Alliance for an Energy Efficient Economy

Contact us:

Saira Tower, 4th Floor, N-161A, Gulmohar Enclave, Yusuf Sarai, New Delhi - 110049

+91.11.40567344 | +91.11.46635600 | info@aeee.in | www.aeee.in |