REFLECTIVE ROOF COATINGS AND LEED

A discussion of reflective roof coatings in creating energy, material and resource efficient new construction and renovations as evaluated by the USGBC LEED Rating System

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ABSTRACT

This paper discusses the role of reflective roof coatings in the US Green Building Council's Leadership in Energy and Environmental Design (LEED™) Building rating system. The purpose is to provide stakeholders with an understanding of how reflective roof coatings contribute to cost effective, environmentally sound new building and renovation projects that use the LEED building rating system. Emphasis is on the structure of LEED and how reflective roof coatings (RRC) contribute to fulfilling LEED prerequisites and credit requirements. The paper focuses on white elastomeric coatings, but the findings apply to any RRC that are LEED compliant.

PURPOSE

The purpose of this paper is to:

1) Raise the awareness of the qualities and attributes of reflective roof coatings (RRC) in the green building movement and the LEED rating systems,
2) Encourage stakeholders to value RRC in the integrative design process when resolving price / cost / value design and construction budget issues, and
3) Enable LEED project teams to fully evaluate RRC when compiling LEED credit requirements.

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DISCLAIMER

INTRODUCTION

The emergence of the high performance green building movement and its attendant impact on how buildings are designed, constructed, operated and maintained has fostered industry wide discussions of how stakeholders can best achieve their goals in a cost effective and timely manner.

Primary goals include energy, material and resource efficiency, reduced operation and maintenance, upgrading and the adaptive reuse of existing buildings, and optimizing facilities for the health and productivity of the occupants, among many others.

In the last decade the evolution of various building rating systems developed to optimize building performance while providing superior indoor environmental quality has contributed to a move away from the traditional linear approach to project development and ownership to a more integrated process. Chief among these is the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED™) building rating systems. Because of the importance of building energy performance, occupant comfort and the need for cost effective, technically reliable maintenance regimes, the Reflective Roof Coatings Institute and all of its members have a vested interest in understanding their role in achieving LEED certified buildings, and how the U.S. Green Building Council can support the success of their membership.

AN OVERVIEW of LEED RATING SYSTEMS

The U.S. Green Building Council (USGBC) is a private 501(c)(3) membership based, non-profit organization headquartered in Washington, DC. It was founded in 1993 as a trade organization to promote sustainability in how buildings are designed, constructed, and operated. To achieve this it has developed a variety of programs and services, and works closely with key industry and research organizations and federal, state and local government agencies. Much of the USGBC's programs and member services are consensus based and heavily dependant on membership involvement and the participation of volunteers. The USGBC is best known for the development of the Leadership in Energy and Environmental Design (LEED™) green building rating systems and Greenbuild, a green building conference and expo that promotes the green building industry, including environmentally responsible materials, sustainable design and construction techniques and public policy. The USGBC was one of eight national councils, which helped found the World Green Building Council in 1999.

LEED began its development in 1994. From 1994 to 2006, LEED grew from one standard for new construction to a comprehensive system of six interrelated standards covering all aspects of the development and construction process. USGBC established benchmarks for the LEED Green Building Rating System in 2000 and subsequently launched *LEED 1.0.* The original LEED rating system categories are Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality and Innovation in Design. Office buildings provided the inspiration for the original version of *LEED 1.0.* LEED has evolved since its original inception in 1998 to more accurately represent and incorporate emerging green building technologies. *LEED for New Construction Version 1, NCv1.0,* was a pilot version. These projects helped inform the USGBC of the requirements for such a rating system, and this knowledge was incorporated into *LEED NCv2.0. LEED NCv2.2* was released in 2005, and v3 in 2009. In September 2011, the LEED rating systems were organized via the *LEED Rating System Guidance Version 4* to assist LEED users in selecting the proper LEED rating system for the project under consideration.

