Everything You Need to Know About Cool Roofing

Cool Roof Rating Council

AIA Credits

Hanley Wood is a Registered Provider with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members available on request.

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Copyright Materials

Learning Objectives

Upon completing this program, the participant should know how to:

1. Identify what a cool roof is and what options are available for cool roofing materials
2. Determine what economic and environmental benefits can be realized
3. Define the role and mission of the CRRC
4. Identify what rating codes are in place and when and where cool roofs are required

Presenters

- **Bill Kirn**, National Coatings, and CRRC Technical Committee Chair
- **Stan Graveline**, Sarnafil, and CRRC Treasurer
- **Peter Turnbull**, PG&E, and CRRC Vice Chair
- **Dave Roodvoets**, SPRI and CRRC Board Member

What is a Cool Roof?

By: Bill Kirn
National Coatings
CRRC Technical Committee Chair

NBC News
Cool Roof Video

What is a Cool Roof

- Simple, lay definition
- Technical definition

What is a Cool Roof in Simple Terms?

- A roof surface that stays relatively "cool" as compared to the ambient, or surrounding, temperature

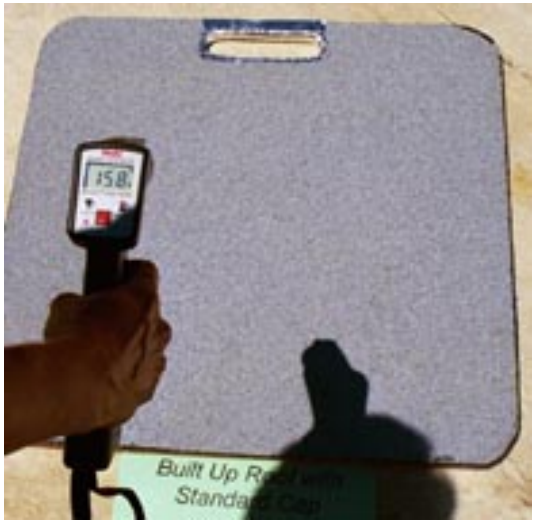
Or…

- The roof surface temperature is usually only slightly higher than the air temperature

How Cool is a Cool Roof?

Sacramento, CA; July 12, 2000
89ºF, about noon, with local delta breeze

EPDM single-ply	BUR topped with aggregate	BUR topped with capsheet
173 °F	159 °F	158 °F



Courtesy Dan Varvais, Applied Polymer Systems

How Cool is a Cool Roof?

Sacramento, CA; July 12, 2000
89ºF noon delta breeze

Cool single-ply

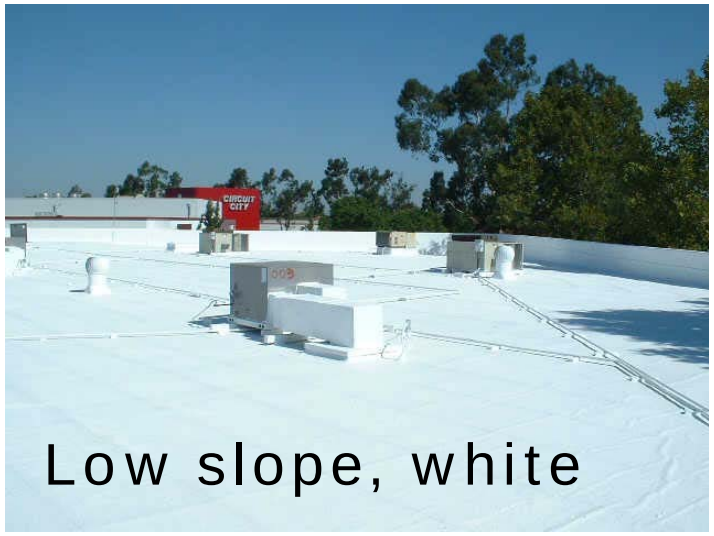
121 °F

Cool coating over BUR

108 °F

Courtesy Dan Varvais, Applied Polymer Systems

Some Examples of Cool Roof Technologies



Low slope, white

Steep slope, white

Steep slope, cool & colored

White is ‘cool’ in Bermuda

and in Santorini, Greece

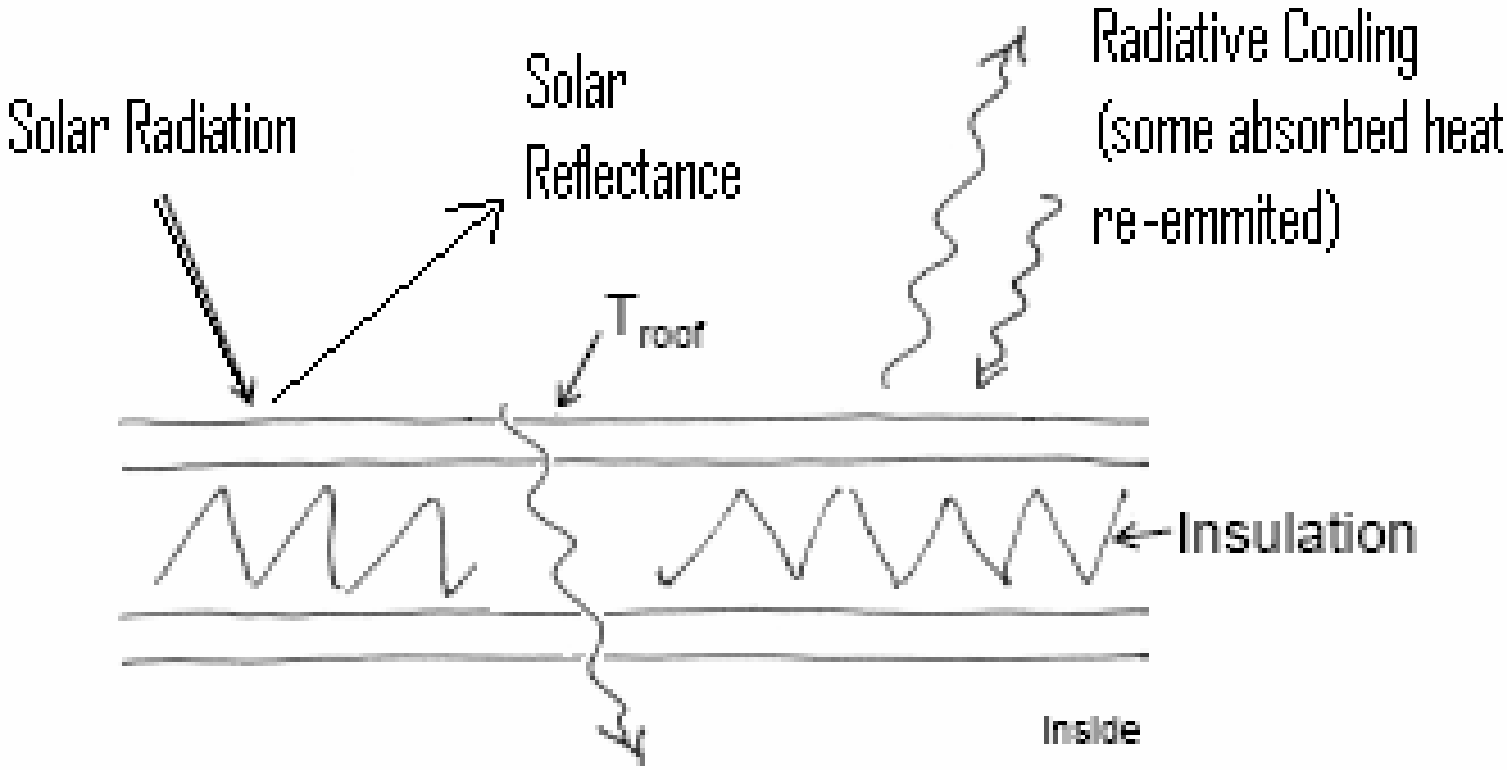
Cool Roofing Materials Availability for Low-Sloped Roofs

- Many materials available
  - coatings (white-tan, light gray)
  - single-ply membrane (white)
  - granule surface asphalt cap sheets
  - painted metal (white, light, cool colored)

Cool Roofing Materials Availability for Steep-Sloped Roofs

- Limited but expanding material availability
  - Tile
  - Coatings
  - Metal
  - Shake
  - Shingles
- Currently over 70% of steep-sloped roofs in the U.S. use fiberglass asphalt shingles

What is a Cool Roof in Technical Terms?



