U.S. China Clean Energy Research Center Building Energy Efficiency Consortium (CERC-BEE)

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Science & Technology Center of MoHURD, CABR, CSUS, Universities: Tsinghua, Chongqing , Tongji, and Tianjin

Strategy to Achieve Cost Effective Very Low Energy Buildings (VLEBs)

U.S. / China construction market ~ 2B square meters
CO_2 savings ~ 100Mt/year by 2025

Building Design

Integrated Design
Protocols and design tools for VLEBs

Behavior
50-70% reduction in energy use

Policy

Data and Energy Management
Energy use reductions

Policy Analysis and Incentives
New joint policies

Building Equipment

Natural Ventilation Design
Optimization of efficiency / comfort

Lighting Controls
New lighting control algorithms

HVAC Systems
Efficiency improvements

Envelope

Roofing technologies / Cool Roof Coatings
Long life high solar reflectance

Insulation
New cost effective air sealing technology

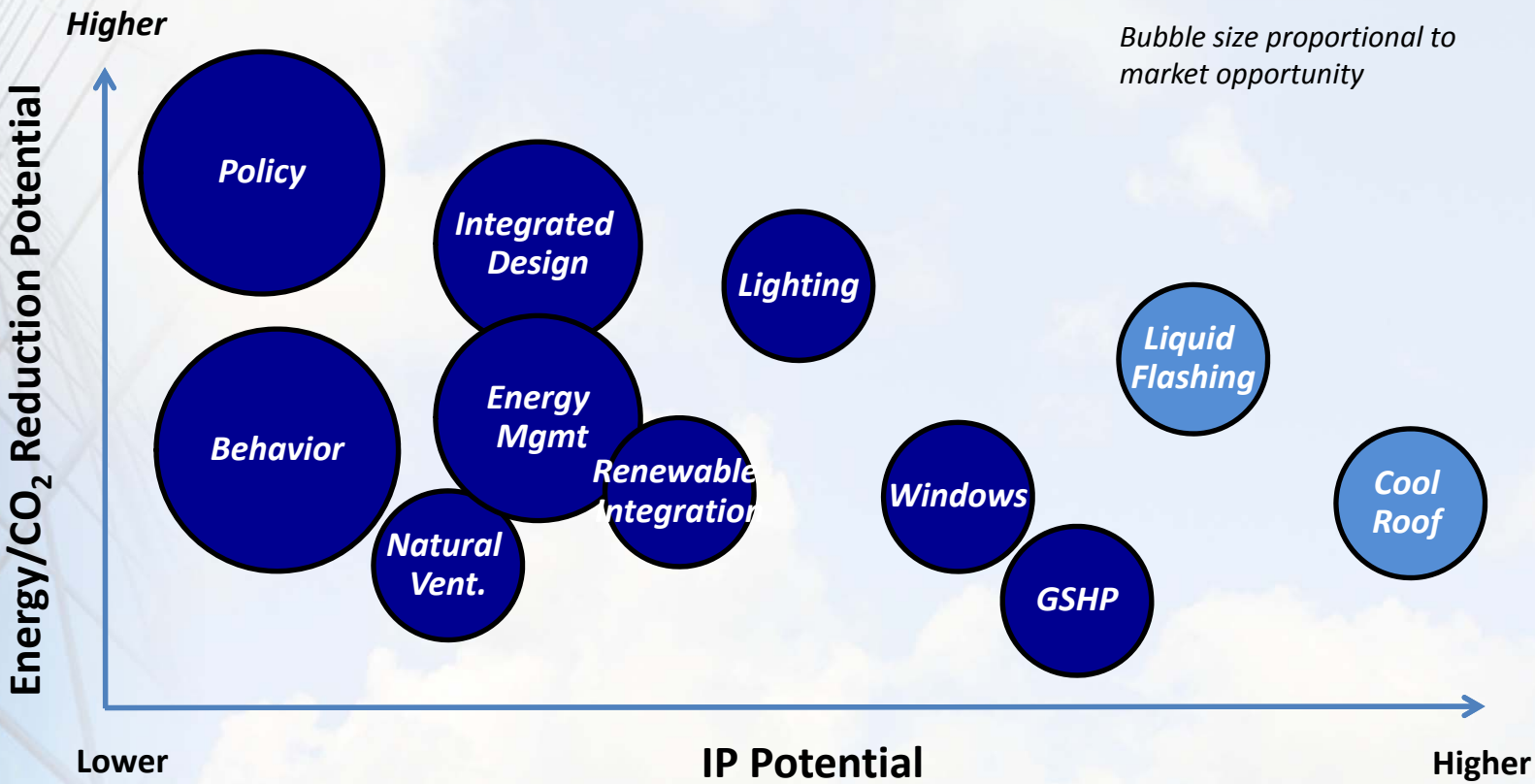
Advanced Window and Shading Technologies
Perimeter energy reduction of 15% - 30%