The evolution of LEED is based in large part on membership participation in public input and comment periods from which USGBC and GBCI staff distill sequential version of LEED. The RRCI and its member companies are welcome to participate in any way that advocates for their interests. Today, LEED consists of a suite of rating systems for the design, construction and operation of buildings, homes and neighborhoods. The five overarching categories correspond to the specialties available under the LEED Accredited Professional program.

The Rating System suite currently consists of:

Complete Construction

- LEED for New Construction and Major Renovations
- LEED for Schools
- LEED for Healthcare
- LEED for Retail: New Construction and Major Renovations
- LEED for Homes

Core and Shell Construction

- LEED for Core and Shell

Commercial Interior Construction

- LEED for Commercial Interiors
- LEED for Retail: Commercial Interiors

Existing Buildings: Limited Construction

- LEED for Existing Buildings Operation and Maintenance

LEED for Neighborhood Development is also available, but does not pertain specifically to individual buildings and is therefore not germane to the discussion of how reflective roof coatings are typically applied. However, *LEED for Neighborhood Development (LEED ND)* supports and rewards users of *LEED ND* for the inclusion of LEED certified buildings, as well as any effort to reduce heat islands.

After four years of development based on its experience administering *LEED v2.2*, the USGBC undertook aligning credits across all LEED rating systems and weighting credits based on environmental priority. This effort is manifest in the current *LEED v3*. It consists of a new continuous development process, a new version of LEED Online, a revised third-party certification program and a new suite of rating systems known as *LEED 2009*. In response to concerns that LEED requirements are cumbersome and difficult to learn, in 2009 USGBC supported the development by BuildingGreen, LLC of LEEDuser, a third-party resource that contains tips and guidance, written by professionals in the field, on applying LEED credits and the LEED certification process. The current LEED Version 3 rating systems are organized around the related building types listed above. This organization informs the LEED Reference Guides, which are written to facilitate LEED certification submissions for qualifying building types, as well as testing to become LEED Accredited Professionals (LEED AP) with specialty.

LEED 2009 (LEED Version 3)

In LEED 2009 there are 100 possible base points distributed across five major credit categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, plus an additional 6 points for Innovation in Design and an additional 4 points for Regional Priority. Buildings can qualify for four levels of certification based on the total number of points rewarded by the Green Building Certification Institute. They are:

The *LEED for Homes* rating system applies to residential architecture of limited scope and scale. The *LEED for Homes* rating system is different from *LEED v3*, with different point categories and thresholds that reward efficient residential design. However, if the home includes the application of reflective roof coatings, the benefits can be included in the documentation.

Categories

LEED points are distributed across the major credit categories of Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality. Reflective roof coatings contribute primarily to prerequisites and credits in the Sustainable Sites, Energy and Atmosphere, Materials and Resources and Interior Environmental Quality categories in a number of LEED building rating systems.

Prerequisites

Basic prerequisites for participating in LEED 2009 include compliance with all environmental laws and regulations, occupancy scenarios, building permanence and pre-rating completion, site boundaries and area-to-site ratios, and obligatory five-year sharing of whole building energy and water use data from the start of occupancy (for new construction) or date of certification (for existing buildings). RRC contribute to *Energy and Atmosphere Prerequisite 2: Minimum Energy Performance.*

Bonus credits

In addition to the 100 points constituted by the five main categories (Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality), an additional 6 bonus points can be obtained for credits in Innovation in Design and 4 bonus points are available for improvements in LEED-selected categories determined to impact Regional Priorities. LEED project teams are invited to present how reflective roof coatings can be used in innovative ways or creative building solutions. All Innovation in Design credit approaches or strategies must be able to be quantified, exhibited as part of the finished project, and documented in LEED Online format with all other LEED project submission information.

LEED for Homes

Additional performance categories in the LEED for Homes rating system are *Locations and Linkages*, which recognizes the importance of transportation access, open space, and physical activity outdoors, and *Awareness and Education*, which recognizes the need for buildings and developments to educate occupants. The role of RRC in these scenarios is valid with respect to educating all stakeholders to their value in energy conservation, urban heat island reduction and architecture as pedagogy.

