Firestone
BUILDING PRODUCTS
NOBODY COVERS YOU BETTER™

Saving Energy and Money On Your Commercial Roof

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CENTER FOR ENVIRONMENTAL INNOVATION IN ROOFING

Learning Objectives

- Identify the benefits and limitations of various commercial roofing solutions that provide significant energy savings and enable buildings to achieve sustainability requirements
- Evaluate the effectiveness of green roofing solutions based on location, return on investment, anticipated energy savings and long-term performance
- Recognize potential challenges that might be encountered during the installation and ongoing operation of various green roofing solutions
- Confidently specify roofing solutions that use the rooftop as an energy efficient platform to save building owners money and enhance overall building performance

What is a Green Roof?

- System choices
  - Solar or photovoltaic (PV) rooftop solutions
  - Garden roof
  - White, reflective roof
- Key Considerations
  - Recycled products
  - Air quality factors
  - Stormwater management
  - Durability

Energy Savings and Sustainability

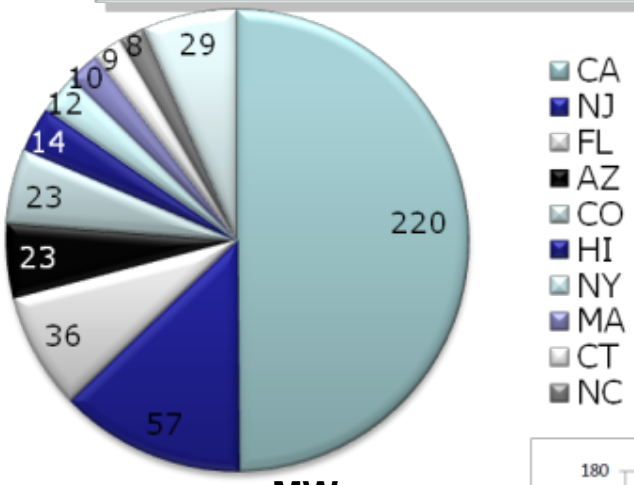
- The rooftop is an energy efficient platform
  - Implications of solar installations
  - Daylighting options
  - Vegetative roofs
  - Reflective roofing surfaces
  - Properly insulated roofs

Market Trends

Top Ten States in 2009

Source: SEIA, IREC

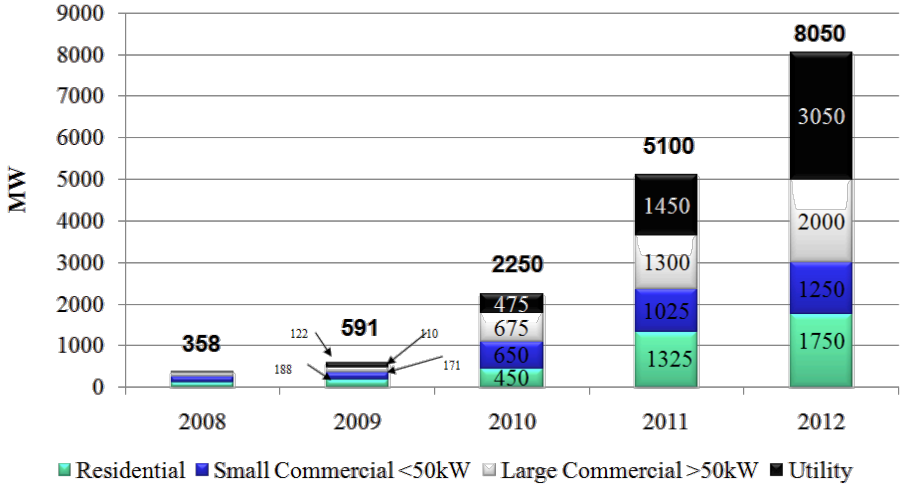
California's market share fell from 62% in 2008 to 50% in 2009 as emerging state markets posted stronger growth.



MW

North America PV Installations

Source: Photon Consulting, March 2010



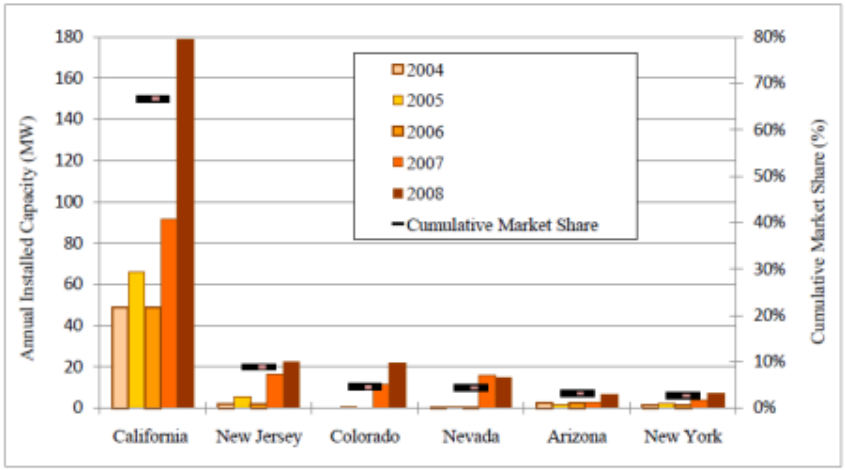


Figure 1.10. Annual grid-connected PV capacity and cumulative market share in top U.S. state markets, 2004–2008 (Sherwood/IREC 2009)

Photovoltaic (PV) Systems

Ballasted Solar Roof Tile

Thin Film PV System

Opel, Zaragoza, Spain, 200.000m²
EPDM & TPO

Anchored PV System

Minimize potential future liabilities from leaking solar penetrations

PV Roofing Challenges
Maintaining Roof Watertightness

Countermeasures:

- Use compatible penetrations and attachments
  - Elevate framing and conduits above the roof surface to promote drainage
  - Utilize round framing at penetrations in lieu of angles, channels, I-beams, etc. (easier to flash a round penetration)

- Verify the roof structure and system can accommodate the added building lodes
  - Verify that the roof structure can accommodate the dead load weight of PV array and framing*
  - Verify that wind uplift forces acting on PV framing and modules can be accommodated by the roofing system*

* Also see "Building Codes" for additional recommendations

PV Roofing Challenges
Maintaining Roof Watertightness

Countermeasures:

- Protect membrane and flashing surfaces from PV-generated heat and reflected UV
  - Install an additional sacrificial layer of roof membrane directly beneath the PV system to protect the underlying waterproofing membrane from accelerated heat aging
  - Install additional layers of membrane or coatings at vertical roof flashings (curbs, walls, etc.) to protect the flashings from accelerated UV aging
  - Establish a periodic inspection program to verify the condition of the roofing and flashing membranes, looking specifically for accelerated heat and UV aging effects

PV Roofing Challenges
Maintaining Roof Watertightness

Countermeasures:

- Protect the roofing system from PV-related system service and maintenance loads
  - Consider an additional sacrificial layer of roof membrane directly beneath the PV system to protect the underlying waterproofing membrane from damage due to foot traffic or maintenance equipment.
  - Design and install a protective walkway system to direct maintenance traffic and protect the underlying waterproofing membrane from damage due to foot traffic or maintenance equipment.
  - Install a high compressive strength cover board between the roofing membrane and the underlying thermal insulation to protect the insulation from crushing due to service traffic.

PV Roofing Challenges
Maintaining Roof Warranty

Warranty Concerns:

A valuable tool….

- Provides for repair of leaks during the warranty term; subject to terms, conditions and limitations
- Establishes ongoing communication and accountability between the roof system manufacturer, roofing contractor and building owner

... but with important conditions and limitations

- Roofing system must be designed and installed in accordance with roofing manufacturer specifications
- PV system details and integration must be accepted by the roofing manufacturer
- Building owner or owner's agent must follow maintenance and notification requirements of warranty

PV Roofing Challenges
Maintaining Roof Warranty

Countermeasures:

1. Make sure the roof system manufacturer has accepted all PV system details - especially attachments and penetrations - prior to installing the PV system

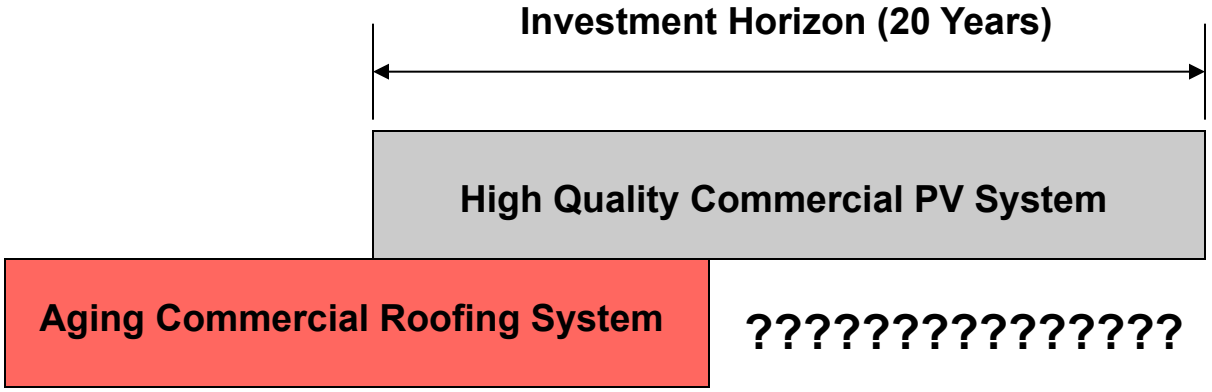
2. Initiate a long-term roof/PV system maintenance program, coordinated between the roofing and PV contractors

