The Writing's on the Wall
Recent Cool Wall Research and Measures

Thank you for joining. We will start in a few minutes.

NEW! Two audio options:

1. **Listen via computer**
2. **Call in to 1-855-210-5748**

EPA

HEAT ISLAND REDUCTION PROGRAM

State and Local Energy and Environment Program

The Writing's on the Wall
Recent Cool Wall Research and Measures

February 22, 2018

Hosted by:

U.S. EPA Heat Island Reduction Program

Cool Walls Webcast Agenda

- **Introduction**
  Victoria Ludwig, U.S. EPA Heat Island Reduction Program
- **Building energy and greenhouse gas benefits**
  Ronnen M. Levinson, Lawrence Berkeley National Lab
- **Urban climate and other co-benefits**
  George Ban-Weiss, University of Southern California
- **Existing cool wall codes and programs**
  Haley Gilbert, Lawrence Berkeley National Lab
- **Hawaii's adoption of cool wall codes and measures**
  Howard C. Wiig, State of Hawaii
- **Q&A Session**

HEAT ISLAND REDUCTION PROGRAM

Webcasts now use Adobe Connect

Troubleshooting Tips

- Try a different web browser (e.g., Firefox, Chrome)
- Download the latest version of Adobe Flash Player
- Check with your Information Technology (IT) department about your internet security settings
- Find help online
- Add epacallcenter@epa.gov to your email contact list

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How to Participate

Audio

- **Computer**
  - Audio will begin when the Host signs on
  - Tip! Unmute your speakers or headphones
- **Phone**
  - Call in to 1-855-210-5748
  - Tip! Mute your computer speakers to avoid audio feedback
- **Participants are muted**

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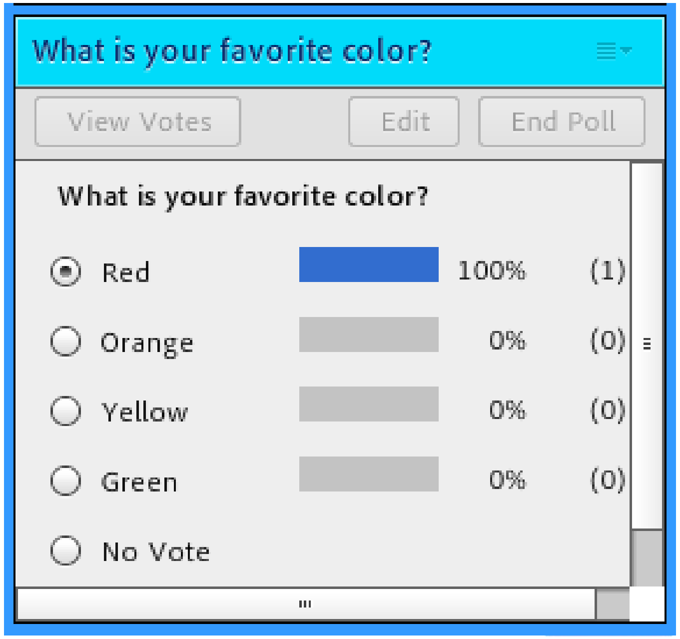
How to Participate

Question and Answer

- Enter your question in the Q&A box
- Questions will be moderated at the end
- EPA will post responses to unanswered questions on the Heat Islands webpage

Polling

- We'll ask several poll questions during the webcast



Introduction

Victoria Ludwig

U.S. EPA Heat Island Reduction Program

EPA’s Heat Island Reduction Program

- **Mission**

  Outreach and technical assistance program working with local officials, researchers, non-profits, and industry to identify opportunities to implement effective heat island reduction programs and policies.

- **Program Audiences**
  - Local and state policymakers and program implementers
  - Academia/researchers
  - Other federal agencies
  - Non-profit organizations
  - Industry

HEAT ISLAND REDUCTION PROGRAM

Heat Island Program Resources

- ***Compendium of Strategies*****: *Reducing Urban Heat Islands***: Heat island science, detailed info on mitigation strategies, local examples, policy options
- **Website**: Basic information on heat island topics, calendar of events, newsroom, links to other resources
  - NEW: Updated content on measuring heat islands
- **Examples**: Database of more than 75 local and statewide initiatives to reduce heat islands
- **Webcasts**: Topics include case studies, public health connections, advances in mitigation policy
- **Newsletter**: Recent news on projects and policies, research, funding opportunities

Contact Information

Victoria Ludwig

U.S. Environmental Protection Agency

202-343-9291

Website

EPA Heat Island Newsletter Sign-Up

Building Energy and Greenhouse Gas Benefits

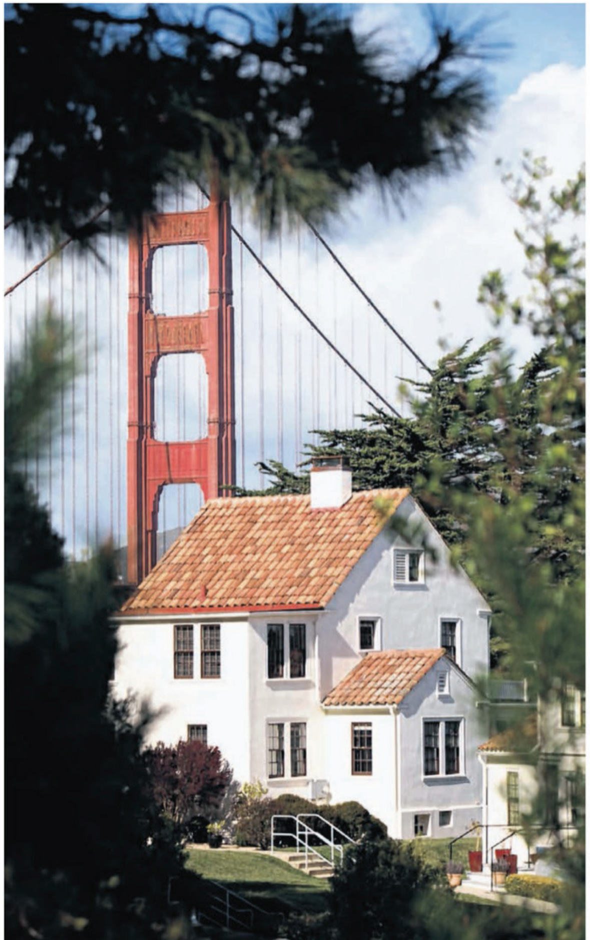
Ronnen M. Levinson

Lawrence Berkeley National Lab

LBNL Heat Island Group

BERKELEY LAB

USC University of Southern California


Source: Lea Suzuki, San Francisco Chronicle, 10 February 2013

Building energy and greenhouse gas benefits of cool walls

Ronnen Levinson*, Pablo Rosado, Sharon Chen, and Hugo Destaillats

Lawrence Berkeley National Lab (LBNL)

* RMLevinson@LBL.gov

The Writing's on the Wall: Recent Cool Wall Research and Measures

U.S. EPA Webinar • 22 February 2018

FUNDING PROVIDED BY THE CALIFORNIA ENERGY COMMISSION

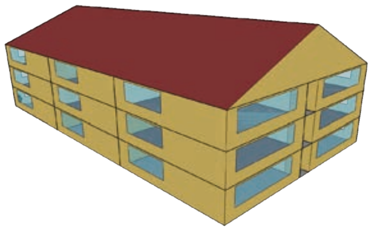
A “cool” wall reflects sunlight to reduce cooling load, save energy, and lower emissions

Wall solar reflectance

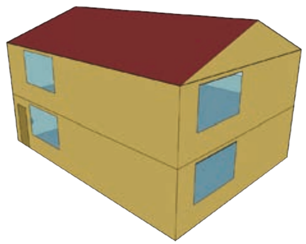
- Conventional ≈ 25%
- Cool color ≈ 40%
- Off or dull white ≈ 60%
- Bright white ≈ 80%

We used EnergyPlus to model cool-wall heating, ventilation, and air conditioning (HVAC) energy savings