Key Cool Roof Parameters

Core idea: **Keep the Surface *Cool***

- **Solar Reflectance**: portion of light reflected
- **Thermal Emittance** (infrared): portion of absorbed heat reemitted
- Both measured from 0 to 1, higher value is cooler
- Both important, although reflectance has the greater effect

Solar Reflectance

Typical Solar Reflectance Values for Typical “non-cool” Roofs:

- Low Slope
  - EPDM = 0.1
  - Smooth Surface BUR/MB = 0.1
  - Aggregate covered BUR = 0.15
  - “White” asphalt cap sheet = 0.25
- Steep Slope
  - Typically = 0.1 - 0.25

Solar Reflectance

Typical Solar Reflectance Values for Cool Roofs:

- Low Slope
  - 0.65 or 0.70 and greater
- Steep Slope
  - minimum of .25 and up to .65

Solar Reflectance Test Methods

- ASTM C1549 (“Lab”)
  D&S Meter

- ASTM E1918 (“Field”)
  Pyronometer

Thermal Emittance

Typical Thermal Emittance Value for Cool Roofs:

- Representative value 0.75 and greater
  - Tennessee Williams, Baked Potatoes and Space Blankets
  - No apparent emittance difference between low and steep slope

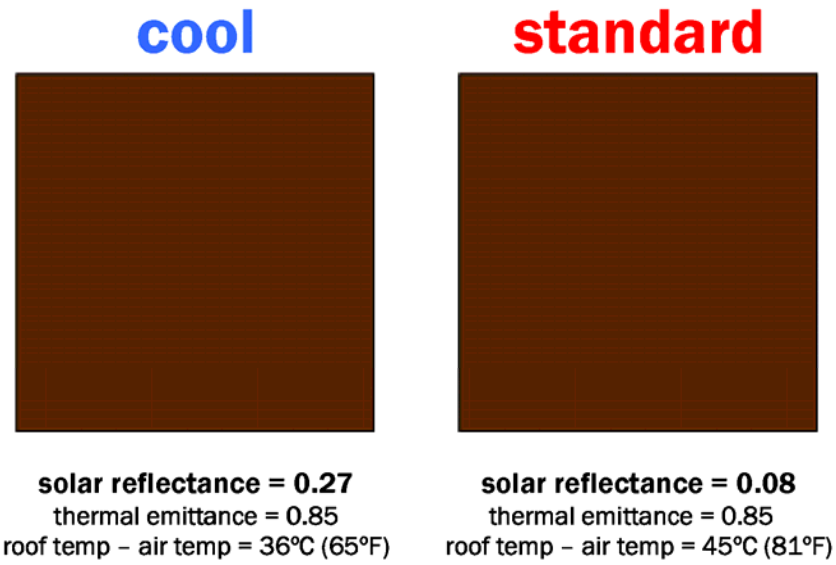
Thermal Emittance Test Method

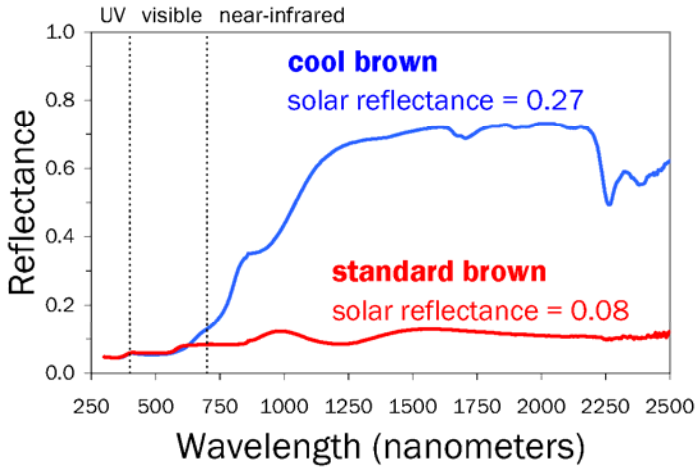
- ASTM C1371

Cool and Standard Brown Metal Roofing Panels

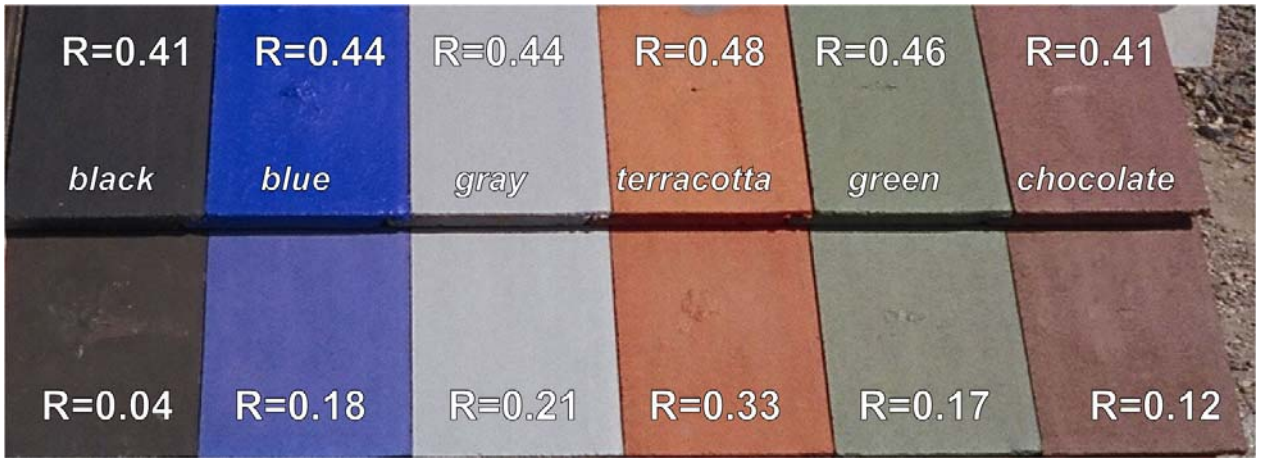
- Solar reflectance ~ 0.2 higher
- Afternoon surface temperature ~ 10ºC lower

Courtesy BASF Coatings





Cool and Standard Color-Matched Concrete Tiles



Courtesy American Rooftile Coatings

cool

standard

ΔR=0.37 **ΔR=0.26** **ΔR=0.23** **ΔR=0.15** **ΔR=0.29** **ΔR=0.29**

- Can increase solar reflectance by up to 0.5
- Gain greatest for dark colors

Summary of Cool Roofing Options

Roofing Product	**Cool Variety**
Ballasted BUR, Single Ply	White gravel
BUR w/ smooth asphalt coating	White or reflective coating
BUR w/ aluminum coating	White or reflective coating
Single ply EPDM, TPO, CSPE, PVC, PIB	White coating or white membrane
Modified bitumen (SBS, APP)	White, reflective coating, white granules
Metal roofing (painted and unpainted)	White or cool color paint
Concrete tile	White or cool tile or cool color paint
Fiber cement tile	White or cool tile or cool color paint
Metal tile	White or cool tile or cool color paint
Clay tile	White or cool tile or cool color paint

What are the Economic and Environmental Benefits of Cool Roofs?

By: Stan Graveline

Sarnafil

CRRC Treasurer

Why Care About Cool Roofs?

3 Classes of Benefits:

1. Owner/occupant benefits

Cool Roof Benefits: Owner/Occupant

- **Reduced A/C tonnage (capital cost)**
- **Reduced energy bill**
- **Improved comfort**
- **Longer roof life**

Case Study:
Measured Energy Savings and Demand Reduction from a Reflective Roof Membrane on a Large Retail Store in Austin, TX

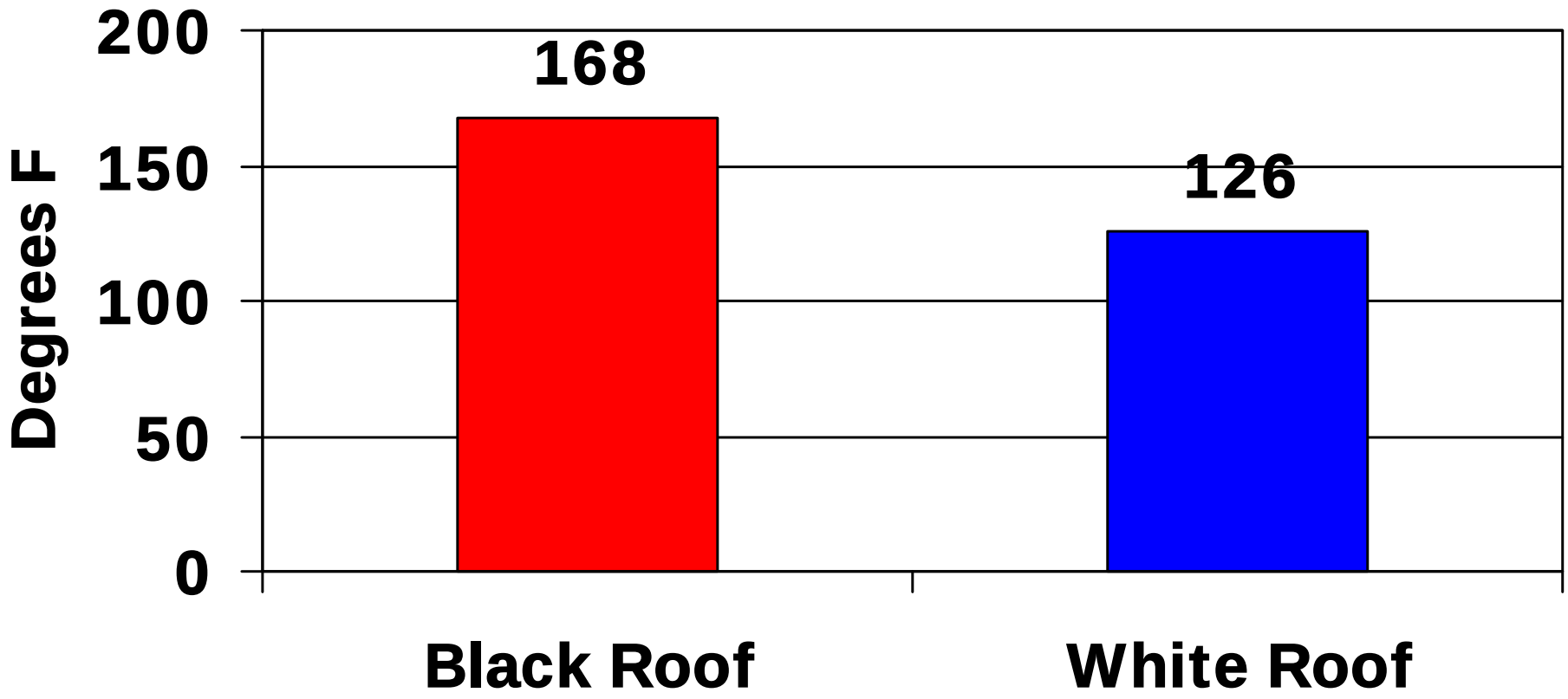
- A study conducted by the Ernest Orlando Lawrence Berkeley National Laboratory
  - S. Konopacki, H. Akbari
- Under a contract with the EPA and the DOE