3. Maintain communications with the roof system manufacturer, especially involving the reporting of observed problems

PV Roofing Challenges
Matching Roof/PV Investment Horizon

An Ineffective Match:

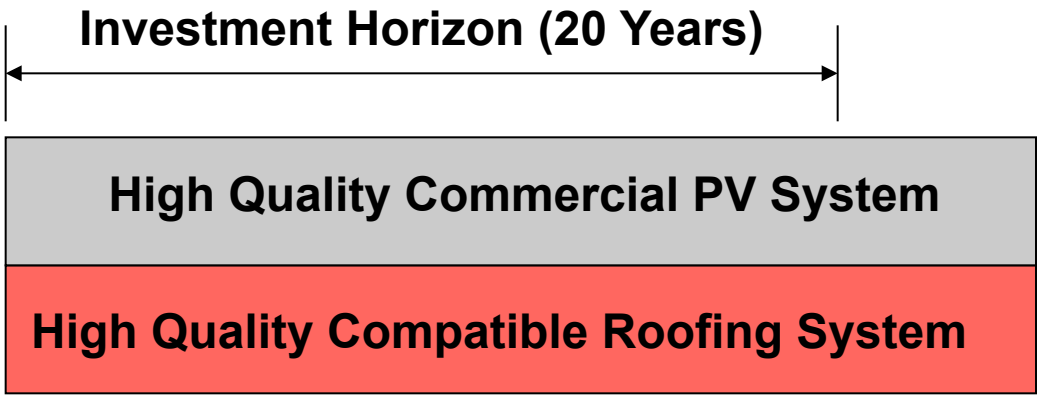
A high quality commercial PV system installed over an aging roof that may not be designed for compatibility with the PV system



PV Roofing Challenges
Matching Roof/PV Investment Horizon

An Effective Match:

A new high quality commercial PV system installed in conjunction with a new high quality commercial roofing system designed for compatibility with the PV system



PV Roofing Challenges
Maintaining Continuous Operations

Operating Concerns:

- Unusual weather events may damage the PV roofing system and disrupt continuous operations
  - Wind storms and wind-blown debris may damage both the PV system and the roofing system
  - Hail storms may damage both the PV system and the roofing system
- Major roof repair or replacement, if required, may disrupt continuous operations
  - Major roof system repairs or replacement may require the disassembly of the PV system

PV Roofing Challenges
Maintaining Operations After Weather Events

A rooftop PV system should be designed not to simply "make it through the storm" but to minimize the need for major repairs or replacement that could compromise the continuous operation of the PV system.

PV Roofing Challenges
Maintaining Operations After Weather Events

Operating Countermeasures:

- Wind storms and wind-blown debris
  - Install high wind resistant roofing and PV systems that jointly meet or exceed building code requirements
  - Add additional wind anchorage at critical corner and perimeter areas
  - Consider an additional sacrificial layer of roof membrane to protect the underlying waterproofing membrane from damage due to wind-blown debris
- Hail storms
  - Roofs must be specifically designed to resist hail damage, especially in hail-prone regions
    - "Hail-rated" roofing systems are available for almost all types of major roofing systems
    - Hail-rated systems frequently include the use of a thicker primary roofing membrane and a hail-resistant cover board

PV Roofing Challenges
Meeting Building Codes

Code Concerns:

- Fire ratings
  - The combined PV/roofing system must meet or exceed external fire standards as required by the governing building code
  - Conventional PV arrays usually do not affect the fire rating of the underlying roofing system, but thin-film laminates generally must be tested and certified to meet fire code requirements
- Wind ratings
  - The combined PV/roofing system must meet or exceed wind uplift resistance standards as required by the governing building code
  - Both conventional PV arrays and thin-film laminates generally must be tested and certified to meet wind uplift code requirements

PV Roofing Challenges
Meeting Building Codes

Code Countermeasures:

- Fire ratings
  - Verify that the combined PV / roofing system meets or exceeds all fire safety requirements of the governing building codes
  - Obtain copies of valid fire rating reports or seek written approval from the governing code official for an exception to the code
- Wind ratings
  - Verify that the combined PV / roofing system meets or exceeds all wind uplift requirements of the governing building code. Obtain copies of valid wind uplift rating reports or seek written approval from the governing code official for an exception to the code

PV Roofing Challenges
Managing Safety Risks

Safety & Risk Concerns:

- Working at heights
  - Falls at roof edges
  - Falls through roof openings
  - Falls from ladders and scaffolds
- Working with high voltage
  - High voltage wires and conduit
  - Access to junction boxes and circuits
  - Ground protection
- Maintaining proper insurance coverage
  - Coverage for working at heights and with high voltage (workman's compensation and general liability)

PV Roofing Challenges
Managing Safety Risks

Safety & Risk Countermeasures:

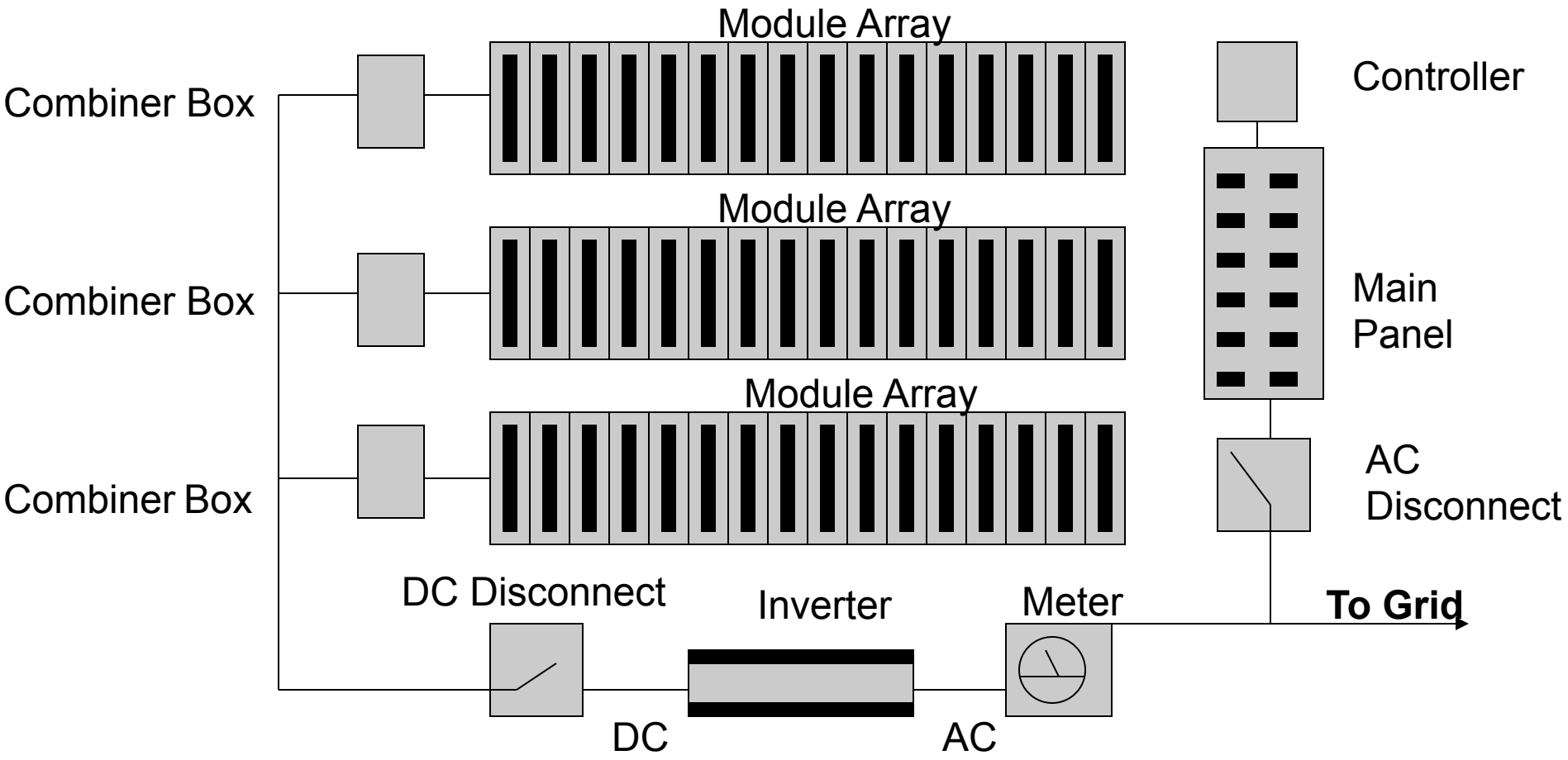
- Working at heights
  - Install permanent fall protection features (walkway railings, ladder cages, warning lines, etc.) as part of the completed PV roofing system
  - Limit roof access only to technicians fully trained to work at heights and using OSHA-approved fall protection
- Working with electricity
  - Use walkways and railings to separate roof service traffic from conduit runs and junction boxes
  - Use “lock-out”/“tag-out” controls at all high voltage equipment
  - Limit access to PV equipment and conduit to technicians fully trained to work with high voltage and using OSHA-approved safety equipment

PV Roofing Challenges
Managing Safety Risks

Safety & Risk Countermeasures:

- Maintaining proper insurance coverage
  - Limit roof access only to authorized personnel
    - Maintain a log recording the arrival, departure and purpose of all authorized visitors to the roof
  - Require workman's compensation and general liability insurance certificates for all PV / roof system service personnel
  - Verify that the building's general liability coverage includes accidents and damages arising from the operation of a PV roofing system.