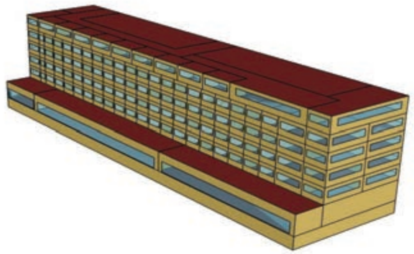
Apartment building



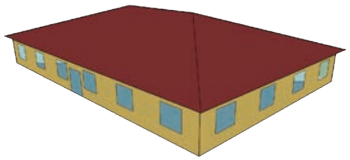
Single-family home



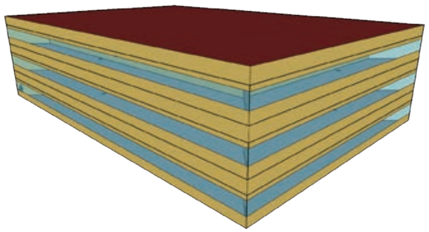
Large hotel



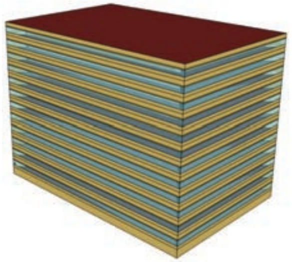
Small office



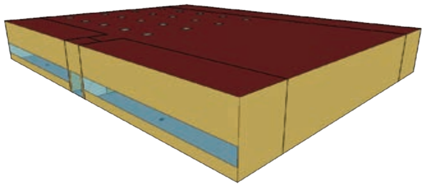
Medium office



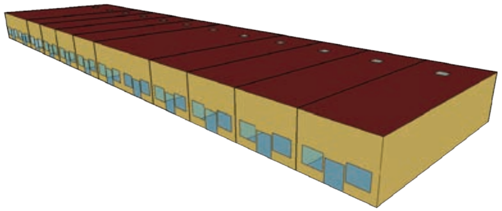
Large office



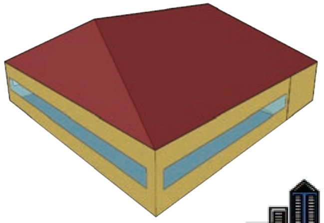
Stand-alone store



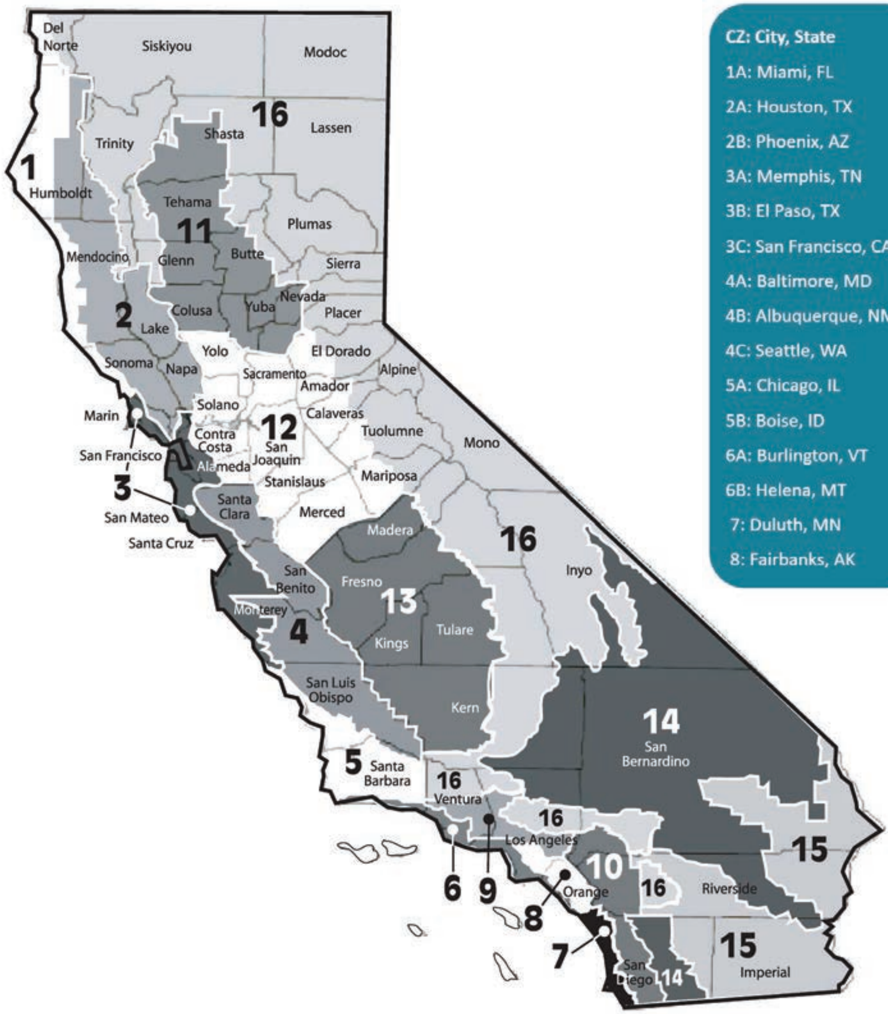
Strip mall



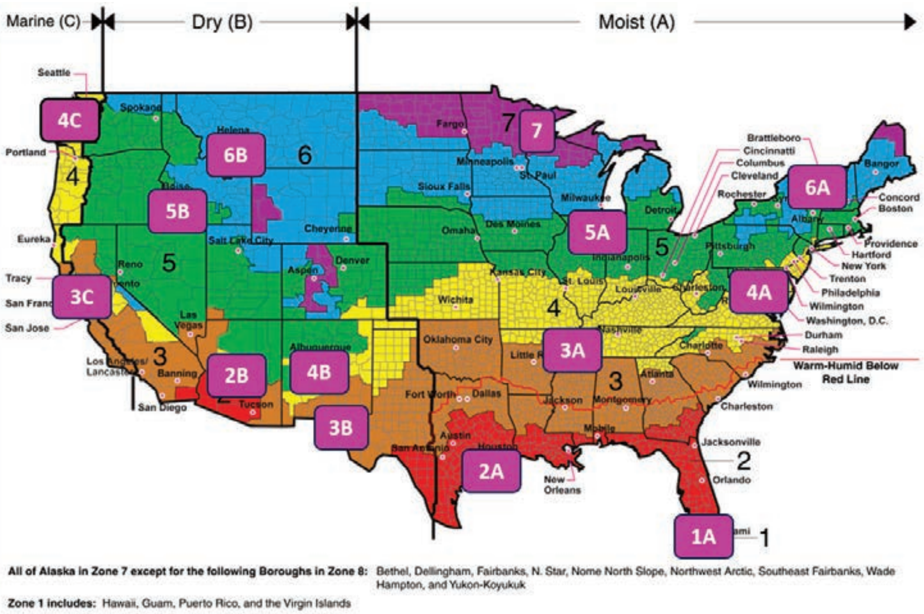
Restaurants (sit-down and fast-food)



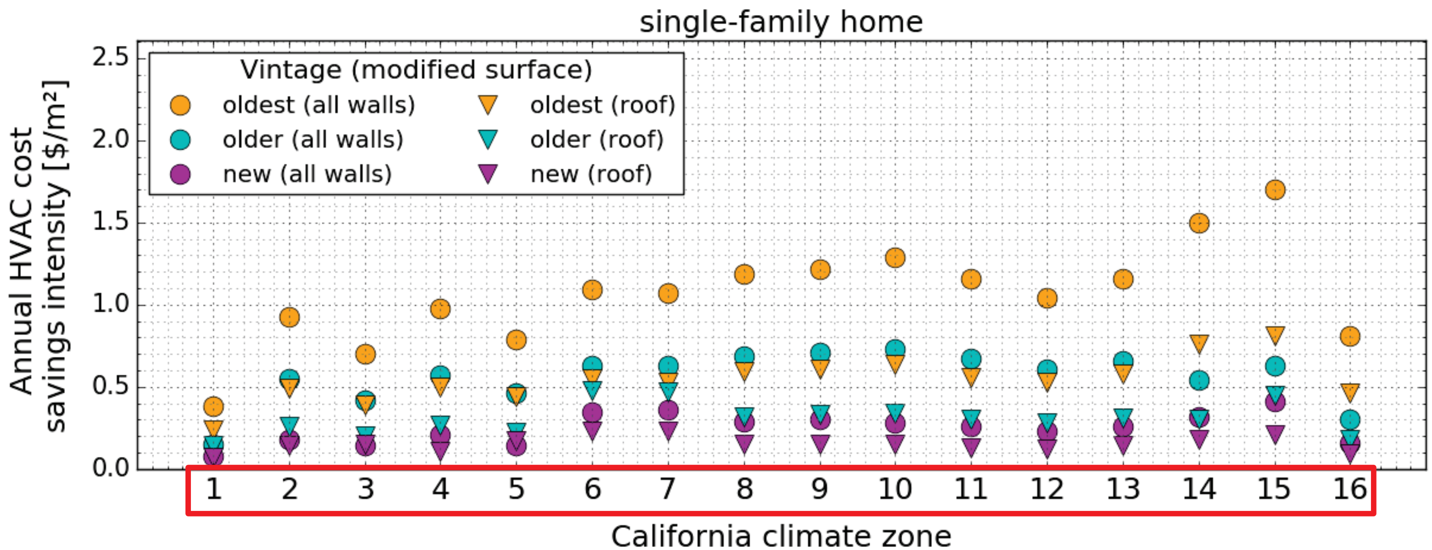
We evaluated annual energy, cost, and emission savings in each California and U.S. climate zone (> 100K simulations!)

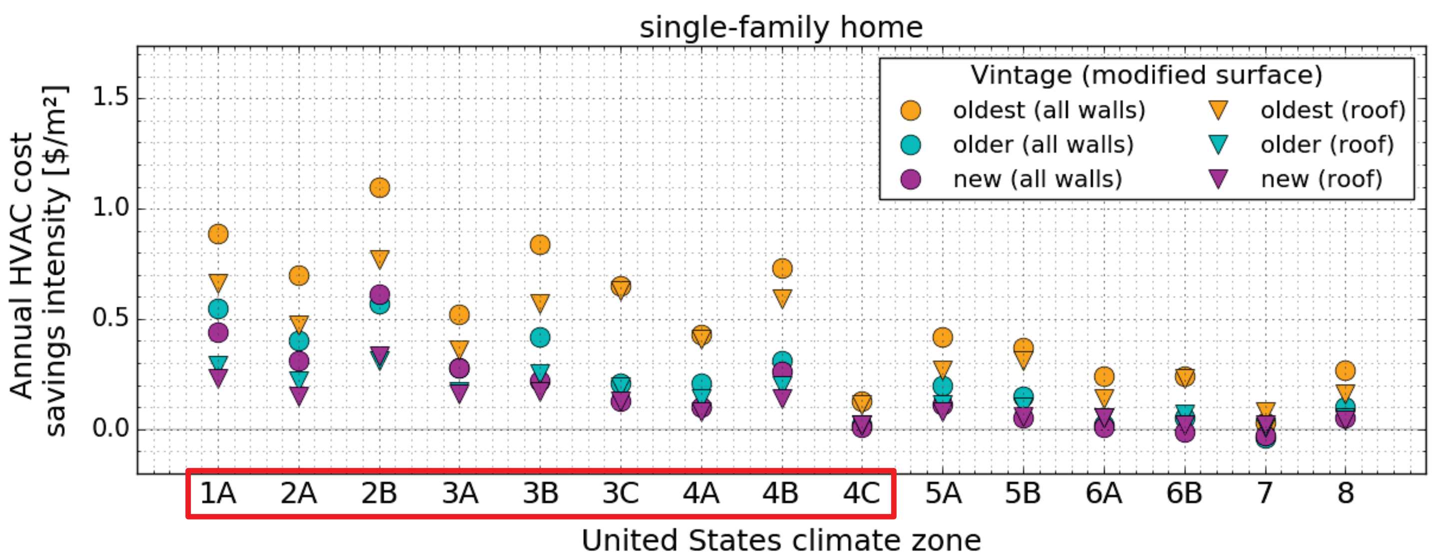


CZ: City, State
- 1A: Miami, FL
- 2A: Houston, TX
- 2B: Phoenix, AZ
- 3A: Memphis, TN
- 3B: El Paso, TX
- 3C: San Francisco, CA
- 4A: Baltimore, MD
- 4B: Albuquerque, NM
- 4C: Seattle, WA
- 5A: Chicago, IL
- 5B: Boise, ID
- 6A: Burlington, VT
- 6B: Helena, MT
- 7: Duluth, MN
- 8: Fairbanks, AK



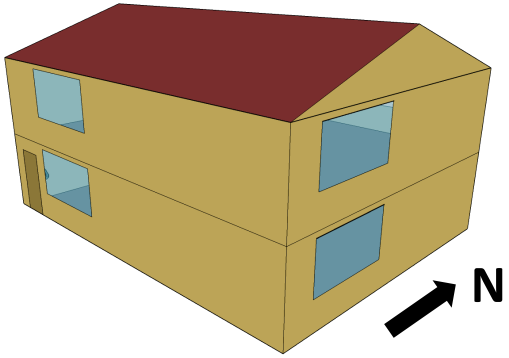
Cool walls save energy, carbon dioxide in homes, offices, and stores in all California climates + U.S. climates 1 - 4



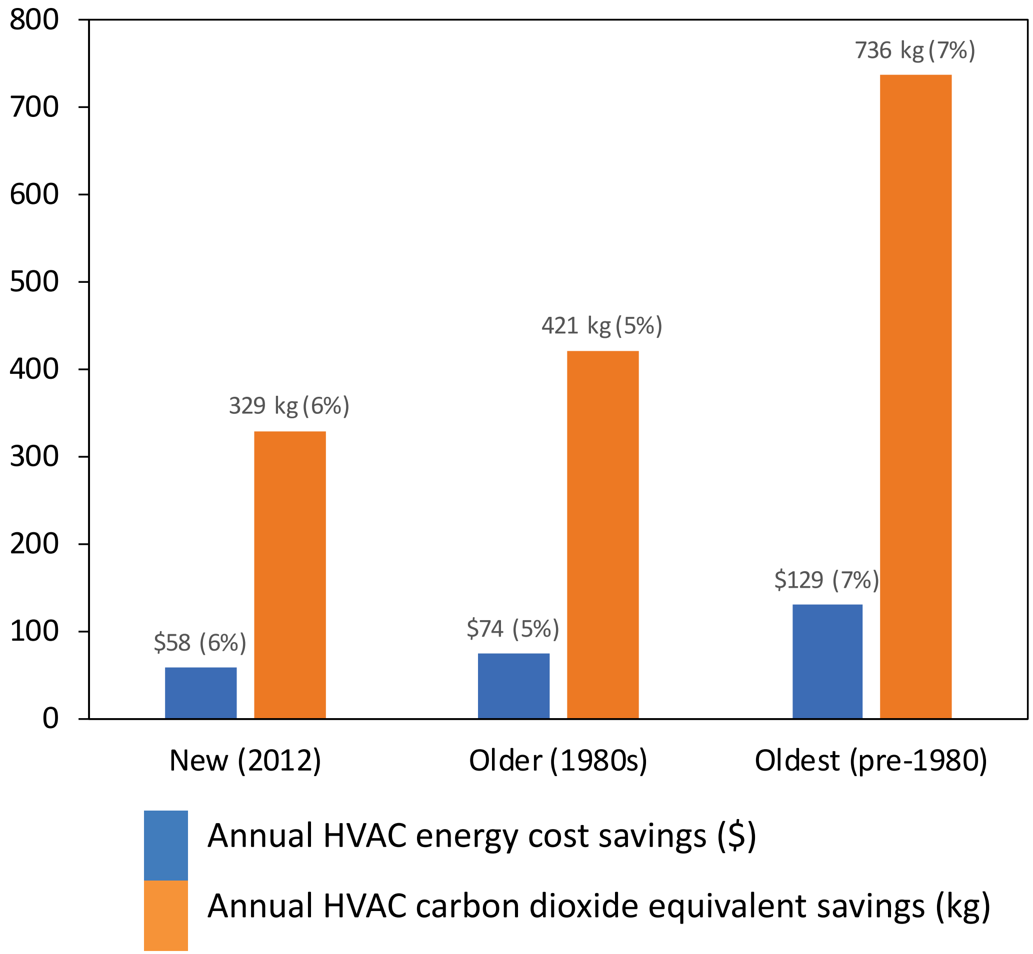


Example: Single-family home in Houston, TX

Single-family home



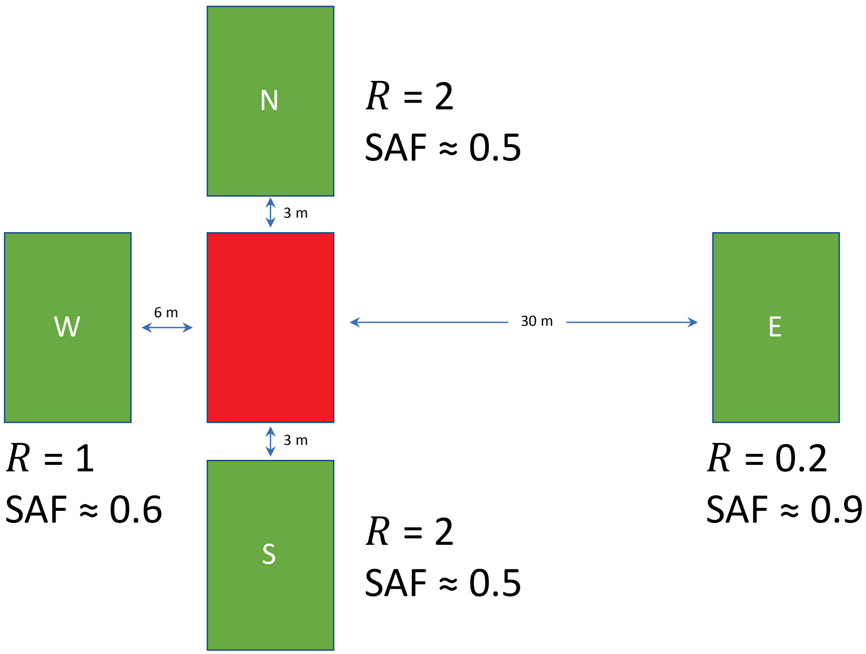
Floor area: 220 m² (2,400 ft²)
Net wall area: 180 m² (1,900 ft²)
Wall albedo: 0.25 → 0.60
Building orientation: averaged