Certification is generally voluntary, but required or under consideration as a requirement for certain buildings in many U.S. localities. Through its partnership with the Green Building Certification Institute (GBCI), the USGBC offers industry professionals the chance to develop expertise in the field of green building and to receive accreditation as LEED Green Associates or LEED Accredited Professionals (LEED AP) with specialty. It behooves all members of the RRCI to obtain some level of LEED professional recognition, either as a means to become more proficient in administering LEED submissions, as a way of being effective LEED submission team members and technical representatives, or simply well informed green building industry resources.

THE ROLE of REFLECTIVE ROOF COATINGS (RRC) IN THE LEED CERTIFICATION PROCESS

There are two basic types of reflective roof coatings: white elastomeric coatings and aluminum coatings. The selection of one of these two types of coatings is typically based on a myriad of project goals including microclimate, existing roof conditions, the material to be coated and the condition it is in, desired energy savings, code requirements and budget.

The focus of this paper is on ASTM D6083 acrylic roof coatings. Other chemistries include Polyurethane (ASTM D6947), Silicone (ASTM D6694), Fluoropolymer, and Styrene Ethylbutylene Styrene (SEBS). These materials have a valuable role to play and are recognized in the LEED rating systems for several reasons. Chief among them are their ability to reduce the urban heat island effect, their contribution to energy conservation with the attendant benefit of carbon emission reduction, and the ability to extend the life of roofing systems specifically, and existing buildings generally.

Reflective roof coatings have both a direct and indirect role to play in the LEED certification process. LEED team members must have an understanding of how RRC materials can contribute to achieving specific credits commonly associated directly with roofing and re-roofing activities, as well as the important role they have in optimizing energy performance, reducing the construction waste stream and contributing to effective day lighting strategies, among others.

In order to fully understand the role of RRCs in LEED and whether they contribute directly or indirectly to achieving *Prerequisites* or *Credits* we must first address the building type and LEED rating system being used. Further, it must be determined whether the project classifies as new or existing construction, or a mixture of the two. LEED uses a "40/60 rule" to provide guidance for making a decision when several rating systems appear to be appropriate for a project. This is important when considering which Credits can be directly attributed to using reflective roof coatings and which are indirect, as opportunities vary from rating system to rating system. To use this rule the LEED Team must 'assign' a rating system to each square foot of the building based on the guidance in this document. For example, *Existing Buildings: O&M* is used for an existing structure and an addition being built onto it. The proper rating system depends on the resulting percentages. The entire certifying square footage of the project must be used in this exercise. If the project is determined to qualify best under *LEED for Existing Buildings, Operation and Maintenance,* the credit opportunities associated with RRCs will differ from those under *LEED for New Construction and Major Renovations.* The entire gross floor area of a LEED project must be certified under a single rating system. It is subject to all prerequisites and attempted credits in that rating system, regardless of a mixed construction or space usage type. Generally, the 40/60 Rule is applied as follows:

a) If a rating system is appropriate for less than 40% of the gross floor area of a LEED project building or space, then that rating system should not be used.

b) If a rating system is appropriate for more than 60% of the gross floor area of a LEED project building or space, then that rating system should be used.

c) Project teams with buildings and spaces that do not fall into the scenarios described in a) and b) must independently assess their situation and decide which rating system is most applicable.

Stakeholders concerned with the influence of RRCs on a LEED project are encouraged to refer to the *Rating System Selection Guide Version 4* for a more complete discussion. Table One is included to provide an overview of how RRCs contribute to the various rating systems. The following is a more in depth review of the *Prerequisite* and *Credits* most commonly associated with Reflective Roof Coatings.

Sustainable Sites Credit 7.2: Urban Heat Island Reduction – Roof addresses the elevated summertime temperatures in cities in temperate climate zones, year round conditions in cities in semi-tropical and tropical zones, and the attendant increased energy demand for cooling. The intent of the credit is to minimize impacts on microclimates and human and wildlife habitat. Requirements to achieve this credit are based on using roof surfaces with sufficiently high Solar Reflective Index (SRI) ratings on at least 75% of the roof surface.

