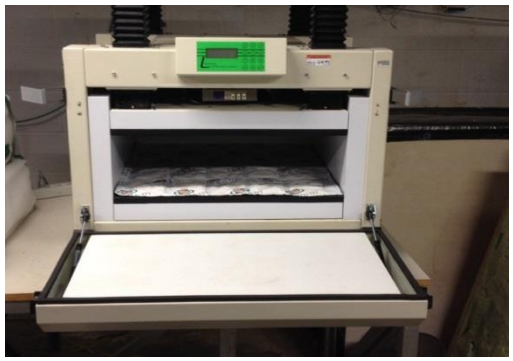
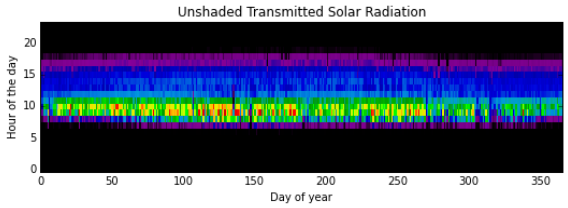
US India Joint Center for Building Energy Research and Development (CBERD)

Building Envelopes

2016 Building Technologies Office Peer Review





U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Christian Kohler, CJKohler@lbl.gov
Berkeley Lab

Project Summary

Timeline:

Start date: October 2012

Planned end date: September 2017

Key Milestones:

- Initiation of cool roof test apparatus experiments in 4 climates with the first set of materials – September 2015
- IBPSA BS2015 paper on Laser Cut Panels – September 2015
- ORNL-CEPT inter laboratory PCM test comparisons – June 2016

Budget:

Total Project $ to Date:

- DOE: $480k
- Cost Share: NA

Total Project $:

- DOE: $675K
- Cost Share: NA

Key Partners:

International Institute of Information Technology, Hyderabad
Centre for Environmental Planning and Technology University (CEPT), Ahmedabad
Saint-Gobain Research India
Saint-Gobain/CertainTeed (USA)
Pluss Polymers

Project Outcome:

Enable rapid solar shading evaluation for fins, overhangs and awnings for designers. Evaluate the use of phase-change materials in mixed-mode buildings. Create infrastructure for cool-roofs and phase change materials in India that allows US manufacturers to sell their products in India.

Project Scope: Envelopes

- Heat transfer through the building envelope
  - Walls – phase change materials (PCM)
  - Roofs – cool roof materials
  - Windows – light redirection and solar reduction
  - Foundation – not addressed in this project

Project Team

- US
  - **Lawrence Berkeley National Laboratory**
    - Ronnen Levinson, Charlie Curcija, Robin Mitchell, Christian Kohler
  - **Oak Ridge National Laboratory**
    - Andre Desjarlais, Kaushik Biswas
  - **DOE**
    - Karma Sawyer, Chioke Harris, Brent Nelson
- India
  - **CEPT Ahmedabad**
    - Rajan Rawal, Yash Shukla, Agam Shah
  - **IIIT-H Hyderabad**
    - Vishal Garg, Hema Rallapalli, Sraavani G
  - **Saint Gobain Research India**
    - Rathish

Purpose and Objectives

Problem Statement:

- Mixed mode or unconditioned buildings are often not comfortable. Potential for phase change materials.
- Lack of cool roof standards and infrastructure in India.
- Evaluating the effect of non co-planar shading solutions (overhangs, awnings, fins) for windows is difficult.

Target Market and Audience: Code officials, architects, developers, and building owners that influence commercial and government building product selection in India. 2030 technical potential savings in India are 2.2 TWh/y site energy, 2.6 Mt/y CO_2 for cool roofs alone. US Manufacturers of cool roof and phase change materials and window shading.

Impact of Project: Create Indian cool roof and phase change walls **infrastructure** based on field experiments, simulation and rating assistance. Facilitate proper **selection of solar shading** solutions for windows and increase daylight use in Indian buildings. Support to DOE's attachment ratings effort in the US. Allow **US manufacturers** to seamlessly sell their US rated products in India.

