Cooling Initiatives Carried out in India by the Sustainable and Smart Space Cooling Coalition Members

Alliance for an Energy Efficient Economy (AEEE)

Sustainable and Smart Cooling – Towards A Low-Carbon Pathway for Cooling India

AEEE's vision is to lead the drive towards sustainable and smart cooling strategies that enable thermal comfort for all as a social imperative, while minimizing/avoiding the adverse environmental impacts.

In 2016, AEEE spearheaded the formation of the Sustainable and Smart Space Cooling Coalition (SSSCC), a confluence of research, academic and industry organizations, with a mission to lead India's transition to a responsibly cooled built environment by advancing research and policy recommendations and enabling market transformation. The Coalition prepared Thermal Comfort for All that aggregated current body of knowledge on space cooling under the 'Lean, Mean and Green' – a hierarchical approach to space cooling.

In Phase two, AEEE is undertaking a deep exploration of the techno-economic feasibility of low-energy cooling technologies in Indian conditions; accessing the opportunities and challenges in designing an overarching window labelling programme for India.

AEEE has also undertaken holistic analysis of national cooling demand and refrigerant demand across different sectors by 2027; AEEE has assessed direct and indirect emissions impact (in CO^2 equivalent); proposed recommendations in the form of a policy brief for the government and key stakeholders.

AEEE is mapping the impact of adaptive thermal comfort standards on air conditioning usage patterns. Psychometric field tests of RACs were conducted to study their energy performance at different set-points. The nation-wide survey premised on the knowledge gap of people's RAC use preferences, especially set-points.

AEEE is carrying out a scoping study to develop baseline and low carbon scenarios for affordable housing, with a focus on providing thermal comfort.

CLASP

Building India's Standards & Labeling Program

Since 2001, CLASP has supported the government of India and India's Bureau of Energy Efficiency (BEE), to build, strengthen, and accelerate India's appliance energy efficiency policies. CLASP worked with BEE to develop India's very first voluntary policies for air conditioners and refrigerators, implemented in 2007.

Since that time, India's standards and labelling program has grown tremendously, increasing the number of covered products and the stringency of existing energy performance requirements.

Keeping India Cool

Electricity use from air-conditioning is projected to rise dramatically in India – from 48 TWh electricity in 2015 to 313 TWh electricity by 2029. In 2015, BEE began an ambitious effort to develop energy efficiency policy roadmaps for nearly every type of residential and commercial space cooling product on the market. Additionally, policies for chillers central AC units for large commercial spaces – will avoid an estimated 27.12 Mt of CO2 in 2020, with a potential 40% improvement in energy consumption.

With support from CLASP, BEE will soon revise energy standards for ceiling fans. The current five-star rating for India's energy label is expected to be the new one-star rating, increasing efficiency by about 25%.

The Council on Energy, Environment and Water's (CEEW)

Research on cooling and HFCs in India

CEEW has been undertaking research on HFCs in India since 2012. CEEW's approach hinges on two important pillars:

- Original research: CEEW has been leading intellectual research on issues around HFCs in India. Over the last five years, CEEW has published pioneering research on several HFC-related issues including making a business case for phasing down HFCs, modeling India's long-term HFC emissions, calculating the mitigation potential and associated costs to the economy in transitioning away from HFCs, evaluating the skill gap in the air-conditioning sector, developing an R&D platform, among several others. CEEW is currently researching and analyzing incentives and regulatory approaches to phase-down HFCs in India.

- Continuous stakeholder engagement: CEEW has good networks with industry and service sector stakeholders, government as well civil society within and outside of India, contributing to the global debate on HFCs. CEEW has organized and hosted over fifteen events in the past years dedicated to various aspects of HFC phase-down and cooling in India, in addition to participating in track-II dialogues, and convening regular bilateral meetings with representatives of Indian industry, Government and civil society.

These efforts have resulted in CEEW being tasked as an expert by the Ministry of Environment, Forest and Climate Change to develop India's National Action Cooling Plan (NCAP). CEEW will be leading and participating in various working groups that will constitute the NCAP, including the service sector, R&D and overall strategy working group.

Centre for Advanced Research in Building Science and Energy (CARBSE), CEPT University, Ahmedabad

Thermal Comfort – Space Cooling

CARBSE carries out in depth research in the fields of energy efficient buildings design, thermal comfort and cooling, energy efficient building construction process, environment friendly construction materials and resource audit & management.

