सत्यमेव जयते
Ministry of Science and Technology
Government of India

Mission Innovation
Affordable Heating & Cooling of Buildings
IC#7 Country Workshop

Mission Innovation Challenge IC# 7 "Affordable Heating & Cooling of Buildings"

Workshop Date: August 01st, 2017

Venue: India Habitat Centre, New Delhi

Conference Report

1. Introduction

Mission Innovation (MI) is a global initiative of 22 countries and the EU to accelerate clean energy innovation globally (http://mission-innovation.net/). MI has identified seven innovation challenges (ICs), out of which India is actively working on three challenges, one of them is Affordable heating and cooling of buildings called IC7.

Participants of MI-India Workshop on Affordable Heating & Cooling of Buildings

India is in early stage of activities pertaining to IC#7. Department of Science and Technology with assistance from CEPT University and Alliance for Energy Efficiency Economy (AEEE) organised a workshop on Aug 1, 2017 in New Delhi. Objective of workshop aimed to collate inputs from key stakeholders and build consensus on the priority research and development.

The framework and agenda of the workshop is enclosed as Annexure I. The list of participants is attached as Annexure-II.

This report summarise proceedings of workshop.

Objective of workshop: Create Awareness about Mission Innovation programme in general, about Innovation Challenge # 7 and discuss India's priorities in the area of "Affordable Heating and Cooling of Buildings" and Explore possibilities for India's R&D initiatives.

Brief on proceedings: Dr. Rajiv Sharma, Head, Tech. Mission Division, Dept. of Science and Technology, Government of India provided welcome note. He briefed on DST's programs to promote innovation in building sector. Mr. Ajay Bakre, Director General, Bureau of Energy Efficiency, Ministry of Power, and Government of India addressed gathering with his insightful inaugural address. He emphasised importance of energy efficiency to mitigate climate change. He provided overview of BEE's successes and programs. He emphasised need to connect government initiatives with industry and academia. Mr. Bakre explained about the Energy Conservation Building Code 2017 (ECBC 2017) and the Clean Energy Ministerial for accelerating the transition to clean energy.

He also mentioned about the synergies required between clean energy and energy efficiency. He demonstrated concern towards the following topics which were suggested to be discussed during workshop:

1. How to take activities to the state government agenda so that implementation takes place through the state government
2. Increase Transport vehicle (Metro and other public transport vehicles) energy efficiency and cabin comfort
3. Collaboration between academic institutes and industry to reduce the gap between research and industry application

Dr. Sanjay Bajpai, Adviser & Associate Head, Technology Development Mission, Dept. of Science and Technology, Government of India talked about DST's national and international programs. He deliberated about outcome based research and importance of consortia mode of research activities. Dr. Bajpai also mentioned about need for capacity building in area of built habitat and energy efficiency. Dr. Satish Kumar, Executive Director, Alliance for Energy Efficient Economy, provided framework for country report on 'Affordable Heating and Cooling'. He explained why India needs to focus on heating and cooling with such large population, climatic conditions and growing aspirations. He also mentioned about the current policies, missions and the national drivers for the same.

Mr. Rajan Rawal, CEPT University briefed participants about expected outcomes of workshop and provided format for breakout sessions. Workshop proceeded with breakout sessions. Concluding remarks were given by Dr. Renu Swarup, Senior Adviser, Dept. of Biotechnology, and Government of India. She described MI framework and India's plan to work on international level. Future Steps and Vote of Thanks was given by Dr. JBV Reddy, Technology Mission Division, Dept. of Science and Technology, Government of India

Outcomes targeted during workshop:

1. Gather inputs from key stakeholders and build consensus on the priority research segments that should be covered under broad topic of "Affordable Heating and Cooling of Buildings".
2. Strike the right balance across design, science, engineering and technologies that will help in India's sustainable growth, decarbonisation strategy, energy efficiency and resiliency of Indian building and habitats.

3. Collate tangible ideas and to foster collaboration between academia, private sector, civil society and also with mission innovation countries.
4. Provide guidance to DST on topics or segments that can be supported by national level initiatives of DST and topics or segments would benefit with international collaboration.