Research shows electricity demand for cooling increases 1.5–2.0% for every 1°F (0.6°C) increase in air temperatures, starting from 68 to 77°F (20 to 25°C). This suggests that 5–10% of community-wide demand for electricity is used to compensate for the heat island effect. Urban heat islands increase overall electricity demand, as

well as peak demand, which generally occur on hot summer afternoons in temperate microclimates, and much of the year in more tropical zones. During extreme heat events, which are exacerbated by urban heat islands, the resulting demand for cooling can overload energy supply systems. In the worst case this can cause a utility to institute controlled, rolling brownouts or blackouts to avoid power outages. Companies that supply electricity typically rely on fossil fuel power plants to meet this peak demand, which in turn leads to an increase in air pollution and greenhouse gas emissions. The primary pollutants from power plants include sulfur dioxide (SO2), nitrous oxide particulate (PM) carbon monoxide (CO) and mercury (Hg). These pollutants are harmful to human health and contribute to complex air quality problems such as the formation of ground level ozone, fine particulate matter and acid rain. Increased use of fossil-fuel-powered plants also increases emissions of greenhouse gases, such as carbon dioxide (CO2), which contribute to global climate change. LEED 2012, which at this writing is still in the public comment phase of development, is anticipated to put additional emphasis on carbon reduction, both from off site power generation and on site energy consumption of fossil fuels.

To achieve **SS Credit 7.2** LEED requires a minimum SRI of 78 on roof slopes equal to or less than 2:12 (16.6%), and an SRI of 29 on roof slopes greater than 2:12 to satisfy the requirements of this credit. All ASTM D6083 acrylic roof coatings meet these criteria, including all non-tinted and most tinted coatings. Again, the ratings must apply to a minimum of 75% of the roof surface. Other noncompliant materials may be used for the remaining 25%. Achieving this credit is largely a matter of documenting the physical area of the roof and the characteristics of the RRC surface material. There are no additional energy related calculation requirements for this *Credit.*

The role of RRCs in energy conscious architecture is well documented and contributes directly to achieving ***Energy and Atmosphere Prerequisite 2: Minimum Energy Performance*** and ***Energy and Atmosphere Credit 1: Optimize Energy Performance***. Light colored roof coatings are commonly used in hot, sunny climates, especially in internal load dominated buildings where cooling and dehumidifying are the primary space conditioning loads. Roofs experience significant solar heat gain as a function of their slope and resultant direct exposure to the sun. Typical built-up flat roof surface materials such as modified bitumen and tar and gravel, with albedos from 0.10 to 0.20, can absorb over 70 percent of the direct gain solar incident radiation that falls on them and can reach temperatures of 170°–200°F. This increases the cooling load in the building and shortens life of the roof.

Light-colored RRC roofs can reflect a significant percentage of the incident solar energy. The measure of reflectivity and absorptivity is *albedo*. The higher the albedo of a surface, the less energy it absorbs, and the cooler it remains. High-performance elastomeric white reflective coating systems contain substantial levels of UV-blocking pigments that reduce the influence of incident radiation on the roof surface. This provides a corresponding reduction in the need for cooling. A roof with a cool coating doesn't experience such large daily temperature fluctuations, so it helps reduce the tendency to trigger peak demand charges. Because the roof undergoes less thermal fatigue, reflective roof coatings are usually sold as maintenance products because they extend the life of the roof.