PV Roofs
Typical Commercial PV System (with Net Metering)



Daylighting

- Daylighting provides natural light to replace electric lights inside buildings
  - Reduces electricity usage for lights
  - Reduces cooling costs by minimizing heat from light source
- Transmits 35% more light while still providing 100% diffusion compared to any standard industrial skylights on the market
- Directs more of the transmitted light to the work place without glare, hot spots or UV damage to merchandise or furnishings
- Catch up to 20% more light at low sun angles than standard shapes
- Offers 3-4 year ROI

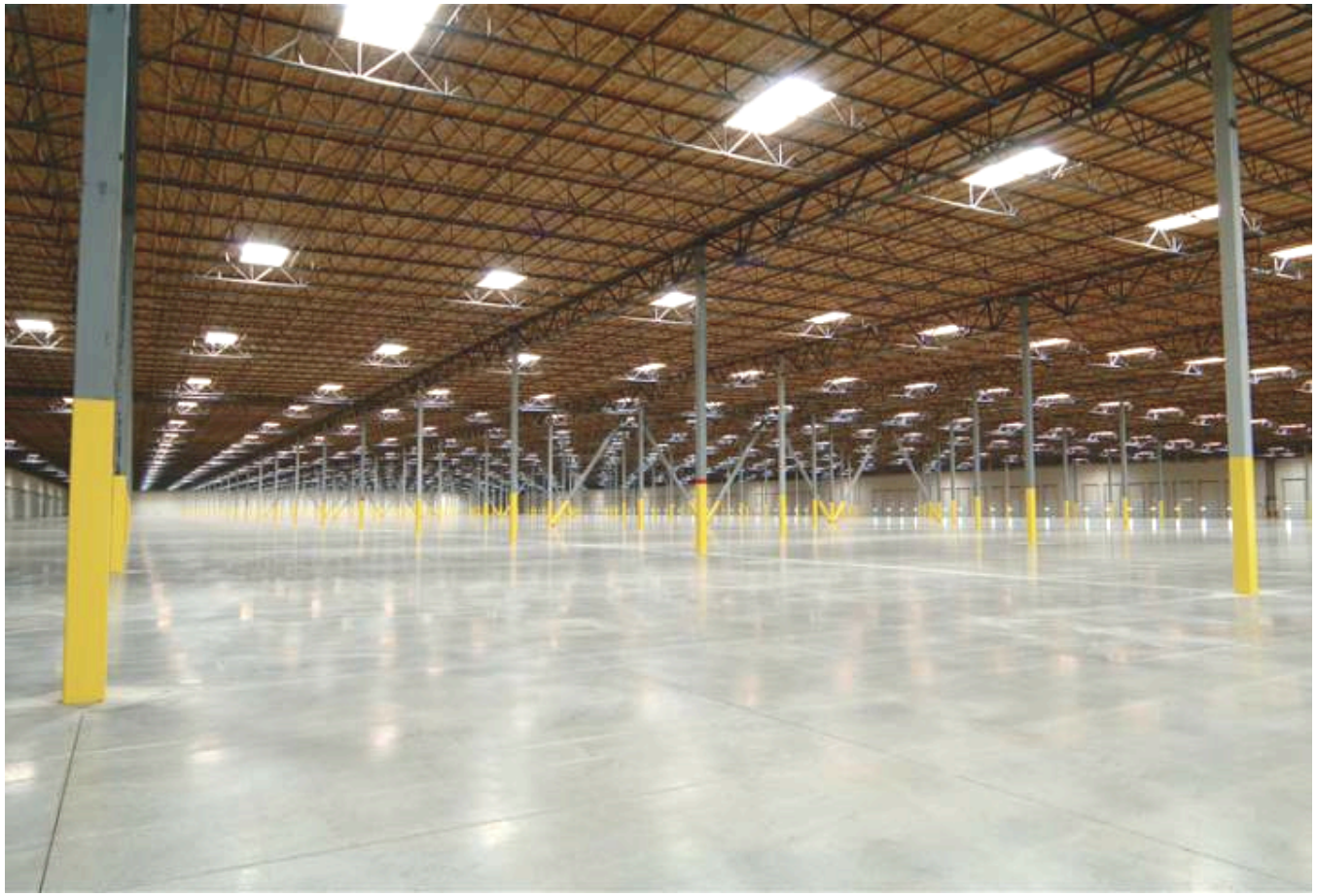
Energy and Effectiveness
Electric Lights

- Common industrial building
- Lights on and burning energy however sometimes still dark

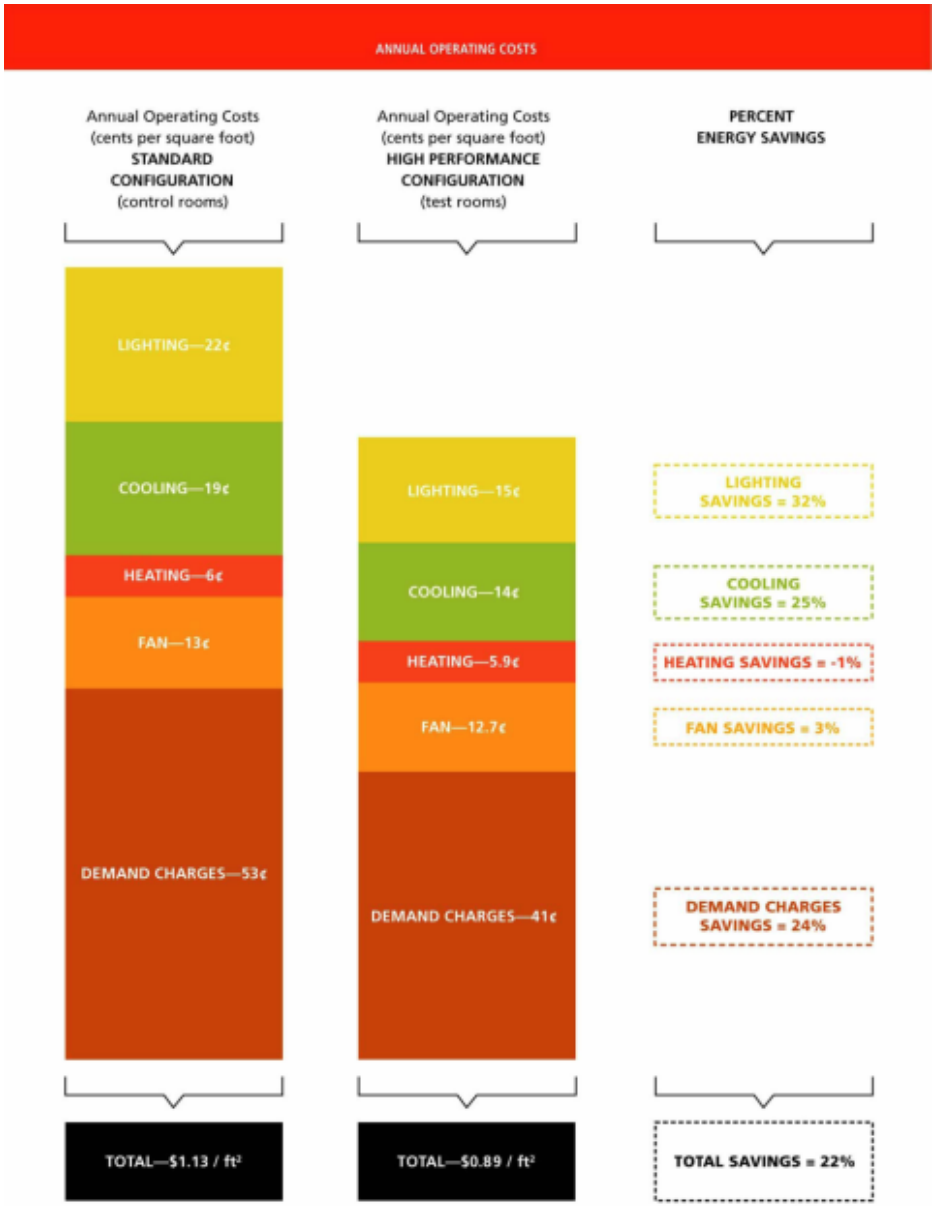
Energy and Effectiveness
Clear Skylight Glazing

