Cool Roof Activities at LBNL

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Building Envelope Technology Roadmapping Workshop • San Antonio, TX • 26 June 2012

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

Building Technologies Program

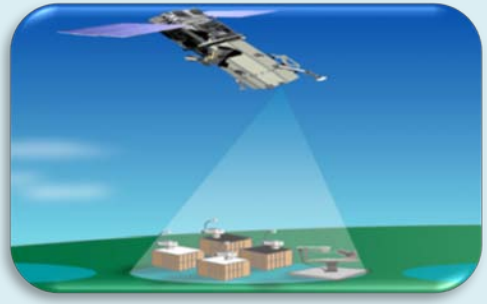
Berkeley Lab Heat Island Group works to cool buildings, cities, and the planet

Advanced Surfaces

Laboratory method for accelerated aging of roofing materials
(DOE)

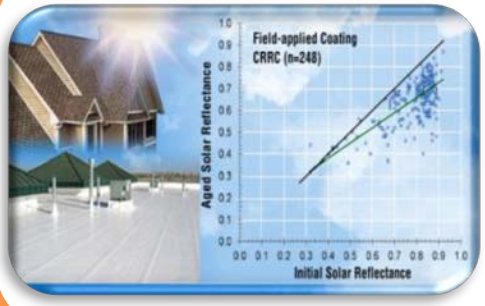
Global Cooling in India

How much do cool roofs reduce radiative heat flow to the Earth system?
(DOE)



CA Roof Reflectance

Mapping the albedos of California's roofs using multiband aerial imagery
(CARB)



Next-Gen Materials

Developing cool roofing products with superior aged solar reflectance
(DOE)

Cool Communities

Helping Californians make smart choices about cool surfaces and vegetation
(CEC/CARB)

US-China CERC-BEE

Bringing cool roofs to China
(DOE)

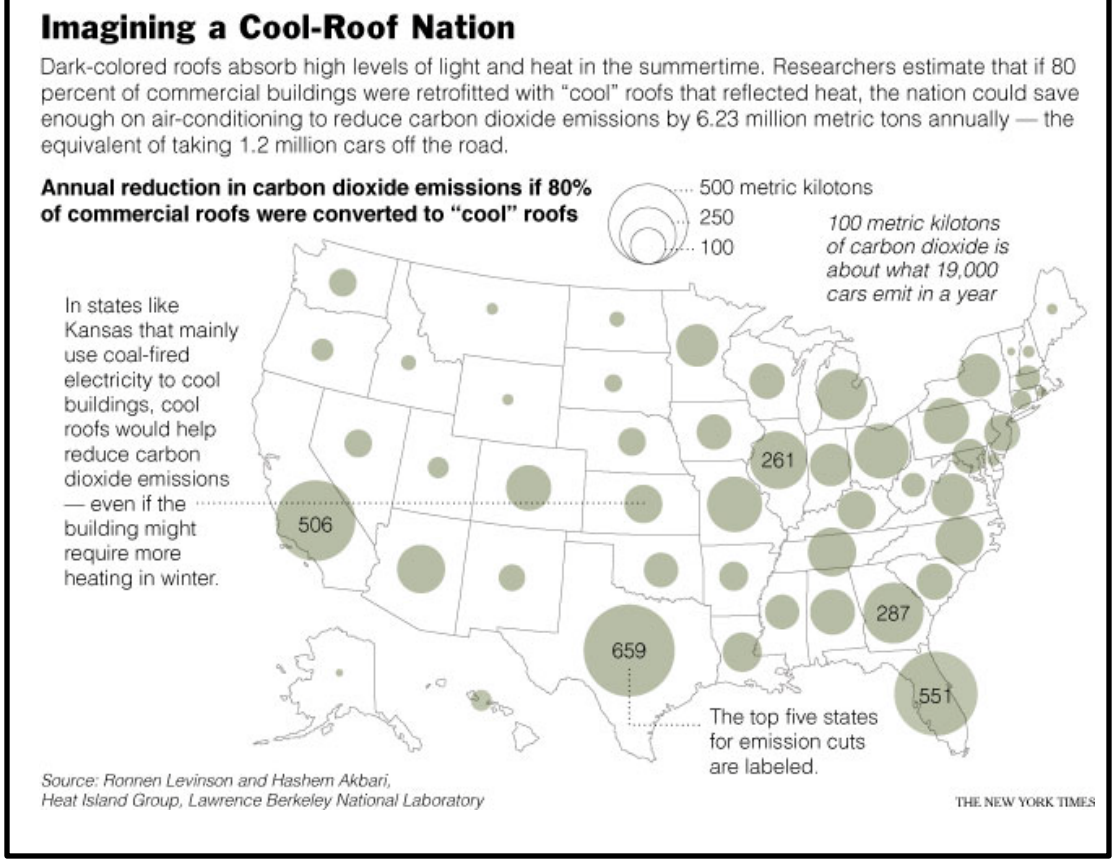
Making U.S. commercial building roofs white would offer $11B in lifetime energy savings