100,000 sq. ft., Austin, TX

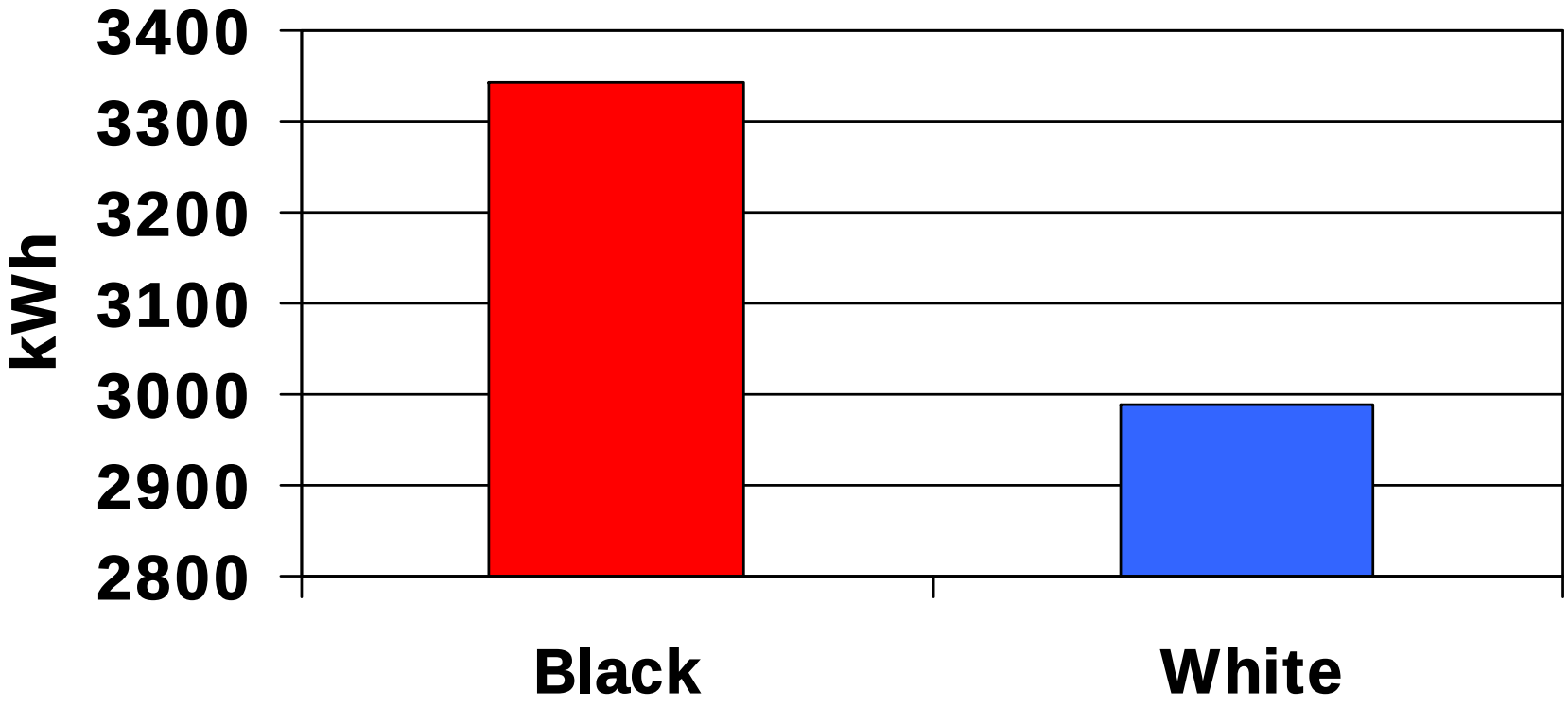
Methodology

- Measured weather conditions, temperatures inside the building and throughout the roof layers, and air conditioning and total building power consumption
  - With a black EPDM roof
  - After replacement with a white thermoplastic roof (same insulation, HVAC systems left in place)

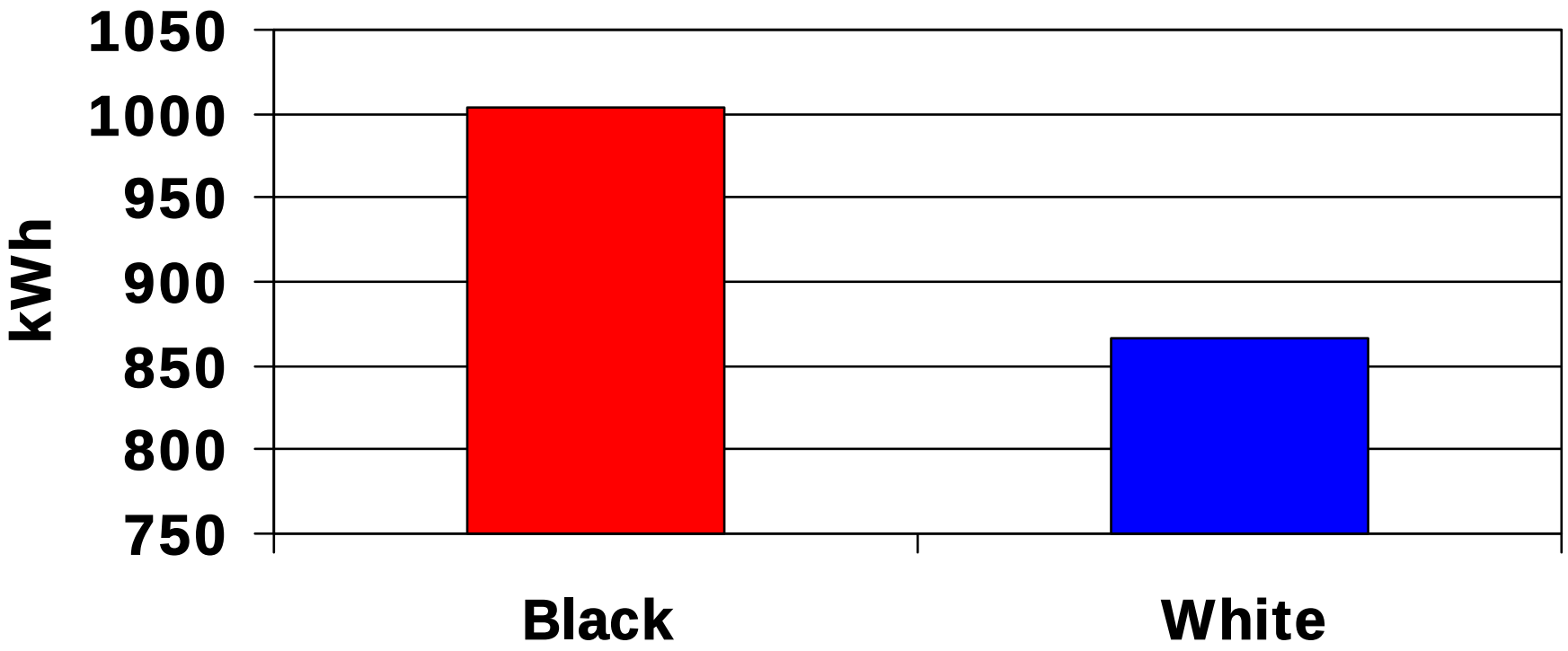
Average Summertime Maximum Roof Surface Temperature



Daily Air Conditioning Savings: 11%



Peak Hour Demand (1 - 4 PM)
savings: 14%



Without considering any tax benefits or other utility charges,
annual abated energy expenditures totaled:

$7,200.00
($0.07/ ft^2)

Is there a “winter penalty” in Northern climates for Cool Roofs?

If any, it is minimal…

- Winter days are shorter (less hours of sunshine)
- The sun is lower on the horizon and less intense
- Higher incidence of cloudy days

If any, it is minimal…

- Roof may be covered in snow for long periods
- Heating costs typically 2 – 3 X < AC costs (per Btu)