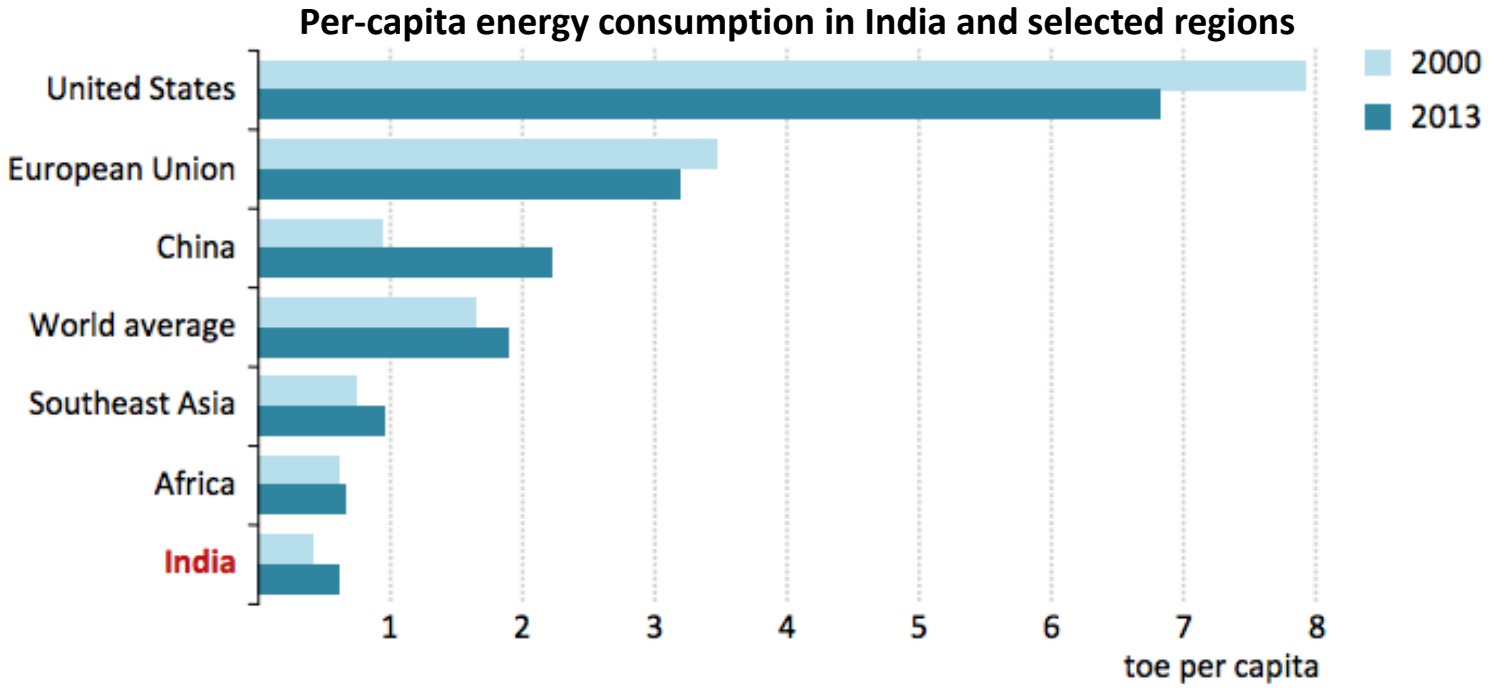
Approach

Approach: Cool roofs: Assess energy savings in Indian climates via simulation (Indian cool roof calculator), real-building experiment and test chamber in 4 climates. Natural exposure trials in 4 climates in India. **PCM**: Develop measurement infrastructure in India, perform field experiment. **Windows**: Assist with construction of measurement devices, collaborate on shading algorithm development

Key Issues: Natural exposure trials takes 3 years, so completion of natural exposure and adaption of lab aging practice may follow end of CBERD.