Renewable Energy / Distributed Generation Integration

Integration and Operation in Real Time
Optimized technology selection, real time controls

New Heat Pump Design
System energy use reductions >30%

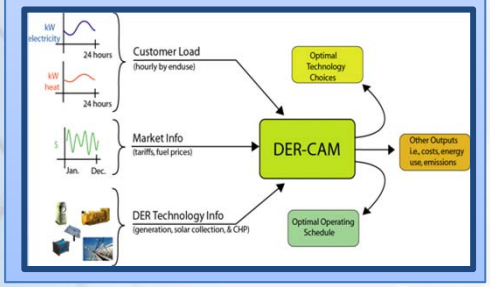
Portfolio Overview



Outcomes

Technologies

Software



New Patent Applications

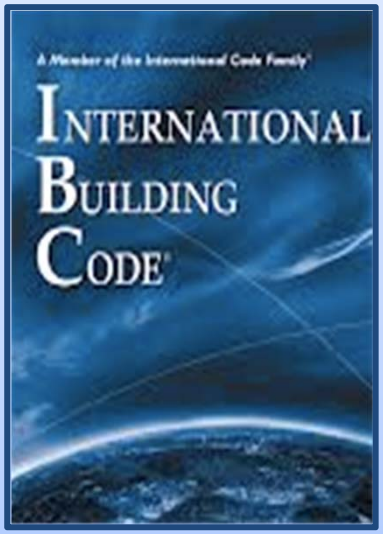
Demonstration Buildings

Early Commercialization

Tools and Guidebooks

Market

Wide Adoption of Cost Effective VLEBs



Policy

Collaboration Model

Research Institutions ⟷ Industry Partners

Resource Sharing

R&D Synergy

CSTC, MoHURD
CSUS
CABR
Tsinghua University
Chongqing University
Tongji University
Tianjin University

LBNL
ORNL
MIT
ICF
NRDC

Key 2012 Joint Activities

Program Planning, Strategy Setting, & Review Meetings

- 1st CERC-BEE Annual Review Meeting (Shenzhen, Jan, 2012)
  → Annual report generated (Chinese and English)
- 2nd CERC-BEE Annual Review Meeting (Sanya, July, 2012)
  → Discussed and agreed on key criteria for future project selection
- Joint Program Planning Meeting (Beijing, October 2012)
  → Selected continuing and new projects

Driving Rigorous Execution

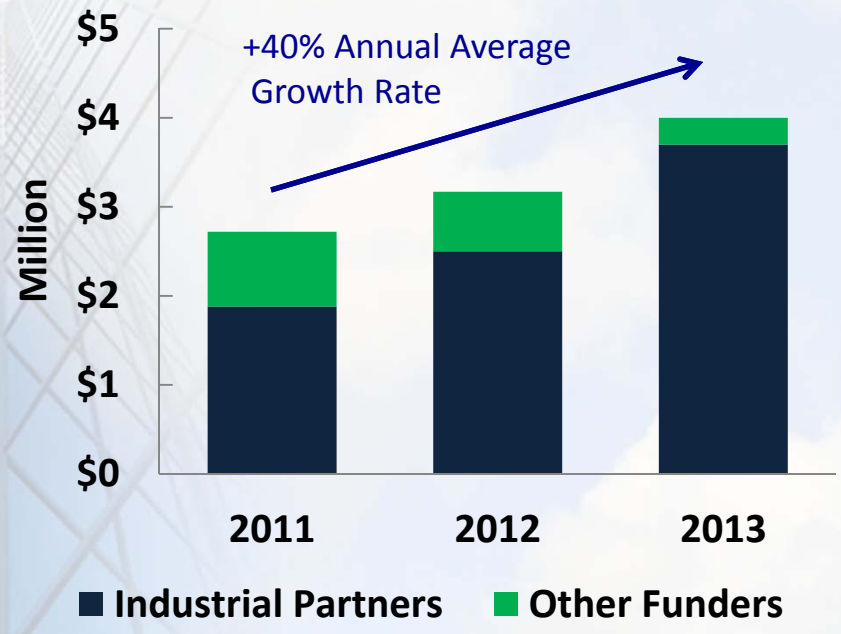
LBNL representatives visited Tongji University in March, 2012 participating in research discussions as well as building integrated PV and GSHP site visits.