Photo courtesy of the Reflective Roof Coatings Institute

In 1998 the industry formed the Cool Roof Rating Council (CRRC) to provide information and develop a rating system by which the qualities and attributes of roof coatings could be compared. Energy Star labeling on roofing products serves as the industry metric for anticipated reflective roof coating performance. When a dark single-ply roof is coated with a white reflective coating, the albedo can rise from 0.2 to 0.65-0.85 and surface temperatures will remain below 135 degrees in sunny weather. With a lightly insulated roof in a cooling climate, heat reflective coatings can save over 40 percent of cooling energy used by the building and have a lifetime of 10–15 years. Roof lifetimes will be extended because of the reduced temperatures. Numerous studies confirm RRC can reduce surface temperatures by 50-80 degrees F and save significant amounts of cooling energy during summer months. The roof coatings that increase the albedo rating by 40 to 60 percentage points can enable significant reductions of 25-67% in cooling energy usage regardless of the amount of roof insulation present. Savings vary with the building type and the ratio of roof surface to occupied floor area.

The intent of ***Energy and Atmosphere Prerequisite 2: Minimum Energy Performance*** is to establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental and economic impacts associated with excessive energy use. The base standard is ANSI/ASHRAE/IESNA 90.1, 2007. While there are a number of options that allow for the use of prescriptive approaches, depending on the size and building type, *Option 1 – Whole Building Energy Simulation*, is most common for commercial construction. In LEED, Prerequisites are mandatory and

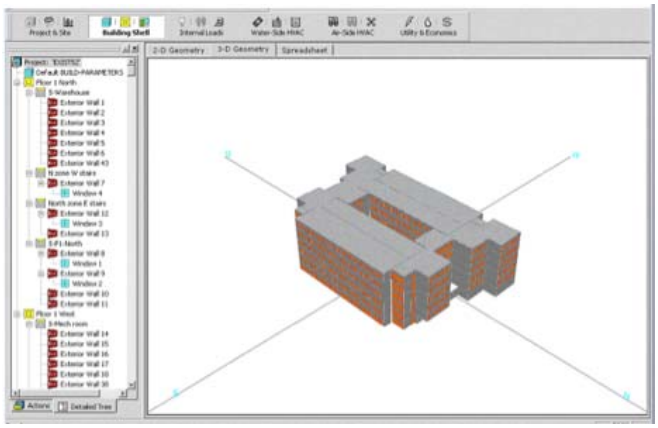
are not rewarded with points that contribute to the overall LEED score. **EA Prerequisite 2** requires the LEED project team to demonstrate a 10% improvement above ANSI/ASHRAE/IESNA 90.1 2007 in the proposed building performance rating for new buildings, or a 5% improvement in the proposed building performance rating for major renovations to existing buildings, compared to the baseline building performance rating. This is done by calculating the baseline building performance rating method in Appendix G of ANSI/ASHRAE/IESNA Standard 90.1 2007 using a computer simulation model for the whole building project. RRCs are involved directly in this exercise to the extent they contribute to reducing the calculated (modeled) baseline energy performance to, or below, the minimum 10% for new buildings and 5% for existing buildings and major renovations.

Photo courtesy of Reflective Roof Coatings Institute

LEED includes both a prerequisite and credit opportunity involving building commissioning. The first is **Energy and Atmosphere Prerequisite 1: Fundamental Commissioning of Building Energy Systems.** The intent of this credit is to verify that the projects energy related systems are installed, calibrated and perform to the owner's project requirements, basis of design and construction documents. Requirements for **EA PR 1** address building systems that use energy, as well as those that produce renewable energy on site. LEED teams are not required to address the use of RRC in **EA PR 1.**

However, the intent of **Energy and Atmosphere Credit 3: Enhanced Commissioning** is to begin the commissioning process early in the design process and execute additional activities after systems performance verification is completed. There is a trend in whole building commissioning to take a very comprehensive view of building envelope performance. This includes the use of thermal imaging, and testing for moisture migration and infiltration. LEED teams seeking **EA Credit 3** are encouraged to include roof assemblies in their enhanced commissioning scope. It is necessary for those responsible for the design, specification, installation and testing of roof assemblies to coordinate with the LEED project administrator to insure the proper documentation of materials used, the construction techniques and sequences, the testing procedures and the anticipated performance metrics and results are included in the commissioning documents and field work. RRC technical representatives, suppliers and contractors all have a role in completing **EA Credit 3** requirements, which, by credit definition, must be documented beginning in schematic design and no later than the completion of design development.