Distinctive Characteristics: Field tests and software code development in India are much cheaper than in the US, leveraging Indian investment for US market benefits. Identical cool roof test chambers in four Indian climates permit controlled measurement of energy savings.

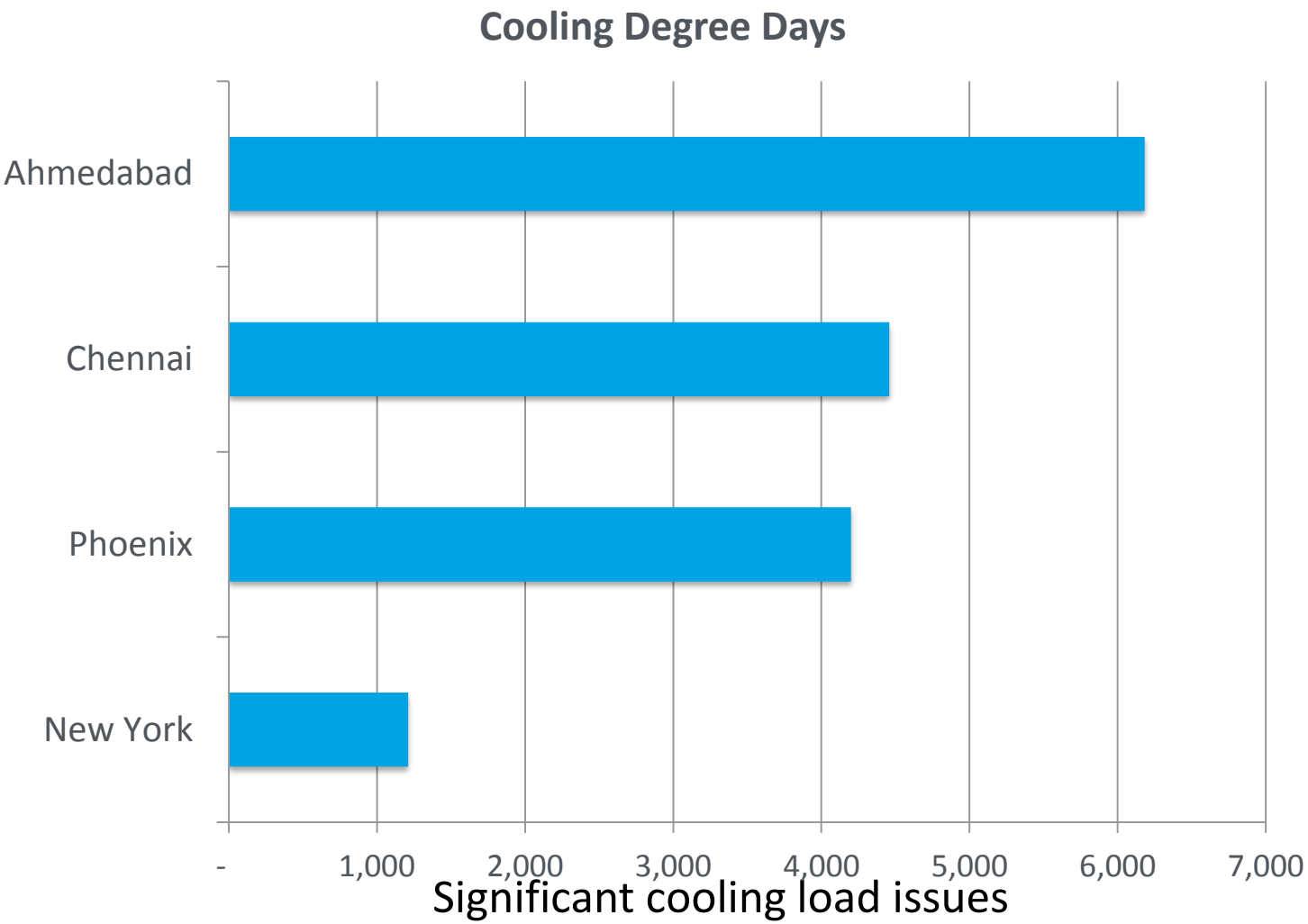
Efficiency in the Indian context



Source: 2015 IEA India Energy Outlook

- With strong economic growth, urbanization and increased standard of living the per-capita energy consumption will grow rapidly
- Amory Lovins:
  Efficiency is the attitude: 'Do the same or more with less.'

