Cool Roofing: An Emerging Hot Topic
The Metal Initiative

Coalition of companies and trade associations formed to educate building owners, facility managers, architects and contractors about the use and selection of metal roofs and walls in commercial buildings.
Cool Roofing

Presentation Content

- Overview
- Principles of Cool Roofing
- Case Study
- Research
- Urban Heat Island Effect
- Initiatives and Programs
- Standards, Codes and Laws
- Summary
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Buildings responsible for:

- Almost 2/3 of nation’s electricity consumption
- More than 1/3 of total primary energy use
- Conservation measures within these structures more important than ever.
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- Cool roofing gaining in popularity due to its ability to reduce cooling and heating usage.
- Utilities interested because can help reduce peak demand during summer, preventing power disruptions.
- Environmentally, cool roofing can help mitigate phenomenon known as “heat island effect.”
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- Heating and cooling generally major expenses in operation of a building.
- Any reduction through use of energy efficient building envelope components makes sense.
- Roof can be least energy efficient building envelope component.
- No wonder cool roofing has become such a hot topic!
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Principles of Cool Roofing
Two categories of roofs:

- **Low Slope**
  - Used on roof pitches from 1/4:12 to 2:12
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Two categories of roofs:

- **Low Slope**
  - Used on roof pitches from 1/4:12 to 2:12

- **Steep Slope**
  - Used on roof pitches of 2:12 or greater
Solar Energy Spectrum

- Ultraviolet energy totals only 3% of total energy striking earth’s surface.
- Visible light energy totals 40%.
- Infrared energy totals 57%.
- When infrared energy strikes earth’s surface, we feel it as heat.
Solar Energy Spectrum

- Ultraviolet (UV)
  - 3% of total energy
  - responsible for sunburn
- Visible (VIS)
  - 40% of total energy
  - visible light
- Infrared (IR)
  - 57% of total energy
  - felt as heat!
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Described by two main terms:

- Solar Reflectance
- Thermal Emittance
Solar Reflectance

- Percentage of solar radiation that is immediately reflected from a surface.
- Usually expressed as decimal (0.65), but may also be expressed as percentage (65%).
- Reflectance of painted metal depends on color and pigmentation.
Solar Reflectance

- Any energy not reflected is absorbed by the material, which causes it to heat.
  - Some of the heat removed by air flow (convection) over the surface.
  - Some of the heat conducted through the surface.
  - Some of the heat re-emitted to the night sky.
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Described by two main terms:

- Solar Reflectance
- Thermal Emittance
Thermal Emittance

- Percentage of heat that is re-radiated from the surface to its surroundings.
- Always expressed as a decimal (0.90).
- Materials with high thermal emittance cool down faster than those with low thermal emittance.
- Thermal emittance has nothing to do with solar reflectance.
Energy Balance on Roof Surface

- Total Solar Radiation
- Reflected Radiation
- Re-Emitted Energy
- Absorbed Energy
- Net Heat Flux Into Roof

Roof Surface Layer

Convection
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Combination of solar reflectance and thermal emittance determines surface temperature of a roof and its ability to act cool.
## Roofing Material Thermal Properties

<table>
<thead>
<tr>
<th>Material/Type</th>
<th>Solar Reflectance</th>
<th>Thermal Emittance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal (unpainted)</td>
<td>0.60-0.80</td>
<td>0.04-0.10</td>
</tr>
<tr>
<td>Metal (painted)</td>
<td>0.10-0.75 *</td>
<td>0.80 +</td>
</tr>
<tr>
<td>Comp Asphalt Shingles</td>
<td>0.05-0.25</td>
<td>0.90</td>
</tr>
<tr>
<td>Single Ply Membranes</td>
<td>0.70-0.80</td>
<td>0.85 +</td>
</tr>
<tr>
<td>Built Up Roofing</td>
<td>0.05-0.80</td>
<td>0.90</td>
</tr>
<tr>
<td>Modified Bitumen</td>
<td>0.05-0.25</td>
<td>0.90</td>
</tr>
<tr>
<td>Concrete/Clay Tile</td>
<td>0.20-0.70 *</td>
<td>0.90</td>
</tr>
</tbody>
</table>

* depending on color

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*Emissivity is generally high in coatings and paint films, but very low in unpainted metallic surfaces*

Source: ORNL and LBNL
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Rule of Thumb:

- For every 1% increment in roof reflectance, surface temperature decreases 1° F.