In ***Energy and Atmosphere Credit 1: Optimize Energy Performance,*** the contribution of RRCs is usually calculated using building envelope and building systems performance computer modeling. LEED uses ANSI/ASHRAE/IESNA 90.1 and its accompanying Appendix G to benchmark a base building against which applicable energy conservation strategies can be compared. DOE 2.e and several other industry software programs recognize the impact of reflective roof coatings on building thermal envelope performance. Inputs include the physical size and slope of the roof surface, its composite U value and the Solar Reflective Index (SRI). The SRI can be entered as one variable, or by its component parts of emissivity and reflectivity. Coupling this information with space conditioning system type(s), efficiencies and fuel costs can render information on life cycle costs for using RRCs in new and retrofit applications.



Typical energy modeling image

In renovations where the application of an RRC contributes to salvaging a roof that might otherwise be removed, it plays a role in helping the LEED team achieve ***Materials and Resources Credit 1.1: Building Reuse – Maintain Existing Walls, Floors and Roof.*** The intent of this Credit is to extend the life cycle of existing building stock, conserve material resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport. LEED points are awarded based on the incremental percentage of existing buildings that are maintained. The building type must also be considered. For instance, in new construction 1, 2, or 3 points are awarded if the LEED project team maintains 55%, 75% or 95% of the existing building respectively. If the project is a school, 1 or 2 points are rewarded for maintaining 75% or 95% of the existing building. In Core and Shell projects, between 1 and 5 points can be achieved if between 25% and 75% of the existing building is reused. In each

case building surface area calculations are submitted on a spreadsheet to exhibit what surfaces are being maintained and to what extent. In all cases, using RRC to keep existing roofing systems in place contributes to the *Credits.*

MR Credit 1.1 involves another aspect of using RRCs that must be understood. That is, LEED does not penalize the LEED Team for removing non-structural elements of an existing roof when calculating the percentage of the building that remains in play. Therefore, any roof repair or preparation that involves removing damaged or otherwise unsuitable roofing material prior to applying new RRC does not jeopardize the ability to score LEED points.

In scenarios where an existing building is added onto, and the addition exceeds two times the size of the existing building, or six times an existing Core and Shell, salvaging the existing building may not qualify for LEED points under **MR Credit 1.1.** Instead, the existing structure qualifies for consideration under ***Materials and Resources Credit 2: Construction Waste Management***. This is because the existing building is considered to be diverted from a landfill. The intent of **MR Credit 2** is to divert construction and demolition debris from disposal in landfills and incineration facilities, and to redirect recyclables recovered back to the manufacturing process and reusable materials to the appropriate sites. RRCs may still have a role in upgrading the roof of the existing building. This is an example of how RRCs contribute indirectly to achieving LEED credits as opposed to the more direct contribution they make in **Sustainable Sites.**

Credit 7.2: Urban Heat Island, or **Energy and Atmosphere Credit 1: Optimize Energy Performance**.

In projects where roof monitors or other overhead lighting structures with vertical or near vertical glazing are included to enhance daylighting, a reflective roof coating can add significantly to the amount of light that is bounced from adjacent roof surfaces into the aperture of the daylighting structure. In this way RRC contribute directly to achieving **Interior Environmental Quality Credit 8.1: Daylight.** The intent of this Credit is to provide building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into regularly occupied spaces of the building. Requirements vary with building type and rating system but generally are based on providing a minimum of 10 foot candles (fc) and a maximum of 500 fc in clear sky conditions at 9AM and 3PM on September 21 in regularly occupied spaces. Computer modeling, prescriptive methods, lighting measurements or a combination of each can do lighting calculations. The development of highly accurate daylighting software that is compatible with industry standard software designed to calculate whole building energy performance makes computer modeling the best choice.

