COOL ROOF MARKETS AND PRACTICAL EXPERIENCES

HEINZ MEIER, SIKA SERVICES AG
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QUALICHeCK WORKSHOP, ATHENS
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COOL ROOF DEFINITION
“COOL” ROOFS

- In the Southern parts of the world white roofs and even entire buildings have been in use for centuries
- Limited possibilities for active cooling in summer - and winters are mild
- In a typical super market store the roof is > ¾ of the building envelope
- Energy accounts for a major part of the operational costs
DEFINITION (ONE OF MANY...) 

- Cool roofing can help address the problem of heat islands, which results in part from the combined heat of numerous individual hot roofs in a city or suburb.
  - Cool roofing products are made of highly reflective and emissive materials that can remain substantially (e.g. 30°C) cooler than traditional materials during peak summer weather.
  - Building owners and roofing contractors have used these types of cool roofing products for more than 20 years to reduce the energy consumption for A/C devices.

- Difficulty is that Roofing materials are exposed to weather and pollution. Their initial values in the virgin state will vary over time, depending on location, climate and surrounding.
  - To assume the initial Solar Reflectance values will remain is wrong!

- What are the accepted and industry’s state of the art procedures?
  - CRRC (Cool Roof Rating Council) exposition @ 3 US locations for 3 years
SOLAR REFLECTANCE INDEX (SRI): CRRC MEASUREMENTS

- SOLAR REFLECTION (also called «Albedo»)
  - White membranes have a high solar reflection and a low absorption, whereas black membranes have a low reflection but a high absorption. This absorption can be observed and sensed by the temperature increase. The value for the solar reflection is between 0.00 and 1.00.

- EMISSION (Thermal Emittance)
  - The emittance is the ability of a surface to reflect its stored energy as radiation. A high emittance helps to keep the roofing surfaces cooler. The value for the emittance is between 0.00 and 1.00. It is material dependent and can be modified by the use of suitable fillers.

- SOLAR REFLECTANCE INDEX (SRI)
  - The Solar Reflectance Index (SRI) is a calculated value for the ability of a roof build-up (or just a membrane) to reflect the solar energy. It is defined that a “standard black” has a value of 0 and a “standard” white has a value of 100.
**“DEFINITIONS” OF COOL ROOFING PRODUCTS (US FOCUS)**

<table>
<thead>
<tr>
<th></th>
<th>Solar Reflectance</th>
<th>Thermal Emittance</th>
<th>Solar Reflectance Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENERGY STAR®</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low slope&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aged&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>0.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Green Globes™</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>0.65</td>
<td>0.90</td>
<td>78&lt;sup&gt;(3)&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>California Title 24</strong></td>
<td>Low slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aged&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>0.63</td>
<td>0.75</td>
<td>75&lt;sup&gt;(4)&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>USGBC LEED, v2009</strong></td>
<td>Low slope, initial</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78&lt;sup&gt;(3)&lt;/sup&gt; (min 75% of roof)</td>
</tr>
<tr>
<td><strong>USGBC LEED, v4</strong></td>
<td>Low slope&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td></td>
<td></td>
<td>&gt; 82</td>
</tr>
<tr>
<td>Aged&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td>&gt; 64</td>
</tr>
<tr>
<td><strong>ASHRAE Standard 189.1</strong></td>
<td>Low slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>78 (min. 75% of roof)</td>
</tr>
</tbody>
</table>

1. A roof surface having a maximum slope of 2 inches rise for 12 inches run.
2. Three years’ exposure.
3. Roughly equivalent to, for example, 0.65 reflectance and 0.90 thermal emittance, although a number of different combinations of reflectance and emittance can achieve this value.
4. May not apply in every climate zone.
HEAT-ISLAND TEMPERATURE PROFILE

Sketch of an Urban Heat-Island Profile

Late Afternoon Temperatures (°F)

92°

85°

Rural Suburban Residential Commercial Downtown Urban Residential Park Suburban Residential Rural Farmland
It is often questioned if the lower roof surface temperature can contribute to
- the overall temperature reduction in a wider surrounding
- the reduction of the heat island effect
  (since the lower temperatures are limited to roof-close areas only)
PROOF OF COOL ROOF EFFECT BY NASA MEASUREMENTS

- Thermal images taken from space verify that the above roof above is not a source of excessive urban heat (“hot spots” in orange colour)
COOL ROOF MATERIALS AND APPLICATION
MEMBRANE TYPES

- **Single-ply Membranes**
  - Produced in a factory by either calendering or extrusion coating
  - Supplied on rolls of 15 to 40 meters length and 1-3 m width
  - PVC or TPO based with built-in reinforcement layer
  - Mechanically or adhered fastened
  - Welded seams

- **Liquid Applied Membrane (LAM)**
  - Monolithic, fully bonded, cold applied PU coating which is applied either by roller or spray, and cures to form a seamless and durable Waterproofing Membrane.
  - 1 C Liquid Applied Membranes
  - 2 C Liquid Applied Membranes

