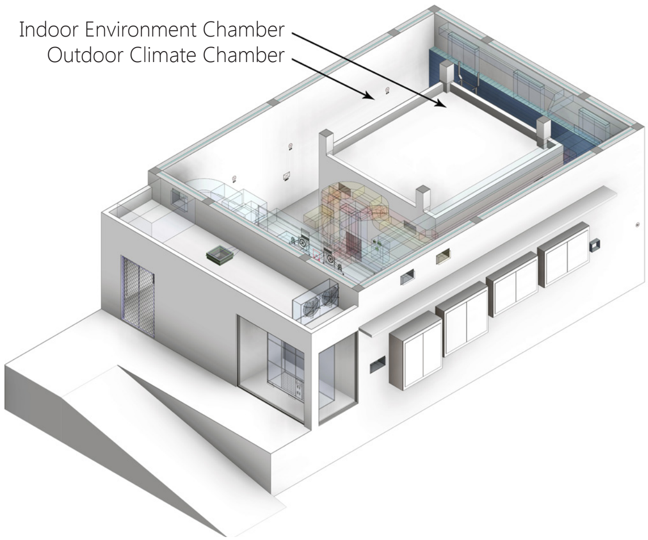
Driving Efficient Low Energy Cooling Technologies Assessment to Technology Tech-Transfer (Delta-T)

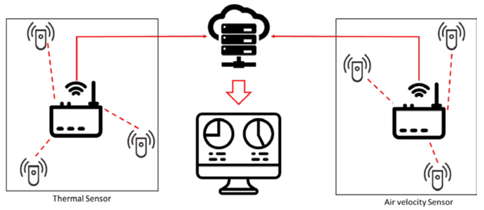
India, with a population of nearly 1.2 billion, is the world's third-largest greenhouse gas emitter. It has pledged to reduce carbon emission per unit of gross domestic product up to 35% by 2030 from the 2005 level. The building sector is experiencing unprecedented growth leading to higher energy consumption (Govt of India, 2015). India's electricity demand is expected to rise from 775 TWh in 2012 to 2499 TWh by 2030. Estimates by National Institution for Transforming India (NITI Aayog) indicate that the mitigation activities for moderate low carbon development would cost India around USD 834 billion till 2030 at 2011 prices (de Dear, Leow, & Foo, 1991). With an increase in affordability and power supply, the future shall see a steep rise in demand for air conditioning. By 2030, 60% of commercial space and 40% of residential households in India are expected to be air-conditioned. The space cooling systems adopted in developing nations like India have a great impact on the economy as well greenhouse gas emissions.

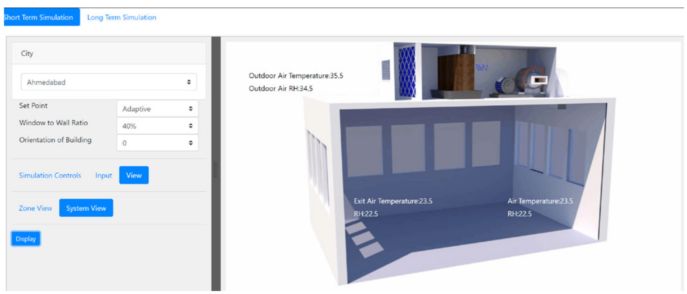
The ISO and ASHRAE thermal comfort standards are used to design space conditioning systems, where the systems operate at 22.5 ± 1°C. The ASHRAE 55-2010 standard includes an adaptive thermal comfort model to differentiate the thermal response of occupants in air-conditioned and naturally ventilated buildings. However, until now there has been a lack of a contextual model for adaptive thermal comfort for India, even though a large proportion of existing as well as new buildings are either fully naturally ventilated or use natural ventilation for most of the year, supplemented by air-conditioning.



Aims

- Quantify the energy-saving potential of smart low energy cooling systems.
- Identify opportunities and develop cost-effective scalable energy & environment monitoring sensing and controls systems to integrate with LEC system to enhance performance.
- Develop effective communication tools to work with existing energy models





Methodology

The project has worked in three distinct but symbiotic activities.

Activity A (Field measurements):

To evaluate the energy and thermal comfort performance of low energy cooled buildings, year-round monitoring was carried out in six buildings.

In each building, instruments were installed to log and monitor the end-use of energy consumption, outdoor weather condition, supply air temperature, relative humidity, and air velocity of low energy cooling system and. Indoor environmental parameters every hour.

Three times in a year 'Right now, Right Here' surveys were conducted to analyze the thermal sensation, thermal and air velocity preference, and thermal acceptability of occupants

Activity B (Laboratory experiment):

This activity used thermal comfort experiments with a thermal manikin and low energy cooling to investigate the relationship between cooling and comfort. Researchers developed affordable sensors and control systems to increase the effectiveness of low energy cooling systems. Thermal manikin provides detailed modelling of human behaviour as well as comfort experiences (including skin temperatures) by humans at various positions in the body. India model of adaptive thermal comfort and ASHRAE defined comfort bands are used to determine initial indoor conditions.

Activity C (Dashboard development):

The tool reads key design inputs from the users and outputs visualization and performance information of low energy cooling systems using "EnergyPlus" (a building energy simulation tool) to generate necessary performance outputs for the visualization screen. The data generated is interpreted on the dashboard by displaying detailed performance parameters of low energy cooling systems such as temperature (°C), relative humidity (%), Electricity (W) at selected time steps for a better understanding of system design.

Outcome

Activity A:

As a part of the activity, researchers developed a low cost and highly accurate indoor environment monitoring system (MAPIE). MAPIE system has the potential to be used for academic purposes.

Activity B:

This activity developed an operational protocol and algorithm for low energy cooling using laboratory experiments. Two mixed-mode control algorithms based on thermal balance were developed.

A Low Energy Cooling Test Bed (LECTB) was constructed. LECTB comprises two chambers – an indoor environment chamber and an outdoor climate chamber. The outdoor climate chamber is capable of replicating outdoor weather conditions for low energy cooling systems and an indoor chamber replicates indoor space conditions. The chambers are designed for easy replacement of the low energy cooling systems to be tested.

Activity C:

This activity was focused on developing a Low Energy Cooling Dashboard that helps architects, engineers and other stakeholders to understand the functioning of five selected low energy cooling systems. The tool reads key design inputs from the users and outputs visualization and performance information of low energy cooling systems.

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