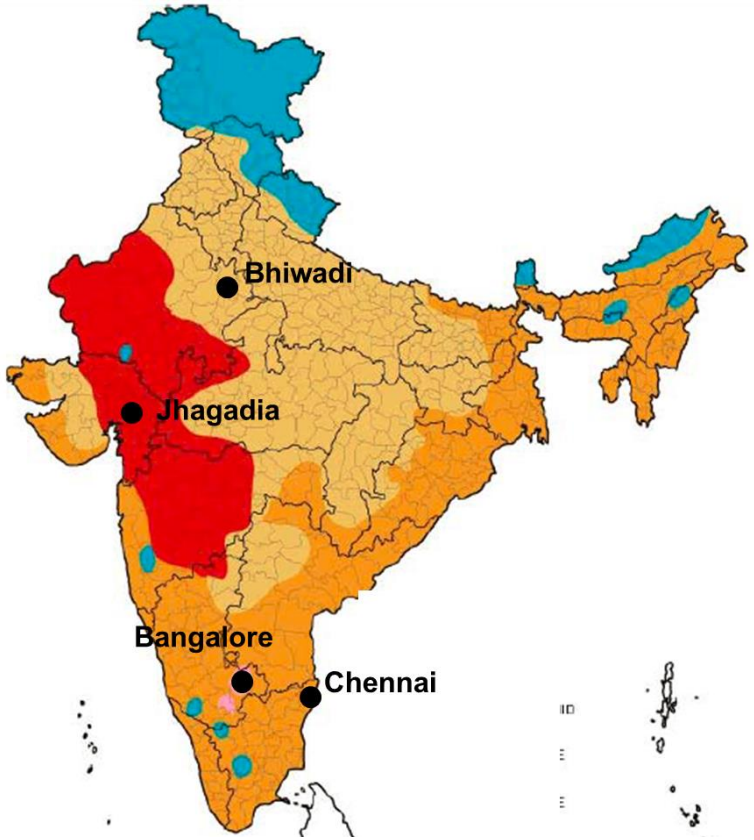
Indian climates



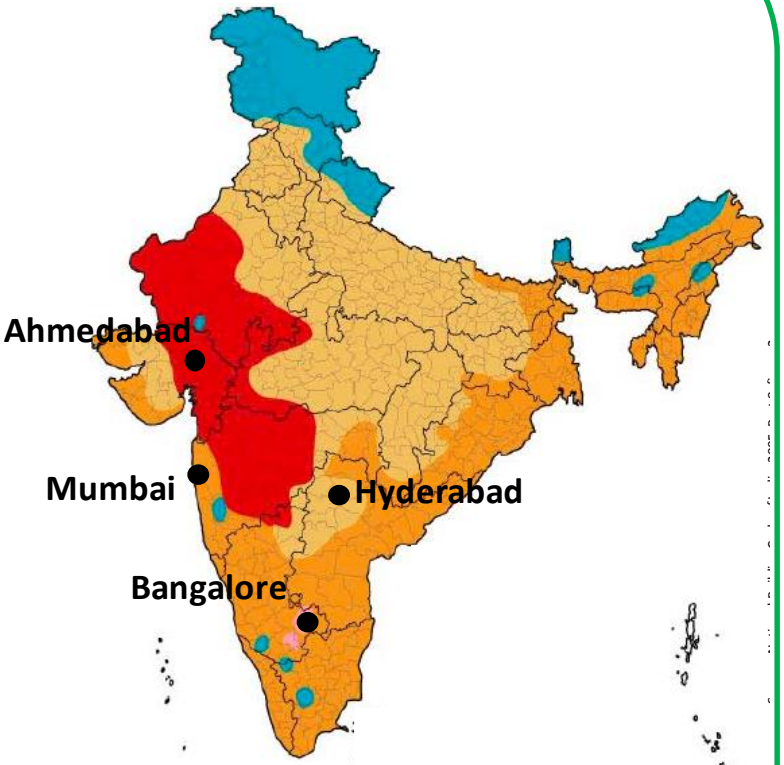
Significant cooling load issues

