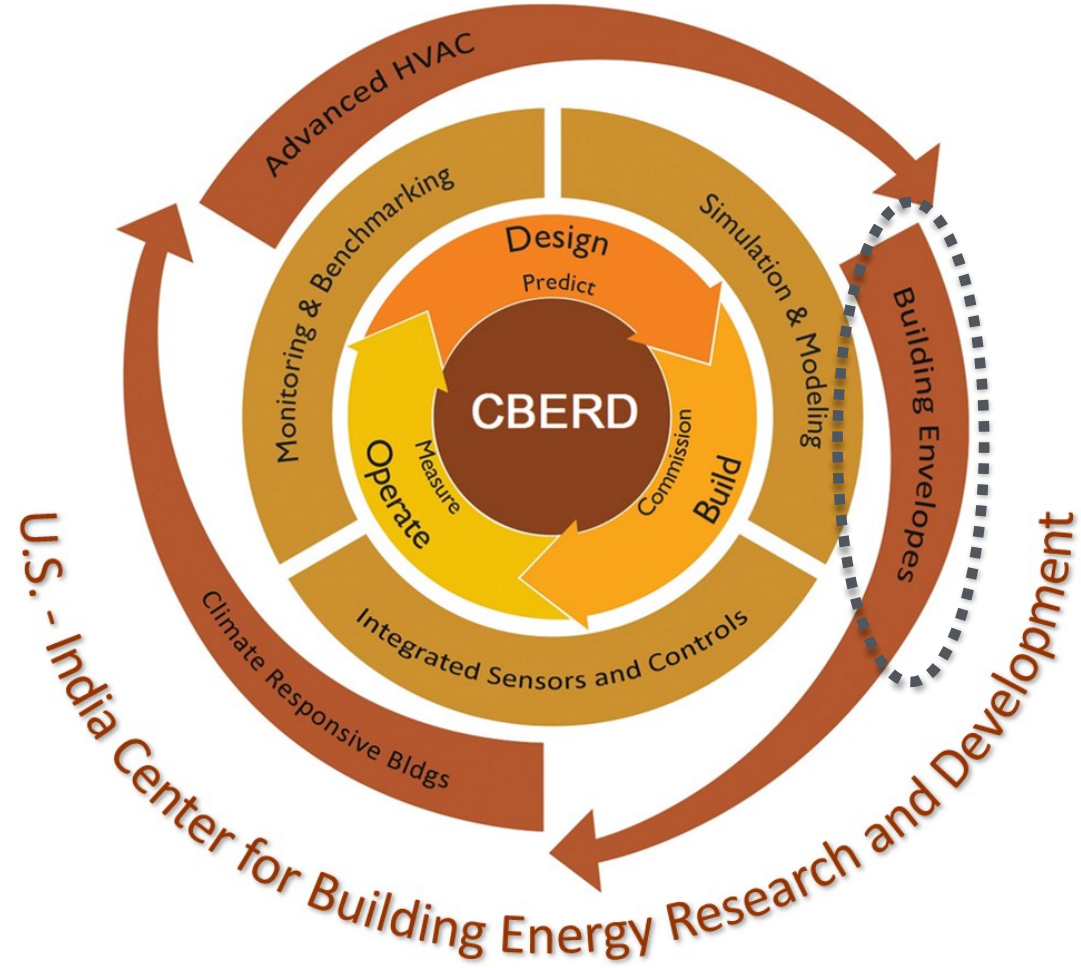
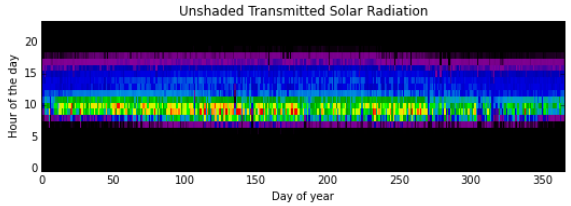
US India Joint Center for Building Energy Research and Development (CBERD)