NRDC and CSTC held a small seminar in March, 2012 discussing energy caps and energy-saving trading.

U.S. CERC Director Robert Marlay visited CSTC in Sept. 2012, holding the first discussion on setting VLEBs as the research goal.

Increasing U.S. Industrial Partner Engagement

Industrial Partner Funding

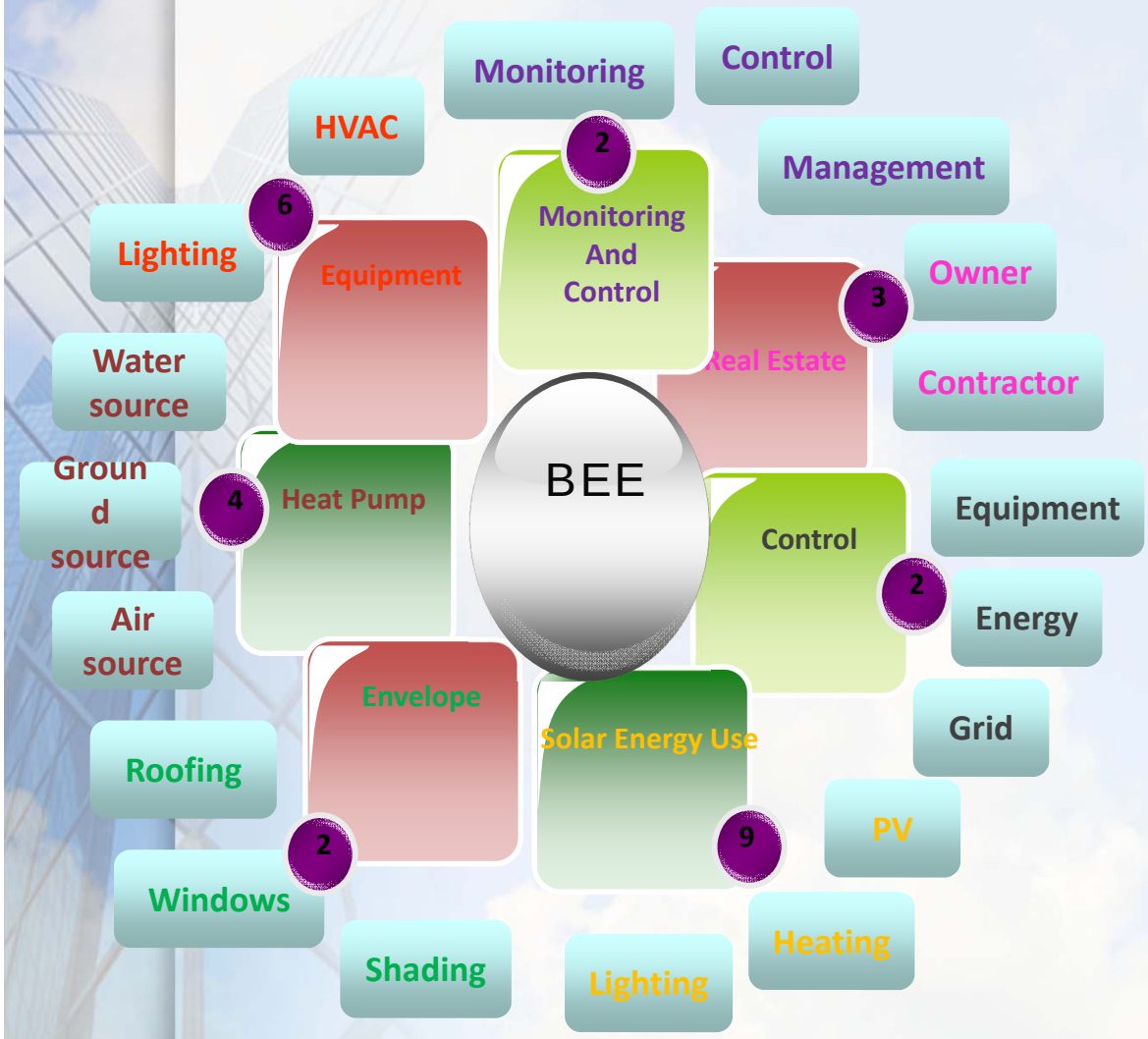


2012 Highlights

- Significant applied funding growth
- C3 joins - Energy Management
- Dow Chemical - Cool Roof Materials
- Lutron (Lighting), United Technology (Controls) pending
- Renewing IP focus
- US/China Joint IAB engagement

Increasing China Industrial Partner Engagement

28 IAB members



Company	Area
Xingye	Solar PV, Solar Heating, Envelope, Controls
Xin'ao	PV
Vanke	Developer
Saidi	Envelop
ROBA	Envelop
National Grid (Nan Rui)	Control
Persagy	Monitoring
Hengyou Yuan	GSHP
Jinghe Lighting	Lighting

中华人民共和国住房和城乡建设部办公厅

关于成立中美清洁能源联合研究中心建筑节能联盟企业委员会的通知

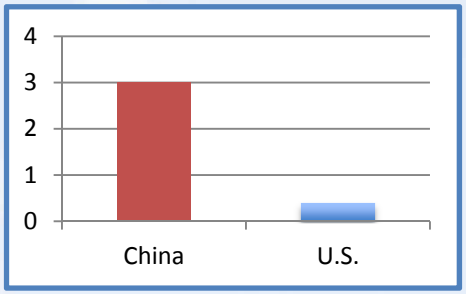
Technical Achievements

Monitoring and Simulation	• On-line comparative energy benchmarking tool • Expanded use of measured data from real-time monitoring • Behavioral impacts integrated into simulation models
Envelope	• Cool Roof provisions for Chinese national BEE standards • New designs for fenestration materials and systems • High efficiency shading and insulated window systems
Equipment	• Integrated control strategies • Advanced algorithms and demonstration programs for lighting • New advanced evaporative cooling systems
Renewables	• Cloud tool for distributed energy technologies based on load and real-time pricing • Evaluation of renewable energy systems • New ground source heat exchanger designs