- **Main Usage / Advantages**
  - Seamless membrane
  - Ideal for Refurbishment
  - Application with roller (1 C) or airless spray equipment
  - Easy to adjust to complex details, no pre-formed parts required
SINGLE-PLY MEMBRANES

Mechanically fastened roofs

Adhered or self-adhered roofs

Semi-automated fastening and welding

All roof layers bonded on site
LIQUID APPLIED MEMBRANES

1 C Liquid Applied Membranes

- Application of base coat by roller
- Embedding of Reemat reinforcement

2 C Liquid Applied Membranes

- Application of highly elastic, crack bridging 2 C PUR / Polyurea hybrid base coat
- Application of top coat, usually by airless spray
- Application of 1 C top coat
ACRYLIC COATING (WATERBORNE)

- Elastic coating (without reinforcement)
- Elastic, crack-bridging coating (with short fiber reinforcement)
# TYPICAL SRI VALUES OF COOL ROOF RELEVANT PRODUCTS

<table>
<thead>
<tr>
<th>Single-Ply Membranes</th>
<th>SRI (initial)</th>
<th>SRI (3-year) acc. to CRRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>White and «Energy Smart» membranes</td>
<td>ca. 100-110</td>
<td>ca. 80</td>
</tr>
<tr>
<td>Solar Reflective membranes</td>
<td>ca. 110</td>
<td>ca. 90-95</td>
</tr>
<tr>
<td>Tan membranes</td>
<td>ca. 75</td>
<td>ca. 65</td>
</tr>
<tr>
<td><em>E.g. grey EPDM</em></td>
<td><em>ca. 20</em></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LAM and Coatings</th>
<th>SRI (initial)</th>
<th>SRI (3-year) acc. to CRRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid applies PU Membranes</td>
<td>ca. 105</td>
<td>ca. 90</td>
</tr>
<tr>
<td>Acrylic Coatings</td>
<td>ca. 105</td>
<td>ca. 90</td>
</tr>
</tbody>
</table>

Source: [http://coolroofs.org/products/](http://coolroofs.org/products/)
SOLUTION? DEFINED LABORATORY SOILING

Before soiling: accelerated weathering to simulate outdoor weathering (UVA)

Defined application of soiling agent by spraying (distance, time, mass)

- Composition of soiling mixture: salts, Fe$_2$O$_3$, soot, dust, organics

Drying at below +80 °C with an infrared lamp to evaporate the water

After soiling: accelerated weathering to simulate outdoor weathering (UVA)

Measuring SR and TE to calculate SRI after less than 3 days
SRI before and after ageing / Lab soiling

- Initial SRI 2012 (CRRC) before 3-year ageing
- Initial SRI 2015 before Lab Soiling
- 3 Year SRI, 3 years CRRC aged
- SRI after Lab Soiling

Materials:
- PVC 1 white, lacquered
- PVC 1 "SR" white, not lacquered
- PVC 2 white, not lacquered
- TPO white, not lacquered
- TPO "SR" white, glossy...
SRI Reduction 3 years ageing vs. Lab soiling

- PVC1 white, lacquered
- PVC2 white, not lacquered
- TPO white, not lacquered
- TPO "SR" white, glossy...

SRI Reduction after 3 years CRRC aged
SRI Reduction after Lab Soiling
CLEANING OF MEMBRANES

- Even a highly reflective membrane will get dirty over time
- The degree of soiling will depend on:
  - Location / geography / climate
  - Surroundings (Urban, agricultural, industrial)
  - Amount and type of discharge from the building
  - Roof slope

- Regular maintenance is important to keep reflectance at reasonable level
  - Sponge, mop, or brush cleaning is the least aggressive method of cleaning. This works well on new material and is typically used in smaller areas. Apply water and a non-abrasive cleaner to the area and sponge, mop, or brush off.
  - Wire brushes should never be used as they scratch the material and may cause punctures in the membrane.
COOL ROOFING AND ENERGY SAVINGS

- 2000 U.S. DOE, EPA study
  - Large Retail Store in Austin, Texas, 100000 sq. ft. roof
  - Measured Energy Savings and demand deduction before and after replacement of the black EPDM roof with a white PVC roof

Estimated Annual Savings 7.5¢/ ft²

Bar charts showing:
- Average Summertime Maximum Roof Surface Temperature:
  - Black Roof: 168°F (76°C)
  - White Roof: 126°F (52°C)

- Daily Air Conditioning Savings: 11%
  - Black: 3400 kWh
  - White: 2900 kWh
«GREEN BUILDING» PROGRAMS AND LABELS
Green building market will grow twice as fast as ordinary construction market

Establishment of GBCs has proliferated certification programs such as LEED, BREEAM, DGNB, Green Mark and Green Star

Source: ICIS, Factiva, OneSource, WorldGBC, OSHA, US EPA, ILO, NHMRC Australia, Primary Interviews, Transparency Market Research

Note: WorldGBC = World Green Building Council, OSHA = Occupational Safety and Health Administration and NHMRC = National Health and Medical Research Council
«GREEN BUILDING» PROGRAMS

- Roofing related activities
  - Reducing the heat island effect with highly reflecting membranes
  - Controlling storm water runoff with green roofs
  - Using high performance thermal insulation
  - Recycling of membranes
LEED V4

- Main Criteria Group: Sustainable Sites (SS)
- Topic: Heat island reduction (SSc5), 2 points
- Intent: Minimize effects on microclimates and human and wildlife habitats by reducing heat islands.