- First with clear and then opaque domes to knock down light for diffusion

Energy and Effectiveness
Daylighting



Save energy and money with daylighting solutions



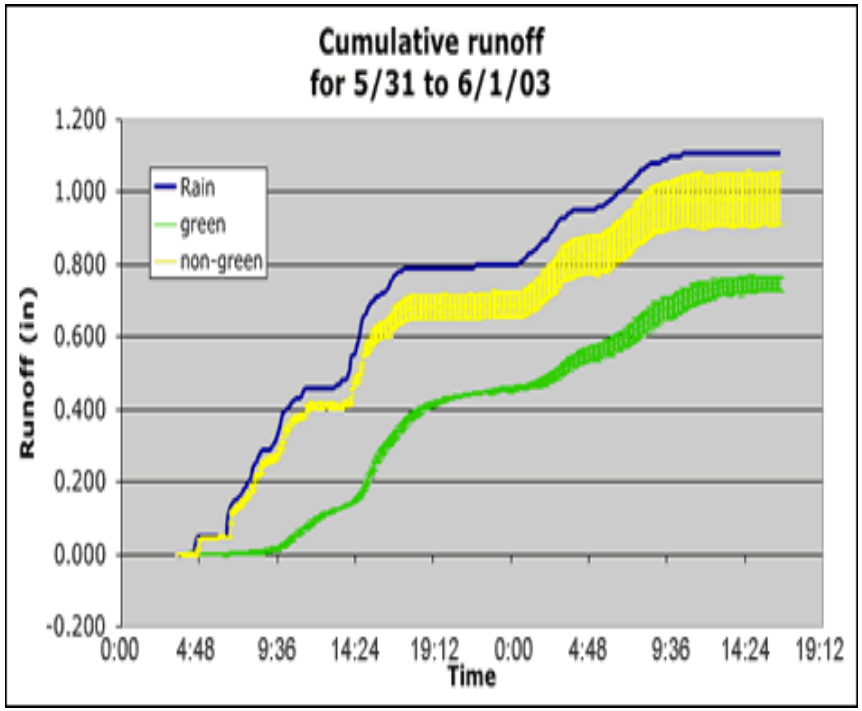
Green Roofing Options
Why Vegetated Roofs?

- Reduced heating and cooling costs
- Reduced peak electric consumption
- Reduced ambient air temperature
- Reduced stormwater runoff / improved water quality

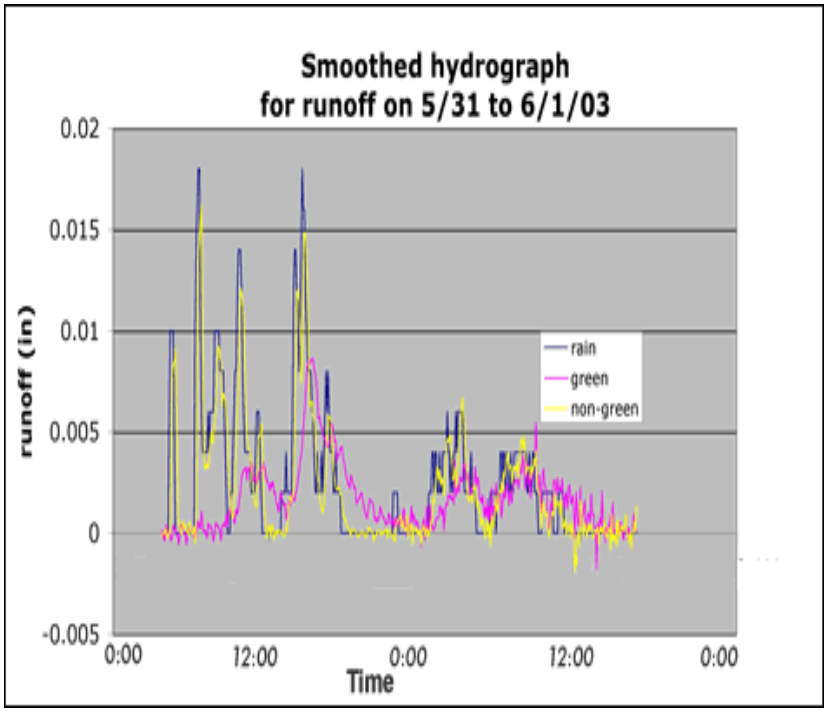
U.S. Environmental Protection Agency
Denver, CO