Daylighting computer modeling software analyzes solar geometry and the influence of building form and features to determine the daylighting contribution to the structure. RRC have the ability to reflect incident radiation that strikes a roof surface. Modeling can incorporate the contribution of reflected light from roof surfaces into adjacent vertical glazing. This can be a result of upper building elevations adjacent to a roof surface of a lower story and / or daylight reflected off a roof into a clerestory or roof monitor designed to capture daylight. LEED does not allow for direct gain or glare when determining what constitutes usable daylight. This needs to be considered when designing daylighting apertures that take advantage of reflective roof surfaces. However, computer modeling can account for scattered reflections or indirect light impinging on a daylighting feature from any direction. In each case, the use of highly reflective roof coatings can significantly improve the performance of the daylighting strategy.

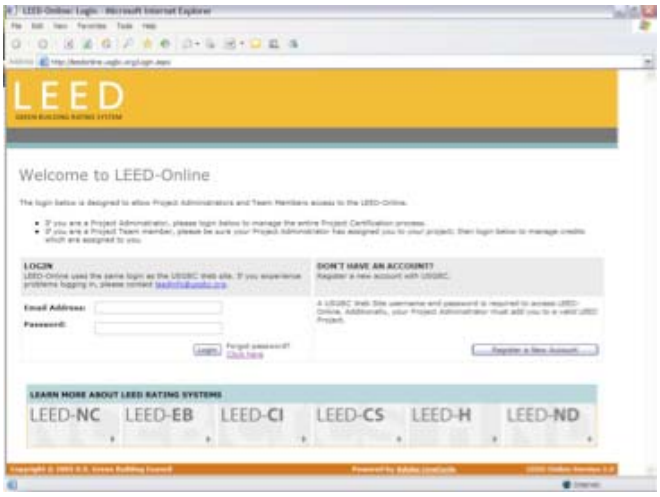
The use of RRC in daylighting can also contribute to **Energy and Atmosphere Credit 1: Optimize Energy Performance.** Daylighting devoid of direct gain into a space can be as much as 75% cooler than fluorescent lighting. Lighting controls that recognize available daylight and reduce supplemental lighting accordingly can therefore contribute to the overall energy conservation strategy of the project. Building systems computer modeling can quantify this relationship and assist the project team in downsizing or "right sizing" the space condition systems. LEED points for **EA Credit 1** are based in part on the capacity of the space conditioning systems installed. RRC can contribute to an energy efficient building envelop as well as an effective daylighting scheme. The LEED project team is charged with capitalizing on these kinds of synergies in both new construction and building retrofits.

Materials and Resources Credit 5: Regional Materials is another opportunity for LEED teams who can discern the material manufacturing and point of sale issues attendant to the reflective roof coatings used on a LEED project. The intent of the Credit is increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation. The requirements are to use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within 500 miles of the project site for a minimum of 10% or 20%, based on cost, of the total material value of the project. Using materials with these characteristics can gain one or two LEED points, respectively. If only a fraction of a product or material is extracted, harvested, or recovered and manufactured locally, then only that percentage (by weight) must contribute to the regional value.

Paints and coatings are often not included in calculating the LEED requirements for **MR Credit 5.** The variables associated with project location and the associated point of purchase makes each project unique. The complex, dispersed nature of the materials procurement and manufacturing processes makes documentation difficult, and the price of the products involved compared to others typically used to achieve the credit limits the impact of RRC in the overall project material value calculations. These issues are best addressed by an RRC technical representative familiar with the nature of the materials, as well as where and how RRC products are manufactured. If the information can be gathered, RRC can be included in **MR Credit 5** calculations, thereby contributing directly to achieving the Credit.

DOCUMENTING THE USE OF REFLECTIVE ROOF COATINGS IN LEED PROJECTS

LEED documentation consists of recognizing the design and construction intent, acknowledging what is actually constructed and verifying all aspects of the project using LEED Online, a user interactive, web based electronic format that facilitates the LEED team's need to interact. LEED Online also enables the requisite third party review by the Green Building Certification Institute (GBCI).