2. Breakout sessions: Points of Discussion

2.1 Group A- Thermal Energy Storage

Attendees:	Name	Institute/ Organization
	Dibankar Rakshit	IIT, New Delhi
	Dr DK Tuli	Centre for Advanced Bio-Energy Research
	Ajay Kumar Yadav	NIT Karnataka
	S. Srinivas Murthy	IIT Madras, IISC Bangalore
	Nandini	Shakti Sustainable Energy Foundation, New Delhi
	S. Kalaiselvam	Anna University
	Tanushree Chakraborty	IIIT Delhi

R&D Gaps:

It was suggested by the group that focus should be more on "Comfort" – heating and cooling of buildings. It's important to maintain a comfort level in the homes throughout the year. The climate of India comprises a wide range of weather conditions across a vast geographic scale and varied topography. Cooling is required for a longer duration in the year than heating. Hence there is rising demand for air conditioning and refrigeration.

Detailed research should be carried out on Energy conservation in building applications with thermal storage by latent heat using phase change materials. Investigation and analysis of thermal energy storage systems incorporating PCMs for use in building applications should be carried out. Possibility of microencapsulation and encapsulated conditioning should also be explored.

It is well known that the use of adequate thermal energy storage (TES) systems in the building sector presents high potential in energy conservation. The use of TES can overcome the lack of coincidence between the energy supply and its demand; its application in active and passive systems allows the use of waste energy, peak load shifting strategies, and rational use of thermal energy.

Thermal Energy Storage – Active systems & Passive systems

Active -

- To focus on Unitary/Small (< 5 tons capacity) – Thermal storage on plant level not possible.
- Intermediate + Large – Thermal storage especially cold storage very important.
- Use of water slurry – should be used as storage.

Passive -

- PCM Tiles
- Ground storage / seasonal storage/ ground-coupled heat exchange
- Building materials

For International collaboration, need and demand of other countries with similar climate conditions i.e. Germany, Switzerland and Sweden should be analyzed and considered.

2.2 Group B - HVAC Technologies

Attendees:	Name	Institute/ Organization
	Shubhashis Dey	Shakti Sustainable Energy Foundation
	Ishvinder Singh Gill	Consultant-HVAC Solutions and Innovative Green Building Technologies
	Bimal Tandon	Director Eng. Carrier Inc.
	Maiya M.P.	IIT Madras
	Varun Pahwa	Bry Air India
	Milind Rane	IIT Bombay
	Atul Bhargav	IIT Gandhinagar

R&D Gaps:

There is a huge gap in terms of basic infrastructure of research labs that should have highly specialized system. They play an essential role in generating data that can be used for a variety of aspects.

Professionals feel that a strong connect between industry and academia is still missing. The idea of a "gap" between research done in academia and its translation into marketable products certainly is not new. What is new are the steps that should be taken by the academic institutions and companies to bridge that gap. These partnerships have become especially relevant in the face of increasing economic pressure and global competition. The need for interdisciplinary approaches and the growing complexity of the problems need solutions.

More practical, applied, experience-based education should be developed. Rethink higher education curricula by identifying opportunities to infuse experience-based, highly specialized courses/programs and real-world learning experiences and embracing new teaching technologies and techniques for typical R&D work. Higher education institutions should build alliances with industry partners, share learning and refine strategies.

There is less manufacturing in India. A factor that has consistently been at the top of the list of constraints to Indian manufacturing has been essential infrastructure.

By laying the groundwork and establishing common data sharing methods, we can increase the capacity for research and development, technology advancement, as well as monitor and control the emerging issues as they develop.

Detailed R&D must be done in terms of affordable heating and cooling of buildings for the following:

- Integrated systems – small unitary systems/single house hold system
- Heat pumps
- Cooling of a building by Earth tubes
- Geothermal
- Water cool system
- Hybrid system
- DC Compressors

Indian firms have been investing abroad for decades. For international collaboration, people should be motivated and encouraged to invest and manufacture in India more. By doing this India will have better products at affordable prices.

Also, it was suggested that India should take a lead and organize a conference on affordable heating and cooling of buildings. Set timeline for important tasks to be completed. The conference shall feature technical presentations, R&D work globally, technology advancements in terms of heating and cooling, besides wide opportunities for several networking too.