Experiment sites

Cool-roof test chamber sites



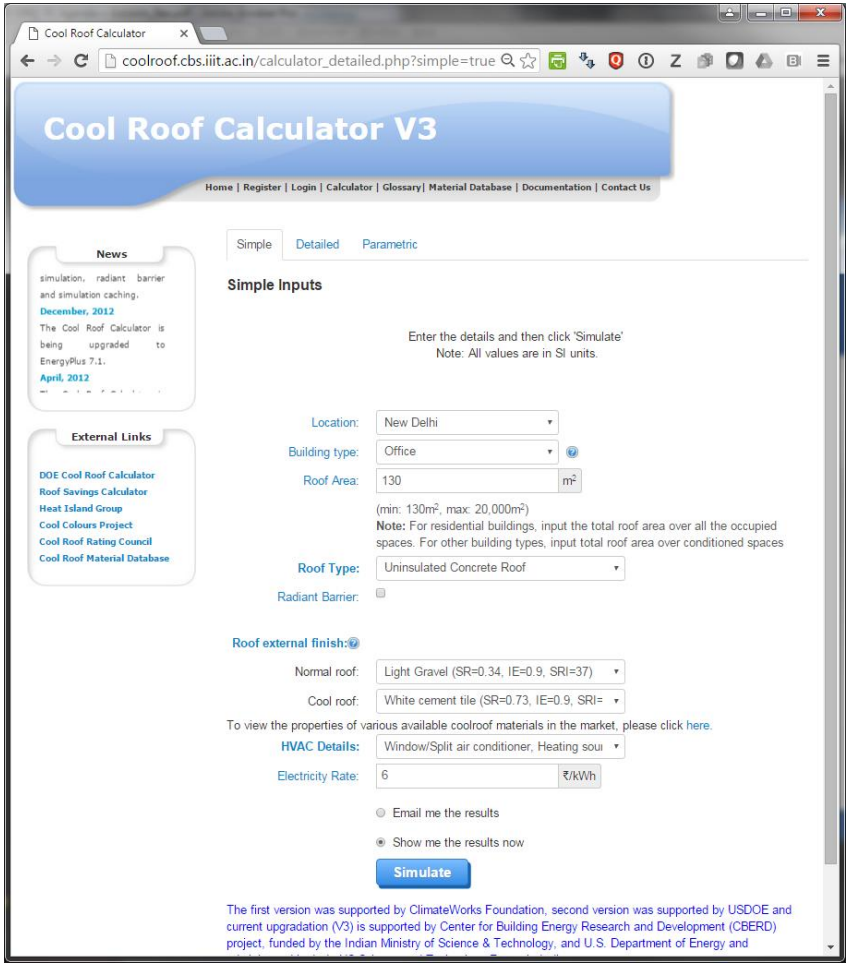
Natural exposure sites (planned)