Vegetated Roofs
Reduced Storm Water Runoff

Both cumulative…



and peak…

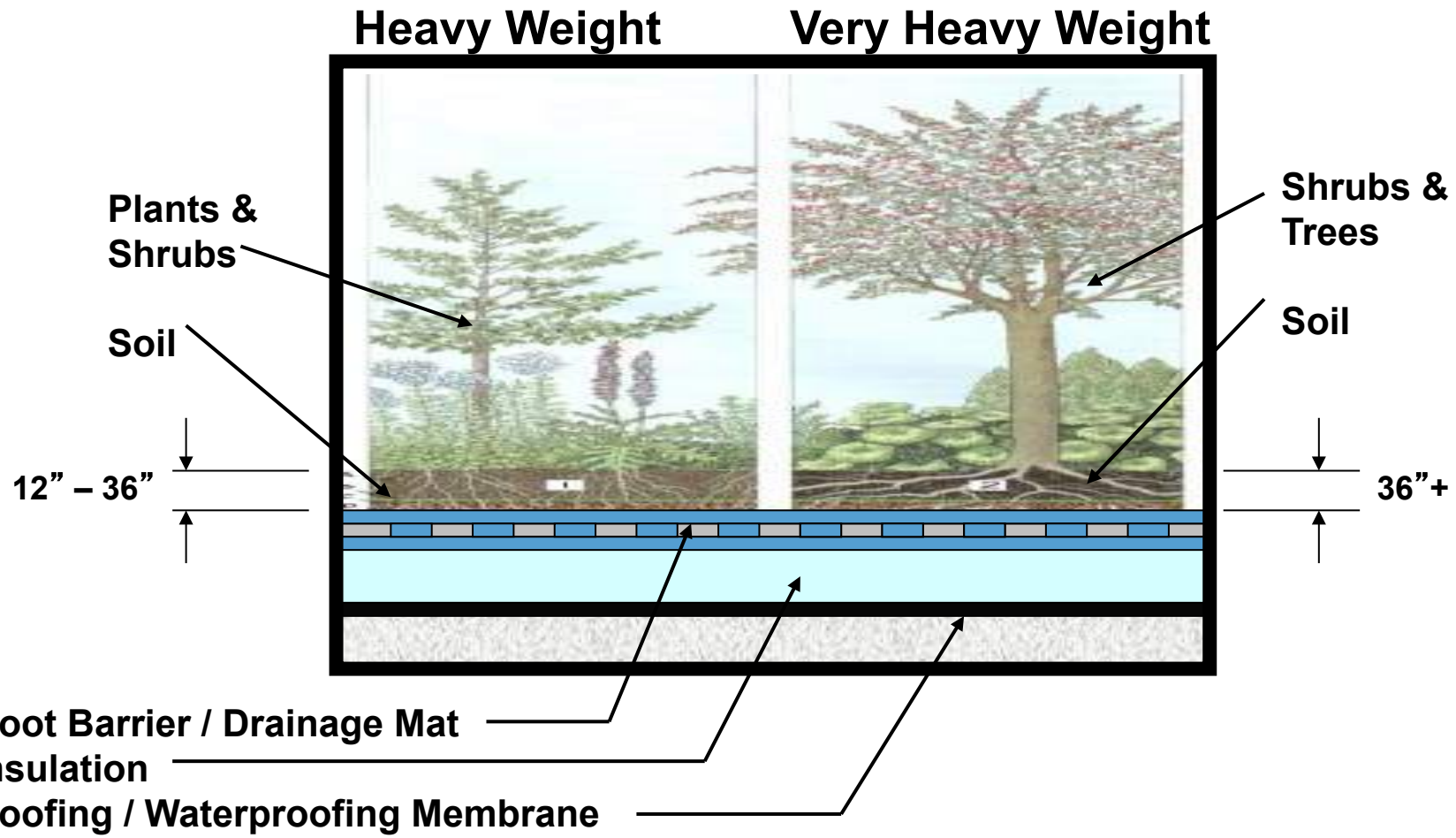


Source: Penn State University Cool Roofing Program

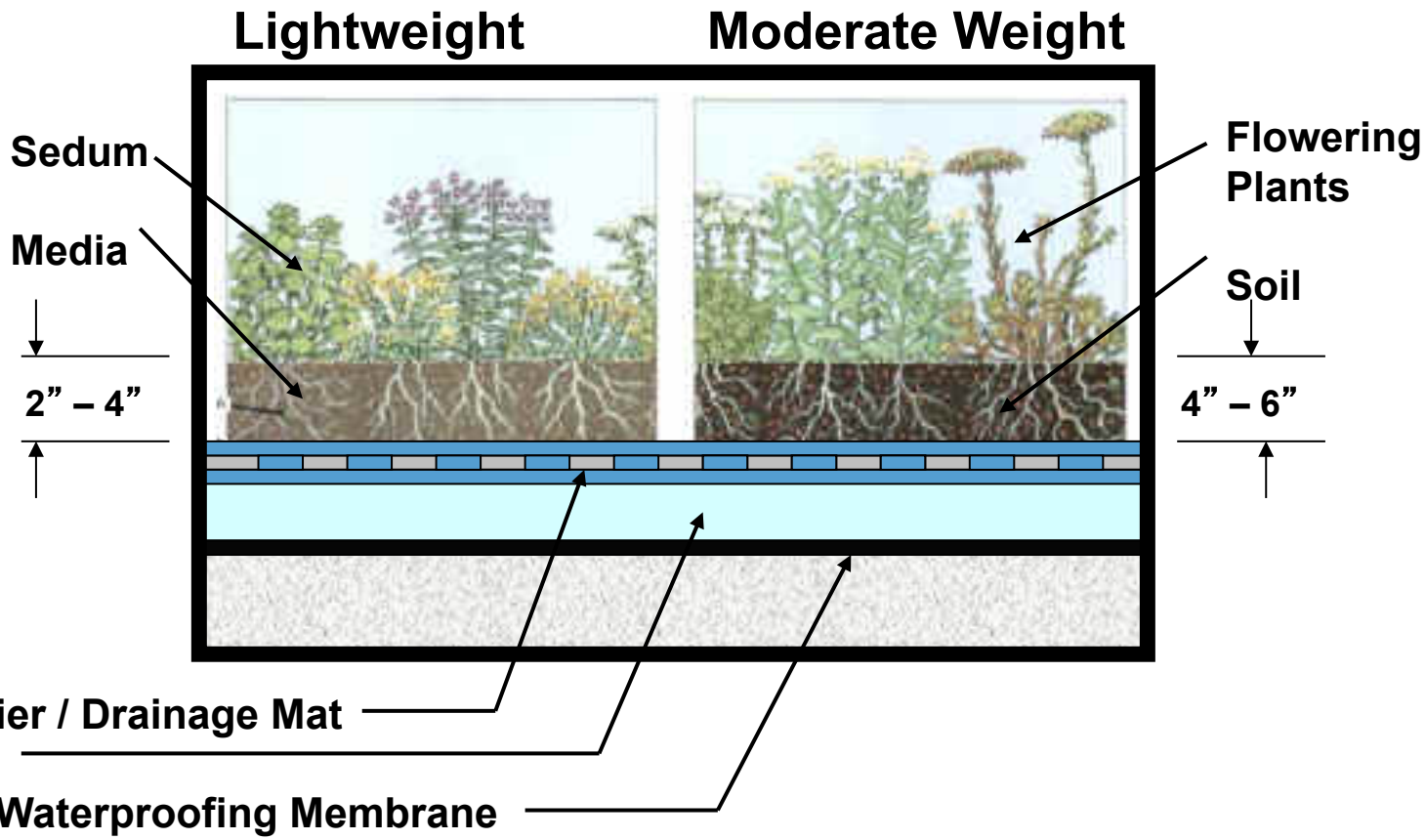
Vegetated Roofs
Improved Storm Water Runoff

Source: Penn State University Cool Roofing Program

Vegetated Roofs
Intensive Green Roofs



Vegetated Roofs
Extensive Green Roofs



Vegetated Roofs
Benefits & Limitations

Benefits:

- Ambient air temperature reduced
- Storm water runoff mitigated
- Wide variety of hardy plants available
- Require as little as 2 to 4 inches of planting medium
- Can be combined with “cool” ballasted roofs to minimize initial costs
- Tray systems available to reduce maintenance requirements

Current Limitations:

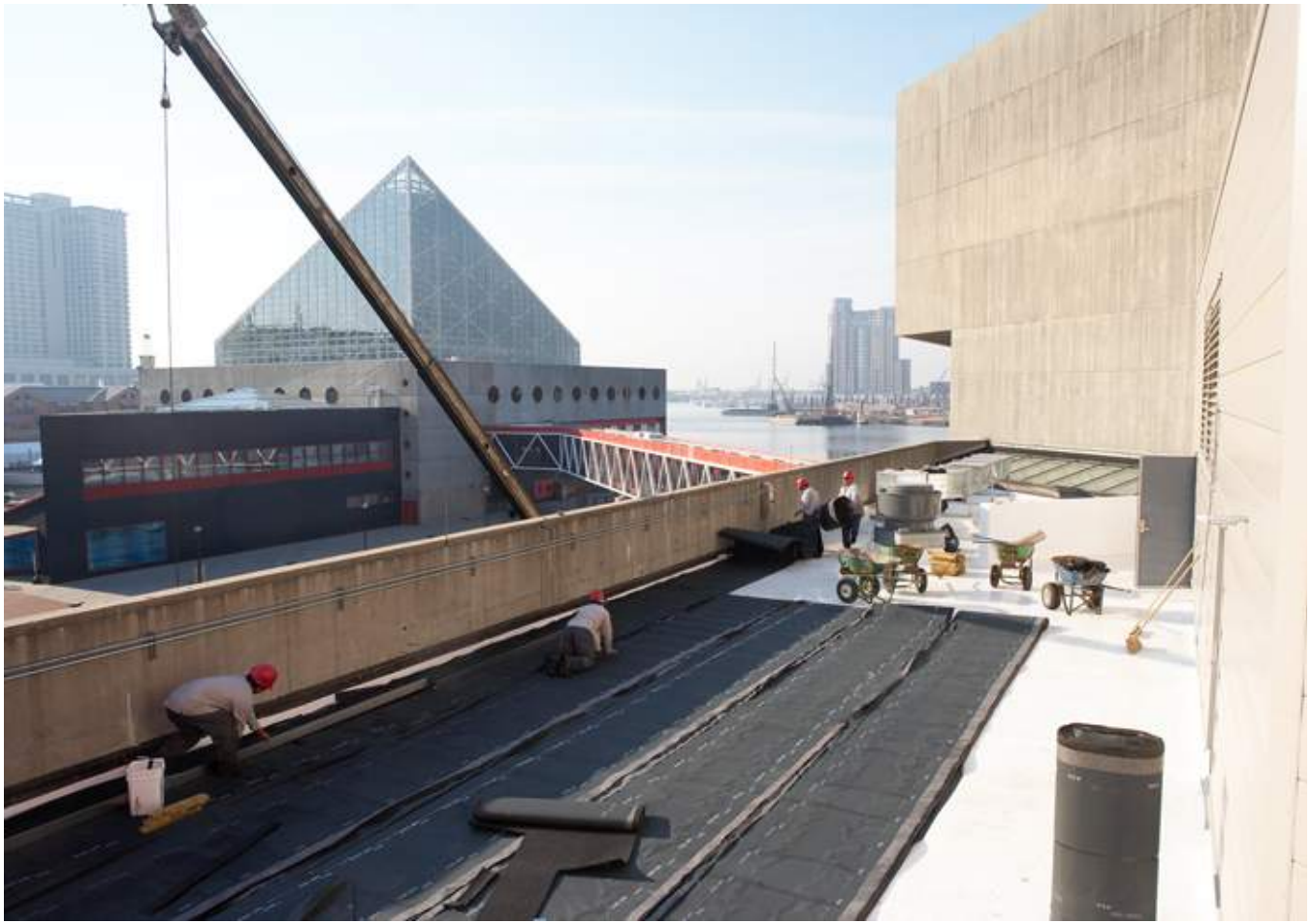
- Underlying roofing / waterproofing system must accommodate increased maintenance traffic
- Underlying roofing /waterproofing system may be required to resist root penetration
- Leak detection may be difficult
- Fire / wind resistance is uncertain
- Roofing / waterproofing repair and maintenance may be difficult
- Even hardy plants may require maintenance for aesthetic reasons

Tray Systems

Pre-vegetative or Post-vegetative

High Quality Roof Installation

Additional Layer of Protection



Soil or Growing Media

Planting

Plants

Add Water and Sunlight!