  **Example**: Improving reflectance from 10% to 50% lowers surface temperature 40° F

- For every 10% increase in roof reflectance, cooling/heating energy costs drop 2¢/sq ft (warm climates).
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Lower roof surface temperature also:

- Increases color stability of prepainted metal panels.
  - Results in enhanced aesthetics.
- Decreases thermal expansion/contraction.
  - Results in added durability and integrity.
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Impact of Color:

- Dark colors absorb more heat than light colors.
  - Roof can be 90°F hotter than ambient.
- Light colors reflect more heat.
  - Roof can be only 25°F warmer than ambient.
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Paints and Pigments:

- Principle suggests that color is indication of reflectivity.
- New pigment technology introduced that changes that assumption.
- New infrared reflective pigments allow darker colors to reflect more solar energy than ever.
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Paints and Pigments:

- Cool metal roofing now available with special paints that increase reflectivity.
- Pigments do not affect color of product.
- Traditional colors can be matched with identical colors of new higher reflectivity paint systems.
Baggett & Poole Elementary Schools
Paulding County, Georgia

- Electric HVAC with gas-fired heating
- Thermostats controlled at district office
- Each with 90,000-square-foot footprint
Case Study

Roof Construction

- R-15 vinyl-faced blanket insulation over purlins
- R-19 6” batt insulation at ceiling level

Baggett: Standard roof with 12% solar reflectance
Poole: Cool roof with 29% solar reflectance
## Case Study

<table>
<thead>
<tr>
<th></th>
<th>Baggett</th>
<th>Poole</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Electric</strong></td>
<td>$67,251</td>
<td>$58,477</td>
<td>$8,804</td>
</tr>
<tr>
<td><strong>Annual Gas</strong></td>
<td>$16,837</td>
<td>$17,586</td>
<td>-$750</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$84,088</td>
<td>$76,034</td>
<td>$8,054</td>
</tr>
</tbody>
</table>
Case Study

1st Year Savings
$8,054

Projected 35-year Savings
$282,000
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Research Studies

Oak Ridge National Laboratory
Oak Ridge

Research:

- Continuous weathering of metal roofs over 3 years.
- Installed in low slope and steep slope orientations.
- Results used to develop whole building energy savings calculator for low and steep slope roofing.
Research:

- Study also compared metal roofing to other types of roofing materials in terms of:
  - Durability
  - Degradation of solar reflectance
Prepainted metal roofing retained 95% of its initial solar reflectance overtime.

- Roof slope has little effect.
- Minor loss similar across all climates.

Important because some codes assume reflectivity of all roof materials degrades at same rate.
Findings:

- Some membrane products lost 40% of their solar reflectance after only 3 years due to dirt retention.
- Metal roofs shed dirt more readily than other materials.
- The dirtier the roof, the more its reflectance is compromised.
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Urban Heat Island Effect
Urban Heat Island Effect

- Phenomenon caused by use of energy-absorbing, dark-colored materials for roads, roofs and parking lots coupled with lack of vegetation and shade.
- Creates a microclimate where ambient temperatures are higher than surrounding areas.
- Hence the “heat island.”
Red areas are the hottest surfaces.

Washington, D.C.

Washington - Baltimore Region

Sacramento, CA.

Long Island Sound

New York City Region

New York

Atlanta

Downtown Atlanta

Airport
Urban Heat Island Effect

- Can increase ambient temperature 6° - 12°F.
- Higher air conditioning loads are required to cool buildings.
- Heat is also a catalyst for smog.
- Higher air temperatures hold more low-level ozone, a contributor to air pollution.
- 0.5° F decrease in heat = 5% reduction in smog.
Cool roofing can mitigate urban heat island effect.