2.3 Group C- Predictive Maintenance and Operational Optimization

Attendees:	Name	Institute/ Organization
	Dr. Jyotirmay Mathur	MNIT, Jaipur
	V. Majunath	Under Writers Lab
	C. Subramaniam	President Elect - ISHRAE
	G.C Modgil	HVAC Consultant, New Delhi
	Vishal Kapur	President ISHRAE

R&D Gaps:

The group discussed how for unitary products, predictive maintenance is almost neglected and only preventive maintenance is carried out.

A preventive maintenance approach means performing regular, prescheduled maintenance checks and repairs — whether they are needed or not. This approach yields better results but is still not optimal. A more efficient way to incur minimal costs and achieve maximum availability is to implement service plans that use proactive and predictive maintenance based on the actual condition of equipment rather than a predetermined schedule. With this approach, equipment is maintained at a continuously high level of performance rather than waiting for something to fail.

Predictive maintenance can be related with building management system(BMS). There should be more focus on Central – integrated approach.

Research is required to find solutions for:

- lifecycle improvement and reduction of power consumption
- Standby capacity
- Fouling trends
- Air pollutants and level of choking
- Pressure drops
- Pump and fan
- Operational health of plant
- Can use of machine language solutions / high-tech technology help reducing the capacity
- Prediction of the failure of product/ equipment

It was suggested by the group that India can collaborate with Oak Ridge National Laboratory, US for various technological advancements and R&D. India could engage with international agencies for promotion and technology collaboration by creating a Central institute in India. This institute should be independent but should have close tie ups with international academic institutes.

2.4 Group D- Building level integration of HVAC

Attendees:	Name	Institute/ Organization
	Aakash Patel	ASHRAE Western Chapter
	S. Senthil Kumar	NIT Trichinaapalli
	Sameer Maithel	GreenTech Solutions
	Ashwani Yella	IIT Bombay
	Tanmay Tathagat	Environmental Design Solutions
	B. Venaktesaperumal	NIT Karnataka
	Ranjan Das	IIT Ropar
	Yash Shukla	CEPT University
	KVL Subramaniam	IIT Hyderabad

R&D Gaps:

The group suggested that advanced research needs to be done to understand how Mixed mode buildings should be designed, operated and controlled. The cooling demand of buildings can be reduced by the use of passive design strategies and further, the benefits can be quantified by use of technology. Also, new generation of simulation tools and engines need to be supported and vetted.

India can collaborate internationally for usage of simulation tools and to understand building physics. Buildings operating in mixed mode need to be supported and also, we should encourage research in the field of affordable heating and cooling of buildings.

2.5 Group E- Human centric studies

Attendees:	Name	Institute/ Organization
	Samdarsh Nayyar	HVAC Consultant, New Delhi
	Smita Chandiwala	Energy Efficiency Expert, New Delhi
	Sanjeev Jain	IIT Delhi
	Mahua Mukherjee	IIT Roorkee
	Mili Majumdar	GBCI

R&D Gaps:

The group suggested that a detailed study should be done to redefine thermal comfort, outdoor and indoor environment, user interaction and movement of people in and out of a building. Also, the scope of the study should be expanded from buildings to the built environment which includes enclosed, semi-built as well as open spaces. Research is needed on indoor air quality and its parameters, the impact of building systems and user behaviour on how built environment functions, biological aspects and health aspects of the occupants. Furthermore, how externalities influence user behaviour; built environment, integration and implementation issue in terms of policy and standards for existing and new construction needs to be researched upon. The urban heat island effect as well as the effect of the micro climate of a place also need to be included in the research.

India can collaborate internationally with countries having similar climatic conditions like Singapore. They also have conducted research in the field of human thermal comfort.

Documentation of the work done and papers being published in India would highly encourage and motivate other countries to support similar projects in India.

2.6 Other Comments/ Suggestions as a part of general discussion after the breakout sessions:

It was suggested by the group that a detailed study is required on the power distribution system and an electrical diagnostic study should be performed in order to maintain electrical power distribution system.

Impact evaluation should be carried out of non-HVAC measures on HVAC measures as well as impact of external environment on all HVAC components should be evaluated. Also, R&D shall be conducted for development of radiant cooling system and radiant condenser. Hardware and software development along with low cost sensor technologies should be encouraged.

Apart from that, it was suggested that research should be carried out to understand and examine the impact of water quality on the supply and distribution system.