PV + Garden + Daylighting

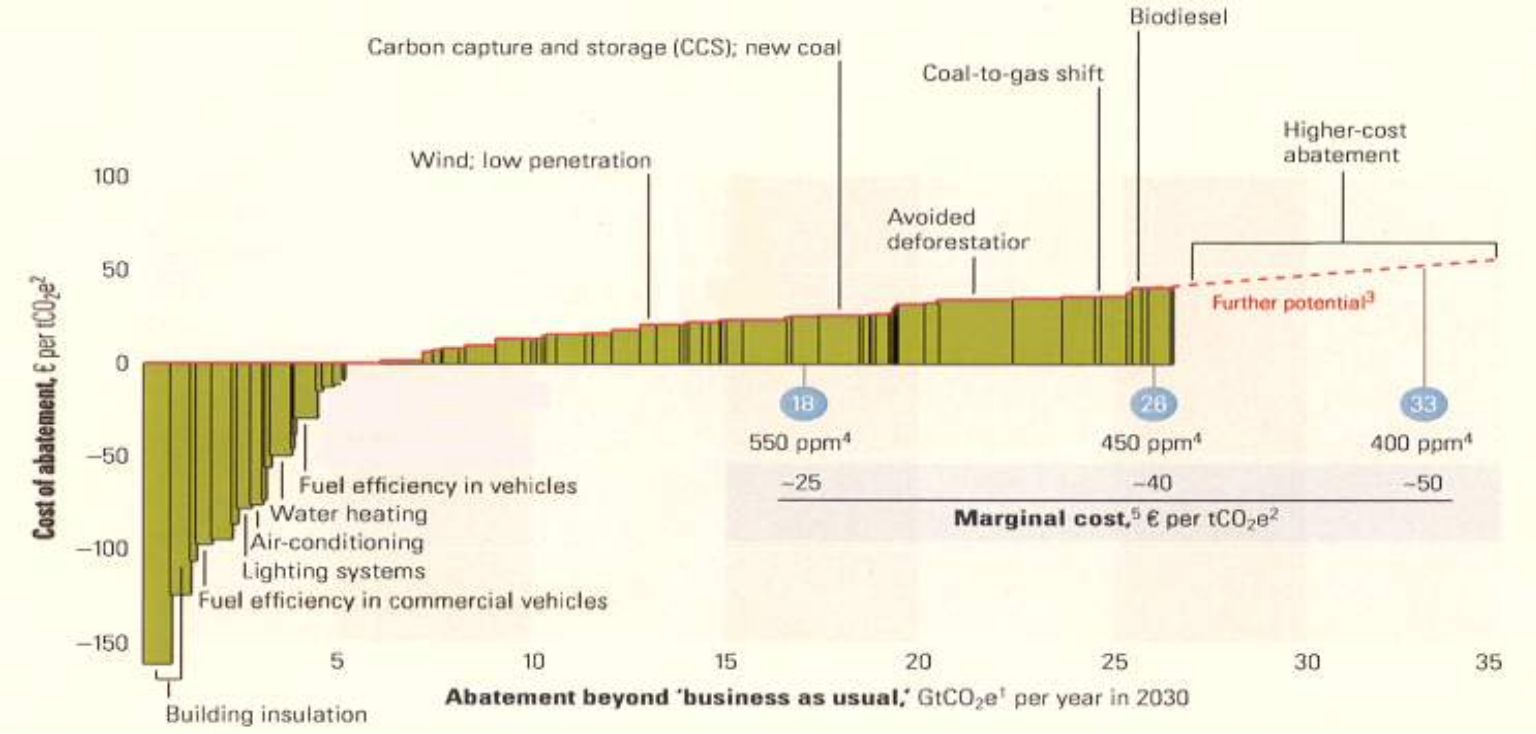
High Performance Roofs = Highly Insulated Roofs

Highly Insulated Roofs
Why Increase Roof Insulation?

Globally: Increased energy efficiency is the most cost effective way to significantly reduce green house gas emissions between now and 2030

Locally: Rising energy costs and local incentives make it a good economic payback almost everywhere

Global Cost Curve For Greenhouse Gas Abatement Measures



The McKinsey Quarterly 2007, No. 1

- **40% of our nation's energy is consumed by heating, cooling and operating buildings**
- **Buildings account for 80% or $238 billion of total US electricity costs**
- **Energy efficiency savings exceed costs**

Highly Insulated Roofs
Current Insulation Standards

- Old Performance Standard:

  ASHRAE 90.1-1999

  “Energy Standard for Buildings”

- New Performance Standard:

  ASHRAE 90.1-2007

  “Energy Standard for Buildings”

- Proposed High Performance Standard:

  ASHRAE 189.1-P

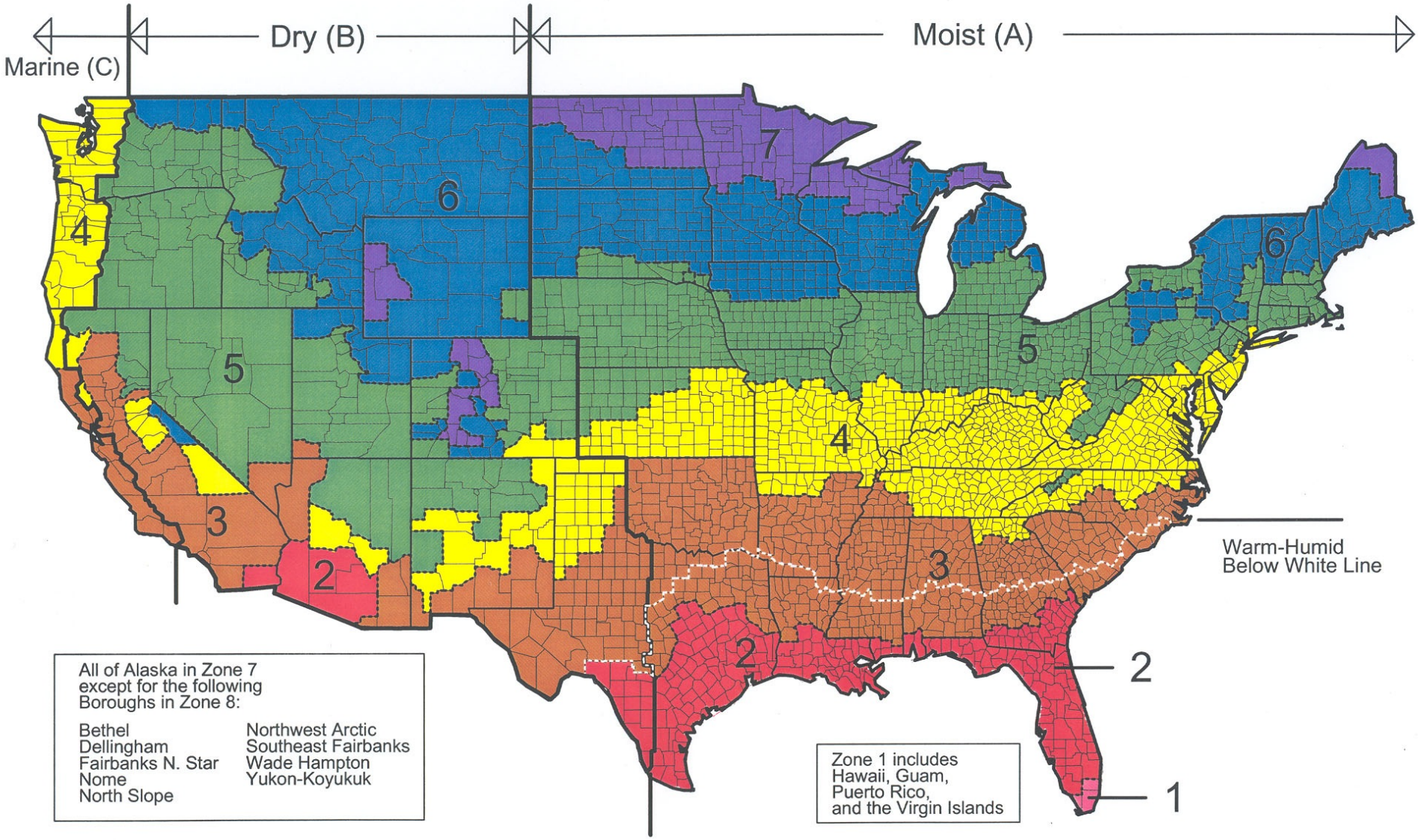
  “Standard for High Performance Green Buildings”

