Cool Roofs and Cool Coatings; Energy Efficiency When the Heat is On

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Presentation Summary

- Is energy efficiency in buildings and roofs important? Some statistics......
- What is a Cool Roof?
- How do you make roofs cool?
- What happens when color matters?
- What is the future?
Buildings Use a Lot of Energy

1/3 of all energy and 2/3 of all electricity used in the US $220 billion in annual energy costs

Source: US Department of Energy, Gensler Associates
Energy Consumption in Buildings

Total Building Envelope Energy Loss:
13.4 quads
14% of energy in US economy and about 3.5% of the world
With **Comfort and Energy Efficiency** in mind, which car do you select to drive in the summer?
Why a Cool Roof?

- Reduces cooling loads
- Reduces peak energy demand
- Can reduce ambient temperature in an urban setting (urban heat island)
  - Improved air quality
  - Further energy savings
- Cool roofs being included into energy codes
Solar Energy Spectrum

Solar Energy Distribution
- 5% ultraviolet (300-400 nm)
- 43% visible (400-700 nm)
- 52% near-infrared (700-2500 nm)
Critical Properties

Reflectance ($\rho_{\text{solar}}$)  Emittance ($\varepsilon_{\text{IR}}$)
What is a Cool Roof?

- Roof surface that has a high solar reflectance and a high thermal emittance
- CA: 70% SR and 75% TE
- EPA EnergyStar Program: 65% SR (new) and 50% SR (after 3 years)
\( \rho_{\text{solar}} \) and \( \varepsilon_{\text{IR}} \) are Both Important

- Total Solar Irradiation: \( I_t \)
- Reflected: \( \rho_{\text{solar}} I_t \)
- Absorbed: \( \alpha_{\text{solar}} I_t \)
- Convection: \( h_{\text{air}}(t_{\text{air}}-t_s) \)
- Net Infrared Radiation: \( \varepsilon_{\text{IR}} \Delta R \) with \( \Delta R = \sigma(T_s^4 - T_{\text{sky}}^4) \)

Net Heat Flux into Roof
When did this Hubbub Start?

Published in 1989
# Long-Term Performance

## Actual Reflectivity Values

WSRCA Weathering Farm Locations  
(Average from 4 Areas)

<table>
<thead>
<tr>
<th>Location</th>
<th>Initial Reflectance:</th>
<th>Reflectance After 4 Years Exposure</th>
<th>Uncleaned:</th>
<th>After Cleaning:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchorage, AK</td>
<td>0.83</td>
<td></td>
<td>0.63</td>
<td>0.72</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>0.83</td>
<td></td>
<td>0.64</td>
<td>0.69</td>
</tr>
<tr>
<td>Las Vegas, NV</td>
<td>0.83</td>
<td></td>
<td>0.70</td>
<td>0.76</td>
</tr>
<tr>
<td>San Antonio, TX</td>
<td>0.83</td>
<td></td>
<td>0.59</td>
<td>0.71</td>
</tr>
</tbody>
</table>
Validating Benefit of Cool Roofs

Effect of ±R, ±E: ±3°F at Peak
# The Calculator

[Image of a calculator interface]

## Dr. Tom Petrie

### My Energy Costs and Equipment Efficiencies:
- **Summertime cost of electricity** (HIGH=0.20; AVG=0.10; LOW=0.05) [$/KWh]
- **Air conditioner efficiency (COP) over cooling season** (HIGH=2.5; AVG=2.0; LOW=1.5)
- **Energy source for heating** (choose one)
  - Electricity
  - Fuel
- **Heating system efficiency** (Furnace or boiler: HIGH=0.8; AVG=0.7; LOW=0.5)
  - (Electric heat pump: HIGH=2.0; AVG=1.5; Electric resistance: 1.0)
- **My Electricity Demand Charges and Duration**:
  - Demand charge during cooling season (HIGH=15.00; AVG=10.00; LOW=5.00) [$/KW]
  - Months charged for peak demand (Typical = 6) [ ]
Energy Calculator Available

www.ornl.gov/sci/roofs+walls/facts/
SolarRadiationControl.htm
Surfacing

Protects against UV, Heat, and traffic
White single ply sheet
What About Snow?

Instant “Cool Roof”
Camouflage Invisible to Night Vision

Conventional Film

Near Infrared Film
Solar Energy Spectrum

- 5% ultraviolet (300-400 nm)
- 43% visible (400-700 nm)
- 52% near-infrared (700-2500 nm)
Conventional vs. Infrared Pigments

The graph compares the reflectance of conventional and infrared-reflecting pigments across different wavelengths. The conventional pigment shows lower reflectance in the visible spectrum and higher reflectance in the infrared spectrum, whereas the infrared-reflecting pigment shows the opposite trend, with higher reflectance in the visible spectrum and lower reflectance in the infrared spectrum.
Higher Reflectance without Sacrificing Color Choice

Regal White
- Standard SR .67
- Cool SR .72

Rawhide
- Standard SR .47
- Cool SR .56

Slate Blue
- Standard SR .21
- Cool SR .33

Brick Red
- Standard SR .25
- Cool SR .30

Charcoal Gray
- Standard SR .14
- Cool SR .28

Hartford Green
- Standard SR .11
- Cool SR .28

Slate Bronze
- Standard SR .08
- Cool SR .26
The Proof: A Case Study

Baggett vs. Poole Elementary Schools
Paulding County Georgia

Baggett – Standard Roof
Evergreen 12% SR

Poole – Cool Roof
Evergreen 29% SR

90,000 S.F. footprint

90,000 S.F. footprint
Energy Bills are Different!

<table>
<thead>
<tr>
<th></th>
<th>Baggett</th>
<th>Poole</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Greystone Power (2004)</strong></td>
<td>SR (12%)</td>
<td>SR (29%)</td>
<td>Savings ($)</td>
</tr>
<tr>
<td>Annual Electric</td>
<td>$67,251</td>
<td>$58,447</td>
<td>$8,804</td>
</tr>
<tr>
<td>Annual Gas</td>
<td>$16,837</td>
<td>$17,587</td>
<td>-$750</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>$84,088</td>
<td>$76,034</td>
<td>$8,054</td>
</tr>
</tbody>
</table>

**Benefit**

**Penalty**
Next Step: “Smart” Reflective Exterior Surface

[Diagram showing a switch that changes between cold and hot outside temperatures]
“Smart” Reflective Exterior Surface Test Panel

Switch at 84°F

Switch at 65°F
Potential Savings Using “Smart” Technology
The DOE Map For Energy Efficiency
Summary

- Energy savings due to white cool roofs are durable and well documented
- Options are available that yield equal savings and peak demand
  - Cool colors
- New technologies are under development
- Impact of cool roofs growing
Thank You!

Questions?