Retrofitting 80% of U.S. air-conditioned commercial buildings with **conventional** white roofs would annually save

- $735M
- 6.2 Mt CO_2 (=1.2M cars)

through energy conservation

New York Times, 30 July 2009



Levinson R, Akbari H. 2010. *Energy Efficiency* 3:53-109.

About 80% of U.S. residential roofing market is dark, hot asphalt shingles

Upgrading these roofs could yield $14B in lifetime energy savings

Reflectance map generated from multi-band aerial images in our CARB-sponsored California Roof Albedo project

Nominal Visible Reflectance
- 0.00 - 0.05
- 0.06 - 0.10
- 0.11 - 0.15
- 0.16 - 0.20
- 0.21 - 0.25
- 0.26 - 0.30
- 0.31 - 1.00

San Jose, CA

Improving white roofs and asphalt shingles should be inexpensive (pennies/square foot)

Keeping White Roofs Clean

- retaining plasticizers
- anti-microbials
- photocatalysts

Making Asphalt Shingles Cooler

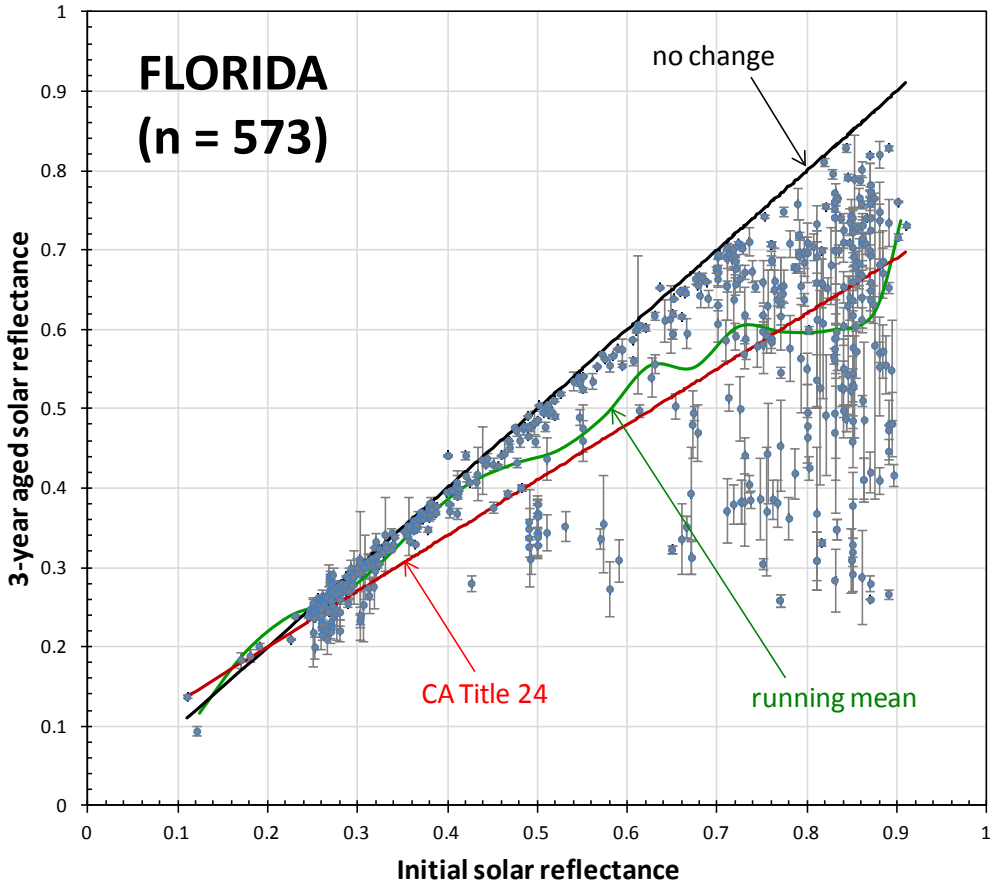
- use white, cool-colored pigments (~ $0.01/ft^2)
- better coating processes