Highly Insulated Roofs
Current Insulation Standards

Minimum R-Values:
Low-Slope Commercial Roof Insulation

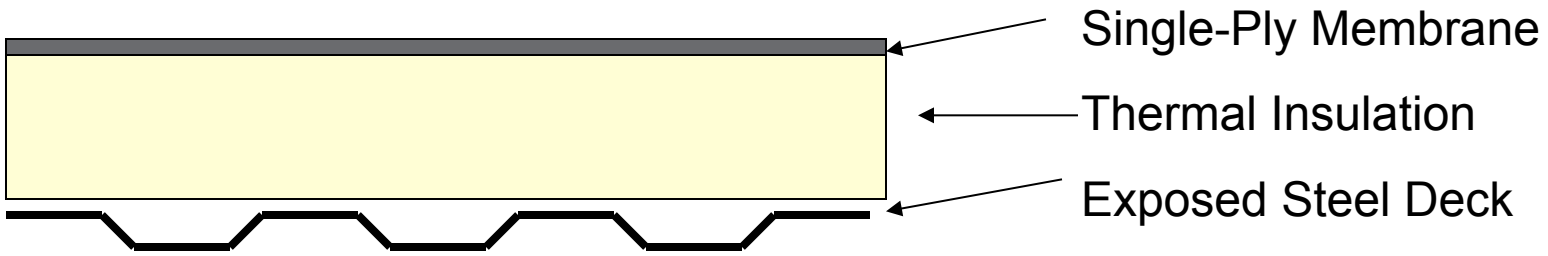
ASHRAE Climate Zone	Typical City Example	Old ASHRAE 90.1 -1999	New ASHRAE 90.1 - 2007	Proposed ASHRAE 189.1P
1	**Miami**	**10**	**15**	**20**
2	**Houston**	**15**	**20**	**25**
3	**Atlanta**	**15**	**20**	**25**
4	**Baltimore**	**15**	**20**	**25**
5	**Chicago**	**15**	**20**	**25**
6	**Milwaukee**	**20**	**25**	**30**
7	**Minneapolis**	**25**	**30**	**35**

ASHRAE Climate Zones



Highly Insulated Roofs
Comparing the Standards

Example:
100,000 Square Foot Warehouse
Chicago, IL
(Roof System Only – Gas Heat / Elec. Cooling)



Highly Insulated Roofs
Comparing the Standards

100,000 Sq Ft Warehouse
Chicago, IL

Scenario	Insulation R Value	Total Annual Heating / Cooling Cost	Annual Savings
Old Standard (ASHRAE 90.1- 1999)	15	$15,295	-
New Standard (ASHRAE 90.1 – 2007)	20	$13,172	$2,123
High Performance Std. (ASHRAE 189.P-1)	**25**	**$10,855**	**$4,440**

Source: NRCA EnergyWise Roof Calculator (Roof System Only, Gas Heating / Electric Cooling)

Cool Reflective Roofs
Why Reflective Roofs?

- Reduced cooling costs
- Reduced peak electric consumption
- Reduced Urban Heat Island Effect
- Minimal cost penalty compared to alternatives
- Field studies suggest long-term benefit with minimal maintenance*

* But at a reduction in actual reflectivity.

Cool Reflective Roofs
Reflectivity Standards

Reflectivity Standards: Low-Slope Commercial Roofing Products

Reference Standard	Minimum Initial Reflectance	Minimum Aged Reflectance	Minimum Initial Emittance (2)	Certification Method
Energy Star (EPA)	65%	50%	n/a	Self-Report
California Title 24 Product Standard	70%	n/a	0.75	CRRC (3)
California Title 24 Long-Term Value (1)	n/a	50%	n/a	CRRC (3)

(1) For energy calculation purposes
(2) Emittance refers to the ability of a material to emit absorbed heat back into the atmosphere
(3) Cool Roof Rating Council Product Rating Program

Cool Reflective Roofs
Long-Term Reflective Performance

Actual Reflectivity Values from Field Weathering Studies (1)

Product:	Initial Reflectance:	Aged Reflectance:	Years Aged:
Acrylic Coatings	75% - 90%	54% - 61%	5
Aluminum Coatings	55% - 75%	40% - 57%	5
Emulsions	15% - 55%	33% - 54%	5
TPO Membranes	83%	59% - 76%	4

(1) MRCA 5-Year Weathering Study for Coatings, WSRCA 4-Year Weathering Study for TPO

Cool Reflective Roofs
Benefits & Limitations

Benefits:

- Economical, especially for integrated reflective membranes
- Effective: demonstrated energy savings in warm climates, even after aging

Current Limitations:

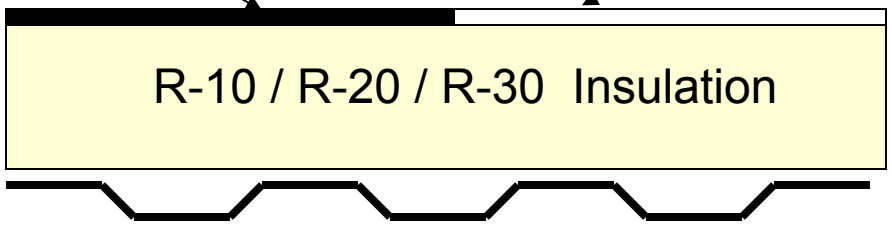
- Some current reflective membranes have a shorter performance history compared to other roof membranes
- Cleaning and maintenance may be expensive & difficult
- Reflective surface may cause glare into windows and increase interior heat loads
- Reflective surface may raise winter heating costs in colder climates

Cool Reflective Roofs
Geographic Comparison

Example:
100,000 Square Foot Warehouse
Heated & Air Conditioned

Black Roof
(5% Long-Term Reflectivity)

Reflective Roof
(55% Long-Term Reflectivity)



Phoenix, AZ

Los Angeles, CA

Portland, OR

Chicago, IL

Atlanta, GA

Cool Reflective Roofs
Geographic Comparison

Heating & Cooling Comparison
Reflective Roof versus Black Roof (1)

City:	Heating Degree Days:	Cooling Degree Days:	Solar Load: (BTU/ SF/ Day)	Annual Savings for Reflective Roof: R-10	R-20	R-30
Phoenix, AZ	1154	3815	1839	$10,100	$4,500	$3,500
Los Angeles, CA	1291	470	1579	$3,300	$1,500	$1,100
Atlanta, GA	3090	1611	1478	$3,800	$1,700	$1,300
Chicago, IL	6450	749	1243	-0-	-0-	-0-
Portland, OR	4461	279	1127	-($1,000)	-($500)	-($400)

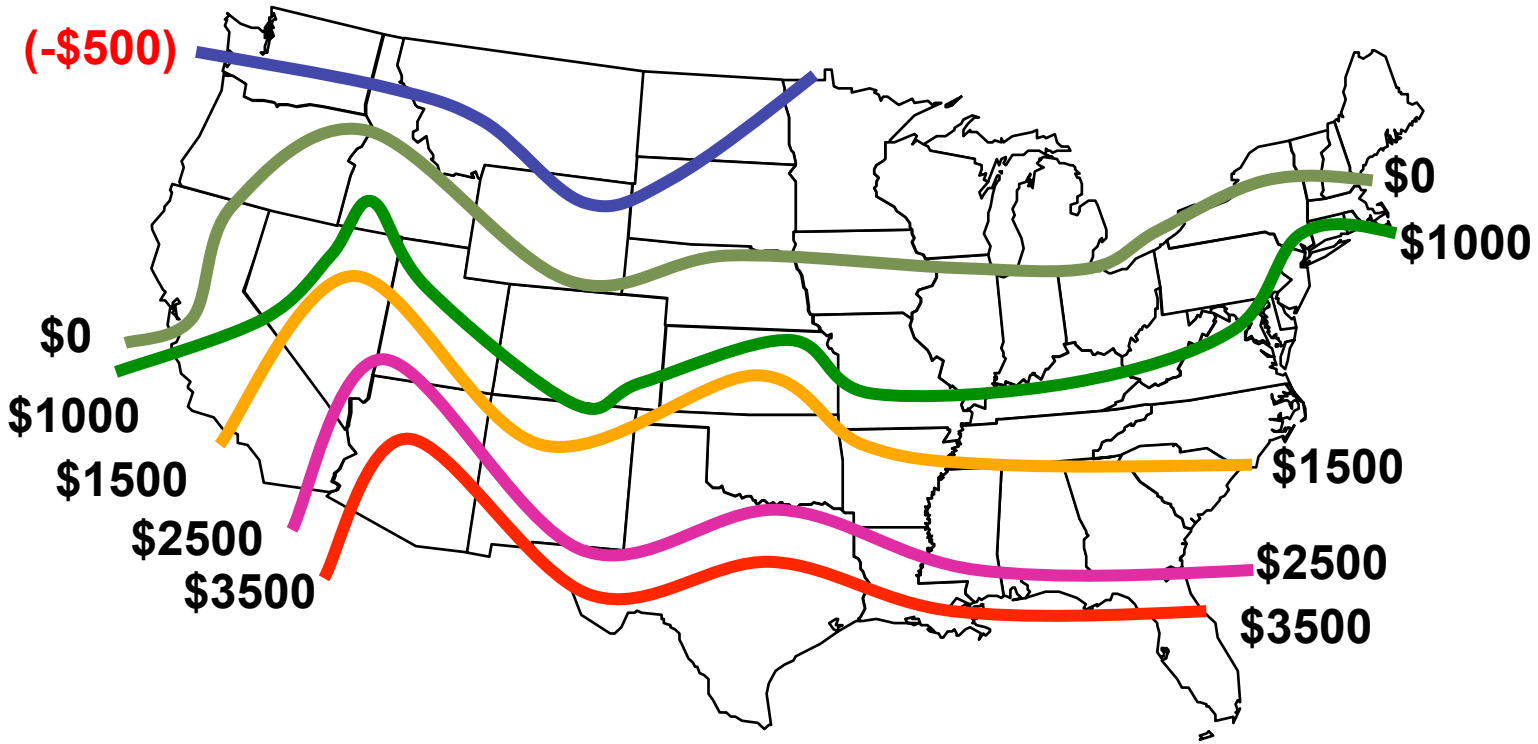
(1) Comparison of 55% Reflective "Cool" Roof versus 5% Reflectivity Black Roof using DOE "Cool Roof Calculator" (http://www.ornl.gov/sci/roofs+walls/facts/CoolCalcEnergy.htm). Calculations based on a heated and air-conditioned 100,000 square foot single-story warehouse. Energy costs derived from 2007 EIA commercial $/KWH electricity costs by state for cooling (Arizona: $0.0824, California: $0.1282, Georgia: $0.0763, Chicago: $0.0707, Oregon: $0653) and estimated 2008-09 winter natural gas costs for heating ($1.20 per Therm). See also "The Economics of Cool Roofing: A Local and Regional Approach." (J.L. Hoff, 2005).