Building Envelopes

2017 Building Technologies Office Peer Review





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

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Berkeley Lab

Project Summary

Timeline:

Start date: October 2012

Planned end date: September 2017

Key Milestones:

- COMFEN version with no co-planar algorithms January 2017
- Natural exposure trials for cool roofing materials March 2017

Budget:

Total Project $ to Date:

- DOE: $590K
- Cost Share: $120K

Total Project $:

- DOE: $675K
- Cost Share: $30K

Key Partners:

International Institute of Information Technology, Hyderabad	IIIT, HYDERABAD
Centre for Environmental Planning and Technology University (CEPT), Ahmedabad	CEPT UNIVERSITY
Saint-Gobain Research India	SAINT-GOBAIN
Saint-Gobain/CertainTeed (USA)	
Pluss Polymers	PLUSS® Synergism at Work

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
- 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.

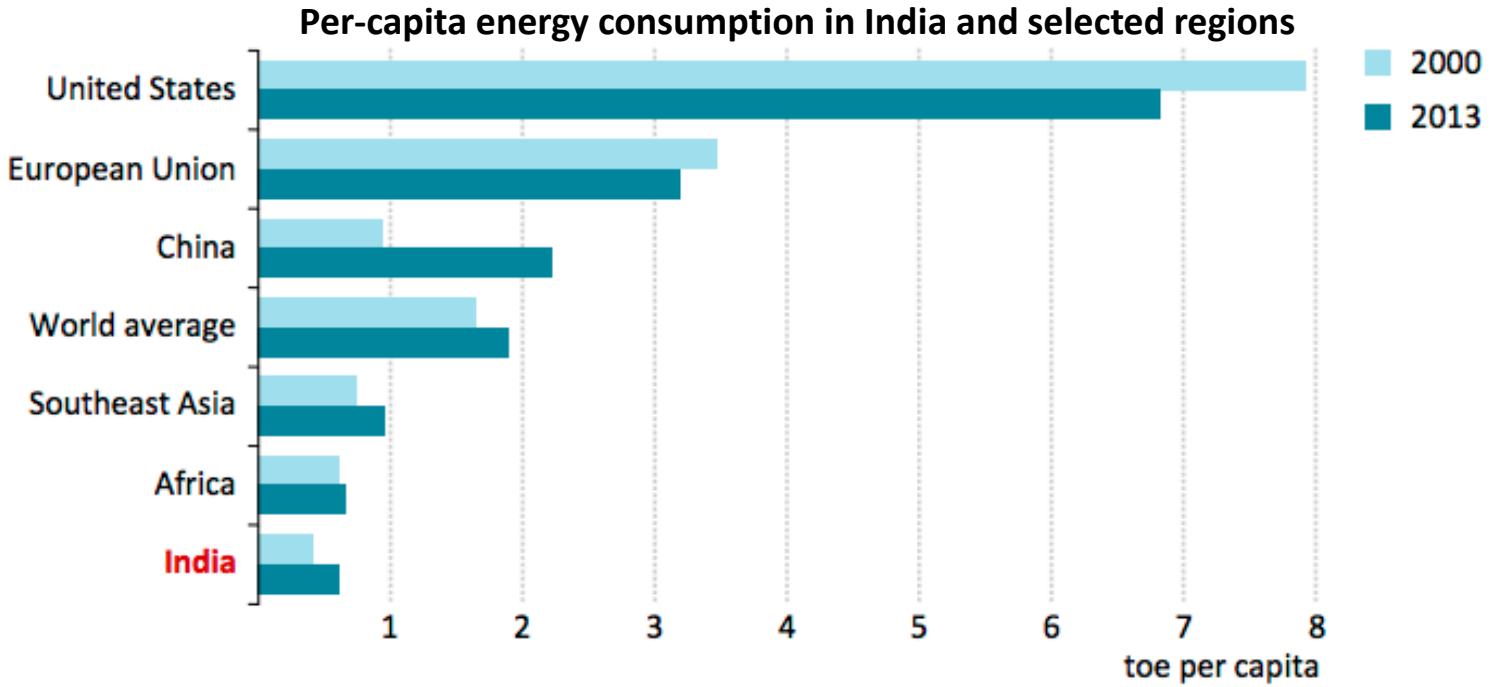
Approach

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 solar shading algorithm development (support DOE BTO MYPP Goal: "*Lack of Ability to Simulate Windows or Building Envelope" and "modulate and control solar load to minimize summer cooling and offset winter heating")*