LEED Online Portal

A LEED project typically starts with a goal setting session(s) or charrette to verify all prerequisites can be met, and which optional credits will be pursued. These initial orientations vary with project type and scope, the experience of the stakeholders, and any other variable that informs the intent of the project such as the project construction delivery process (design / build versus design / bid / build). Beyond the required prerequisites, credits are usually pursued based on project context or location, choices that contribute to the physicality of the architecture including materials and resources, and related building processes such as computer modeling and commissioning. Credits are often evaluated in terms of "price, cost and value." Here price is what is paid for the product. Costs are social costs, environmental costs, equity issues, etc. Value is very subjective and usually based on what is important to the owner or developer. Generally, building products are included in LEED projects based on their ability to cost effectively provide some form of utility while imposing a minimum environmental impact. Reflective roofs provide well-documented and reliable responses to energy conservation goals. Their use is supported by good engineering practice and they enjoy a good reputation in the roofing industry. What remains is to advocate effectively for their inclusion in both new construction and retrofit applications.

Once the decision to use RRC in a LEED project is made, information pertaining to the chemistry, behavioral characteristics and physical parameters of the project are entered into the appropriate LEED Online templates. LEED Online templates provide an electronic format that standardizes project information and data entry for use in obtaining third party verification by the Green Building Certification Institute (GBCI). LEED templates enable LEED team members to share information and participate in the documentation. They also serve as a convenient way to store supplemental data, specifications, and other technical information that supports the inclusion of a specific RRC material. RRC technical representatives can contribute RRC information to the LEED project Administrator for inclusion in the process. The contractor also participates by providing proof of purchase and field application information as required. LEED is an honor system that assumes the product information entered into templates represents that which is actually constructed. LEED Teams are not limited to using a material in only one credit opportunity. In fact, the integrated design process and LEED encourages LEED teams to take advantage of the relationships and synergies between products and processes to insure the investment made reaps the maximum return of LEED points earned. The LEED Prerequisite and Credit templates provide the third party reviewer the means to evaluate and cross check all aspects of the submission. The RRC data entered into the LEED template for **Sustainable Sites Credit 7.2; Urban Heat Island - Roof** must match that for **Energy and Atmosphere Credit 1: Optimize Energy Performance,** and **Interior Environmental Quality Credit 8.1 – Daylight.** The information required for LEED submissions pertaining to RRC is readily available and easily imported into energy and daylight modeling software as well as the LEED templates. It is based on recognized industry standards for testing and supported by good engineering practice. However, the GBCI third party reviewers reserve the right to ask for clarification or additional information on any aspect of a LEED submission and inconsistencies in the submission are subject to audit. Therefore, it is important for those associated with the use of RRC to be knowledgeable of the LEED process and supportive of a comprehensive and accurate LEED submission.

CONCLUSIONS AND RECOMMENDATIONS

Reflective roof coatings have a viable role in the overall LEED building rating process and a central role in a number of LEED Prerequisites and Credits. Their reputation for reducing energy consumption, improving comfort and extending the life of existing roofing systems and buildings is well documented. Each is a basic tenet of the U.S. Green Building Council, the Green Building Certification Institute and many others who support the high performance green building movement. The Prerequisites and Credits described in this document have been in the LEED rating systems from the beginning. Like many they have evolved and have been refined as newer editions of LEED have been issued. Indications are they will continue to be included in future LEED rating systems as the utility they provide and the benefits associated with them will become more important over time. Therefore, it behooves all stakeholders involved with the manufacturing, specification and installation of reflective roof coatings to be knowledgeable of the material's role in the LEED submission process. Advancements in building energy systems modeling, building forensics, commissioning and ongoing measurement and verification of building performance will reinforce the desirability of reflective roof coatings in high performance green building and U.S. Green Building Council LEED projects.

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