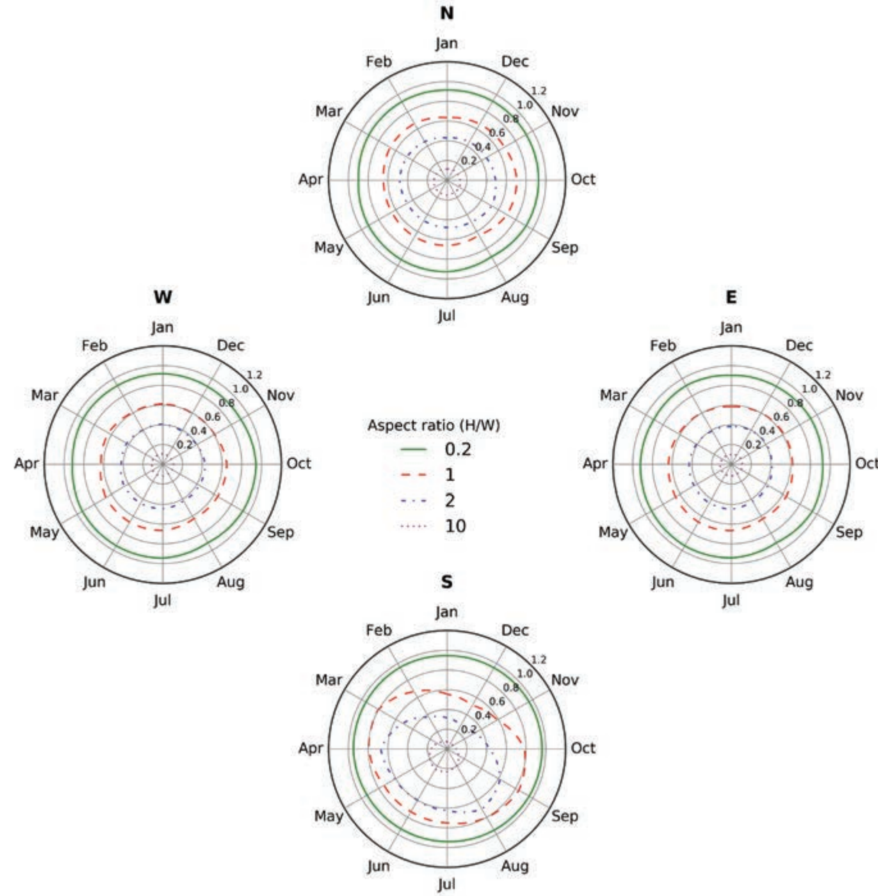
Savings in pre-1980 homes over 2 times that in new h

Can scale savings by Solar Availability Factor (SAF) to adjust for shading & reflection by neighboring buildings

Single-family homes (each 6 m tall)



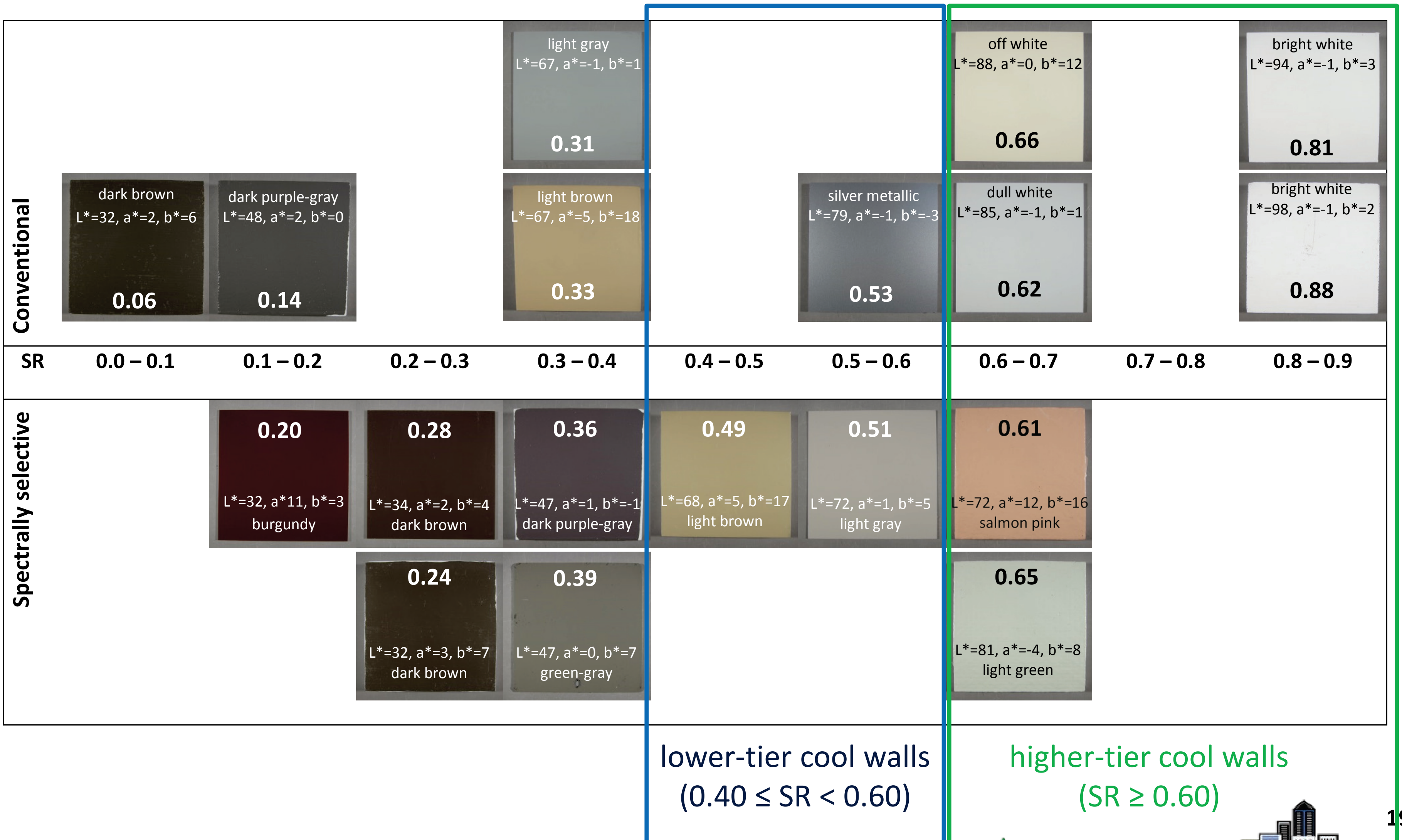
Solar availability factors in climate FR (Fresno, CA)



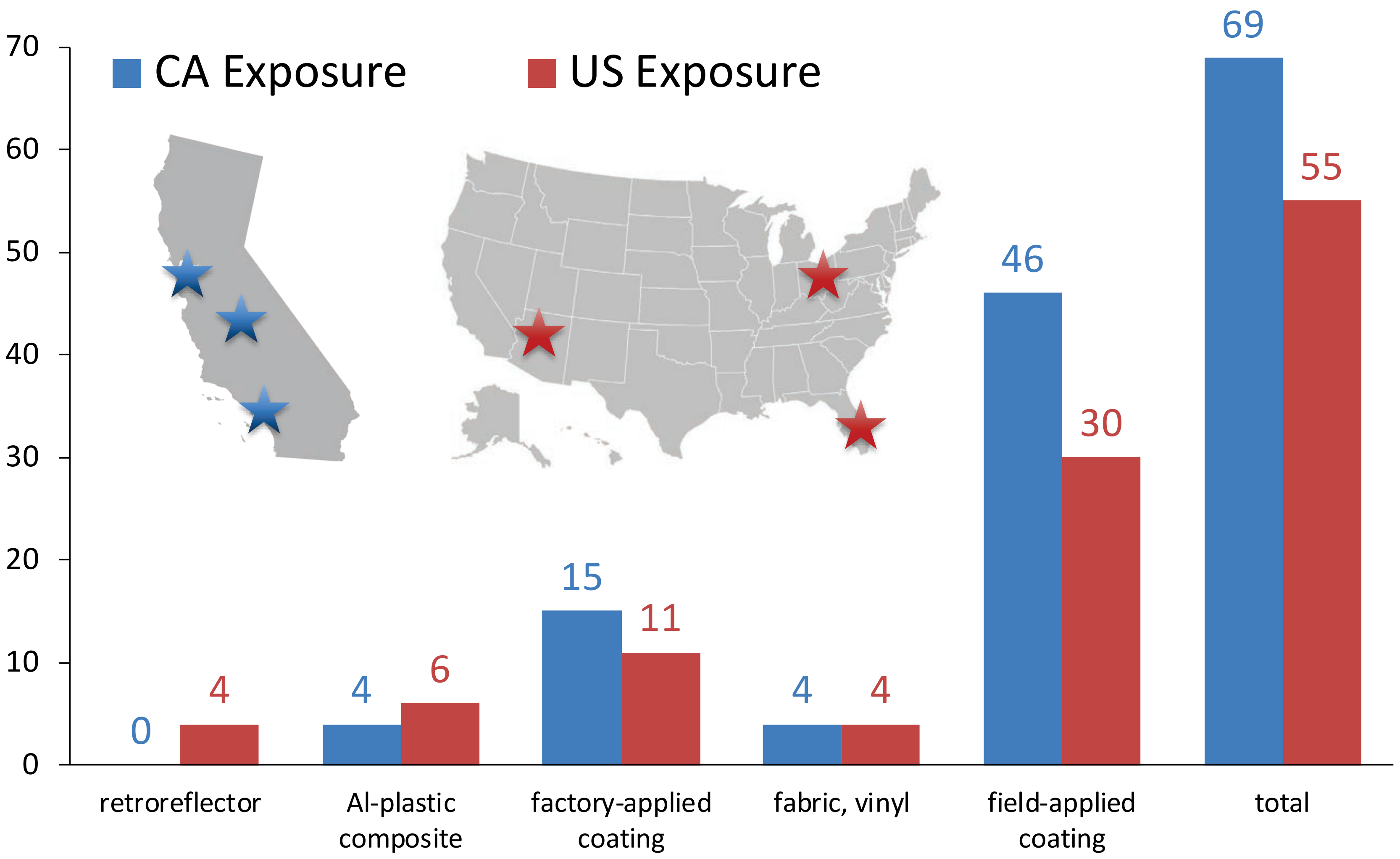
ground albedo = 0.20, central wall albedo = 0.25, neighboring wall albedo = 0.25