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 three Indian climates permit controlled measurement of energy savings.

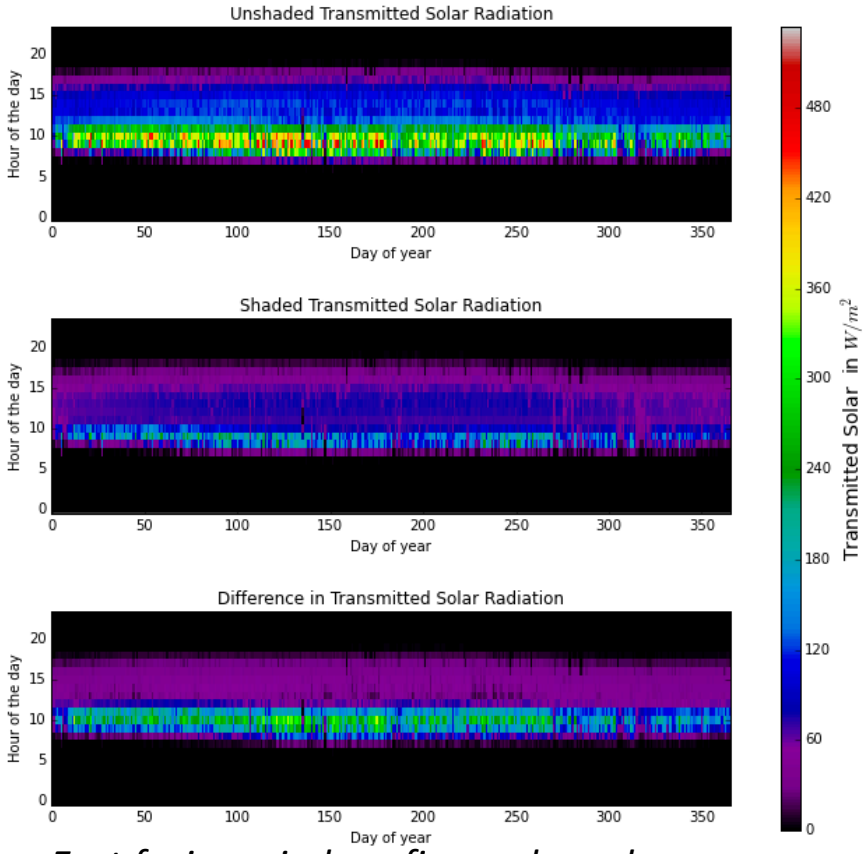
Efficiency in the Indian context



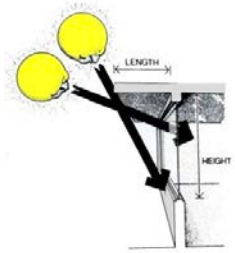
- With strong economic growth, urbanization and increased standard of living the per-capita energy consumption will grow rapidly
- Amory Lovins:
  Efficiency is the attitude: 'Do the same or more with less.'