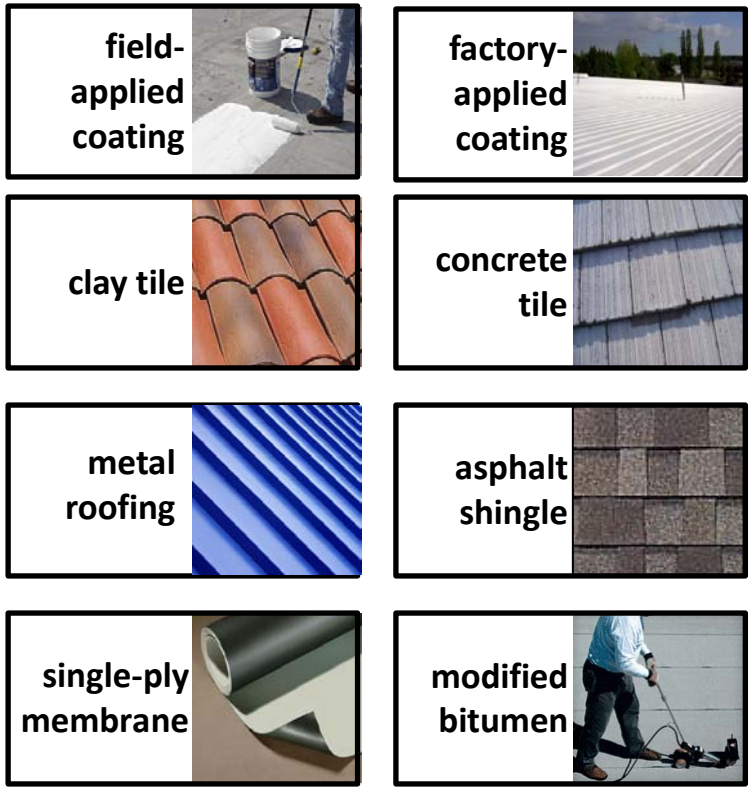
On the market today

SR ~ 0.10
$0.89/ft^2

SR ~ 0.27
$0.92/ft^2

Product performance (solar reflectance) is variable and degraded by natural soiling

