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Sustainable Roofing Strategies: Lowering Energy Costs, Advancing Environmental Goals

From cool roofs that mitigate urban heat islands, to white, green, foam, and slate roofs, sustainable design options are available for every building type

Presented by

- American Hydrotech, Inc.
- Cool Roof Rating Council
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The Vancouver Public Library. Architects: Moshe Safdie & Associates and Downs / Archambault Partners. Photo courtesy of American Hydrotech, Inc.

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Use the learning objectives below to focus your study as you read **Sustainable Roofing Strategies: Lowering Energy Costs, Advancing Environmental Goals**. To earn one AIA/CES Learning Unit, including one hour of health safety welfare credit, answer the questions on page 105, then follow the reporting instructions or go to construction.com/CE/ and follow the reporting instructions.

LEARNING OBJECTIVES

After reading this article, you should be able to:

- Explain how green roofs mitigate urban heat island effect and reduce storm water run-off.
- Analyze how cool roofs and sustainable design strategies can qualify for LEED® credits and other energy programs.
- Describe how fluid-applied coatings and foam roofs are suitable for adverse weather conditions.
- Identify the qualities of slate roofing that contribute to its strength, durability, and long service life.

Sustainable Roofing Strategies:
Lowering Energy Costs, Advancing Environmental Goals

From cool roofs that mitigate urban heat islands, to white, green, foam, and slate roofs, sustainable design options are available for every building type

Written by Barbara A. Nadel, FAIA

Cities play a significant role in reducing greenhouse gases and related energy costs. In 2006, the American Institute of Architects and the United States Conference of Mayors partnered to promote high-performance building design, with a goal of reaching a 50 percent fossil fuel reduction by 2010. American mayors also adopted comprehensive 2030 goals for all buildings, to address national environmental challenges. These policies include climate change, green building, best energy practices, and private sector initiatives.

Buildings are the largest source of energy consumption and greenhouse gas emissions in the U.S. and worldwide, contributing 48 percent of all greenhouse emissions and 68 percent of electricity consumption. According to the National Institute of Building Sciences, buildings generate 35 percent of the carbon dioxide in the air, the primary greenhouse gas associated with climate change. Most of this energy is produced from nonrenewable, fossil-fuel resources. U.S. annual energy consumption is projected to increase by 37 percent and greenhouse gas emissions by 36 percent in the next 20 years.

For architects and the building industry, every aspect of design and specification can potentially reduce energy costs and increase sustainability. When reviewing roofing options, architects and owners should investigate which materials, construction methods and design approaches best apply to each building and site. The analysis should include budgets, long range plans for the building, climate, location, building code jurisdictions, energy programs, tax credits, utility rebates, insurance, life cycle costs, warranties, and performance standards.

For existing buildings, this analysis should include a moisture survey of the existing roof to determine the location and cause of leaks and other problems. Typically, the first decision to be made for existing buildings is whether to tear off the old roof and start again from the deck up, or to install a new roof over the existing one. Analyzing these issues, along with the many available options, can result in sustainable roofing opportunities that support and advance environmental goals. This article will explore design criteria and materials for sloped and low-sloped roofs. Design factors for green roofs, cool roofs, white roofs, fluid-applied coating systems, foam roofing, and slate roofs will be discussed.

Urban Heat Island Effect

Heat islands describe urban temperatures that are 2°F to 12°F hotter than nearby suburban and rural areas. Elevated temperatures impact communities by increasing peak energy demand, air conditioning costs, air pollution levels, and heat-related illness and mortality.

Urban heat islands occur when a city is hotter than the surrounding

65 E. Goethe, Chicago, IL. Building tenants can enjoy this rooftop terrace overlooking Lake Michigan. Architect: Lucien LaGrange & Associates.
Photo courtesy of American Hydrotech, Inc.

areas due to roofs and roads made of dark materials that absorb the sun's rays instead of reflecting them, causing the temperature of the surfaces and the air around them to rise. Less available shading from trees and vegetation in cities are also contributing factors. According to the Lawrence Berkeley National Laboratory, the heat island effect is impacted by the following:

➤ Cool roofs: making a building reflective reduces the amount of solar heat it absorbs
➤ Cool pavements: reflective pavements keep parking lots and roads cool
➤ Air quality: cooler air temperatures reduce air pollution and smog
➤ High temperatures: on warm summer days, a city can be 6°F to 8°F hotter than surrounding areas
➤ Vegetation: trees reduce cooling energy use in buildings, by shading them and cooling the air
➤ Energy use: higher temperatures increase air conditioning demand

GREEN ROOFS

The urban heat island effect creates an unhealthy environment, with air pollution and smog. Open green spaces within city centers decrease as land values rise, while rooftops, parking lots, and roads in the cityscape are impervious to water. As a result, drainage and sewer systems become overloaded, thereby increasing the risk of flooding following heavy rains. Continued urban development will exacerbate the problem, making the cost of improving existing sewer infrastructure prohibitive in most communities.