- Installing vegetated roof and/or using roofing materials with SRI equal to or greater than:

<table>
<thead>
<tr>
<th>Slope</th>
<th>Initial SRI</th>
<th>3-year aged SRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-sloped roof</td>
<td>≤ 2:12</td>
<td>82</td>
</tr>
<tr>
<td>Steep-sloped roof</td>
<td>&gt; 2:12</td>
<td>39</td>
</tr>
</tbody>
</table>
LEED ATTESTATIONS V4 AND V2009

- e.g. SRI for single-ply membranes

- e.g. VOC content for acrylic coatings

Sika Services AG
CoolRoof Markets and Practical Experiences / QUALICHeCK Athens
COUNTRY SPECIFIC LEED DOCUMENTS

- e.g. Spain, together with the Spanish Green Building Council
THE INTERNATIONAL EPD® SYSTEM

- An EPD® (Environmental Product Declaration) is a verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of a product.

- The International EPD® System is a global program for environmental declarations based on ISO 14025 and EN 15804. Our database currently contains more than 500 EPDs registered by 150 companies in 27 countries.

- An EPD® (Environmental Product Declaration) is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products.

Having an EPD® for a product does not imply that the declared product is environmentally superior to alternatives - it is simply a transparent declaration of the life-cycle environmental impact.
ENVIRONMENTAL PRODUCT DECLARATIONS (EPD)

- EPD according to EN 15804 for Sika FPO and PVC Roofing membranes
  - Environmental performance (LCA) of products (cradle to gate, end of life)
  - Accepted across Europe, relevant for Green Building projects (LEED, BREEAM, DGNB ....)
  - Additional documents to support Sustainability argumentation being provided to customers together with LCA reports
COUNTRY SPECIFIC EPD DOCUMENTS (USA)

GENERAL INFORMATION

COMPANY
Sika Corporation – Roofing

PRODUCT TYPE
Single Ply Roofing Membrane

PRODUCT
Sikaplan Adhered roofing membrane, with a finished thickness of 40 mils.

MANUFACTURING SITE
Carlisle, MA 02260

EPD SCORE
Cradle to gate

EPD LIMITATIONS
EPDs from different programs (using different PCR) may not be comparable.

DECLARED UNIT
IM2 manufactured, Sikaplan Adhered

STANDARDS
The declared Sikaplan Adhered roofing membrane thickness (40 mils) meets the following standards and requirements:
- ASTM D463
- FM, UL, NRC, CCMC, and DLC
- FM Approval
- Underwriters Laboratories Inc
- Underwriters Laboratories of Canada

ORGANIZATION
Sika Corporation, based in Liverpool, NJ, is a leading manufacturer of products and systems for the construction and mortar admixtures markets.

Sika Corporation’s roofing division has more than 50 years of experience manufacturing high quality, thermoplastic (TPV), single-ply roofing and waterproofing systems for the non-residential market.

PRODUCT DESCRIPTION AND USE
With a true record of performance, Sikaplan roofing membranes are the products of choice for architects, specifiers and building owners who want the peace of mind that comes with buying from the performance leader.

Sikaplan Adhered roof membrane is a thermoplastic (TPV) membrane used in adhered systems. Sikaplan Adhered is fiberglass reinforced, offering exceptional dimensional stability and a low coefficient of thermal expansion suitable for adhering the membrane to the roof substrate. A unique texture coating is applied to the top surface of the membrane which helps to reduce sliding.
COOL ROOF MARKETS?
BLACK-WHITE BELT

- The term «Black-White belt» is often mentioned in philosophic discussions
  - North of the belt only black roof coverage makes sense
  - South of the belt only white roof coverage makes sense

- There is no clearly defined latitude which is a border between «CoolRoof makes sense» and «CoolRoof is nonsense»

- Seasonally and day time different energy price makes much difference
  - Cooling in summer
  - Heating in winter
CONCLUSIONS
CONCLUSIONS

- White and highly reflective roof systems with initial SRI’s > 110 are standard - maintaining a high level is the key

- Cool roofs can be an important contributor to a reduction in the Urban Heat Island Effect and its consequences

- Cool roofs have demonstrated in service that they can provide
  - Cooling energy savings
  - Peak demand electricity reduction
  - Net energy savings
  - can be calculated based on LCA and thanks to Product Rating Programs such as CRRC and ECRC
LET’S GO FOR COOL, COOL ROOFS