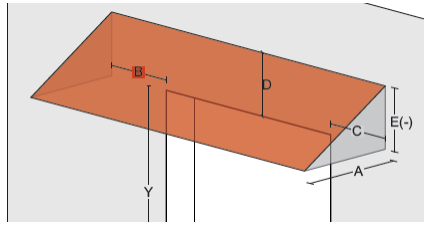
Accomplishment: SHGC for non co-planar shading

- The Solar Heat Gain Coefficient is a common metric for a regular (ie non-shaded) window.
- This method calculate the SHGC of a window with and without a shade to determine the impact of the shade
- Allow comparison of solar control low-e coatings and architectural features like fins, overhangs and awnings.
- Based on EnergyPlus and Berkeley Lab WINDOW



East facing window, fins and overhangs





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Use case for Non Co-Planar Shading SHGC

- Large global pharmaceutical company wanted to build a new building in the US
- Considered external complex shading
- Needed SHGC value to meet global corporate spec for the facade
- Normal incidence SHGC meaningless
- This method would have provided the relevant value
- Shade was value engineered out before we could complete the calcs.

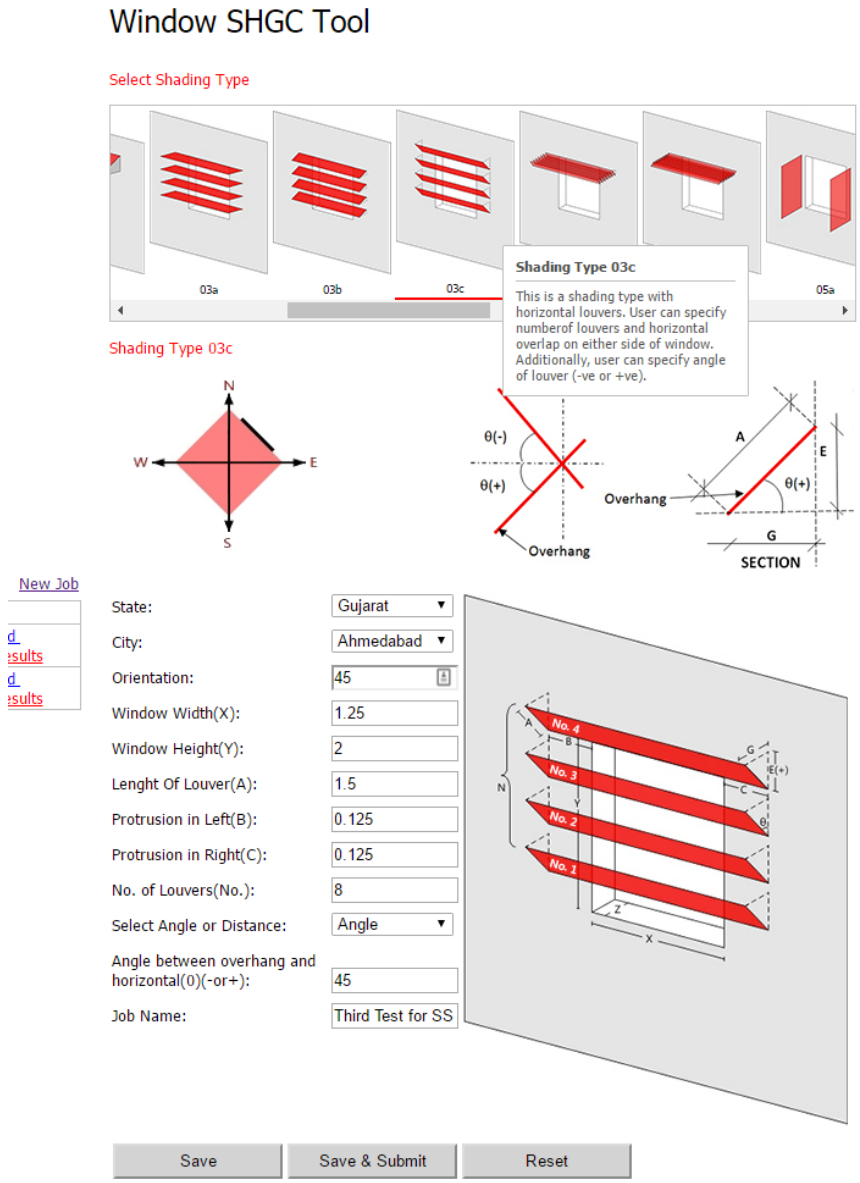
Accomplishment: COMFEN with Non-coplanar SHGC