Reflectivity and R-Value
Balancing Energy Efficiency

Annual Heating / Cooling Cost Savings

Reflective Roof versus Black Roof (1)

(Dollars per 100,000 Sq. Ft. Roof Area / R-20 Insulation / Min. 55% Roof Reflectivity)



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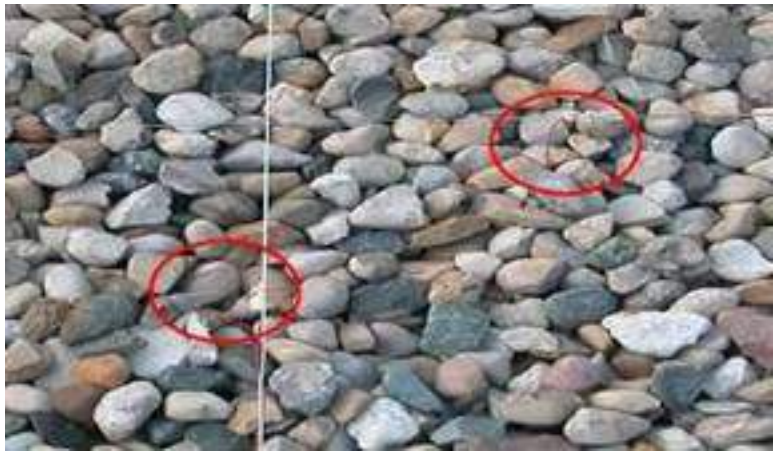
Cool Ballasted Roofs

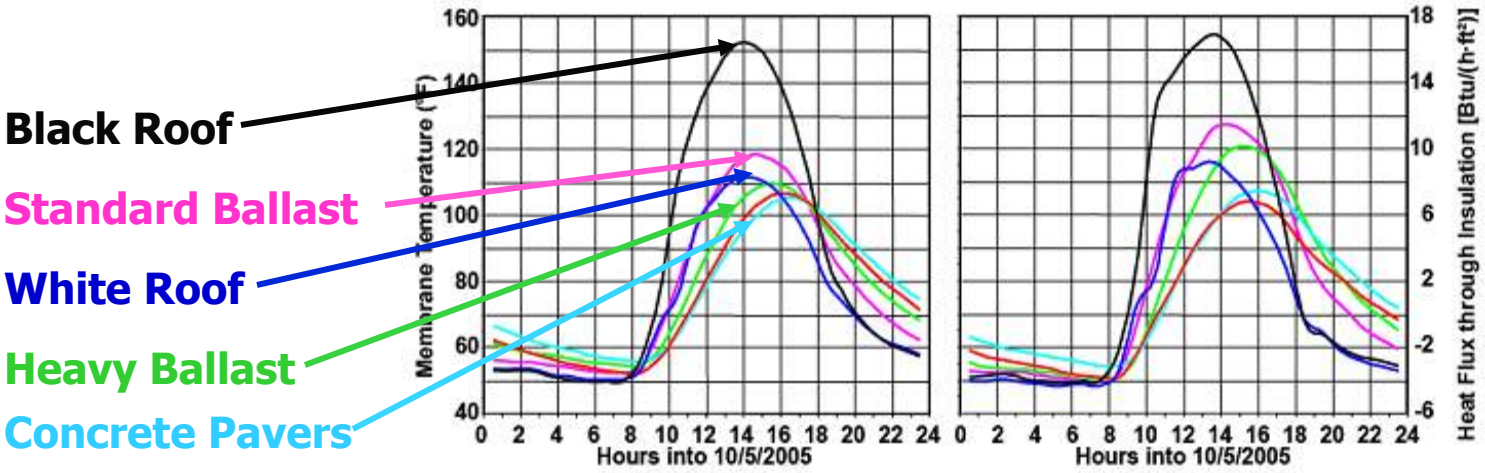
Cool Ballasted Roofs
Tested at Oak Ridge Labs



Envelope Systems
Research Apparatus
Oak Ridge National
Laboratories

Cool Ballasted Roofs
Cool Energy Savings

Ballasted roofs may provide the same peak energy savings and reduced air temperatures as "cool" roofs … and their performance doesn't degrade over time!



Comparative Surface Temperature & Heat Transfer

Source: Oak Ridge National Laboratories Envelope Systems Research Apparatus

Cool Ballasted Roofs
Growing Recognition

- Ballasted roofs with heavy ballast (25 lb/ft2) are now recognized as “Cool Roofs” in the 2008 version of California Title 24:
  - “Roof constructions that have thermal mass over the roof membrane with a weight of at least 25 lb/ft² are exempt from the minimum requirements for solar reflectance and thermal emittance” (1)

(1) Title 24, Part 6, of the California Code of Regulations: Energy Efficiency Standards for Residential and Nonresidential Buildings

Cool Ballasted Roofs
Benefits & Limitations

Benefits:

- Reduced cooling costs with minimal heating cost penalty
- Economical installed cost on buildings designed to accommodate ballast loads
- Established roofing system with a long performance history
- Minimal loss of savings over time due to aging

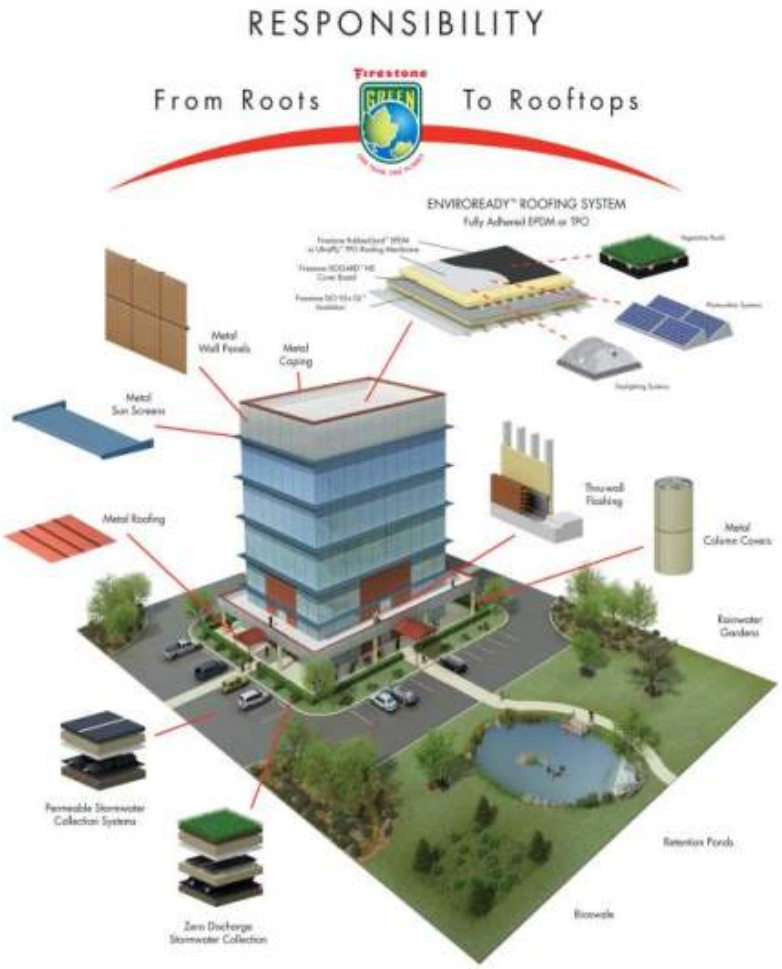
Current Limitations:

- Building must be designed to accommodate additional ballast weight
- May not be suitable for high-wind regions
- May not be suitable for roofs with high levels of roof traffic
- May be difficult to find leaks and make repairs

Responsibility – From Roots to Rooftops

Responsibility is at the heart of everything we do

- from raw material selection throughout the manufacturing process
- from availability and logistics to installation and warranties
- to our customers, including contractors, installers, applicators and distributors
- to our end users, whether they are building or home owners, engineers, specifiers, architects or landscape architects
- to our employees and independent sales reps
- to the communities we live and work in and perhaps most importantly, to the environment



Thank You!