Whole Buildings	• Real time strategies for cost & peak load reduction • Comparative research on energy use of U.S. and Chinese high efficiency buildings
Policy	• Methodologies for energy cap and trade system in buildings and quota system for public buildings • Policy recommendations to promote EE, renewable energy, and green buildings

Concluding Remarks

- Pioneering joint collaboration between U.S. and China
  - Governments, researchers and industry
  - Involves key policy makers MoHURD / DOE
- Huge Impact: CO_2 and cost savings by 2025 ~ 100 $MtCO_2$ ($2B) / year
- Accessing very large market: ~ 2B square m^2 per year U.S. / China new construction
- *Creating opportunities for a sustainable U.S. - China program on building energy efficiency*

U.S. - China Technical Review Meeting, Site Visit Beijing 10/12



New Construction in billions square meters per year (Years 2000-2010)

Building integrated renewable energy demonstration sites, U.S on left, China on right.

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* CO_2 reduction valued at $20/tonne

Thank You

Advanced technology for white roof coatings in U.S. and China

LBNL (Ronnen Levinson)
ORNL (Scott Hunter)
Dow Chemical (Joseph Rokowski)
Chongqing University (Yafeng Gao)
Guangdong Provincial Academy of Building Research (Shichao Yang)

Program overview

Objectives

- Quantify the energy and environmental benefits of cool surfaces
- Strengthen infrastructure for cool roofs in the U.S. and China
- Create white roof coatings with superior reflectance and durability for U.S. and China markets

Funding: $2M over 5 years

Market Size: 3B m^2 upgradeable by 2025 (U.S. + China)