COMFEN is a early design tool for facades and fenestration in commercial buildings, developed with DOE funding by Berkeley Lab

COMFEN CBERD with Non Co-Planar shading analysis released on the web, with **Getting Started Guide**.

https://windows.lbl.gov/projects/CBERD/

Accomplishment: web tool with Non-coplanar SHGC



Web based calculator developed in India based on US developed algorithms

Accomplishment: Cool Roofing Materials Exposure

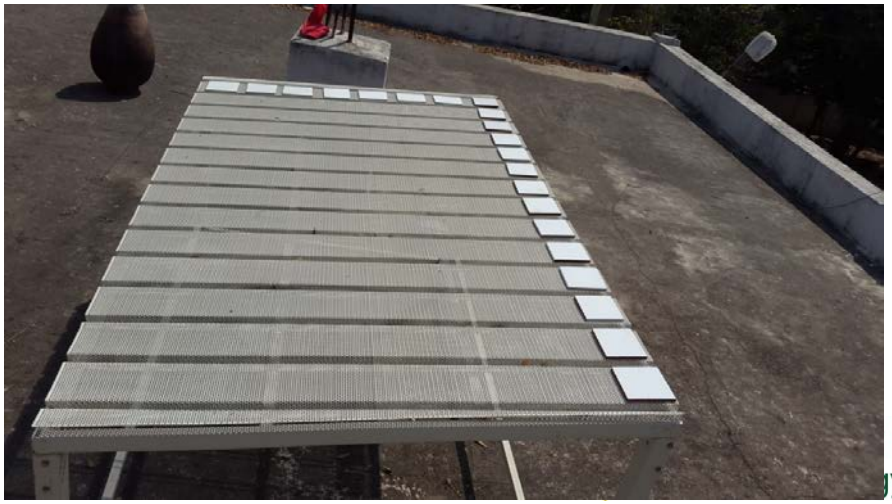
Weathering and Ageing Experiment

- Natural exposure tests to determine change in solar reflectance
- Very limited number of samples received from Indian cool roof manufacturers
- Supplemented by US manufacturer samples
- Installation in progress in 4 sites