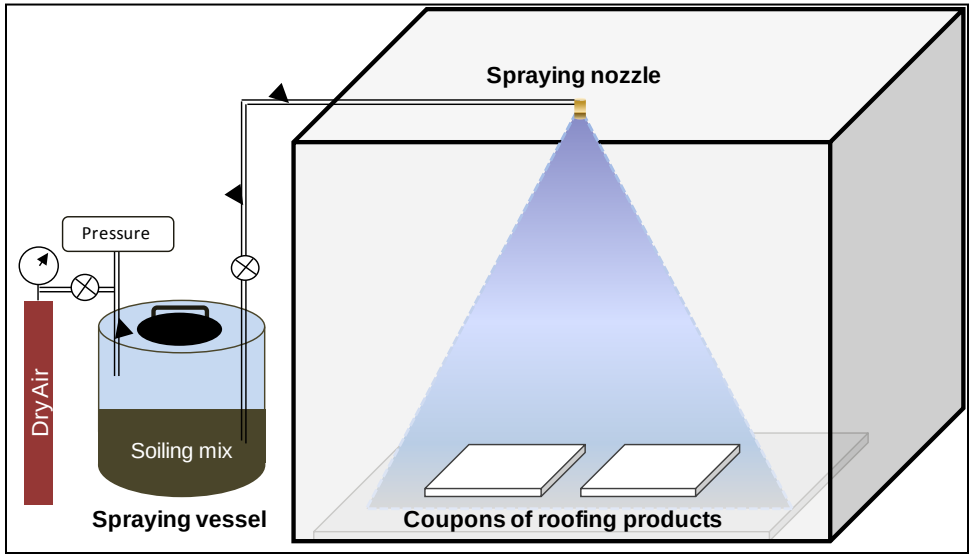




Sleiman et al. 2011. *Solar Energy Materials and Solar Cells* 95:3385-3399

Minimizing loss of solar reflectance could boost white-roof energy savings by 50%

Advanced Surfaces will create ASTM and ISO standards for rapid & calibrated accelerated aging of roofing materials