R = building height H / separation W

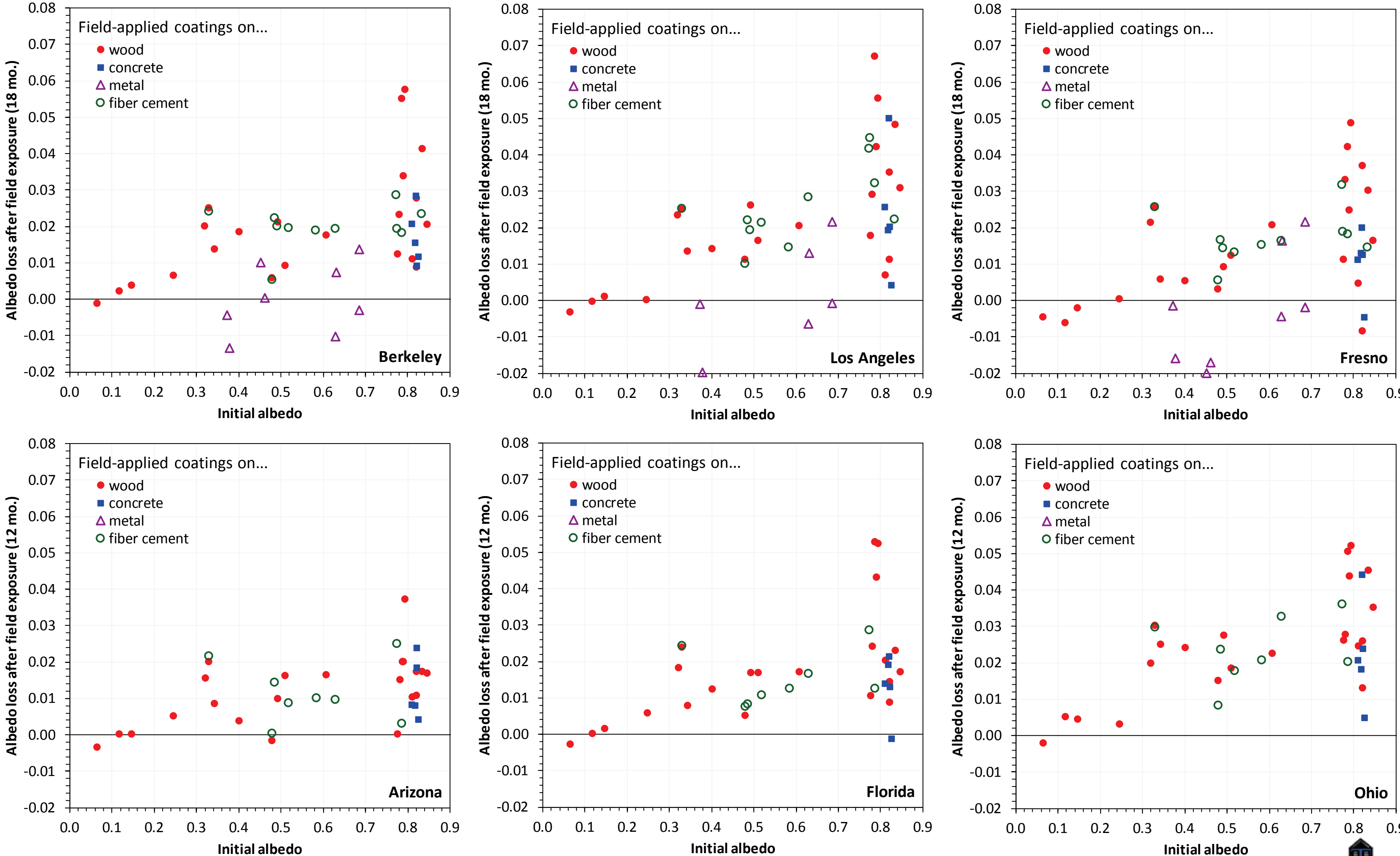
Cool wall products with high solar reflectance (SR) are sold today



Wall products are undergoing 2 year exposure in California, 5 year exposure at U.S. sites



Solar reflectance losses modest (≤ 0.05) after 15 months in California, 12 months in U.S.



Thank you!

Poll 1

Urban Climate and Other Co-benefits

George Ban-Weiss
University of Southern California

USC University of Southern California

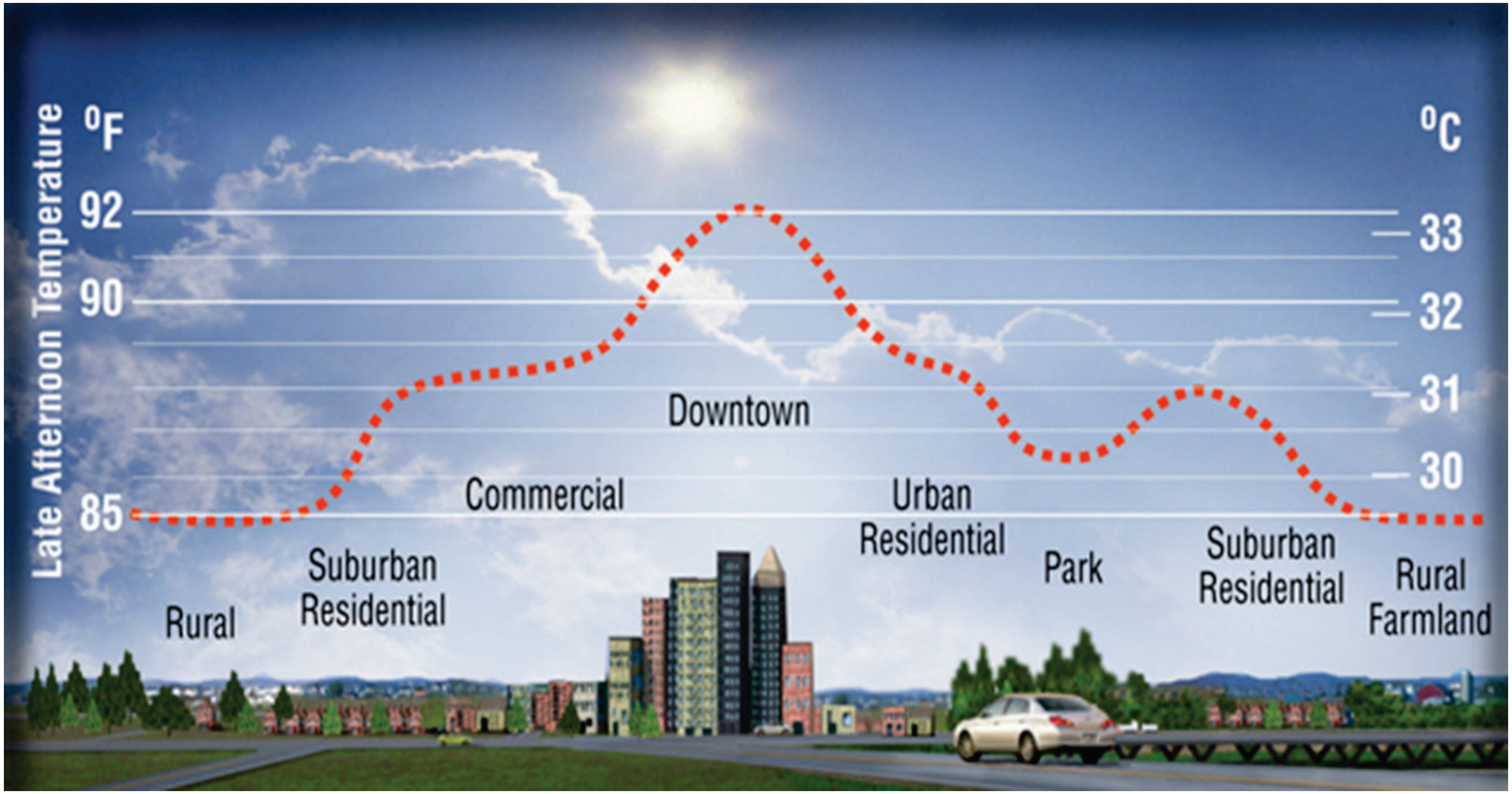
USC Viterbi School of Engineering

Investigating the Influence of Cool Wall Adoption on Climate in the Los Angeles Basin

Presenter: Professor George Ban-Weiss (banweiss@usc.edu)
University of Southern California

Jiachen Zhang, Arash Mohegh, Yun Li (USC)
Ronnen Levinson (LBNL)

The urban heat island (UHI) effect describes cities being warmer than rural surroundings



City dwellers are facing severe heat-related challenges

Adverse impacts of UHI:

Heat stroke & exhaustion

Summertime peak energy use

Some strategies for reducing urban heat

Cool (reflective) roofs

Cool pavements

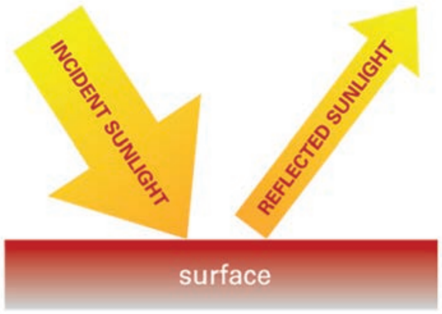
Vegetative roofs

Street level vegetation

Some strategies for reducing urban heat

What about solar reflective cool walls?

Have not yet been systematically investigated



High albedo (a.k.a. solar reflectance)

Albedo: The ratio of reflected to incident sunlight

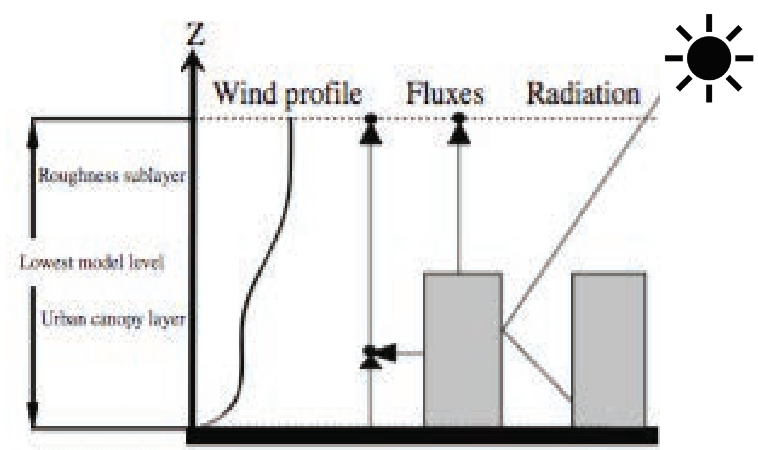
Research goals

- Quantify the climate effects of hypothetical cool wall adoption in the Los Angeles basin
    - Increases in reflected sunlight out of the city
    - Air temperature reductions in urban canyon

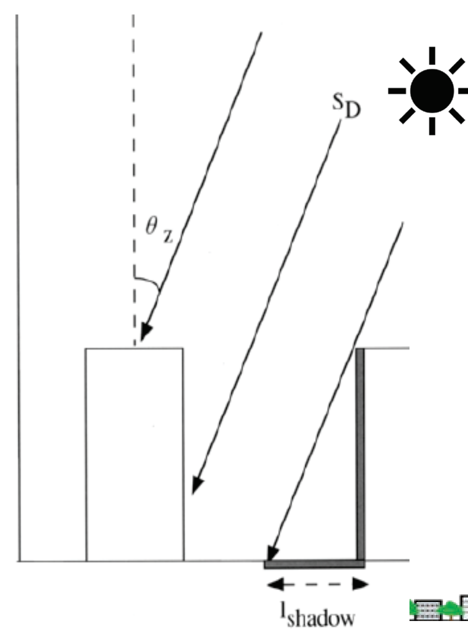
- Compare the climate effects of cool walls to cool roofs