Additional Benefits

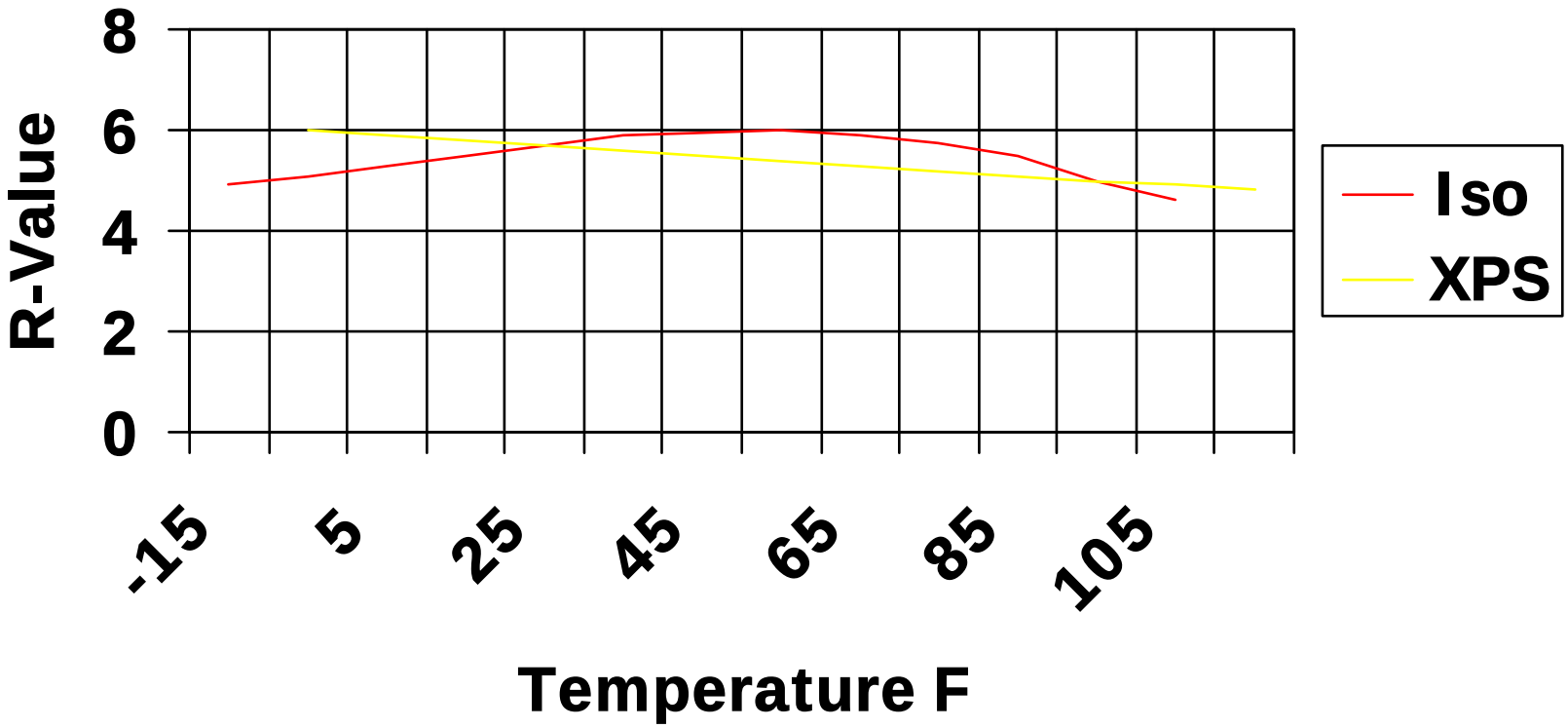
- ASHRAE Standard 90.1 1999 Energy Efficient Design of New Buildings Except Low Rise Residential
  - Allows for a decrease in the minimum amount of thermal insulation when a reflective roof is used in locations where HDD65 < 3,600

    We recommend reflective roofs be used to complement insulation rather than substitute for it

Reflective roofs over thermal insulations

- "The thermal resistance of insulation materials installed immediately below a black membrane has been found to be up to 30% lower than advertised, when measured at peak summertime temperatures in Austin, Texas"
  - Konopacki and Akbari, 2001

PI and XPS Board, R Values at Temperature



BEYOND “COOL” TO “SUSTAINABLE” REFLECTIVE ROOF COATINGS,
Leonard, J., Leonard, T., proceedings of the Cool Roofing…Cutting Through the Glare Symposium, Atlanta, GA, May 12 & 13, 2005

Why Care About Cool Roofs?

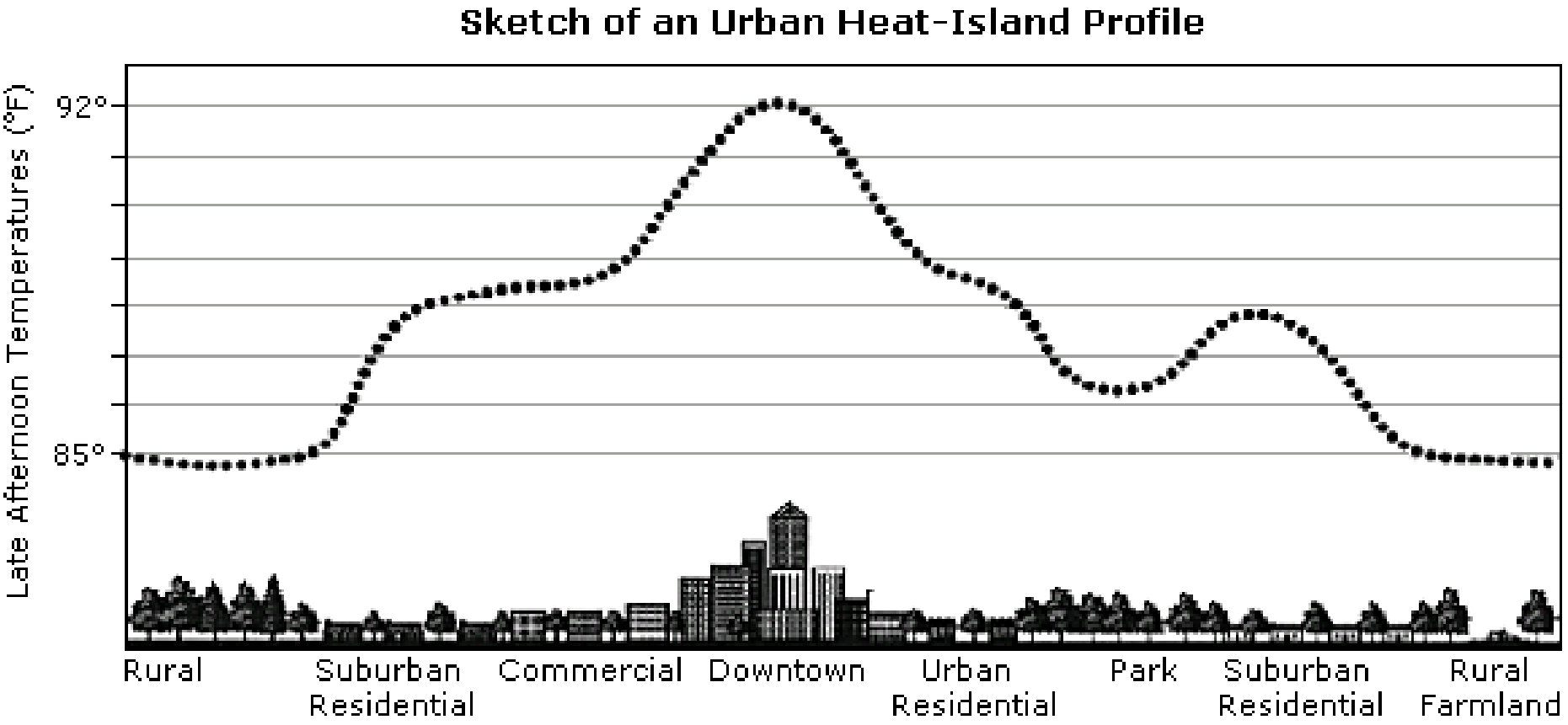
3 Classes of Benefits:

1. Owner/occupant benefits
2. Environmental benefits

Cool Roof Benefits: Environmental

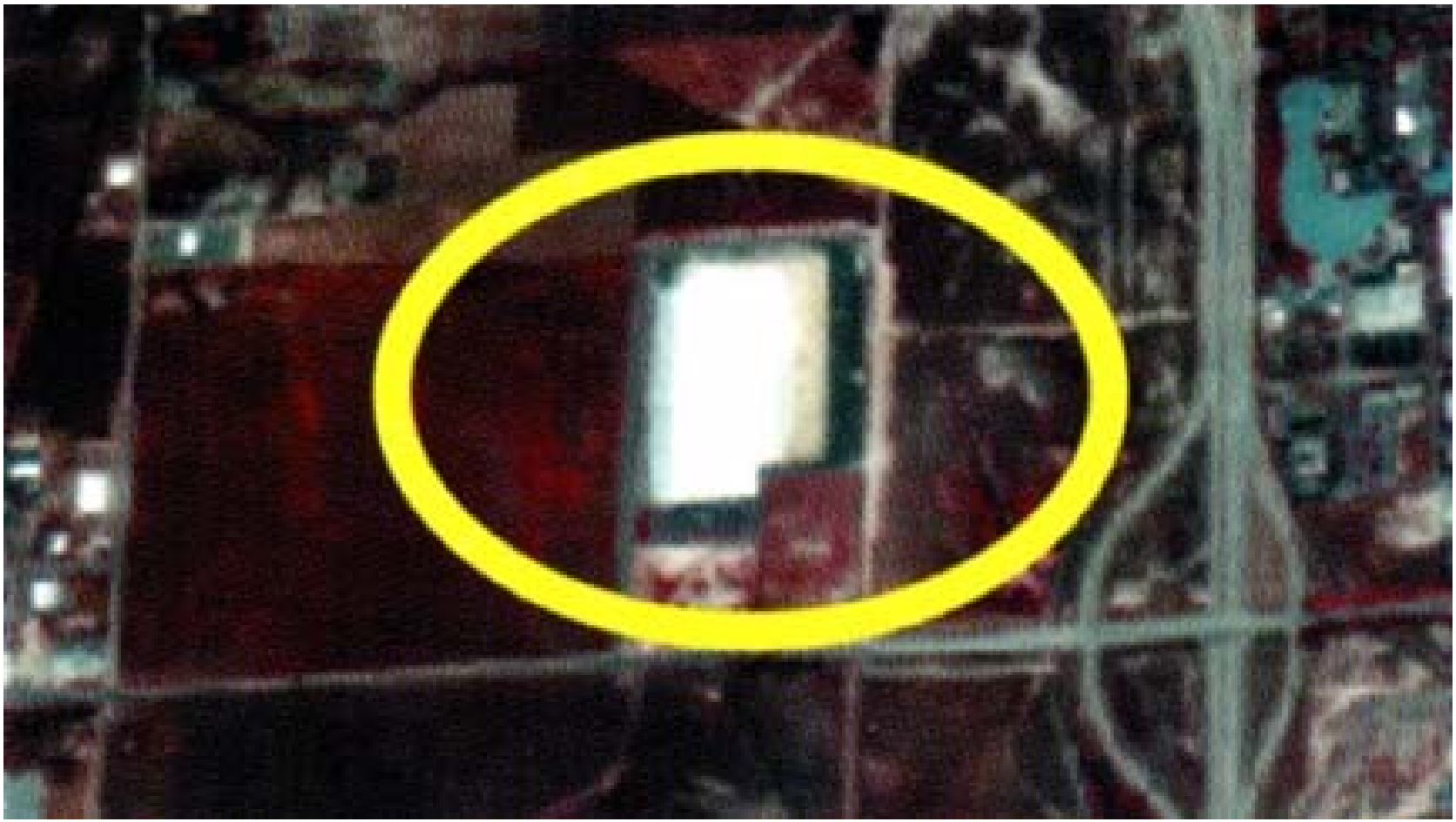
- Urban heat island mitigation (direct reduction in locally absorbed heat)

What's an Urban Heat Island?