Laboratory aging

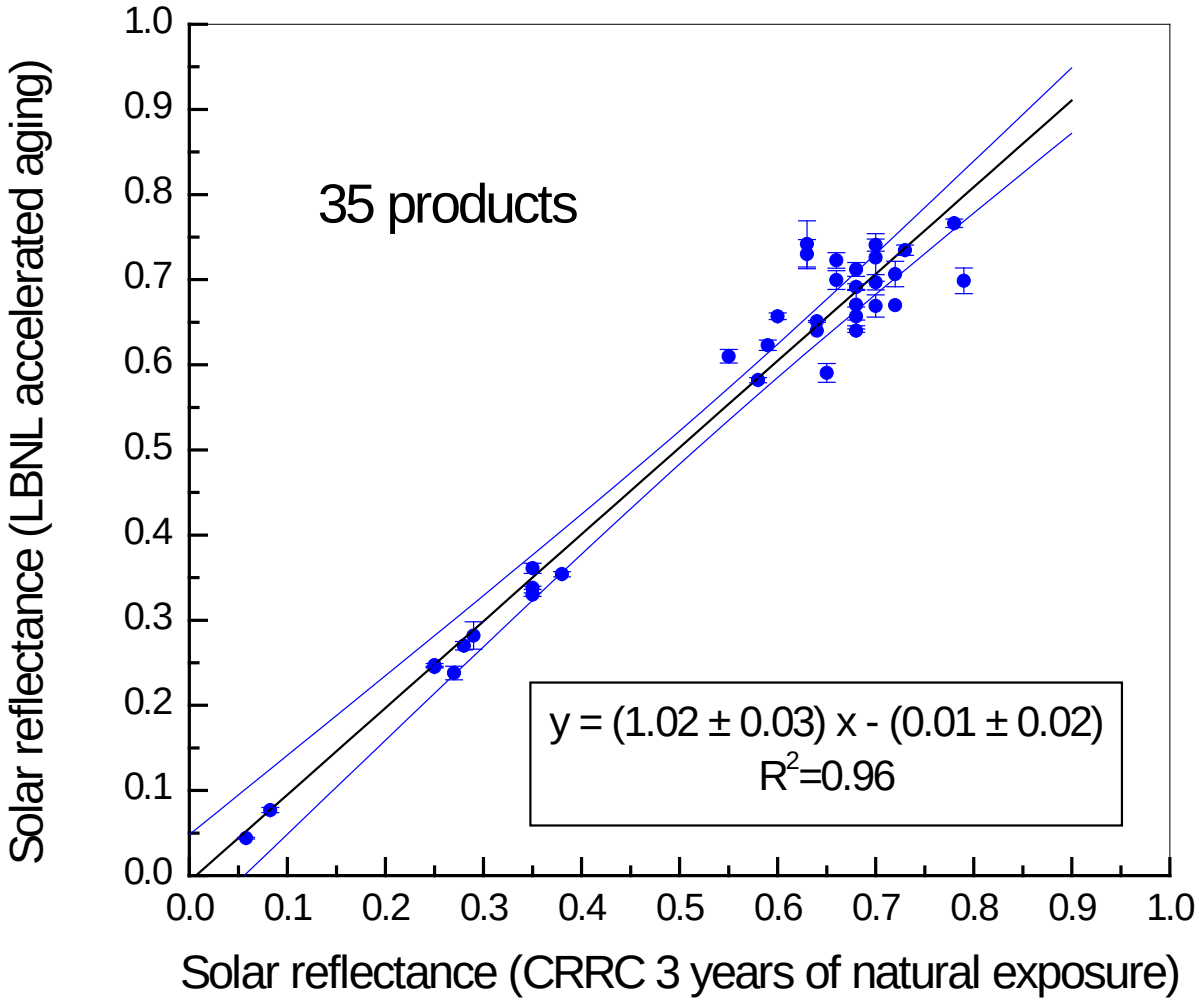
Natural exposure

ASTM INTERNATIONAL
Standards Worldwide

ISO International Organization for Standardization

Standardization

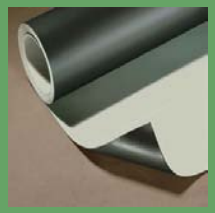
Our method reproduces CRRC's 3-year-aged solar reflectance ratings in 3 days



Field applied coating (n=7)

Metal or factory-applied coating (n=8)

Single-ply membrane (n=11)

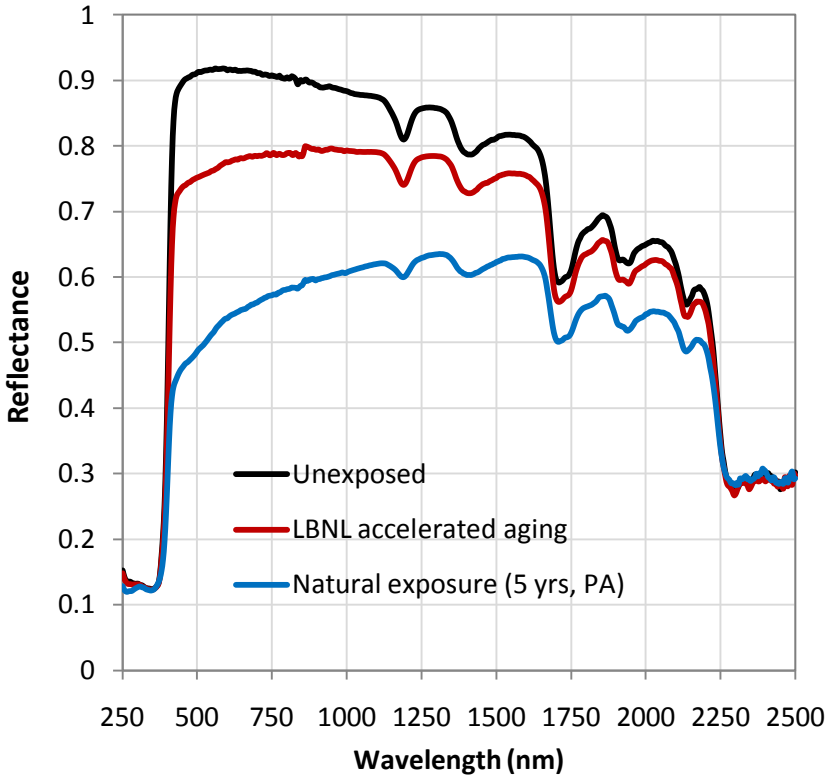


Clay tile (n=2)

Asphalt shingle (n=4)

Modified bitumen (n=3)

CRADA A helps Dow develop white elastomeric coatings that stay clean (and possibly last longer)