We use a WRF Single Layer Urban Canopy Model for our climate simulations

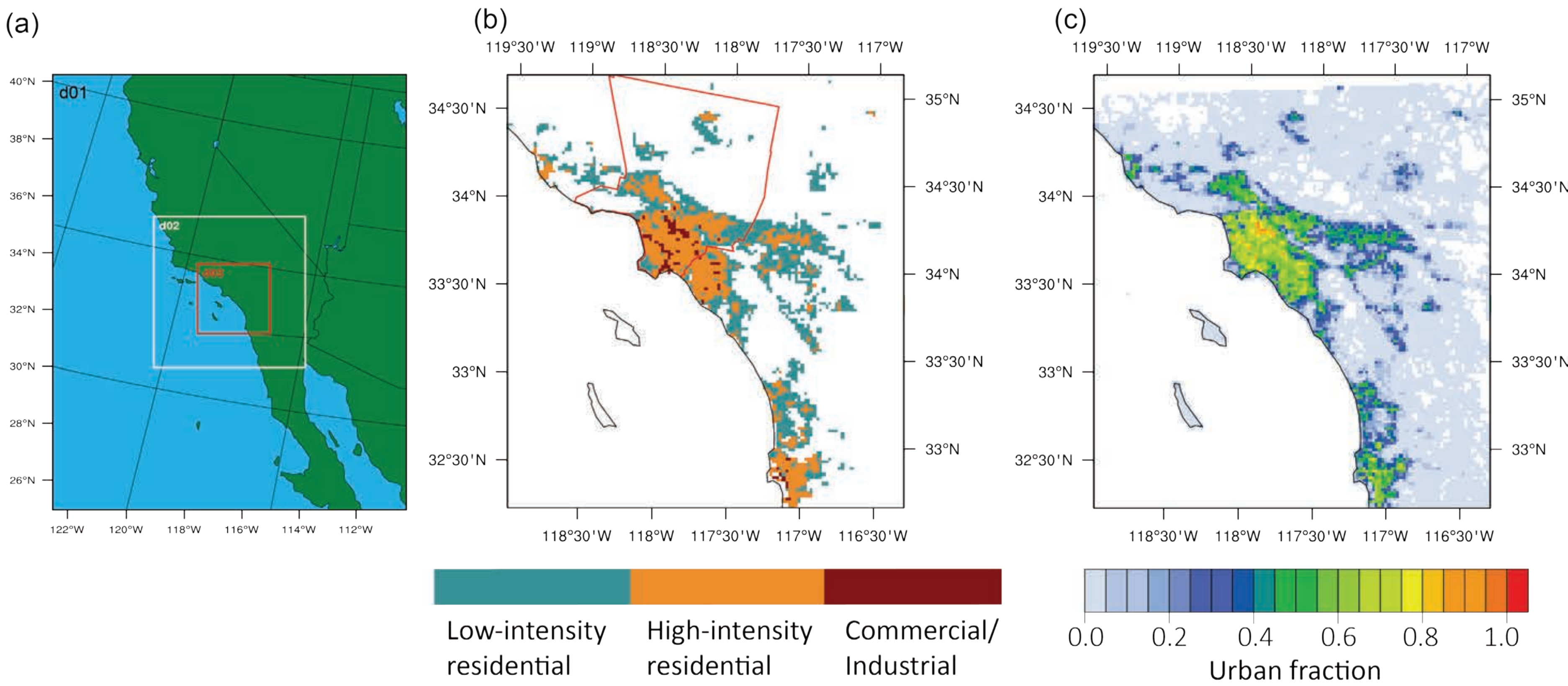
- Weather Research & Forecasting (WRF) model (Version 3.7)
- National Land Cover Database land use classification
- Single layer urban canopy model used for urban grid cells



Single Layer Urban Canopy Model (SLUCM)



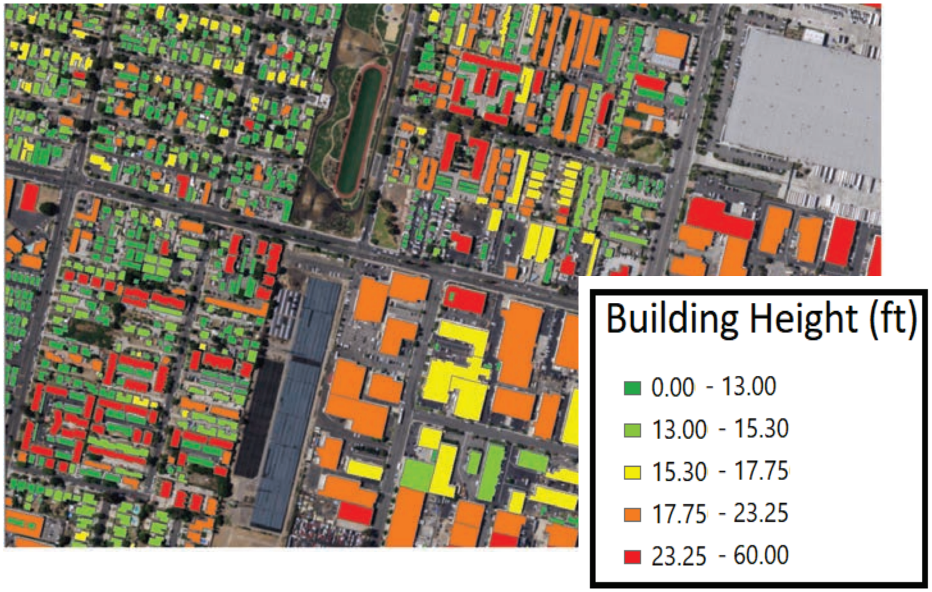
Domain/configuration for WRF simulations



Deriving realistic urban morphology per urban land use type

Ground width, roof width, and building height are derived from Los Angeles Region Imagery Acquisition Consortium (**LARIAC**) program

- Building data (footprint and height for each building in Los Angeles County)
- Street centerlines



Simulated scenarios

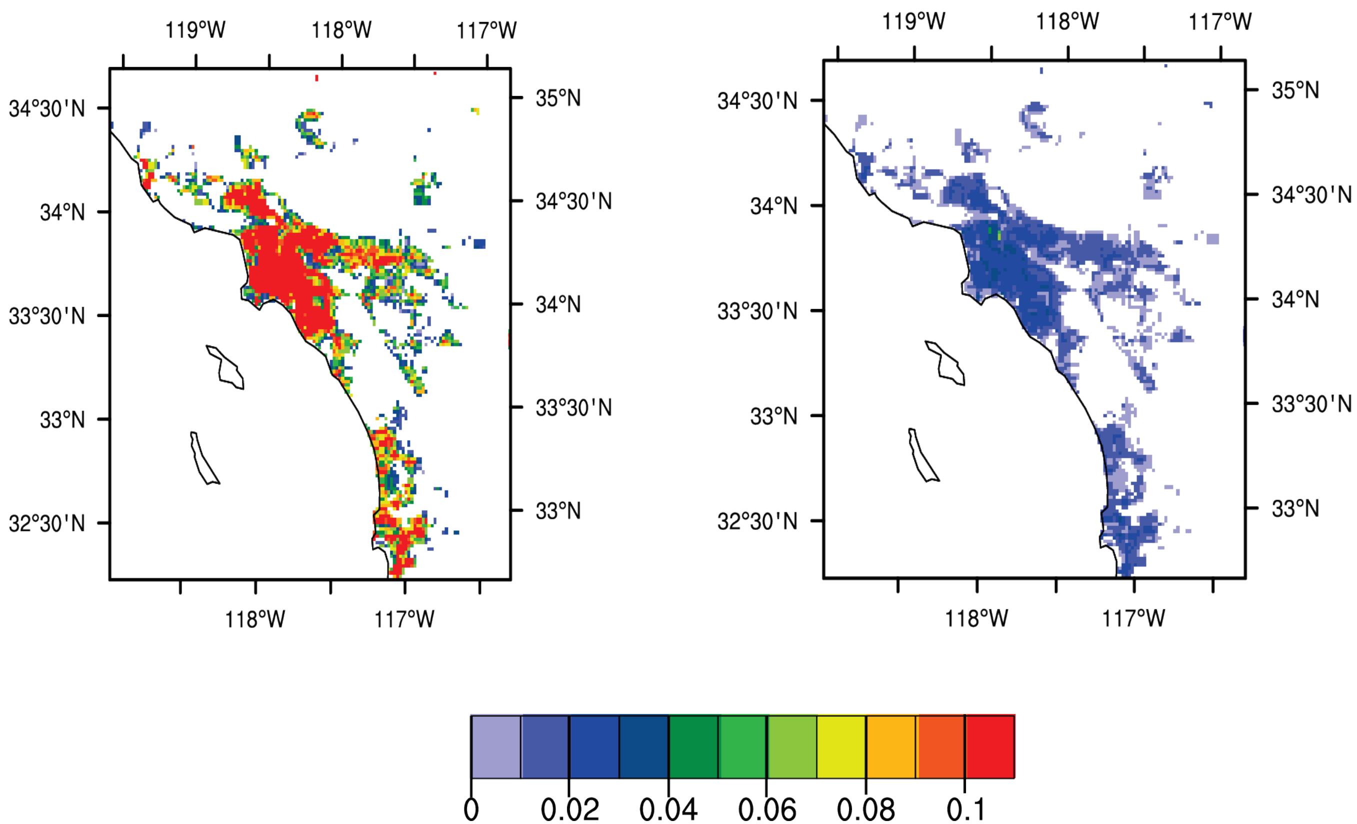
Scenario	Wall albedo	Roof albedo
CONTROL	0.10	0.10
COOL_WALL_LOW	0.50	0.10
COOL_WALL_HIGH	0.90	0.10
COOL_ROOF_LOW	0.10	0.50
COOL_ROOF_HIGH	0.10	0.90

- Simulated July 2012
- Ground albedo = 0.10 in all cases
- We simulated three ensemble members per case

Grid cell albedo increases from cool walls are largest in the early morning (and late afternoon) where urban fraction is highest

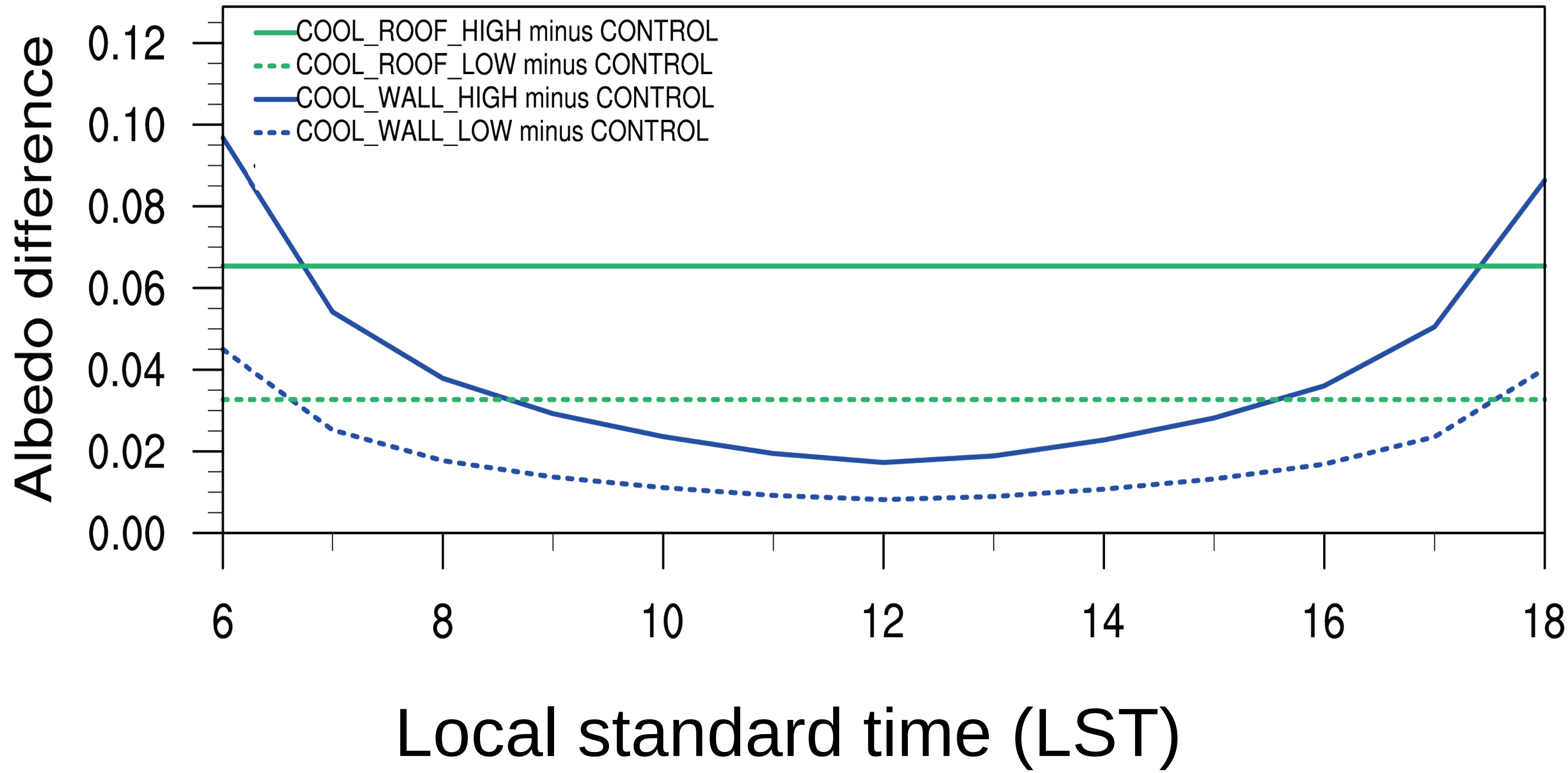
6 am Local standard time

12 pm Local standard time



Change in grid cell albedo

Grid cell albedo increases from cool walls are larger than from cool roofs in the early morning and late afternoon



The daytime cumulative increase in reflected solar radiation induced by cool walls is 43% of that induced by cool roofs

- Solar irradiance (W m^{-2}) on walls is about 40% that on roofs in July in LA County
- Net wall area (excluding windows) is about 60% greater than roof area in Los Angeles
- Solar radiation that is reflected by walls is partially (50-59%) absorbed by opposing walls and pavements, while that reflected by roofs escapes the canopy.