CARBSE's activities:

Development of India specific adaptive thermal comfort models: The trend observed in India was to design AC office buildings (that often operate at 22.5 ± 1 °C all year round) to meet the stringent "Class A" comfort specifications articulated in documents such as ISO 2005 and ASHRAE 55 for AC buildings. The 'IMAC 2014' model was developed from the data collected over four survey campaigns in office buildings conducted over a period of one year. These surveys were administered in naturally ventilated, mixed-mode and AC buildings in five cities from different climate zones of India during three distinct seasons.

Global Innovation Initiative: Aim of project was to achieve a better understanding of human thermal comfort in residential and commercial buildings. Also, to explore opportunities for reducing energy demand through natural ventilation, mixed mode practices and other low energy techniques that provide air movement.

Driving Efficient Low Energy Cooling Technologies Assessment to Technology Tech-Transfer, Delta- T: Three key aims of the project (1) Quantify energy saving potential of smart low energy cooling systems. (2) Identify opportunities and develop cost effective scalable energy & environment monitoring sensing and controls systems to integrate with LEC system to enhance performance. (3) Develop effective communication tool to work with existing energy models for LEC system design development. A state of art Low Energy Cooling testbed design and construction is key highlight of this project.

Low Energy Cooling and Ventilation for Indian Residences, LECaVIR: The project focuses on developing building designs comprising low energy cooling and ventilation technologies that employ smart self-learning control algorithms. For each climatic zone in India, the project will quantify the period of the year (or day) for which NV is feasible. For other periods such as hot, humid periods, MM solutions, using a combination of NV, low energy cooling and AC systems will be developed and tested. There is significant scope within this project to work with technologies which are more energy efficient and which use fewer GWP chemicals or eliminate their use altogether.

Fairconditioning

Academic Curricula Integration Project: The project deeply embeds skills related to working with sustainable cooling technologies (for engineering academia) and efficient building design centered around building physics and relevant sustainable cooling principles (for architecture academia) through a capacity building and change-management program designed to enhance sustainable design pedagogy skills amongst professors, facilitate

activity-based learning process amongst students, as well as accomplish seamless syllabus integration of built-space and HVAC sustainability and efficiency into official University-defined curricula. It informs the entire five-year Undergraduate Architecture Curricula spanning architectural history, theory, design and technical subjects and the HVAC course of Mechanical Engineering Programs. Policy goals include creating an evidence base for robust curricula-integration strategies to influence the BEE policy to include ECBC related materials into Undergraduate Architecture Curricula, and integration into professional development requirements determined by All India Council of Technical Education (AICTE) and Council of Architecture (COA).

Professional Ecosystem Support Project: This project provides comprehensive knowledge, tool support and design-process-transformation support to professional architecture and HVAC consultant firms so that 50%-more efficient than Business-As-Usual buildings emerge by default. The idea leads to energy efficiency and sustainable cooling becoming elemental concerns for every building designed, congruent with the unsparing attention given to structural and fire safety in all buildings. The project also engenders culture shifts in professional design firms through organizational behaviour change workshops and 'nudging tools' that help deconstruct barriers to change. Policy goals include embedding sustainable cooling related skills into professional licensing requirements for Indian Architects and HVAC Engineers, and into formal training of green building consultants aligned with major certification systems (LEED, IGBC, GRIHA).

ICLEI

ICLEI - Local Governments for Sustainability is a leading association of more than 1000 metropolises, cities, urban regions and towns across the world. ICLEI South Asia- the South Asian arm of ICLEI, with a membership base of around 70 cities, works with cities through funding support from national and international partners on agendas that include building low-carbon, resilient, resource efficient, eco-mobile, biodiverse and smart cities, among others.

Cooling Initiatives of ICLEI South Asia: In its work in the Energy and Climate domain, ICLEI South Asia offers technical support to South Asian cities to prepare city-level strategy documents and actions plans, which includes assessing sectoral energy and carbon baselines, identifying interventions to reduce energy use, establishing targets, and recommending financing and MRV arrangements. ICLEI has supported over 15 cities in the preparation of Solar Master Plans under the Government of India's Solar Cities Programme. Given its prominence in urban energy use, cooling is an important area addressed in such activities on action planning.