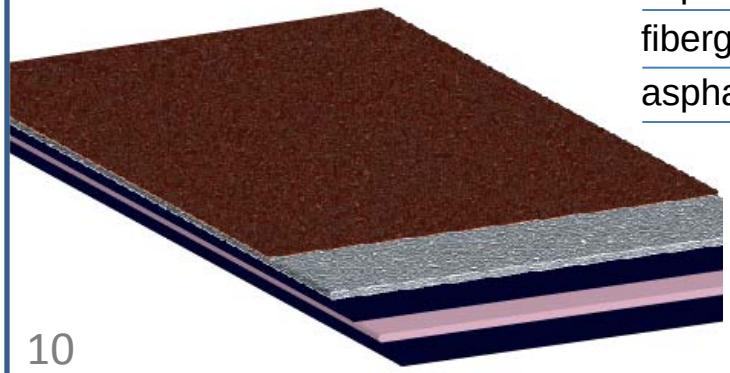
Advanced Surfaces aging method will be enhanced to simulate material degradation for rapid prototyping of stay-clean coatings with exceptionally long service lives.

	Solar reflectance
Unexposed	0.87
LBL accelerated aging	**0.76**
Natural exposure (3 yr CRRC)	**0.76**
Natural exposure (5 yr, PA)	0.54

CRADA B helps Owens Corning develop low cost factory-produced cool asphalt shingles

Approach 1: Improve granule coatings

Approach 2: Use bare granules and spray coating(s)



Approach 3: Solar reflective clear top coat on conventional shingle

CRADA C helps CertainTeed & Dow develop cool retrofit coatings for asphalt shingle roofs

- Estimate energy cost savings
- Avoid previous failures
- Develop prototypes with increased reflectance
- Maintain aesthetics & durability

Retrofit coatings are available for most roofing products *other than asphalt shingles*

before

after

elastomeric coating over capsheet

acrylic coating over tile

Where do we go from here?

Technology transfer

Next generation cool roofing materials

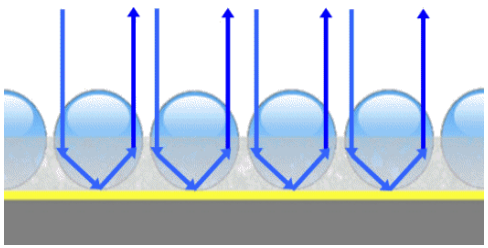
Unconventional solutions

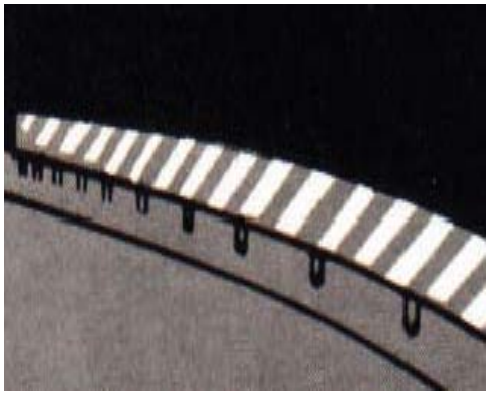
We will explore unconventional technologies…