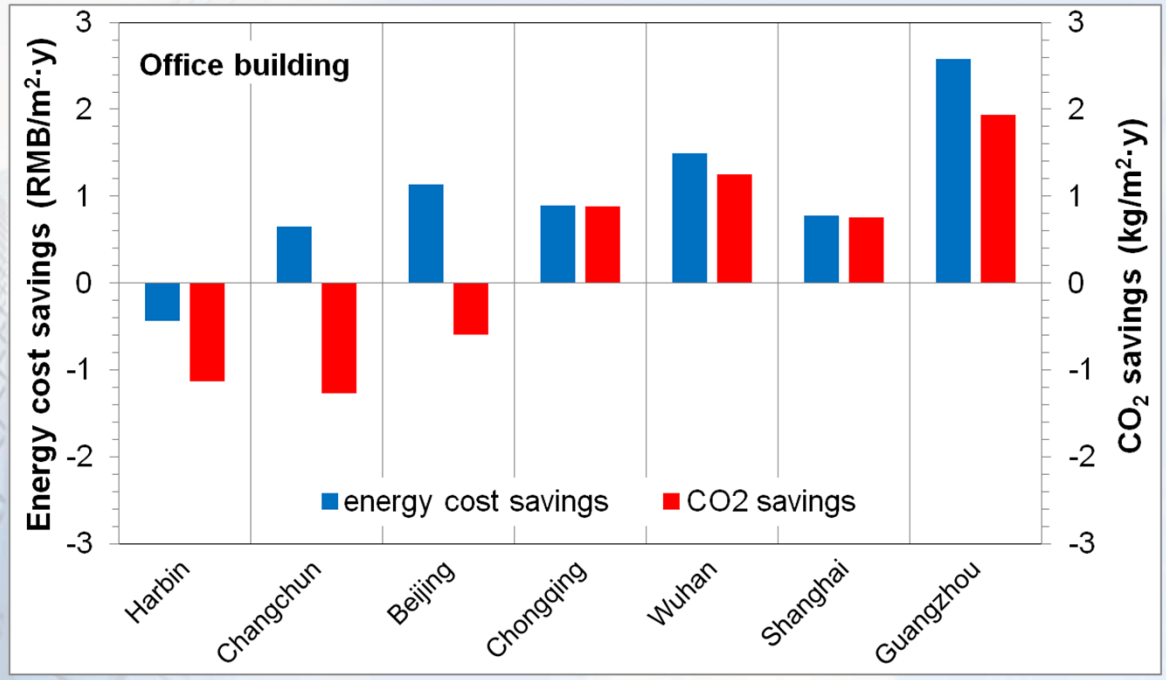
Commercialization Partner: Dow Chemical

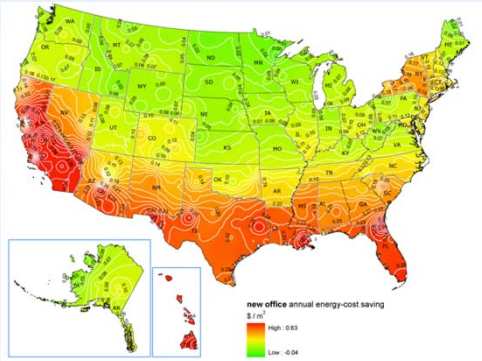
Potential for IP: High

Key milestones:

- China cool-roof simulations (completed)
- China cool-roof demonstrations (ongoing)
- Cool roofs in Chinese building energy standards (2015)
- New coating product yields IP (2013)
- New coating product achieves sales in China and the United States (2016)

Simulations show energy, emission, and cost savings in U.S. and Chinese climates with hot summers