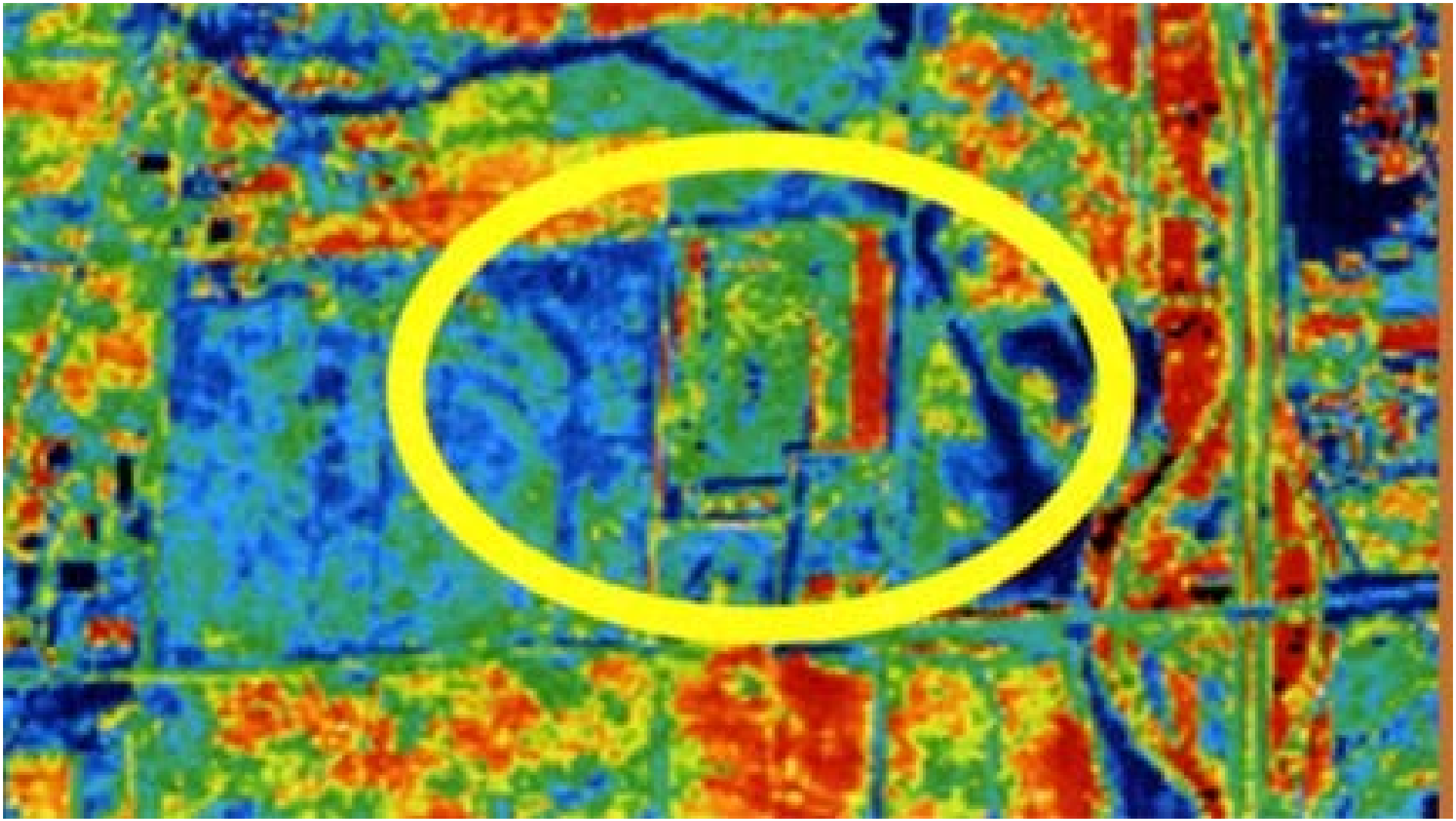


R.C. Willey Intermountain Distribution Center
Salt Lake City, UT (285,000 ft2)

Aerial photo from NASA's Global Hydrology and Climate Center



Thermal Infrared Image from NASA's Global Hydrology and Climate Center



Simply put...

- Its Cooler Where There Aren't As Many Dark Surfaces!
  - Asphalt Paved Roads
  - Dark Colored Roofs
    - Summertime Roof Temperatures Greater than 150 Degrees!!
  - Dark Colored Buildings

Cooler Outside Air Temperature Means...

- Cooler Temperatures Inside Buildings
- Less Need For Air Conditioning and Refrigeration
- Lower Utility Energy Bills
- Fewer “Brown Outs”
- Less Smog

Cool Roof Benefits: Environmental

- Reduced power consumption equals
  - Reduced emissions equals reduced photochemical smog (“Local”)
  - reduced GHG* contribution from power plants (NO_X SO_X, CO_2, etc.) (“Global”)
    - According to a 1998 Department of Energy report on CO_2 emissions every kWh of fossil fuel generated electricity produces 1.3 lbs of CO_2.
    - CO_2 emissions reduction is becoming an increasingly important issue

Lawrence Berkeley National Laboratory Studies

- Five Degrees Hotter in the City Than the Suburbs, On Average In the Summer
  - One Degree Rise in Air Temperature Raises Energy Demand Two Percent
    - More Air Conditioning
    - More Energy Use
    - More “Brown Outs”
    - More Physiological and Psychological Discomfort
    - More Pollution from Electricity Generation

Lawrence Berkeley National Laboratory Studies

- Five Degrees Hotter in the City Than the Suburbs
  - One Degree Rise in Air Temperature Increases Smog by Three Percent
    - Ozone
    - Eye Irritation
    - Asthma
    - Lung Damage

Why Care About Cool Roofs?

3 Classes of Benefits:

1. Owner/occupant benefits
2. Environmental benefits
3. Utility grid benefits

Cool Roof Benefits: the Grid

- Utility/Grid Operator Benefits
  - Reduced need for infrastructure spending (G, T, D)
    - Generation
    - Transmission
    - Local Distribution
  - Mitigation of system peaks
  - Reduced spending = lower rates long term

What is the CRRC?

By: Peter Turnbull
Pacific Gas and Electric (PG&E)
CRRC Vice Chair

What Is The CRRC?

- Self-Standing, 501(c)3 Non-profit Organization Diverse Membership
- Formed in 1998, first products rated in September 2002, patterned after NFRC
- EPA Energy Star was a good start, but Title 24 drove the need for a third party rating system

What is the CRRC?

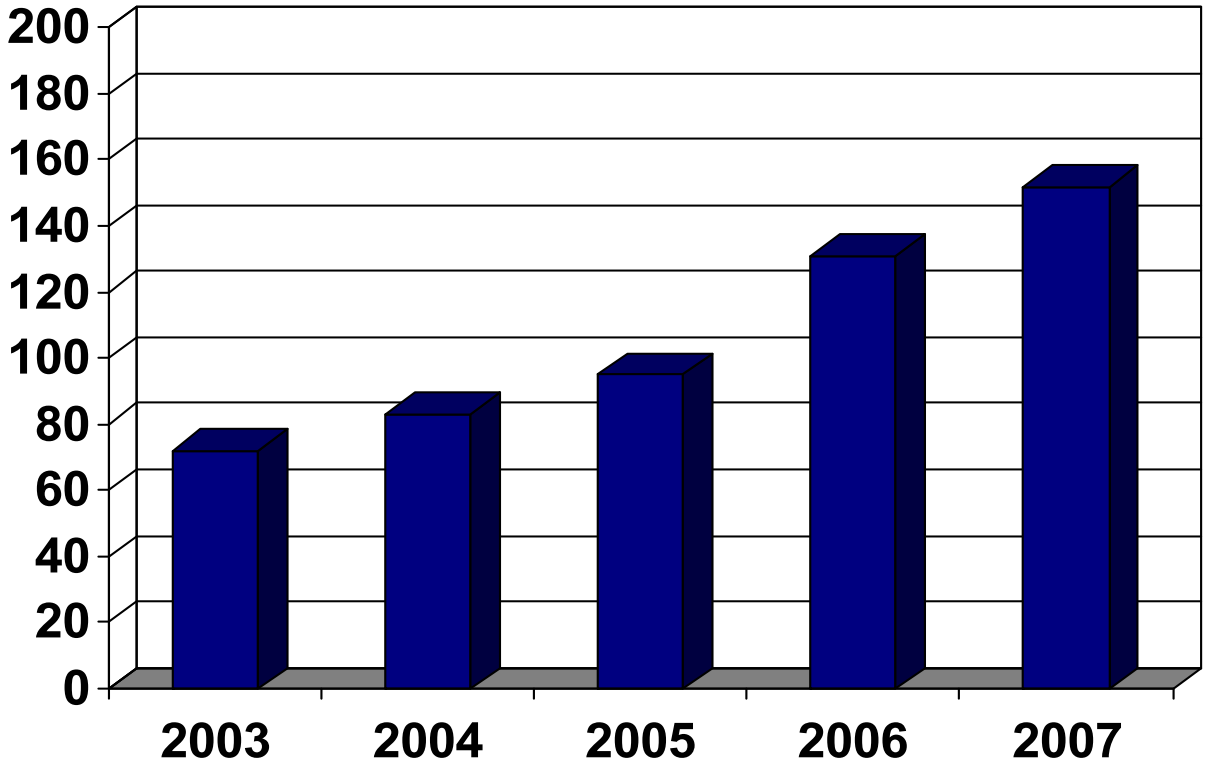
- Governed by a member-elected Board:
  - 6 Class A (manufacturers, trade associations)
  - 5 Class B (utility, state energy office, environmental advocates, roofing consultant, etc.)
  - Other key players – Energy Star, ORNL, LBNL, US DOE