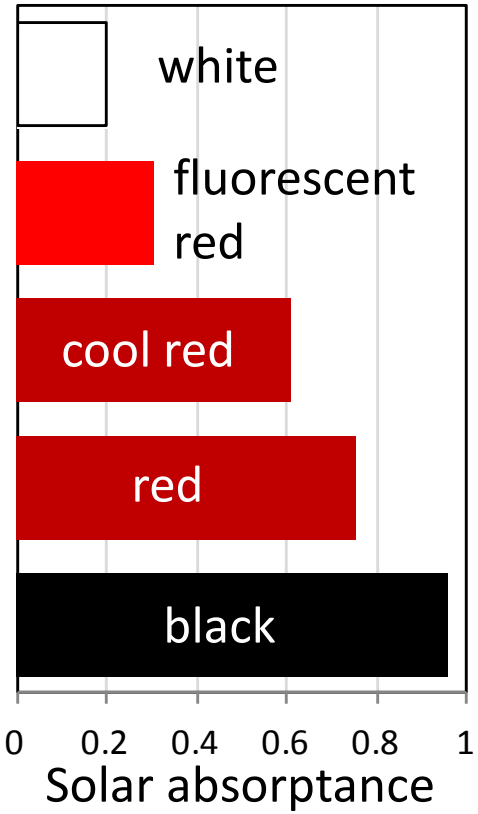
Solar retro-reflectors

Photocatalytic self-cleaning surfaces

Fluorescent pigments





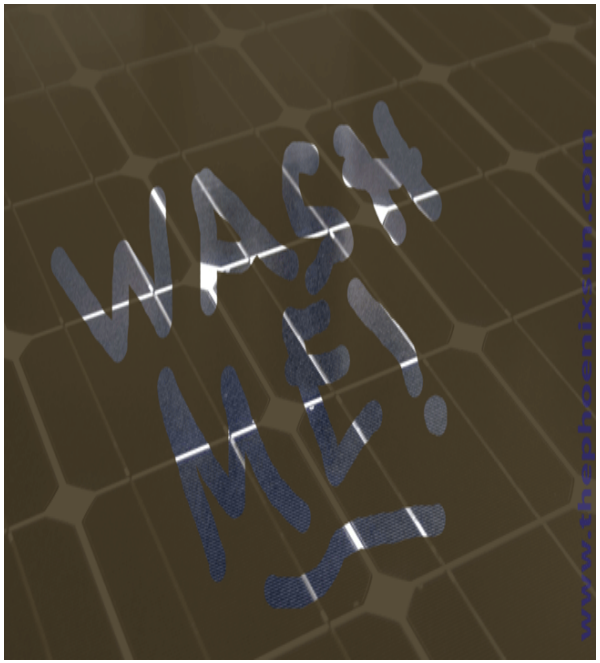


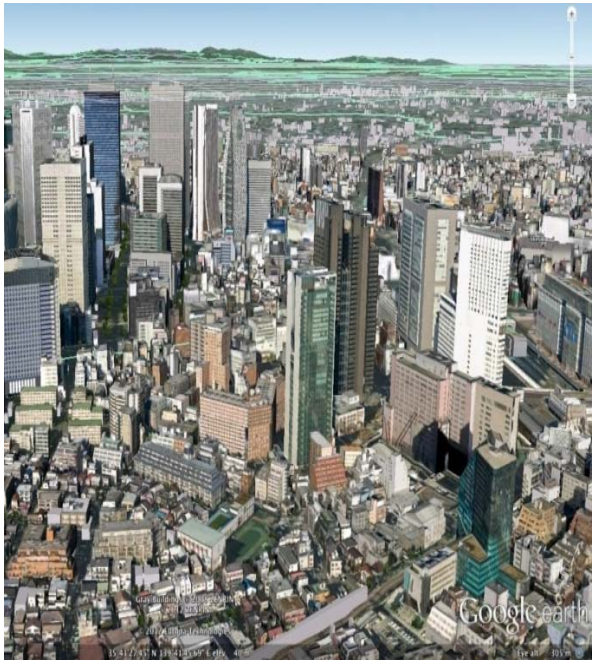
…and go beyond cool roofs

Stay-clean photovoltaics

Cool façades

Cool pavements





Supplemental slides

Advanced Surfaces deliverables and next steps

	Deliverables	Status	Due Date	Next Steps
D.1	Progress report on accelerated aging method (version 1.1)	Version 1.1 was further validated for various roofing materials (90% done) **Submitted provisional application for U.S. patent**	End of FY12 Q4	Explore adding a surrogate for microbiological growth to better mimic hot and humid climates Extrapolate the method to mimic soiling in other locations than the CRRC (U.S. and international)
D.2	Progress report on the results of 21 months of natural exposure	18 months samples retrieved; data analyzed through 15 months	End of FY12 Q4	Continue to collect, analyze naturally exposed samples up to 3 years (Oct. 2013) – identify effects of climate & location
D.3	Workplan for exposure of roofing samples at international locations	Partnered with Dow and international researchers to expose materials in Brazil, France, Italy, UAE and China	End of FY12 Q4	Expose samples at international locations, identify correlations between loss of solar reflectance, soiling composition and location
D.4	Roadmap for creating a ASTM and ISO standards for accelerated aging	Draft standard will be presented at ASTM D08 Plan to attend ISO TC-163 (Sept. 2012)	End of FY12 Q4	Coordinate with industry and ATSM D08 to move forward the process of standard adoption Build consensus by sharing the technology with our international partners