ICLEI is currently partnering with UN Environment on the 'District Energy in Cities' Initiative, working with five Indian cities (Bhopal, Coimbatore, Pune, Rajkot and Thane) to help unlock the market for district energy systems, in particular district cooling. Five city rapid assessments of district cooling techno-economic potential, benefits, and the policies and actions that cities and national government could use to support the realisation of district cooling projects have been undertaken from 2016 onwards. Feasibility assessments for potential district cooling projects have been conducted at real estate sites identified across the five cities. In late-2017, the Initiative has selected Thane as a pilot city for further

activities to support delivery of a commercially-viable district cooling project. Activities in Thane include detailed feasibility study, continuous monitoring of cooling demand in selected buildings, stakeholder engagement, training, preparation of long-terms strategy and ready-to-market district cooling project proposal. Key partners include Energy Efficiency Services Limited, International Finance Corporation, Copenhagen Centre on Energy Efficiency, Empower, Danfoss, Thermax, Carbon Trust among others.

The Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE)

Over past few years, ISHRAE has taken up the task of development of India specific standards as one major area of focus.

ISHRAE's Approach:

- ISHRAE has a standing sub-committee for Standards.
- Work in coordination with Nodal Agencies such as BIS for easy adoption and implementation of standards
- Rather than re-inventing the wheel, taking help from existing standards including ISO, AHRI, EN, BIS and others

Following standards have been developed by ISHRAE taking all major stakeholders along in the development process:

1. standard for liquid-chilling packages using the vapour compression cycle
    - It is a standard rating and performance standard
    - It has defined new set of rating and performance testing conditions (temperature, part load weightages, and fouling conditions) for air cooled as well as water cooled chillers that are more relevant for India.

2. Indoor Environment Quality Standard
    - The standard was developed by ISHRAE, involving experts from different important stakeholder groups, i.e. manufacturers, consultants, academia and test houses
    - The standard includes four major areas: Thermal comfort, Indoor Air Quality, lighting and Acoustics
    - It is a performance based standard and is not specifying use of any particular technique or technology.
    - It includes considerations related to India specific conditions and preferences together with maintaining parity with International standards, through specifying threshold values at three different levels: Class A, Class B and Class C; where class C corresponds to India specific considerations and Class A is at par with International level.

ISHRAE has also developed guidelines on safe and responsible use of refrigerants in HVAC &R.

Malaviya National Institute of Technology (MNIT), Jaipur

MNIT is actively involved with following related to smart cooling:

1. Imparting high quality postgraduate and doctoral level education in the field of energy efficient cooling, sustainability and other related topics.
2. Development of codes and standards related to testing and performance rating of HVAC equipment
3. Assistance to nodal government agencies such as BEE for development of codes, ratings, and implementation of their programs.
4. Pilot and demonstration of new technologies and techniques

Infrastructure:

1. Flexible HVAC lab having capacity to experiment with different low aide and high side configuration including DOAS, Energy recovery wheels, thermal storage, water side economiser through radiant cooling system.
2. Database of more than 8000 thermal comfort surveys collected through measurement and occupant survey in field.
3. Energy audit equipment

Major contributions and ongoing work:

1. Contribution to Indian Chiller Standard, Indian VRF Standard, Indian IEQ Standard, working on Indian AHU Standard and Simulation Standard
2. Conducted more than 50 training programs related to energy efficiency in buildings, green buildings
3. Developed Case Study of ECBC Implementation at one building at MNIT Campus, that is being used for dissemination of knowledge about ECBC, other case study is under development.
4. Design guide using passive features such as earth air tunnels, solar chimney, thermal mass
5. Revision of thermal comfort polygon for Indian conditions including high air velocity conditions
6. Revision of Givoni's Building Bio-Climatic Design Charts
7. Design guide for radiant cooling systems and DOAS

Natural Resources Defense Council (NRDC)

NRDC is engaging extensively with air conditioning companies, manufacturers, government officials, experts, partner organizations like TERI, IGSD, AEEE and various other key stakeholders to produce research and policy papers that examines strategies to increase the market share of climate-friendly, energy efficient and affordable cooling solutions. Particularly, room ACs that are both energy efficient, use climate-safe refrigerants and are affordable. The aim is to also help lay down possible post Kigali recommendations and pathways for India. NRDC has also recently begun supporting pilots in cooling technology innovations and strategies whether active or passive. For example, NRDC supported cool roof pilots in low income communities in Ahmedabad and Hyderabad to demonstrate the opportunity in providing affordable cooling as well as thermal comfort for all with the added benefit of reducing cooling energy demand.