- Roofs with higher reflectance have lower surface temperatures.
  - Helps reduce ambient air temperatures.
  - Improves air quality since less smog is formed.
- Can earn LEED point under Sustainable Site Credit 7.2
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Initiatives and Programs
Initiatives

- California Title 24
- California Energy Commission
- Florida White Roof Credit
- Georgia Energy Code
- New York Tax Incentive
- Chicago Urban Island Code
- Energy Star Roof Products
- LEED
- Federal Energy Bill
Initiatives (continued)

- DOE Programs
- EPA Programs
- LBNL Urban Island Group
- ORNL Building Technology Center
- Millennium Star Product
- ASTM Committees
- ASHRAE Committees
- Cool Roofing Rating Council
- Smart School Program
New LEED-NC Version 2.2 awards a credit for a roof that:

- Meets minimum Solar Reflectance Index (SRI) values.
- Covers a minimum of 75% of the roof surface.

Sustainable Sites Heat Island Effect Credit 7.2
**Sustainable Sites Credit 7.2**

Requirements (SRI minimum)

<table>
<thead>
<tr>
<th>Roof Type</th>
<th>Slope</th>
<th>SRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low slope roof</td>
<td>&lt; or =2:12</td>
<td>78</td>
</tr>
<tr>
<td>Steep slope roof</td>
<td>&gt; 2:12</td>
<td>29</td>
</tr>
</tbody>
</table>
Using LEED calculation for SRI, prepainted metal roofs with:

- Reflectance of 66% or greater comply for low slope.
- Reflectance of 30% or greater comply for steep slope.
Cool metal roofing can contribute to LEED certification points in several other categories.
Recycled Content

Metal’s high recycled content - typically at least 25% - can raise overall building’s average recycled content in order to receive up to 2 LEED points.

Materials & Resources Credits 4.1 and 4.2
Local Supply

Metal panels supplied from location within 500 miles of jobsite can contribute toward points for regional manufacturer.

Regional Materials Credits 5.1 and 5.2
LEED

Energy Performance

- Up to 10 points available using energy performance evaluations.
- Cool roofing is part of energy simulation calculations.

Energy & Atmosphere Credit 1.0
Recyclability

The fact that the metal used in roof panels is 100% recyclable at the end of its useful life helps in the waste management section of LEED.
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Cool Roof Rating Council (CRRC)

- Non-profit organization established in 1998.
- Comprised of manufacturers, trade associations, consultants, government agencies, code bodies, energy suppliers and independent labs.
Cool Roof Rating Council

Mission

- Develop “fair, accurate and credible” methodology for evaluating and labeling all types of roofing products.
- Certification system launched in August 2002.
Cool Roof Rating Council ratings are determined for a fixed set of conditions, and may not be appropriate for determining seasonal energy performance. The actual effect of solar reflectance and thermal emittance on building construction may vary.

Manufacturer of product stipulates that these ratings were determined in accordance with the applicable Cool Roof Rating Council procedures.
Cool Roof Rating Council

- Over 570 roofing products listed in directory.
- Data referenced in LEED and Energy Star programs.
- Promoting in FL, GA, AZ, TX, UT, AL, NV, NC, OK, SC, TN, Chicago and ASHRAE.
- Sole entity responsible for labeling roofing products allowed under California Title 24.
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Standards, Codes and Laws
California leading the way with energy code as part of its overall building code.

Latest version of code, Title 24, became effective October 2005.

For first time, energy code contains language specific to cool roofing requirements.
Why is Title 24 significant?

Because other states are watching.
Current code applies only to non-residential conditioned buildings with a low slope roof.

Does not apply to:

- Non-residential buildings with steep slope roofs
- Hotel/motel guest rooms
- High-rise or low-rise residential buildings
How does it work?
All building permits must include an energy budget:

- Based on climate zones (16 different zones in CA)
- Based upon building components (windows, wall construction, roof, lighting system, HVAC, etc.)
- Each component gets “baseline” or “neutral” value.
- Baseline now includes cool roof value.