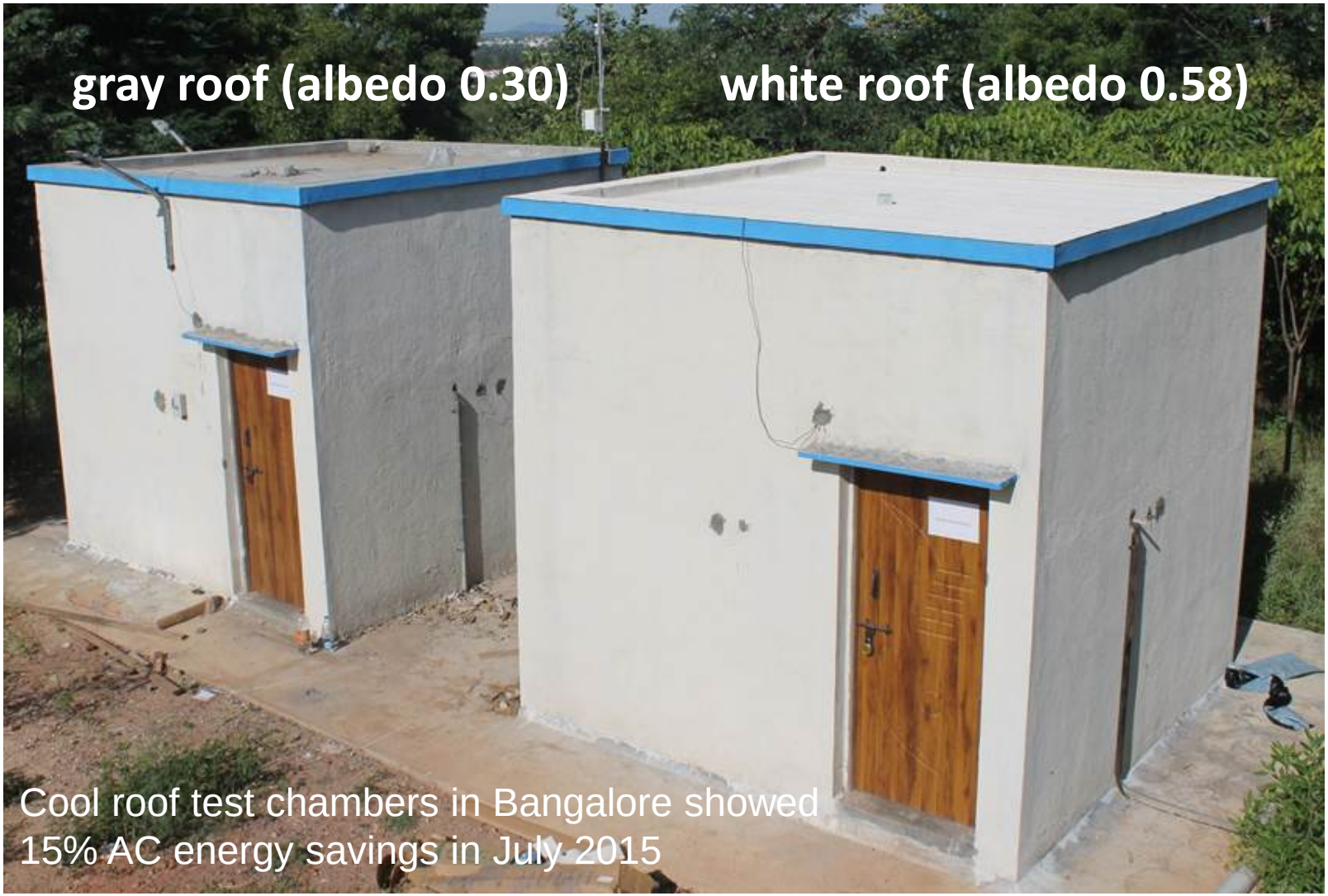
Current racks installed at IIIT-H

Rack size 6’-6”x 4’-0”

Designed to hold 120 specimens in each rack.



Accomplishments: Cool Roof Field Experiments

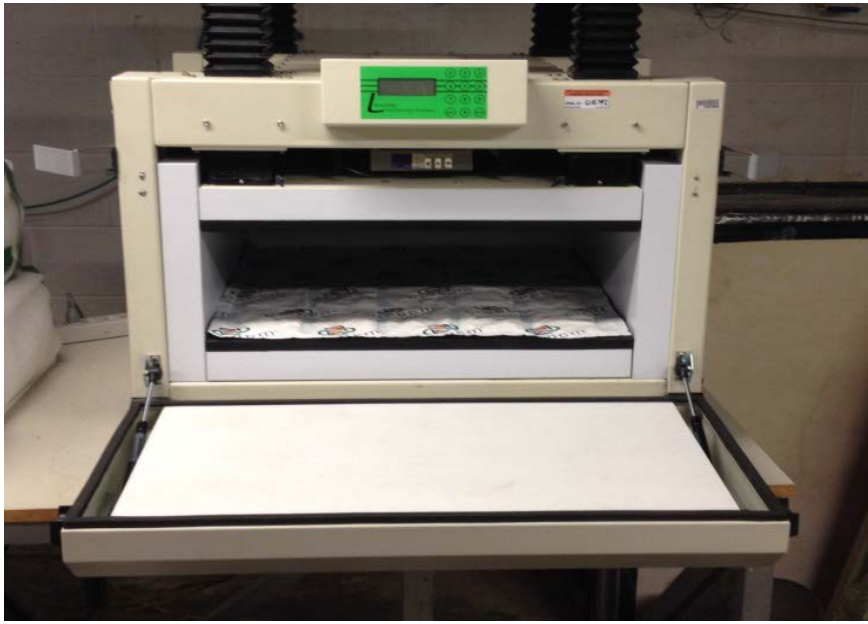


Cool roof test chambers in Bangalore showed 15% AC energy savings in July 2015

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.