CRRC Product Rating Program Numbers

- 5 Accredited Independent Testing Laboratories
- 2 Accredited Manufacturer Testing Laboratories
- 1 Approved Test Farm

Membership

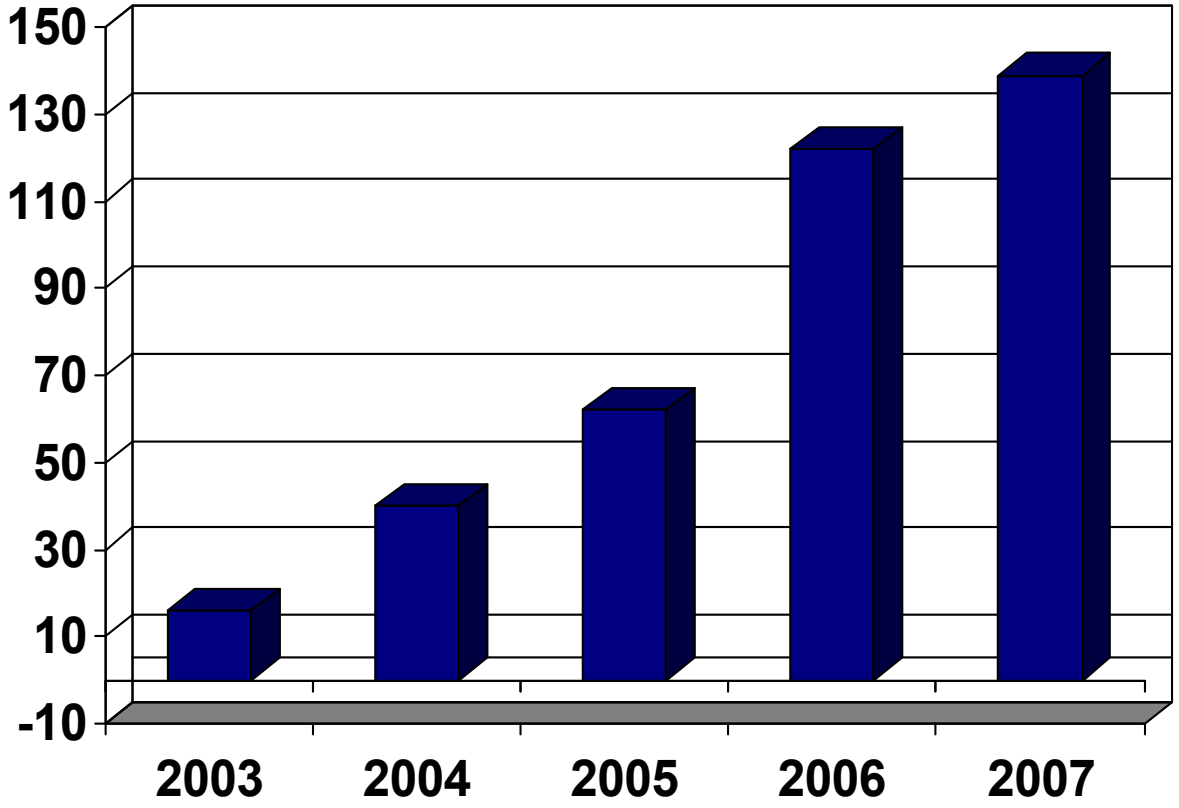
February 2003 – February 2007



- February 2003 – 72
- February 2004 – 83
- February 2005 – 95
- February 2006 – 131
- February 2007 – 152

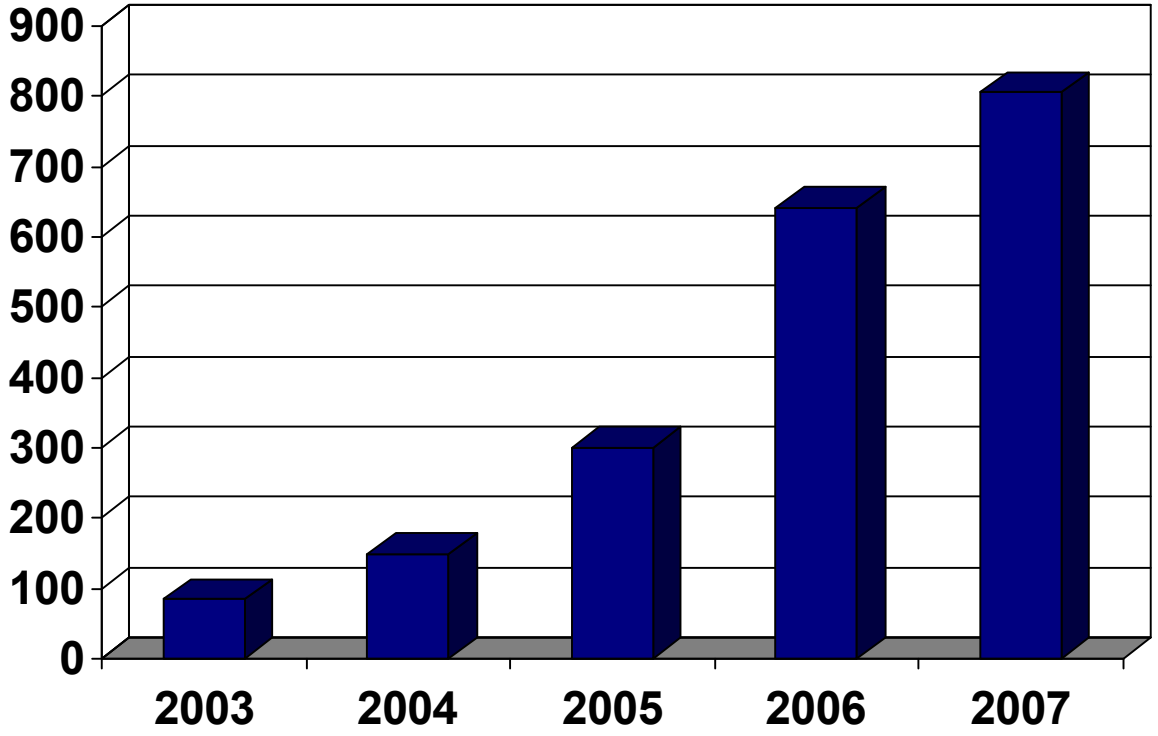
Licensed Sellers and Other Manufacturers

February 2003 – February 2007



- February 2003 – 16
- February 2004 – 40
- February 2005 – 62
- February 2006 – 122
- February 2007 – 139

Rated Products
February 2003 – February 2007



- February 2003 – 84
- February 2004 – 148
- February 2005 – 300
- February 2006 – 641
- February 2007 – 805

Why Is CRRC Needed?

- Fair, accurate, credible rating system
  - Objective, 3rd party source of reliable data for roofing product reflectance and emittance (initial and long-term performance)
- Creates level playing field for the roofing product industry.
- Provides stakeholders with needed data
- Organized to support building code applications

CRRC Basics

1. CRRC's work limited to top roofing layer
2. CRRC Product Label includes both reflectance and emittance data, for both initial and aged values
3. CRRC ***does:***
    1. Rate, or measure, the radiative properties of roof products
    2. Publish performance data on the directory
4. CRRC ***does not:***
    1. Set a performance standard or define "cool" (Energy Star and state standards do that, for example)
    2. "Certify" or "approve" products