In the building energy efficiency work area, ASCI, IIIT Hyderabad and NRDC along with support from advisors at AEEE and BEE are helping guide the implementation of the mandatory Telangana state ECBC codes system. It's India's first mandatory online ECBC compliance system and has been launched in Hyderabad in December 2017, valid from January 2018. The online system has been developed after significant deliberations and stakeholder consultations resulting in a consensus on the compliance framework, making it a model ripe for replication in other cities in Telangana as well as the rest of the country.

Prayas

Summary of Prayas (Energy Group)'s activities on improving efficiency of providing thermal comfort in India[1]: Prayas (Energy Group) is a not-for-profit organization working in India's energy sector for more than 25 years. Our activities cover research and intervention in policy and regulatory areas, as well as training, awareness, and support to civil society groups. We are a part of various expert committees convened by ministries, the NITI Aayog, and several State Electricity Regulatory Commissions including that of Maharashtra. For more: http://www.prayaspune.org/peg/

We have adopted a two-pronged strategy towards improving efficiency of providing thermal comfort in India. The first prong is a top-down approach to facilitate market transformation of appliances providing thermal comfort. One focus appliance is ceiling fan. About 300 million ceiling fans are in use contributing to 20% of India's residential electricity consumption and 30 million more are bought annually. We have been advocating the idea of super-efficient fans which consume less than half of the conventional fan. We collaborated with the Bureau of Energy Efficiency (BEE) and the World Bank to develop a market transformation programme for these fans. The programme was not launched but today atleast 3 new companies are selling super-efficient fans and most of the major ones are ready with a product. As a member of BEE's technical committee meeting, we are now advocating for stricter efficiency standards for ceiling fans.

The second prong of our strategy is a bottom-up approach to address a critical gap on data and research on India's residential electricity demand including that towards thermal comfort. We started with a comprehensive review of existing literature and data available on India's residential electricity consumption. Our next steps involve large scale surveys to gather data on appliance ownership and consumption patterns. This data will be triangulated by measuring actual consumption of smaller sample of households and devices using GSM enabled smart meters. Better data and better understanding of consumption patterns can inform various models and projection scenarios as well as enable better designing of programmes to improve efficiency.

Selected Publications:

1. Ceiling fans: The overlooked appliance. Available on: http://www.prayaspune.org/peg/publications/item/81.html
2. A Guidebook on Super-Efficient Equipment Programme. Available on: http://www.prayaspune.org/peg/publications/item/241.html

[1] These are past and on-going activities conducted under various projects by Prayas (Energy Group)

3. Residential Electricity Consumption in India: What do we know? Available on: http://www.prayaspune.org/peg/publications/item/331.html

Smart Joules

Smart Joules intersects with sustainable cooling in three ways:

1. Buyer of sustainable cooling technologies: Smart Joules is one of the leadings ESCOs in the commercial buildings sector in India, having executed multiple comprehensive efficiency retrofits on a Pay-As-You-Save basis across India. In this role, Smart Joules acts as an intelligent buyer and user of sustainable cooling technologies, since the role requires design, execution, financing and maintenance of technology and operations-related improvements. The company has generated more than 50% savings in centrally cooled systems and has been recognized with multiple national energy conservation awards.

2. Developer of sustainable cooling technology: Smart Joules has a full team dedicated to design, development and deployment of a complete, continuous, data-based building energy optimization system. This low-cost and high-performance system collects data on cooling demands and system performance, and generates and executes control commands in real time to optimize overall system performance.

3. As a passionate and curious thought- and action-based collaborator on potentially high-impact initiatives: Smart Joules collaborates with leading governmental, non-governmental, for-profit and non-profit organizations to envision, catalyze and put into action solutions that could bring about systemic change in the way people sustain thermal comfort. Examples include presenting reports to the Ministry of Power, NITI Aayog and BEE as part of the Hon'ble Prime Minister's Champions of Change initiative, envisioning and hosting the 'Deconstructing Construction' dialogue series along-with cBalance / Fair-conditioning to bring together young real estate developers and sustainable cooling technology and financing leaders, working with AEEE to envision and start 'Deal Days' between technology suppliers and end-users, and others.