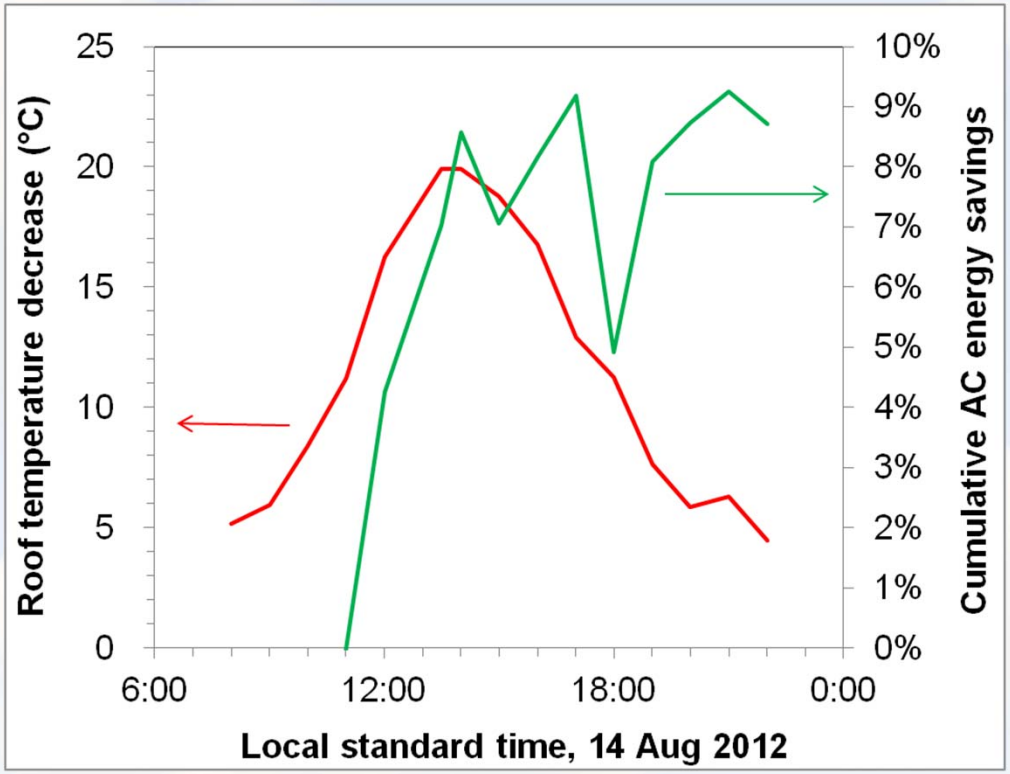


cold → **hot**

- White roofs save source energy, money, CO_2, NO_X, and SO_2 in cities with hot summers
- China and U.S. savings are comparable (after adjusting for solar radiation)

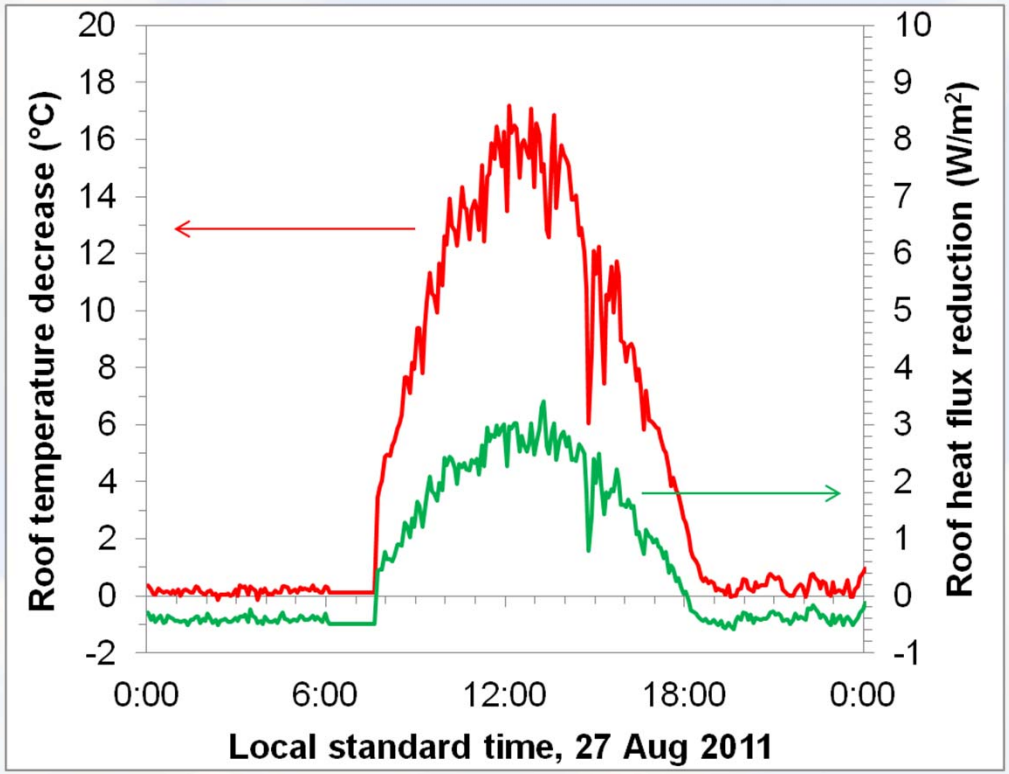
Chongqing University case study demonstrates cooler surfaces and A/C savings in Chongqing office building