CRADA A deliverables and next steps

Task	Deliverables	Status	Due Date	Next Steps
1	Evaluation of solar reflectance spectra of field-aged samples provided by Dow	Completed measurement of radiative properties of a subset of Dow elastomeric coatings (fresh and aged samples)	Q2 FY12	Measure radiative properties of samples exposed at international sites
2	Natural soiling and weathering at three CRRC sites	Three series of Dow coatings were shipped to ATLAS for natural exposure at the 3 CRRC sites	Q2 FY14	Retrieve samples quarterly from exposure sites and measure their radiative properties
3	Accelerated soiling and weathering of Dow samples	Accelerated aging - Preliminary experiments Results compared with the CRRC rated values	Q3 FY12	Apply accelerated aging method to Dow's coatings Compare lab results with site-specific values of solar reflectance for Dow coatings aged in PA and at the 3 CRRC sites
4	Chemical characterization of soiling from laboratory and field samples	Ongoing characterization of soiling on lab and field samples using LBNL facilities	Q4 FY12	Use characterization techniques with samples periodically retrieved from the 3 CRRC sites, and with samples exposed outside the US

CRADA B deliverables and next steps

	Deliverables	Status	Due Date	Next Steps
D(1).1	Report on development of improved granule coatings for cool shingles	Identification of suitable coatings in progress	End of FY12 Q4	Identify more effective cool pigments, use polymeric rather than ceramic coatings, and/or increase coating thickness without causing granule aggregation
D(2).1	Report summarizing developed prototype shingles made by spray coating shingles surfaced with bare granules	NA	End of FY12 Q4	Identify and validate commercially available coatings. Measure solar reflectance of prototype shingles with spray coating
D(3).1	Report summarizing use of currently manufactured shingles with an added top coat to dramatically increase solar reflectance while minimizing changes in aesthetics	Initiated development of visibly clear, near-IR reflective pigments	End of FY12 Q4	Create a cost effective method to produce visibly clear, near-IR reflective pigments. Measure solar reflectance of shingle with spray coating
D(4).1	Final report summarizing long-term durability of the most promising developed product and factory process development	NA	End of FY13 Q4	Quantify long-term structural durability and coating adhesion using weatherometer and appropriate test standards. Quantify resistance to soiling

CRADA C deliverables and next steps

	Deliverables	Status	Due Date	Next Steps
D(1).1	Report summarizing quantification of cost benefits of the retrofit coating	Base energy simulations compiled	End of FY12 Q4	Estimate roof coating production costs. Quantify cost benefits in different climate zones
D(2).1	Report summarizing investigation of previous attempts at coating asphalt shingles	NA	End of FY12 Q4	Investigate previous attempts at coating shingles. Estimate country-wide energy and cost savings
D(3).1	Report summarizing development of coating performance targets and progress on identification of a retrofit coating for asphalt shingles	Identification of existing commercial products in progress	End of FY13 Q4	Identify and validate commercially available coatings that meet our requirements. If none exists, modify available coating to meet requirements
D(4).1	Report summarizing effects of coating on moisture performance and structural properties of shingle, changes in hygrothermal behavior of homes with retrofit coating, and modeling changes in hygrothermal behavior of homes in different climate zones	NA	End of FY13 Q4	Deliverable to be completed by ORNL
D(5).1	Report summarizing long-term durability of shingles with the retrofit coating.	NA	End of FY13 Q4	Use spectrophotometer and accelerated aging protocol to quantify spectral reflectance and resistance to soiling of retrofit coating. Quantify long-term adhesion of retrofit coating using weatherometer