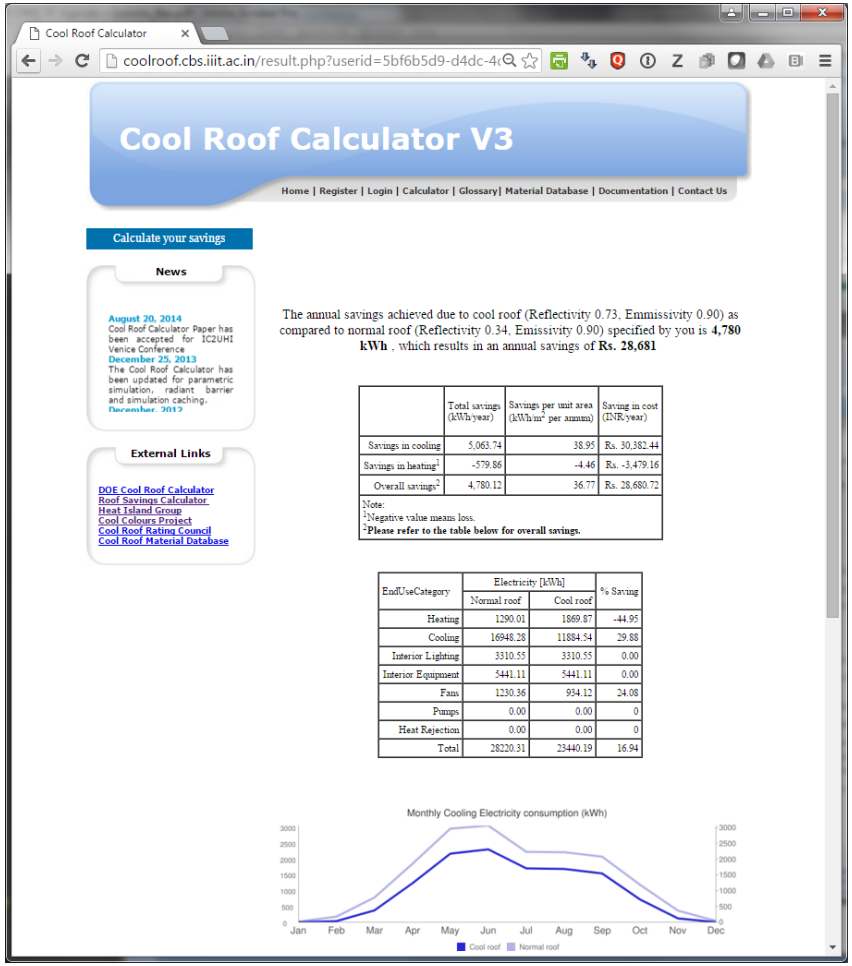
Cool roof test chambers in Bangalore showed 15% AC energy savings in July 2015

Indian cool roof calculator can estimate energy savings in conditioned space or comfort improvement in unconditioned space

simple input



output



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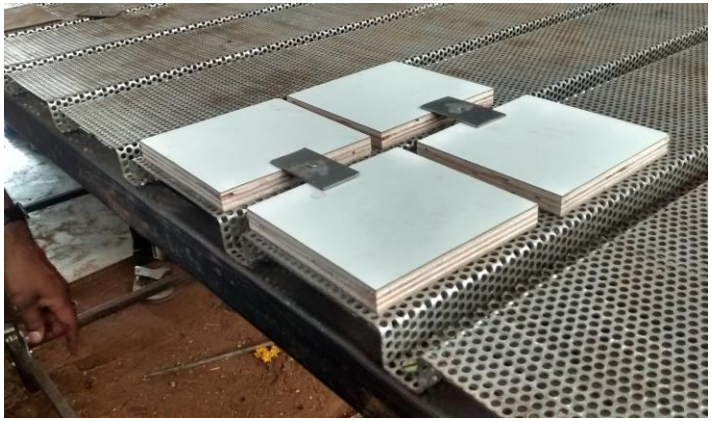
Progress and Accomplishments

Accomplishments: Built and calibrated **cool roof test chambers** at four sites; cool roof experiments underway for past 4 – 8 months. Indian cool roof energy savings / indoor comfort calculator online at http://coolroof.cbs.iiit.ac.in/calculator_detailed.php .