Must meet budget … or no permit.
Title 24

Three ways to comply:

- Prescriptive
- Envelope tradeoff
  - Tradeoff only with envelope components
- Whole building performance
  - Tradeoff with all building components
Prescriptive

Cool roof minimum values

- Reflectivity of 70% or greater
- 3-year aged reflectivity of 55%
- Emissivity of 0.75 or greater

To qualify as a cool roof, must be rated and labeled according to CRRC.

- If not CRRC listed, reflectivity default = 10%
Envelope Tradeoff

- Simple tradeoff equations
- Can tradeoff roof reflectance against other “envelope” requirements, such as windows, window overhangs, roof insulation, etc.
- Cannot make tradeoffs against lighting, water heating, HVAC systems, etc.
Whole Building Tradeoff

- Energy simulation for one year using approved program.
- Building complies if energy use is less than “standard design.”
- Tradeoffs can include lighting, water heating, HVAC, etc.
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- Provides tax incentives for commercial construction.
- Eligible commercial contractor can receive tax deduction equivalent to $1.80 for every square foot of the building, if building is designed to conserve energy.
- Use of energy efficient building envelope components is required.
- Cool roof can be used to lower energy use in building.
More information on these tax credits can be found on the Internal Revenue Service’s website:

www.irs.gov
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ASHRAE

- Specification 90.1 pertains to commercial buildings.
- Cool roof definition:
  - Reflectance: 70% initial.
  - Assume degradation to 55% in 3 years.
  - Emittance: 0.75
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Underwriters Laboratories (UL)

- New UL Classification Category: "Roof Covering Materials, Solar Reflectance"
- Solar reflectance measured: both initial and "maintained" (weathered)
- Thermal emittance measured.
- Included in 2005 Roofing Materials and Systems Directory
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Summary
Summary

- Cool roofing is growing in popularity.
- Solar reflectance and thermal emittance are the key material requirements.
- Testing by independent labs verifies cool properties and durability of metal roofing.
- Metal roofing’s reflectance is retained.
- Color, texture and finish can be engineered for desired reflectance/emittance properties of prepainted metal roofing.
Summary (continued)

- Multitude of cool roof programs exist:
  - Energy Star (Residential)
  - LEED
  - Federal, state, and local initiatives
  - Utility incentives

- Cool roofing has been written into codes/standards:
  - Title 24 (California)
  - ASHRAE
  - State and local energy codes
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In cooler climates, where heating dominates:

- A lower emittance may be desirable.
- Can be met with an unpainted metal roof.
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In **cooler** climates, where heating dominates:

- A lower emittance may be desirable.
- Can be met with an unpainted metal roof.

In **warmer** climates, where cooling dominates:

- A high reflectance and emittance is desirable.
- Can be met with a prepainted metal roof using lighter colors and/or reflective pigmentation.
Cool Roofing: An Emerging Hot Topic
The Metal Initiative

Website address:

www.themetalinitiative.com
Welcome to The Metal Initiative Website

The Metal Initiative is an industry-wide program designed to educate building owners, architects, and contractors about the use and selection of metal roofs and walls in commercial, industrial, and institutional buildings.

This site is your source for information on the benefits of using metal roofs and walls in commercial construction. Here you'll find everything from product information to a photo gallery to a series of case studies. And if you still have a question, you can ask one of our experts. Use this website as a resource and see where metal really shines.

Info@Hand

Need to be in the know? No worries - all the info you need is right in the palm of your hand. Use the quick links to access information frequently requested by builders and architects.

Metal Initiative News

Metal Roofs Score Best in Comparative Analysis of Roof Life Expectancy, Life Cycle Costs, Maintenance Outlays

New Website Touts Benefits of Metal Roofs and Walls

New Initiative to Put More Metal in Commercial Market