Daytime cumulative increase relative to CONTROL

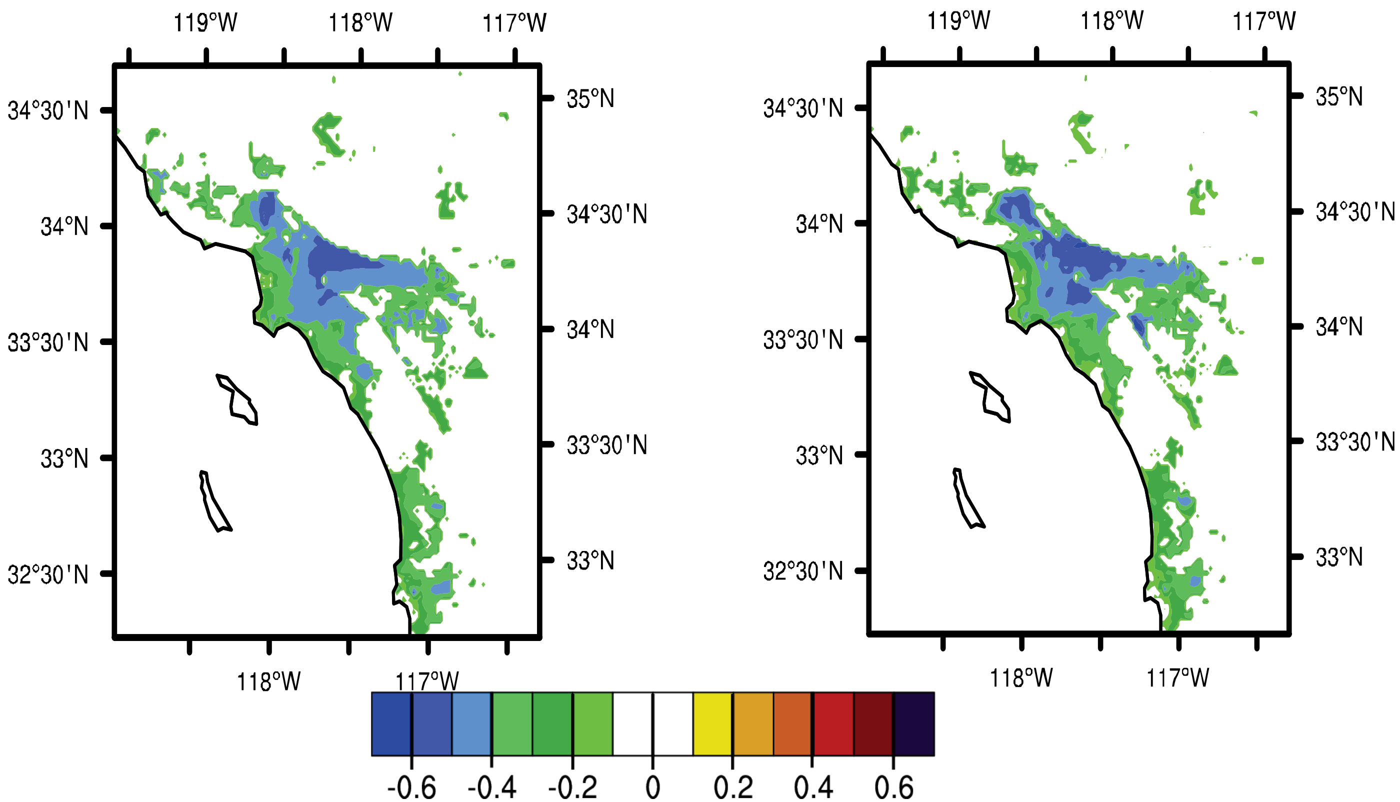
COOL_WALL_HIGH: 783 kJ m^{-2}
COOL_ROOF_HIGH: 1840 kJ m^{-2}

Cool walls reduce canyon air temperatures throughout the LA basin

Implemented a new parameterization to diagnose “canyon” air temperature (Theeuwes et al., 2014)

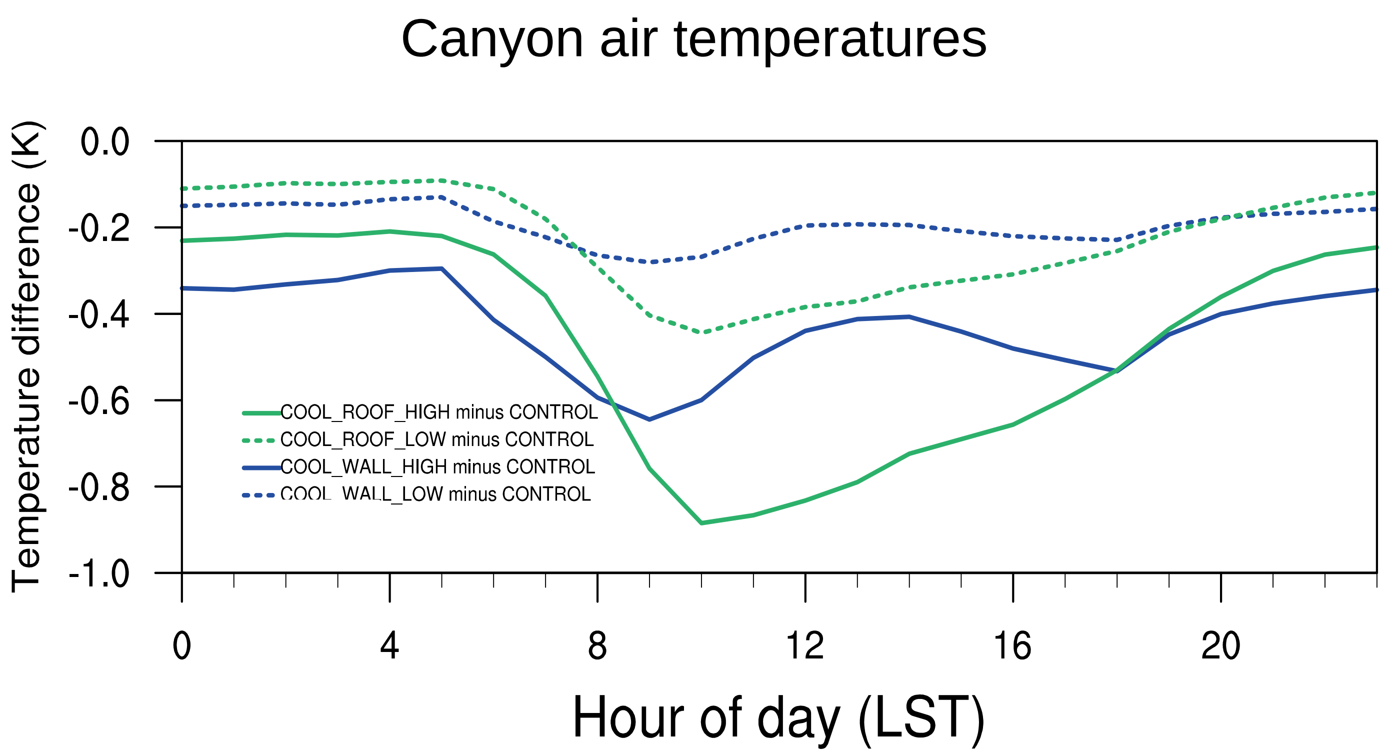
2 pm LST

8 pm LST



Change in canyon air temperature (K)

Cool walls lead to less cooling than cool roofs for most daytime hours



Major contributors to the shape of diurnal cycle:

- Increase in reflected solar radiation
- Planetary boundary layer height (peak at 1 pm)
- Accumulation of solar heat gain

Daily average temperature reduction per 0.10 facet albedo increase

Scenario	Daily average canyon air temperature reduction (K) per 0.10 albedo increase
COOL_WALL_LOW	0.048
COOL_WALL_HIGH	0.054
COOL_ROOF_LOW	0.057
COOL_ROOF_HIGH	0.059

Conclusions – climate in LA county

- The daytime cumulative increase in upwelling sunlight (W m^{-2}) induced by cool walls is 43% of that induced by cool roofs
- Canyon air temperature reductions from cool walls are largest in the early morning and late afternoon
- Daily mean canyon air temperature reductions are similar for cool walls (0.05 K per 0.1 wall albedo increase) and roofs (0.06 K per 0.1 albedo increase)

Acknowledgements

- Research group at USC
- Pouya Vahmani (LBNL)
- Gert-Jan Steeneveld (Wageningen University)
- Joachim Fallmann (Institute of Meteorology and Climate Research, Germany)
- Ravan Ahmadov & Stu McKeen (National Oceanic and Atmospheric Administration)
- Dan Li (Boston University)
- Pablo Rasodo & Haley Gilbert (LBNL)

- South Coast Air Quality Management District and California Air Resources Board

<u>Funding:</u>

FUNDING PROVIDED BY THE CALIFORNIA ENERGY COMMISSION

NSF

Poll 2

Existing Cool Wall Codes and Programs

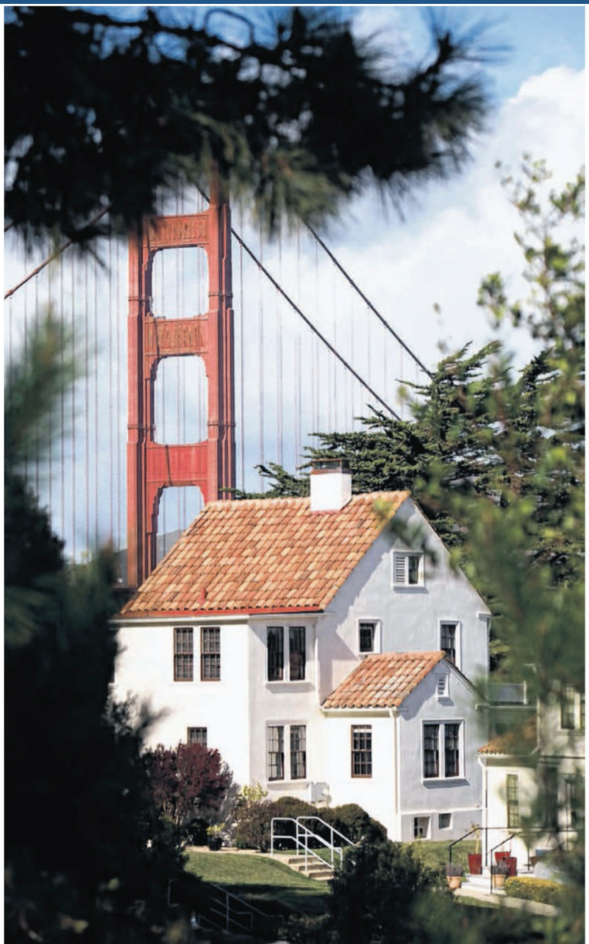
Haley Gilbert
Lawrence Berkeley National Lab

HEAT ISLAND REDUCTION PROGRAM

State and Local Energy and Environment Program

LBNL Heat Island Group

BERKELEY LAB



Source: Lea Suzuki, San Francisco Chronicle, 10 February 2013

Existing cool wall codes and programs

Haley Gilbert (HEGilbert@LBL.gov)