Market Impact: (too early for market impact)

Lessons Learned: Logistics of real-building cool roof experiments proved especially challenging in India, so we built controllable test chambers to simulate core of office buildings.

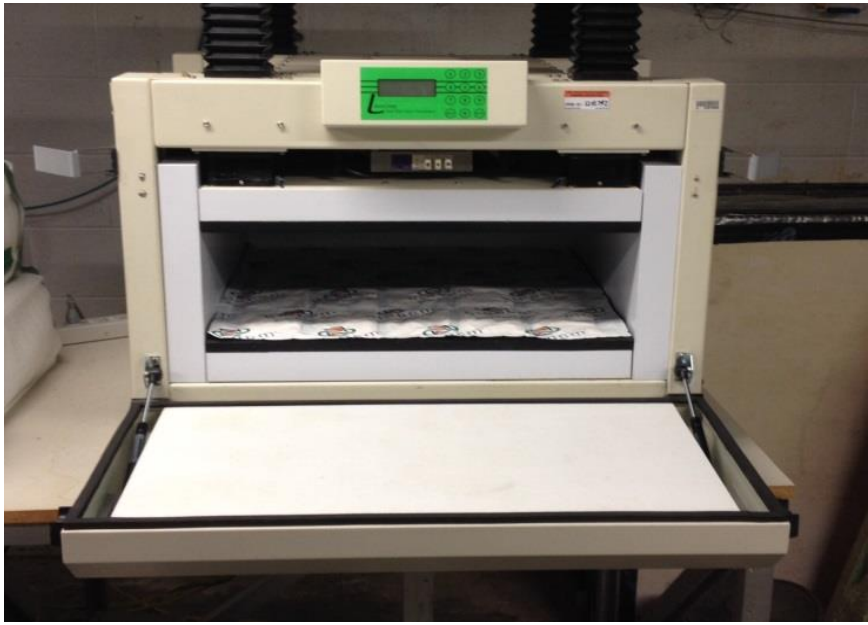


Natural exposure testing

Phase Change Accomplishments

- Facilities now in place in India to monitor PCM performance. Comparison of results with US is ongoing.
- Field experiment is in progress

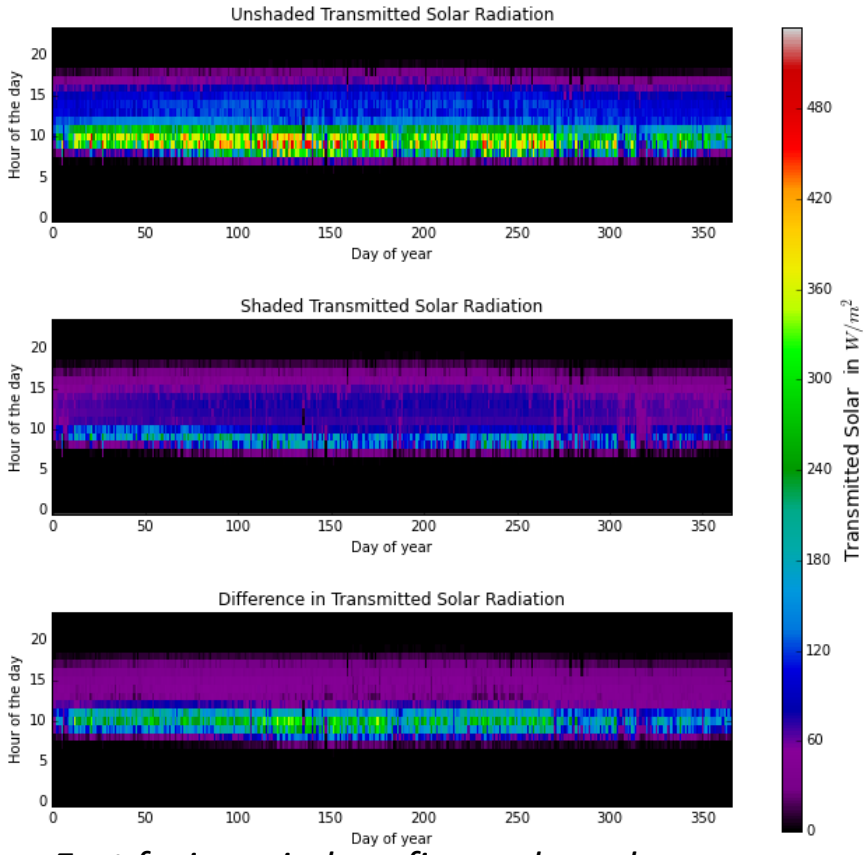
Measurement of performance of ceiling tiles made of new phase change materials in test bed, in naturally ventilated and forced ventilation modes.