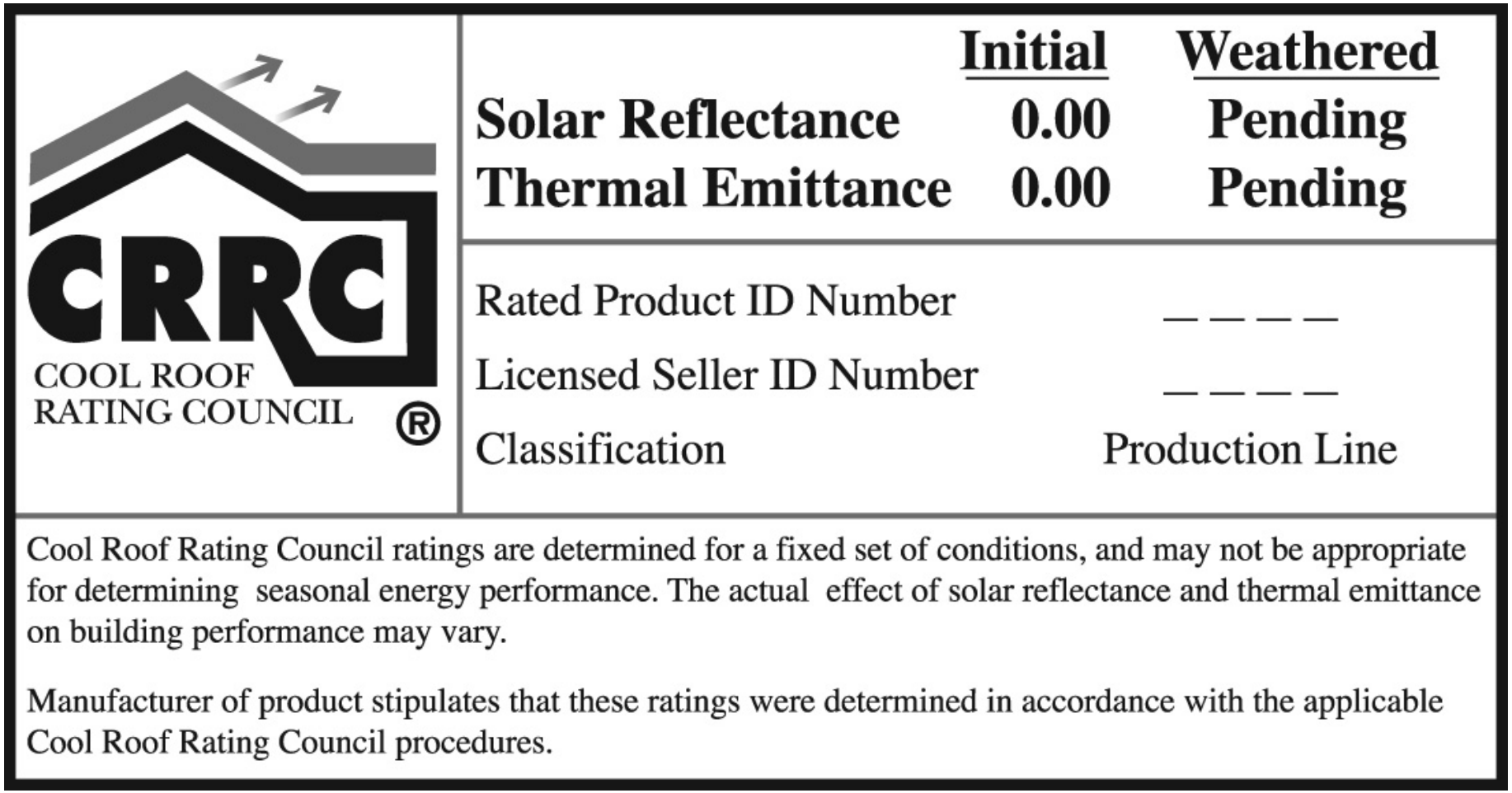
Core of CRRC Product Rating Program

- Requires use of CRRC accredited, independent, 3rd party laboratories
- Set of designated test methods
- Initial and aged ratings
- Specific sample collection requirements
- Random Testing – annual check of randomly selected listed products to verify label data

A “Label” and a “Directory”

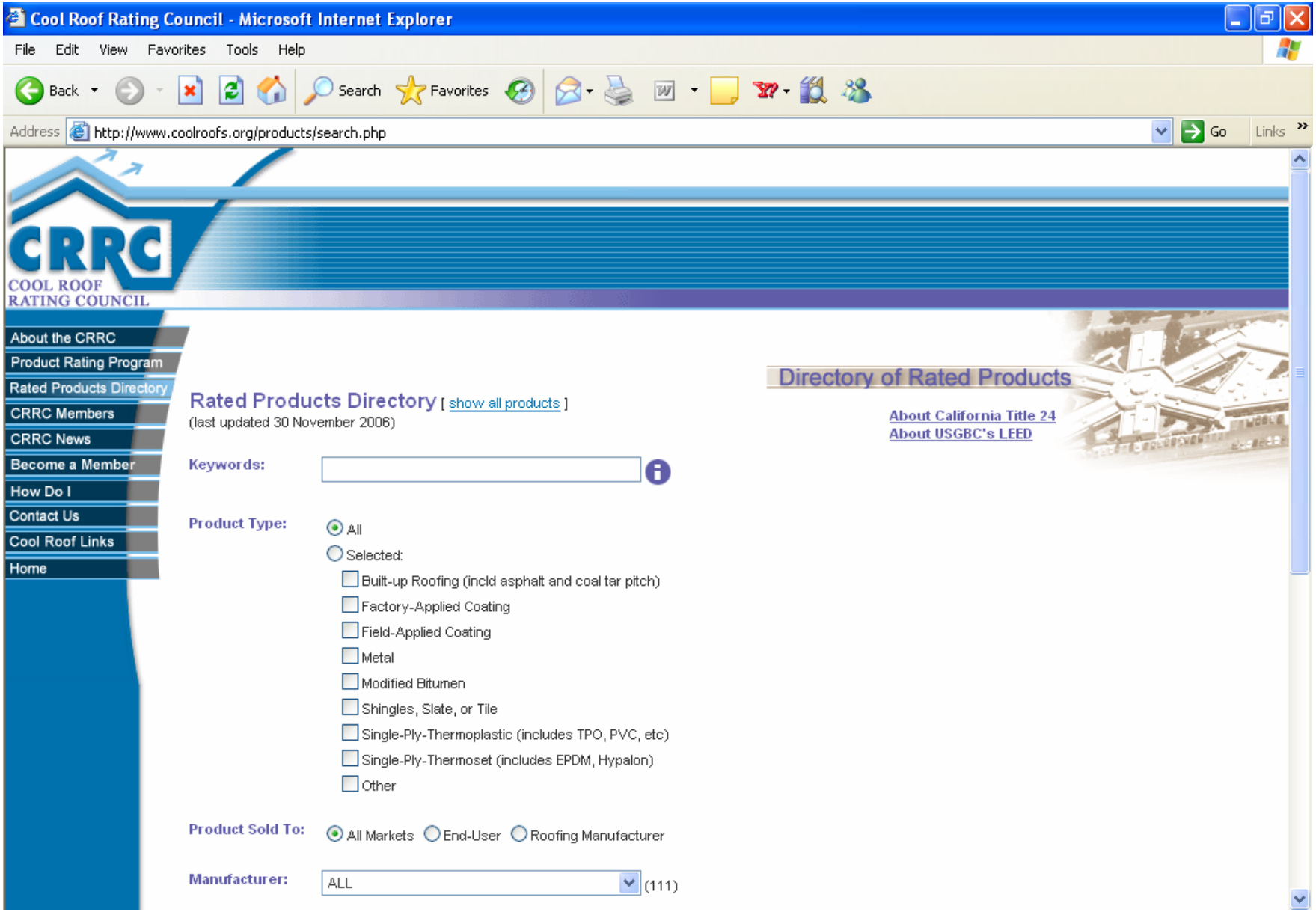
- **Label**:
  - needed for consumers
  - needed for code enforcement
- **Directory**:
  - needed for specifying community, including contractors
  - needed for quick code reference to establish compliance