22 February 2018,
EPA Heat Island webcast

FUNDING PROVIDED BY THE
CALIFORNIA ENERGY COMMISSION

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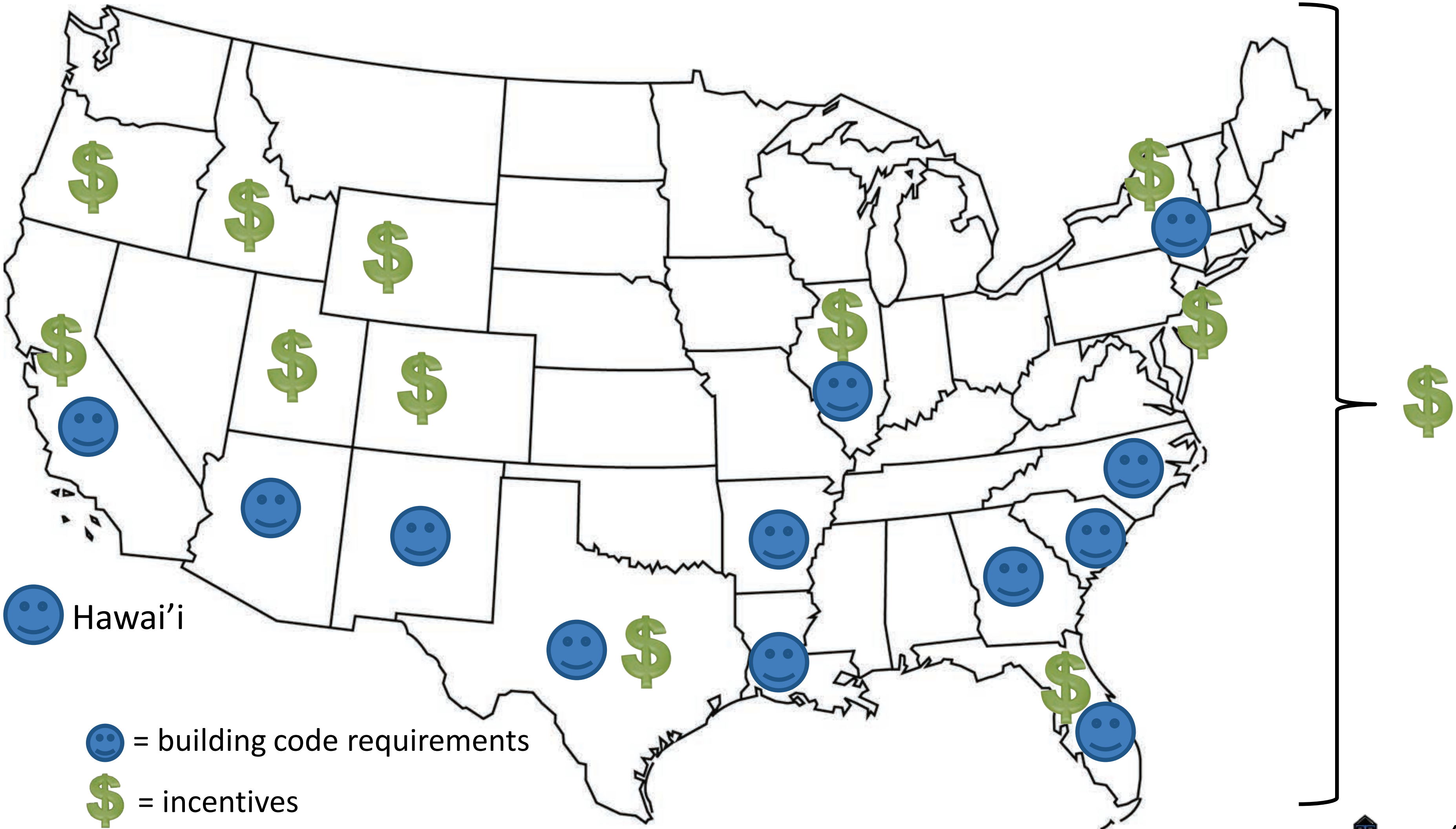
SINCE 1975

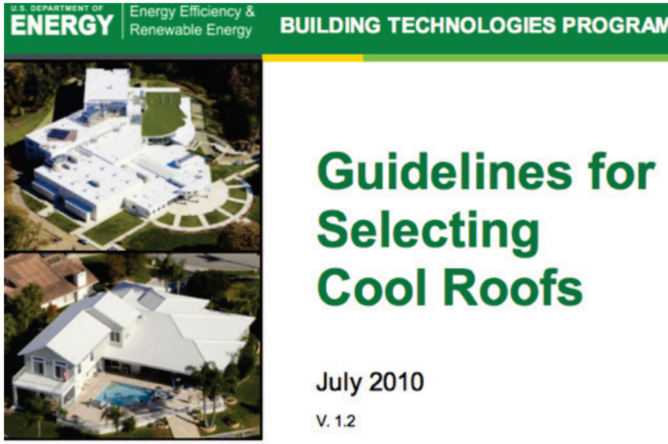
Cool roofs are prescribed and incentivized across the U.S.



Source: http://coolroofs.org/resources/rebates-and-codes

We seek to replicate the cool roof model by advancing the building and climate-appropriate adoption of cool walls

- Create **design guidelines**
- Develop **language for building codes, programs, and incentives**
- Investigate feasibility of a **cool wall rating program**



COOL ROOF RATING COUNCIL

Cool walls are currently found in codes/standards and green building programs

ASHRAE

90.1 ▪ 189.1

CALGreen

STATE OF HAWAII
1959
UA·MAU·KE·EA·O·KA·AINA·I·KA·PONO

GREEN GLOBES

We're working to expand & enhance those cool wall provisions

Example

- ASHRAE 90.1-2016 recognizes cool walls in climate zone 0 (hot & tropical; Bangalore, India)
- Seek to
  - Extend cools walls to zones 1 – 3
  - Enhance code language

We're also working to develop new cool wall measures in codes/standards and green building programs

U.S. Green Building Council's LEED

California's Building Energy Efficiency Standards (Title 24)

International Energy Conservation Code

We're investigating options to incentivize the use of cool wall products

Property Assessed Clean Energy (PACE) programs to finance cool wall installation

An energy efficiency utility rebate

ENERGY STAR certification for cool wall products

We are developing cool wall guidelines for building owners/operators and communities

Building energy, energy cost, and emission savings

Air temperature & pedestrian comfort

Solar availability

Establishing a cool wall product rating system is key

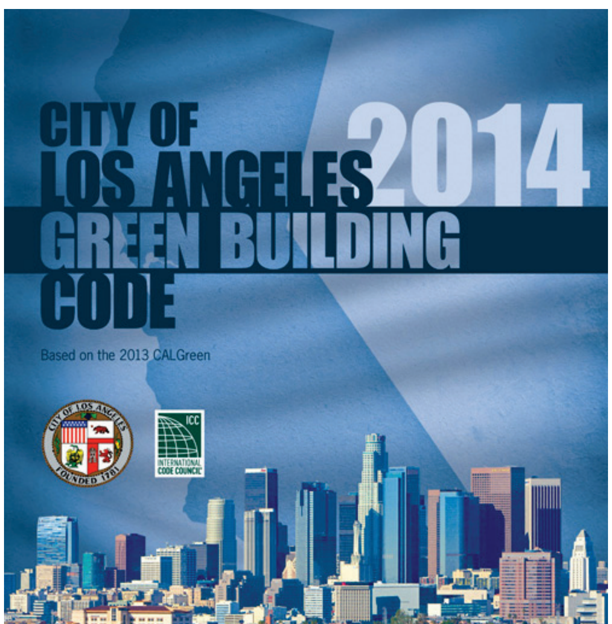
- Develop credible methods to evaluate and label products
- An independent rating system give confidence to measures in building codes/ incentives
- Model on or expand existing programs

COOL ROOF RATING COUNCIL

National Fenestration Rating Council®

Cool walls can easily be implemented at the local level (i)

1. Incentivize through the use of financing programs and/or rebates



2. Include cool wall measures in local municipal building codes

Cool walls can easily be implemented at the local level (ii)

3. Lead by example with municipal buildings
4. Feature in targeted communications for residents
5. Include in programs for weatherization or low-income household retrofits

Los Angeles City Hall

Hawaii's Adoption of Cool Wall Codes and Measures

Howard C. Wiig
State of Hawaii

EPA

HEAT ISLAND REDUCTION PROGRAM

State and Local Energy and Environment Program

The Writing's on the Wall: Hawaii's Cool Wall Energy Code Research

Howard Wiig

Hawaii State Energy Office

EPA's Heat Island Webcast

February 22, 2018

Cool Cars

- Toyota offers titanium dioxide (TiO_2)-infused colors that reduce interior temperatures by some 12°F on sunny days.
- One reviewer -- Ronnen Levinson: First Toyota, then the world?

Incorporating Cool Walls into National Energy Codes

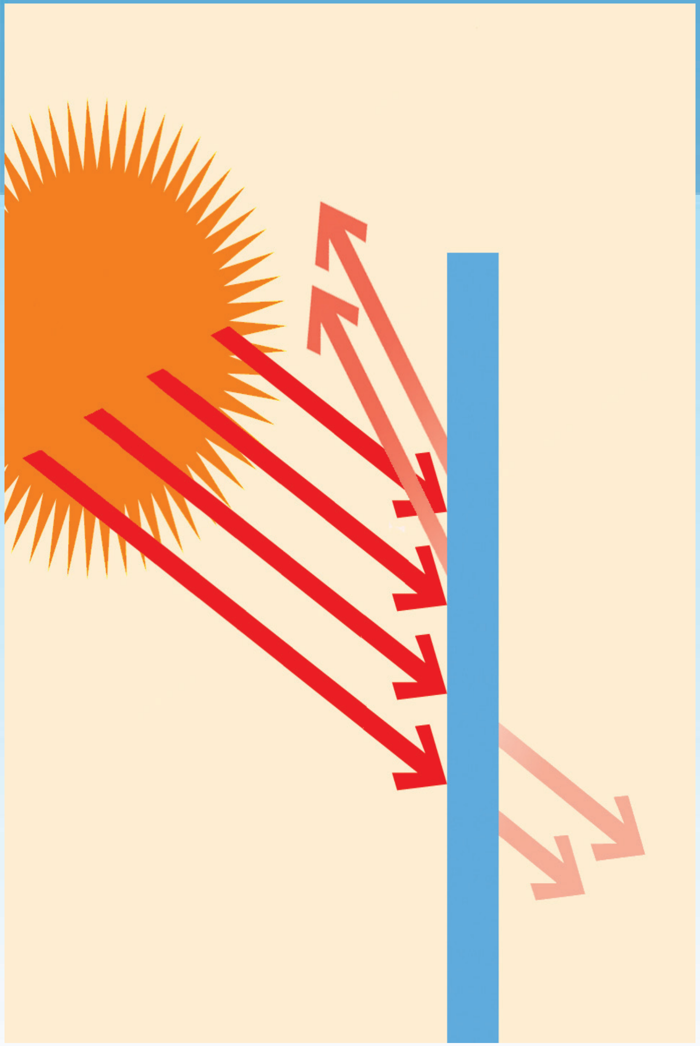
- Hawaii State Energy Office (HSEO) played key role in improving International Energy Conservation Code (IECC), including creating a Tropical Climate Zone and requiring reflective roofs.
- HSEO will propose reflective walls for future energy codes

HAWAII STATE Energy Office

Getting Codes Adopted

- At hearings, found a like-minded veteran
- Identify allies
- Horse trade
- Beer with builder

Cool Wall Code Option

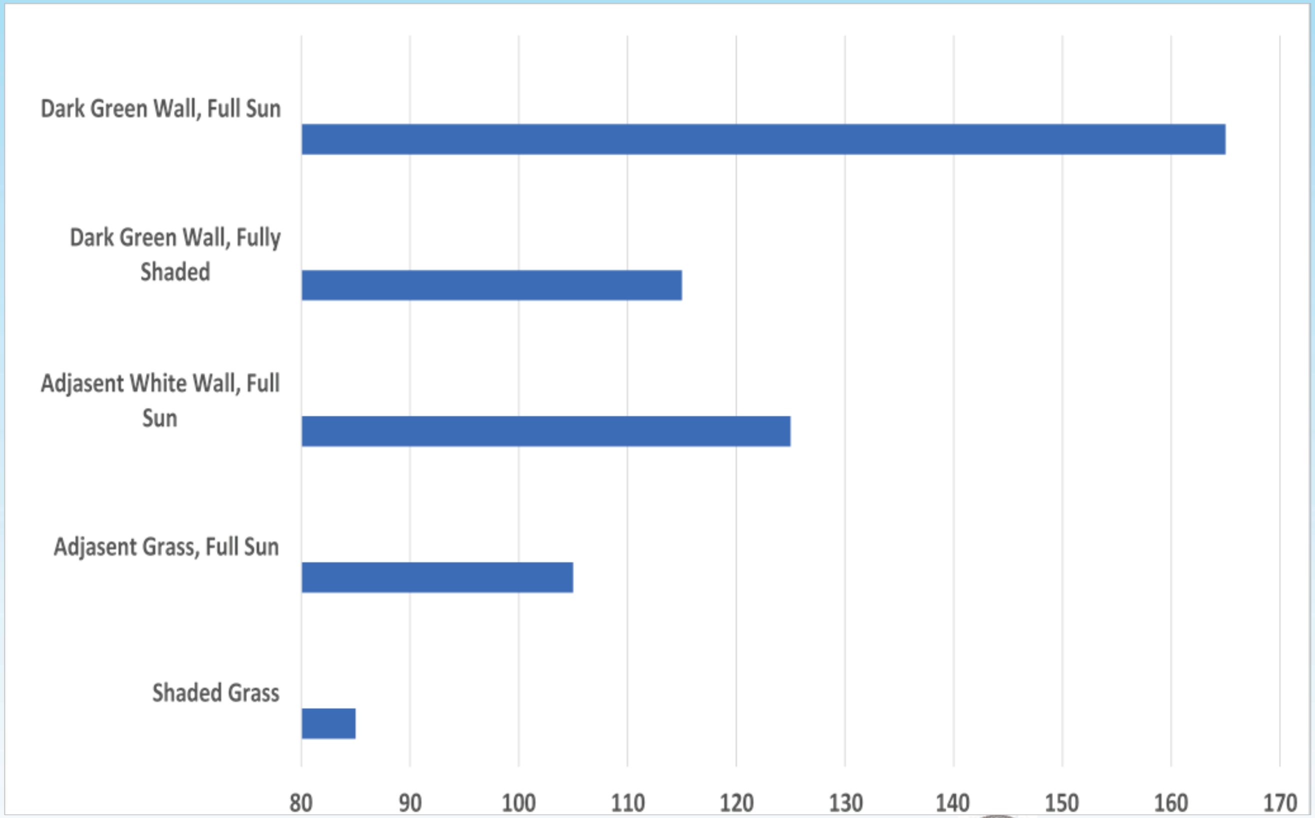


The 2015 IECC requires that steel-frame homes have R-4.2 exterior insulation, adding up to $8,000 to a new home's cost and requiring 43 years to pay back.