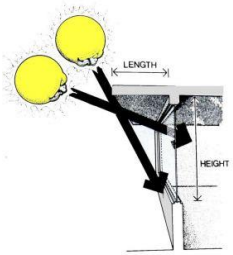
Laboratory measurement of phase change materials.

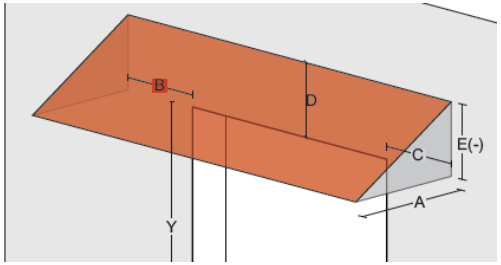
Accomplishment: SHGC for non co-planar shading

- Calculate the SHGC of a window with and without a shade.
- Allow comparison of solar control low-e coatings and architectural features like fins, overhangs and awnings.
- Parametric calculations for >15 shading types, 4 orientations, 4 cities and 3 glazing types
- Based on EnergyPlus and Berkeley Lab WINDOW
- Will be incorporated into COMFEN



East facing window, fins and overhangs





Accomplishments: Windows and Daylighting

- COMFEN India release:
  - Early design simulation tool developed by LBNL with DOE funding, adopted to Indian building types, schedules and HVAC systems by Indian team.
  - Allows wider proliferation of DOE supported software tools, and potential future software code contributions.
  - https://windows.lbl.gov/projects/CBERD/
- Regional Data Aggregator Framework released. This effort de-centralizes the collection, review and maintenance of glazing spectral data. Previously DOE funded at LBNL. The plan is that each region processes its own spectral data, and submits it to one international harmonized glazing database.
- Design assistance for a outdoor goniophotometer to properly characterize the solar and optical properties of Tubular Daylighting Devices.

Project Integration and Collaboration

Project Integration: Monthly conference calls between US and Indian teams

Partners, Subcontractors, and Collaborators: ORNL, IIIT-H, CEPT, SGRI, CertainTeed, Pluss Polymers.

Communications:
Papers presented at Urban Heat Island Countermeasures conference in Venice (Oct 2014) and Singapore (May 2016),
and at ACEEE Summer Study (Aug 2016).
Journal paper published in Journal of Building Engineering (2015), and in Energy and Buildings (2016)
Mulchandani, H., Shah, A., Rawal, R., Curcija, D.C. (2015) Daylight performance evaluation of laser cut panels in office buildings in India Context. IBPSA Building Simulation conference paper

Next Steps and Future Plans

Next Steps and Future Plans:

- Develop lab aging practice for cool roofs in an Indian climate.
- Create web based calculator based on non co-planar shading algorithms
- Update cost data in COMFEN India
- Analyze results from phase change material field trial

REFERENCE SLIDES

Project Budget

Project Budget: $135K per year for FY13-17
Variances: NA
Cost to Date: Total funding received to date $480K, total cost to date= $390K
Additional Funding: NA

Budget History					
Oct 2012– FY 2015 (past)		FY 2016 (current)		FY 2017 – Sept 2017 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$405K	NA	$135K*	NA	$135K*	NA

* Total expected funding

Project Plan and Schedule