Collaboration between academic institutes and government for data sharing via various possible platforms should be encouraged. Dept. of Science and Technology, Government of India should link and come up with strategies for collaboration with other ministries. Furthermore, it was suggested to find out ways to put data in the public domain for easy access.

The photographs of participants involved in group discussion are enclosed in Annexure III.

Annexure-I: Framework and agenda of the workshop

Framework for Breakout sessions:

1. **Breakout session**: Specific area/segment identification to have a holistic list of broad priorities that require research support. Framework may focus on the needs and requirements or the impact such as energy, decarbonisation, enhanced thermal comfort, and cost.
   - **Output of the breakout session**: Each breakout groups should come out with no more than three research topics/segments, preferably broken down into expected outcomes and their impact.
2. **Facilitated Discussion**: Once research topics and segments have been identified in the first 50 min session, more time needs to be spent discussing and providing some concrete guidance on what kind of research proposals can be supported or funded by DST. This can take the form of:
   a) Current R&D gaps that exist in the country;
   b) What is R&D in the context of "Affordable Heating and Cooling of Buildings?"
   c) What are the key topic for international collaboration?
   d) How can platforms for learning/exchange/peer review with international research institutes be created?
   e) Seeking clarity on what kind of projects to be supported – what's the criterion that is used? Science and technology promotion, impact on human habitat, close linkage and feeding into what policies need to be developed supported by knowledge and technology?
   f) How research calls can encourage innovation and short-medium term sector priorities through effective processes and evaluation mechanisms?
   g) How should India engage with International agencies such as IEA for promotion of technology collaboration?
   h) What could be models for enhancing public private partnership especially in the context of IC on Affordable Heating and Cooling of Buildings

Annexure-II: List of Participants

Sl. No.	Name	Organisation/ Institute Name
1	Sanjay Bajpai	Department of Science and Technology, Delhi
2	Rajeev Sharma	Department of Science and Technology, Delhi
3	Rajan Rawal	CEPT University
*4**	*Archana Walia*	*CLASP India*
*5**	*Ashok Lall*	*Ashok B Lall Architects*
6	Aswani Yella	IIT Bombay
7	Atul Bhargav	IIT Gandhinagar
8	B. Venaktesaperumal	NIT Karnataka
9	Bimal Tandon	Director Eng. Carrier Inc.
10	Darshi Dhaliwal	TOTO Watt
11	Dibankar Rakshit	Indian Institute of Technology, New Delhi
12	G.C Modgil	HVAC Consultant, New Delhi
13	Guruprakash Sastry	Infosys
14	Ishvinder Gill	
15	JBV Reddy	Dept. of Science and Technology
16	Jyotirmay Mathur	MNIT Jaipur
17	KVL Subramanian	IIT Hyderabad
18	M. Jaya Bharata Reddy	NIT Tiruchirapalli
	S. Senthil Kumar	NIT Tiruchirapalli
19	Mahua Mukherjee	IIT Roorkee
20	Maiya M.P.	IIT Madras
21	Mili Majumdar	GBCI
22	Milind Rane	IIT Bombay
23	Neeraj Kapoor	Kalpakrit
*24**	*Nishritha Bopana*	*Indo US Science and Technology Forum*
25	Ajay Kumar Yadav	NIT Karnataka
26	Aakash Patel	ASHRAE Western Chapter
27	Ranjan Das	IIT Ropar
28	S, Subramanian	President Elect - ISHRAE
29	S. Kalaiselvam	Anna University
30	S. Srinivas Murthy	IIT Madras, IIsc Banglore
31	Samdarsh Nayyar	HVAC Consultant, New Delhi
32	Sameer Maithel	GreenTech Solutions
*33**	*Sanjay Prakash*	*SHiFt*
34	Sanjeev Jain	IIT Delhi
35	Satish Kumar	Alliance for Energy Efficient Economy
36	Shubhashis Dey	Shakti Sustainable Energy Foundation
37	Smita Chandiwala	Energese
38	Tanmay Tathagat	Environmental Design Solutions
39	Tanushree Chakraborty	IIIT Delhi
40	V. Majunath	UnderWriters Lab
41	Varun Pahwa	Bry Air India
42	Vishal Kapur	President ISHRAE
43	Yash Shukla	CEPT University

Annexure III: Photographs of participants during panel and group discussion

Members of Group A

Members of Group B

Members of Group C

Members of Group D

Members of Group E