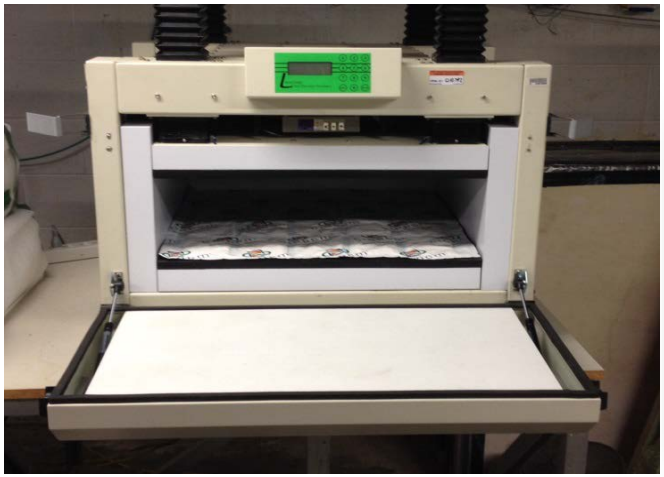


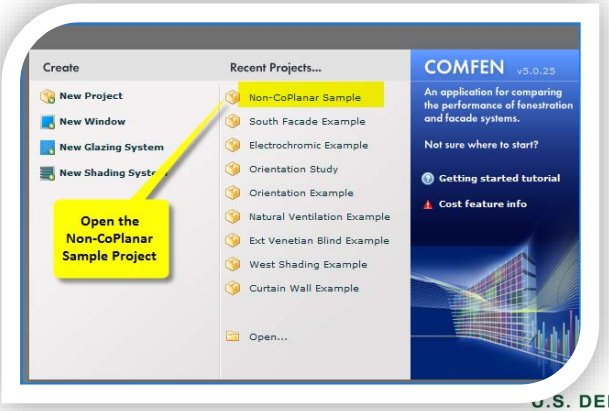
Laboratory measurement of phase change materials.

Progress and Accomplishments

Accomplishments: Built and calibrated **cool roof test chambers** at three sites. Initiated natural exposure testing. **Phase Change experiments** underway for over one year. **Non co-planar SHGC calculation algorithms** implemented in COMFEN and Web Tool

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





Project Integration and Collaboration

Project Integration: Monthly conference calls between US and Indian teams

Partners, Subcontractors, and Collaborators: ORNL, IIIT-H University, CEPT University , Saint Gobain Research, CertainTeed, Pluss Polymers.

Communications:

Three papers on Cool Roofs in process (submitted/revisions):

- Reporting the results of field experiments in real buildings (IIITH)
- Results from controlled experiment with first set of materials (SGRI)
- Energy simulation study for assessing the effect of cool roofs on energy use and thermal comfort (IIIT-H)

One paper on Non Co-planar solar shading:

- Kohler, Christian, Yash Shukla, Rajan Rawal. "Calculating the effect of external shading on the solar heat gain coefficient of windows", Building Simulation 2017, San Francisco, August 2017

Next Steps and Future Plans

Next Steps and Future Plans:

- Develop lab aging practice for cool roofs in an Indian climate.
- Roll-out web based calculator based on non co-planar shading algorithms
- Provide webinar training for the solar shading module in COMFEN
- 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 $590K, total cost to date= $570K
Additional Funding: NA

Budget History					
Oct 2012– FY 2016 (past)		FY 2017 (current)		FY 2018 – Sept 2018	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$540K	$120K	$135K*	$30K		

* Total expected funding

Project Plan and Schedule