- White roof up to 20°C cooler
- White roof daily A/C saving about 9%
- Larger *absolute* U.S. savings result from longer A/C operating hours, lower cooling set points for room air



Guangdong Academy case study shows cooler surfaces, reduced roof heat flux in naturally ventilated Foshan building

- White roof up to 17°C cooler
- White roof's 24-hour net heat influx 65% lower
- Results consistent with U.S. measurements



Dow Chemical
New Reflective Coatings Technology

New acrylic coatings for novel cool roofs

Coating Performance Targets:

- Double long-term dirt resistance & energy savings
- Increase water resistance and durability by 50%

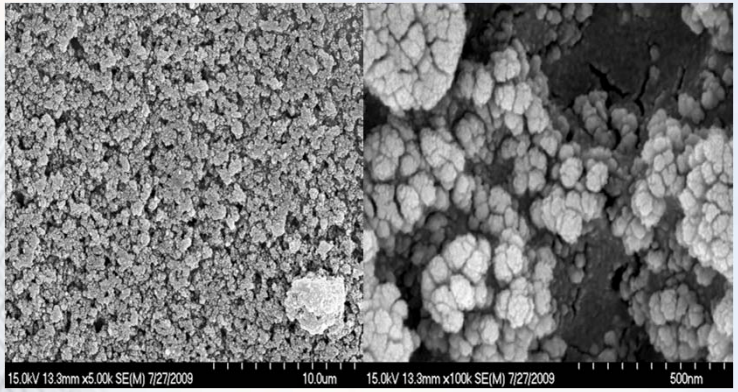
Current Acrylic Technology:

- Excellent exterior UV resistance, but…
- Not waterproof due to hydrophilicity
- Reduced long term solar reflectance due to soiling (soot and dirt) & microbial growth (fungi, moss, algae)

Goal:

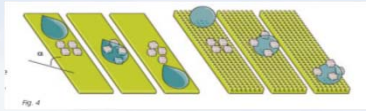
- Improve performance profile for white roof coatings
- Increase demand
- Secure IP for new technology

ORNL developed silica-based superhydrophobic surfaces

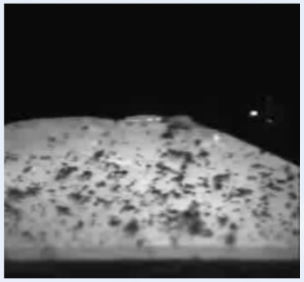


Photomicroscopy of nanosilica particles and resultant superhydrophobic surface

Self-Cleaning Superhydrophobic Surfaces



Dirt particles remain on a normal surface



Slow cleaning

Water drop collect surface dirt on superhydrophobic (SH) surface

Fast cleaning

Novelty: Treated silica pigment has broad use & low cost

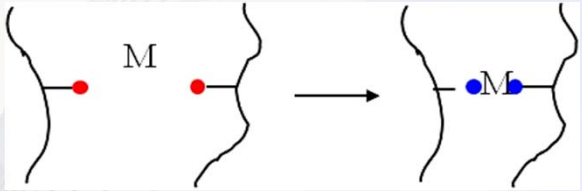
Solution: Superhydrophobic (SH) coatings prevent wetting, soiling and microbial growth but are solvent based

Dow acrylic technology is water-based and exterior durable

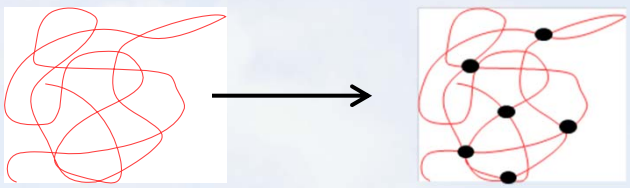
Action: Combine ORNL, LBNL & Dow expertise in joint effort (CRADA) for cost effective waterborne roof coatings