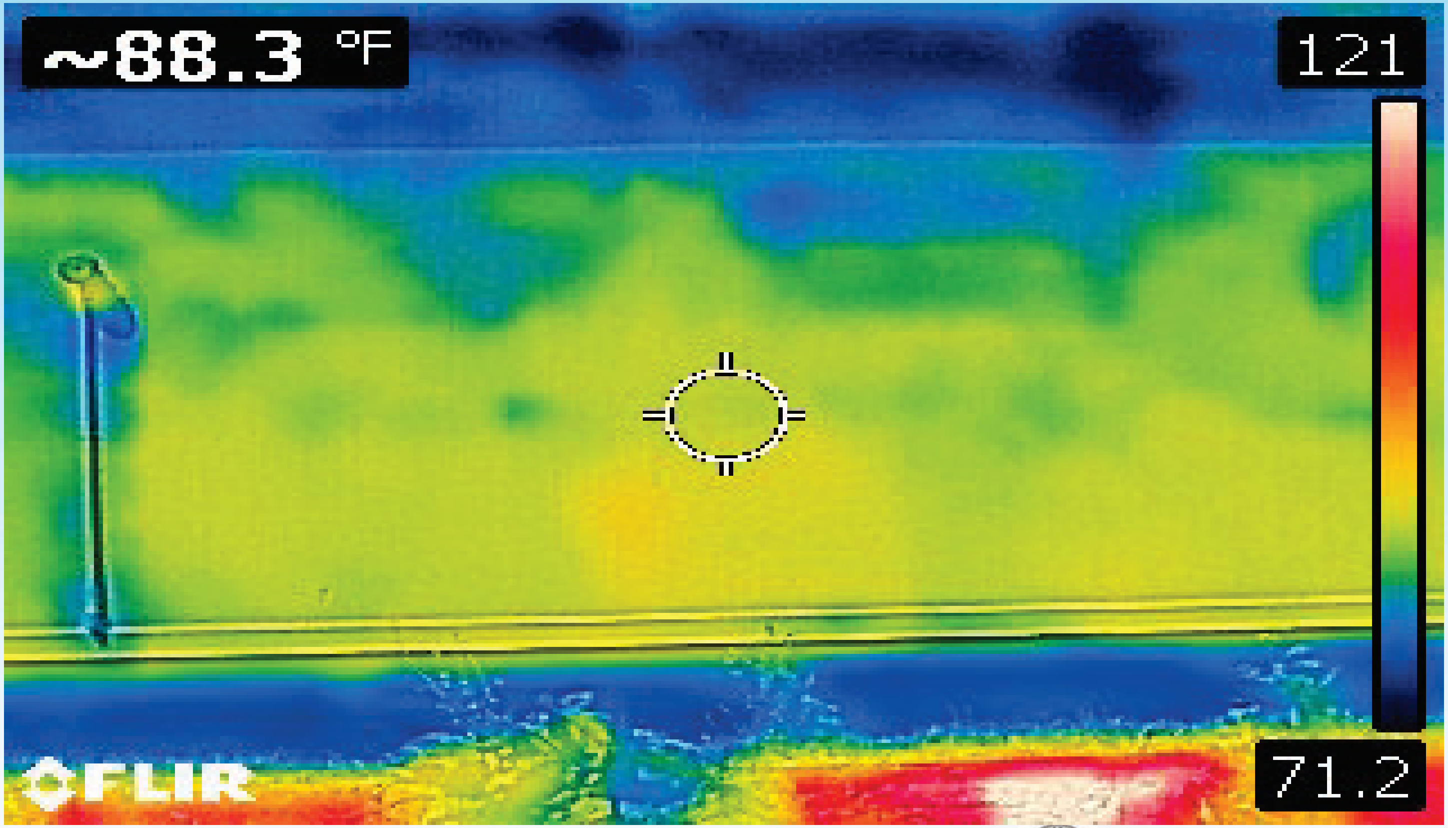
Walls with a visible light reflectance of .64 yielded equal savings at little or no added cost.

Surface Temperature Comparisons: Sun/Shade/ Light Color/Grass

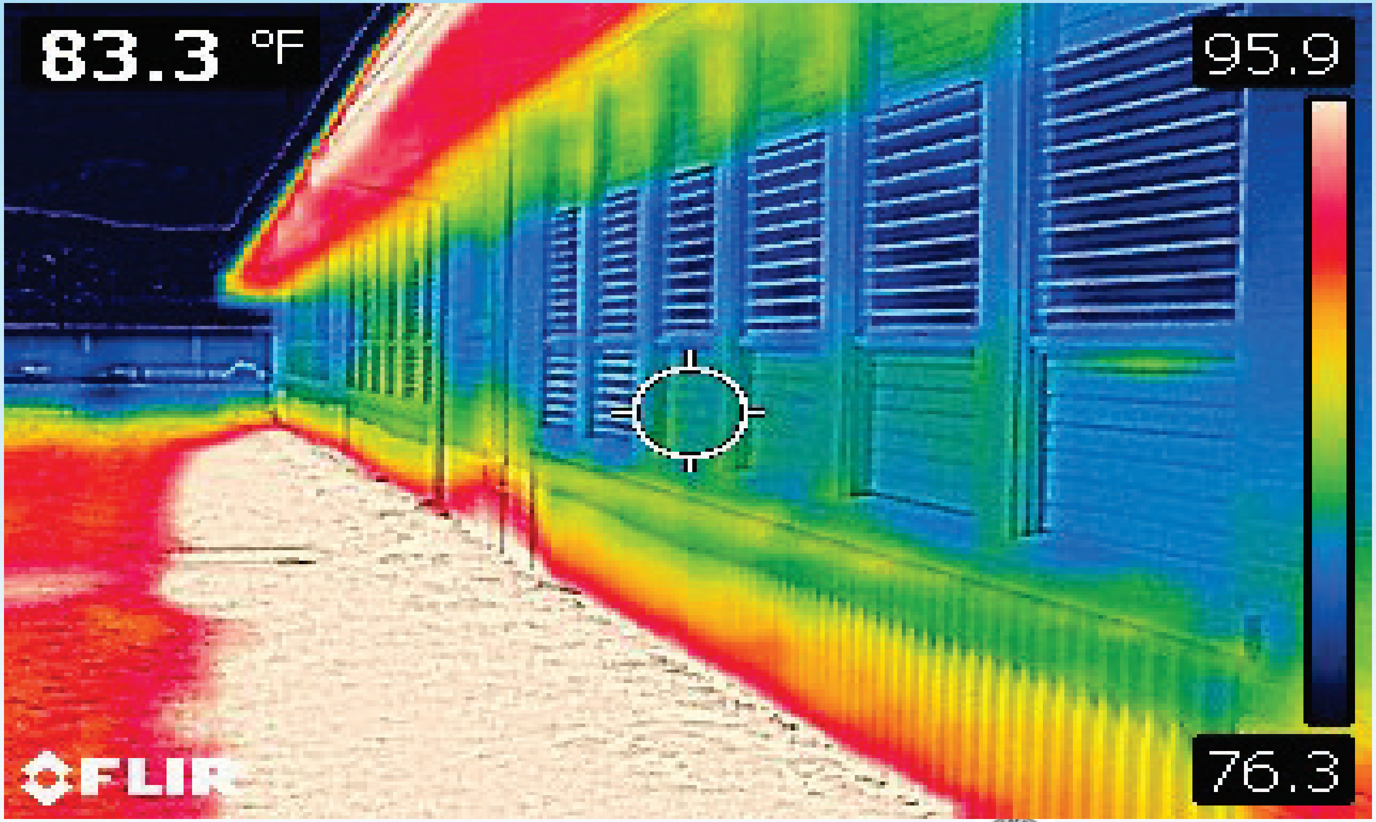
Pupukea Heights, North Shore, Oahu (°F)



Before Light Coating: Laie Elementary School Interior Temperature



After Light Coating:
5°F Interior Temperature Drop

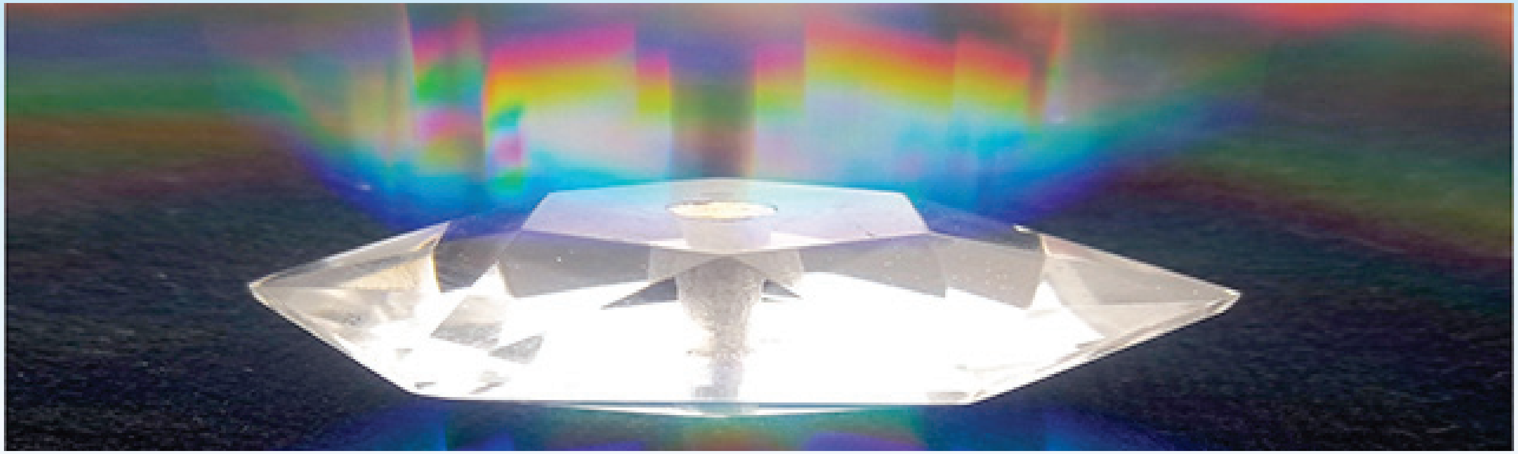


HAWAII STATE Energy Office

Extreme Materials Lab at Hawaii Institute of Geophysics and Planetology

Dr. Przemyslaw Dera

The size of pigment particles/crystallites has a strong effect on the performance of reflective paint pigments. Nanocrystalline TiO_2 has been shown to have superior properties over standard TiO_2.



Cool Walls Intern at Hawaii State Energy Office?

Dr. Dera may be able to secure Science Foundation grant to include a summer intern to conduct cool walls research.

Follow up Research

Question: Should shading be added to a cool walls code? Shading makes a huge impact in cooling-dominated climates

Question:
Does the addition of TiO_2 add to coatings' cost?

Exempt the north faces of buildings from cool wall requirements? Architectural flexibility

Mahalo

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The 2015 IECC:

http://shop.iccsafe.org/codes/2015-international-codes-and-references/2015-international-energy-conservation-code.html

State Energy Code Website:

http://energy.hawaii.gov/hawaii-energy-buildings-Code/2015-iecc-update

Connect with the Heat Island Program

Victoria Ludwig

U.S. Environmental Protection Agency

202-343-9291

Webcast Feedback Form

Heat Island Program Website

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HEAT ISLAND REDUCTION PROGRAM