CRRC Label Content

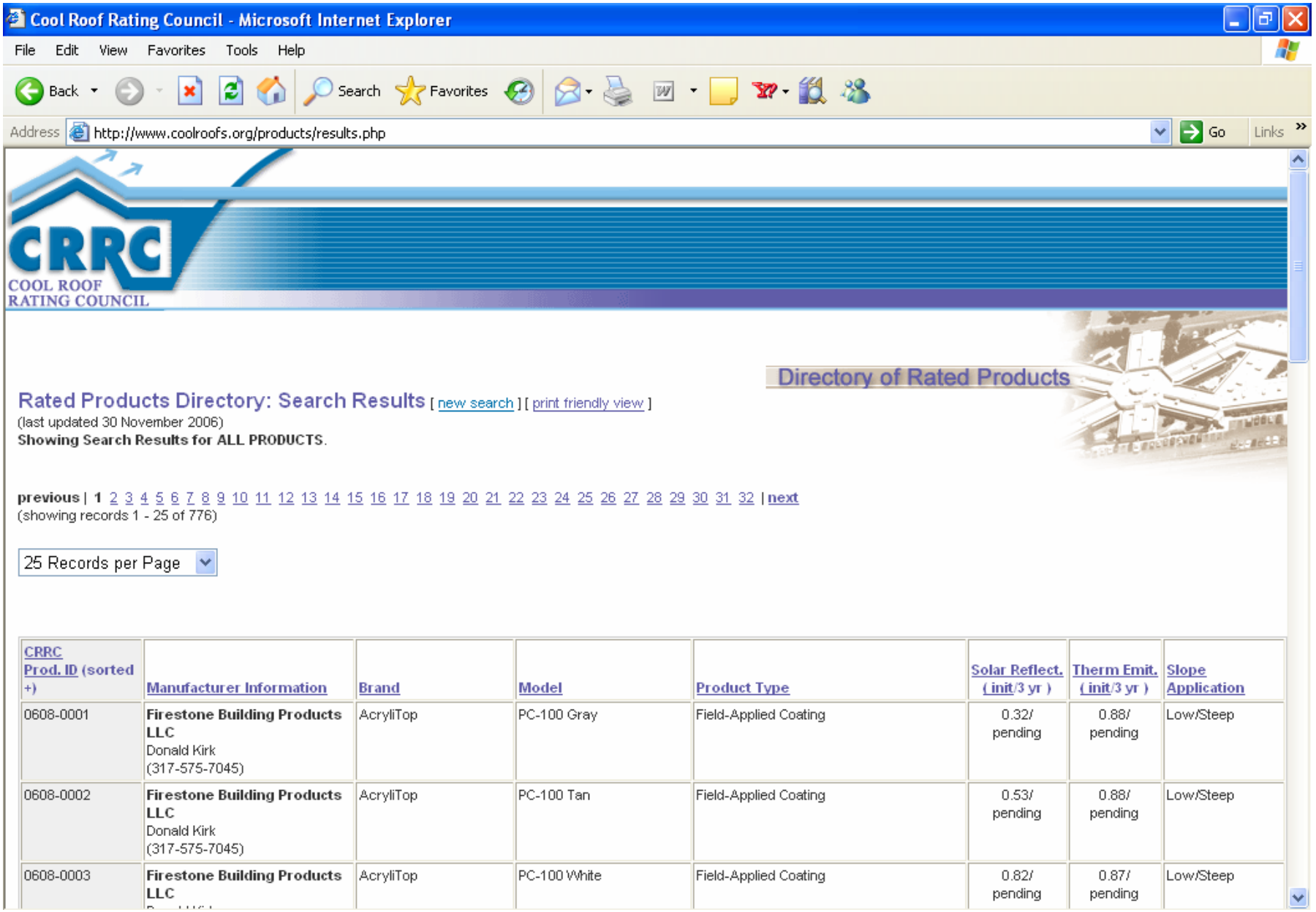


- Aged Data is “pending” until aged results are available
- First aged results to be published around March 2007

CRRC Searchable Product Directory



“Sortable” Search Results



CRRC Prod. ID (sorted +)	Manufacturer Information	Brand	Model	Product Type	Solar Reflect. (init/3 yr)	Therm Emit. (init/3 yr)	Slope Application
0608-0001	**Firestone Building Products LLC** Donald Kirk (317-575-7045)	AcryliTop	PC-100 Gray	Field-Applied Coating	0.32/ pending	0.88/ pending	Low/Steep
0608-0002	**Firestone Building Products LLC** Donald Kirk (317-575-7045)	AcryliTop	PC-100 Tan	Field-Applied Coating	0.53/ pending	0.88/ pending	Low/Steep
0608-0003	**Firestone Building Products LLC**	AcryliTop	PC-100 White	Field-Applied Coating	0.82/ pending	0.87/ pending	Low/Steep

CRRC Rating Program Used By:

- Contractors, Builders, Architects, Specifiers
  - provides reliable source of data
- State Energy Codes
  - basis for credit or requirement (reflectance > X%)
- Utilities
  - determine peak and overall energy savings; provide data for rebate programs
- EPA/Environmentalists
  - interested in reducing CO_2 emissions (global warming) from power plants
- Air Quality Agencies
  - model air pollution; provide credits in state implementation plans (SIPs)

What Ratings Codes and Programs are in Place, and When and Where are Cool Roofs Required?

By: David L. Roodvoets

Single Ply Roofing Industry (SPRI)

CRRC Board Member

2 Types of Code Efforts:

- Voluntary
  - Energy Star
  - USGBC LEED
  - Green Globes
  - ASHRAE
- Mandatory
  - California's Title 24
  - City of Chicago

Voluntary

- Energy Star
- USGBC LEED
- Green Globes
- ASHRAE

Energy Star

- EPA's voluntary program (manufacturer provided data)
- Complementary to CRRC
- Household name recognition
- Looks only at solar reflectance
- Sets a minimum requirement for 'cool' products
- Qualifying companies can use the Energy Star logo on their products
- CRRC ratings are accepted but not a required data source for Energy Star qualification

Energy Star Specification

Low-slope roofs:

- Products must exhibit an initial solar reflectance value of 0.65 or greater
- Products must exhibit a solar reflectance value of 0.50 or greater after 3 years (at this time is with cleaning permitted before retesting)

Steep-slope roofs:

- Products must exhibit a solar reflectance value of 0.25 or greater
- Products must exhibit a solar reflectance value of 0.15 or greater after 3 years

Update effective May 2007 to include thermal emittance and SRI

US Green Building Council's Leadership in Energy and Environmental Design

- Voluntary green building rating system
- Different versions of LEED:
  - New Construction
  - Existing Buildings
  - Core and Shell
- All have a credit for cool roofing

LEED for New Construction
Version 2.2

- Cool Roofs play into LEED in 2 ways
  - Sustainable Site: Credit 7.2 Heat Island Effect: Roof, which is 1 Point
  - Cool roofs contribute to the energy performance (roughly ½ point)

LEED for New Construction
Version 2.2

- Intent: Reduce heat islands to minimize impact on microclimate and human and wildlife habitat.
- Three Options to comply:
  - Option #1: Solar Reflective Index
  - Option #2: Vegetated Roof
  - Option #3: Combination of Options #1 and #2

Option #1

- Use roofing material having a Solar Reflectance Index (SRI) equal to or greater than the values in the table below for a minimum of 75% of the roof surface.
- Low Slope (= or Less than 2:12) SRI 78
- Steep Slope (greater than 2:12) SRI 29
- References the CRRC

Green Globes

- *Green Building Initiative's* green building program
- Credit for cool roofing similar to LEED NC v2.2
  - The Green Globes system is a "green" management tool that includes an assessment protocol, rating system and guide for integrating environmentally friendly design into commercial buildings

A Note About Sustainability vs. Energy Savings

- USGBC's LEED program and the Green Globes system take into account a broader sustainability scope rather than focusing purely on energy savings,
- However, energy saving measures are an essential component of sustainability

ASHRAE

The American Society of Heating, Refrigeration and Air-Conditioning Engineers

- 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings,
- 90.2 Energy Standard for Low-Rise Residential Buildings
- Advanced Energy Design Guides which provide 30% Energy Savings over Standard 90.1, require reflective roofs

ASHRAE

- Provides Trade Off of Insulation and Reflective Roofs for areas with less than 3600 heating Degree days
- Recommends using both Insulation and Reflectance
- Requires Reflective Roofs For Buildings that Exceed Standard 90.1 by 30%

ASHRAE 90.1

- *ASHRAE Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings (*section 5.3.1.1)
  - Allows reduced roof insulation (U-factor) if a cool roof is used
    - Recommendation that reflective roofs be used to complement insulation rather than substitute for it
  - Defines a cool roof as min. solar reflectance of 0.70 and min. thermal emittance of 0.75.

ASHRAE 90.2

- *ASHRAE Standard 90.2 Energy Efficient Design of Low-Rise Residential Buildings* (section 5.5)
  - Allows for reduced roof insulation with a cool roof
  - Defines cool roof as minimum solar reflectance of 0.65 and thermal emittance of 0.75 or an SRI value of 75
  - References the Cool Roof Rating Council

Mandatory Measures

- California's Title 24
- City of Chicago

California's Title 24
Building Energy Efficiency Code

- Sets an energy budget for residential and nonresidential buildings
  - New buildings and additions/alterations **(alterations can include re-roofing)**
- As of October 2005, includes a prescriptive requirement for cool roofs

“Prescriptive” means - -

- T24 provides a list of minimum energy efficiency measures – the list is like a prescription – for how to construct a building to meet the energy budget
- The alternative to prescriptive is *performance* (computer-model how the building will perform energy-wise) – can trade off among energy efficiency measures

Cool Roofs Are on the "Prescriptive" List for Nonresidential Buildings (Cool roofs are NOT mandatory)

This means either:

- Follow the prescription for a cool roof (next slide), OR
- Do some other measure to have equivalent energy savings
  - Use either the overall envelope prescriptive method (allows tradeoffs among components of bldg envelope) OR
  - Model the building via (approved) software – may make more sense for designing new bldg than for reroof

What is a Cool Roof under California's Title 24 Energy Standards?

Must…

- Be rated through CRRC (Title 24, Part 1, §10-113)
- Be properly labeled (Title 24, Part 1, §10-113)
- Meet reflectance and emittance requirements (≥ 0.70 and ≥ 0.75 respectively, or go by a formula if emittance is lower) [Part 6, §118(i)1 and 2]
- For coatings liquid-applied in the field, meet performance requirements [Part 6, §118(i)3 & Table 118-C]

Title 24 Cool Roofs Apply to - -

- Conditioned space
- Low slopes (≤ 2:12)
- Nonresidential buildings except Occupancy Use “I” (institutions, hospitals, jails, etc) and hotels/motels

- *There are some allowances for cool roofs to help meet energy budgets for some high slopes and residences, using performance modeling*

Cool Roofs Are Optional (NOT prescriptive) for - -

- Hotels and motels
- High-rise residential buildings
- Unconditioned warehouses
- Refrigerated warehouses, other spaces held under 55°F, and spaces held over 90°F
- Buildings cooled by evaporative coolers
- Roofs with slopes over 2:12

Nonresidential Re-roofing

Cool roofs apply if - -

- more than 50% or 2,000 sq/ft of low-sloped roof (whichever is less) is being replaced, recovered, or recoated [§149(b)1B]
  - This means put on a cool roof

  or
  - Do some other equivalent energy efficiency measure with the building envelope (such as roof insulation)

Next Title 24 Update

- Effective 2008 or 2009
- May include
  - Adding prescriptive reflective requirements for steep roofs
  - Adding aged reflectance/emittance
  - Removing cool roof requirements for some building types that are heated only, no air conditioning (a few climate zones only)

City of Chicago