New acrylic technology for extended durability

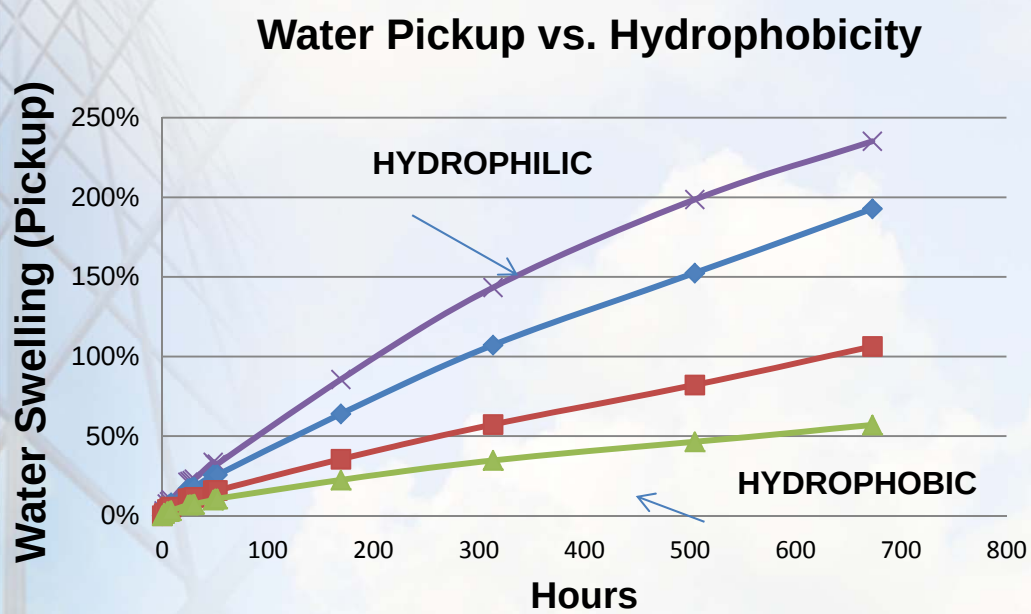
New : Higher crosslinking & hydrophobicity increase durability & water resistance



Old Technology



New Technology
(planned IP filing)

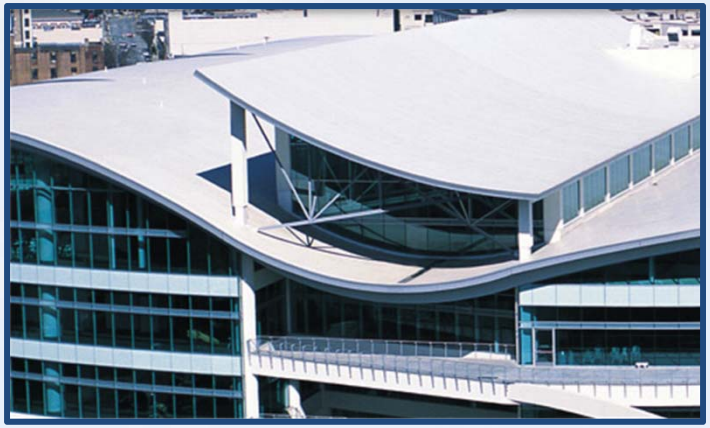


Challenge: Modify ORNL superhydrophobic materials for use in waterborne coatings:

- Leverage Dow core R&D organosilane expertise
- Leverage Dow Chemical high shear processing to disperse hydrophobic materials, e.g. polyolefin
- Employ LBNL/ORNL accelerated aging technology for prototyping

Project outcomes

- Demonstration and quantification of cool roof benefits in China and U.S.
- Adoption of Chinese rating systems, incentives, and standards similar to those in the U.S.
- Research and development leads to new IP and commercialization of advanced cool roof coatings*



* The potential cool roof markets in China and the U.S. are very large (2B m^2 in China, 1B m^2 in U.S.) Upgrading roofs could save 200 TBtu/y (210 EJ/y) source energy and 14 Mt/y CO_2 by 2025 at no cost premium.

Thank You