Replacing the impervious system of a conventional roof with a green, or garden, roof can substantially reduce storm water run-off and restore the balance with nature. Green roofs combine high-performance waterproof membranes with garden planting roof technology. Many green roof assemblies are lightweight, and can be installed on new and existing buildings. Three types of green roof sassemblies are commonly used for urban applications:

➤ Extensive: These are designed to be lightweight, and support hardy plants, with low-maintenance, and no irrigation in most climates. This is the optimum choice for mitigating urban heat island effects and reducing storm water runoff.

➤ Semi-intensive: Another lightweight assembly that has deeper soil, designed to support sod lawns and perennials. Irrigation depends on plant choices and climate. It is typically accessed by nearby hardscape areas, such as a patio, or other usable space.

➤ Intensive: Greater soil depths are needed to support different plants, shrubs, and trees. This rooftop system can replicate yards and gardens and be designed for recreational use. Irrigation and regular maintenance are necessary.

Green roofs provide many ecological, technical, and building owner benefits, such as:

➤ Ecological: Green roofs cool and humidify the surrounding air, creating a microclimate with beneficial effects in the immediate vicinity. They provide natural habitats for plants and animals, such as birds and butterflies. Green roof vegetation reduces dust and smog levels. Nitrates and aerosol contaminants are absorbed out of the air and rainfall, and bound into the soil.

➤ Technical: Depending on the design, green roofs can reduce storm water run-off by 50 to 90 percent. The peak flow volume is greatly reduced, and peak flow periods are delayed by as much as four hours, minimizing impact on sewer systems. Green roofs reduce temperature extremes on roofs, thereby reducing cooling costs. Typical extensive green roofs reduce reflective sound by up to three decibels (dB), and improve sound insulation by up to eight dB. This is most effective for buildings near airports, factories, or busy freeways.

➤ Owner incentives: Like a protected membrane roof (PMR) assembly, a green roof protects the roof membrane from climate extremes and physical abuse, and increases roof longevity. Converting usable rooftop space to green roofs increases property values by creating an amenity for building occupants. In hospitals and extended care facilities, the ability to view and access a natural setting provides a therapeutic environment.

Green Roof Assembly

Traditional roofing assemblies consist of three components: the roof structural deck, insulation, and the membrane assembly. The roofing should protect the building and the insulation from moisture. In protected membrane roofs, extruded polystyrene insulation is placed on top of the waterproofing membrane for superior moisture resistance. In a conventional roof, the insulation is placed under the waterproofing membrane. Insulation placement relative to the membrane impacts the membrane's performance.

A green roof assembly is an extension of the PMR. This system protects the membrane from foot traffic, damage and degradation from freeze-thaw cycles, and ultraviolet radiation. It features the membrane adhered to the deck, covered by insulation and a ballast on top. The membrane's service life is extended because it is not exposed to the environment.

Green roofs must keep buildings watertight, and provide environments conducive to vegetation survival. An effective assembly includes proven technology, such as a fluid-applied rubberized asphalt membrane, which has been used for over 40 years. Membranes are available containing 25 percent recycled materials, and are commonly used in fountains, pools and applications with wet, submersed conditions. This membrane system has several advantages: it is seamless and monolithic, bonded directly to the substrate, can be installed on substrates with little or no slope, is easy to detail at penetrations and terminations, and resistant to fertilizers and mild acids.

Design Issues

Choosing roof membranes is critical to the long-term success of a watertight green roof. Roof membranes should be able to function in a wet environment, have a successful performance history, and be installed by trained applicators. Other planning and design issues that should be analyzed are as follows:

➤ Structural requirements: include reviewing the height, size, slope, and maximum loadbearing capacity of the roof. The architect should determine the type of roof structure, number and position of drainage outlets and roof penetrations, roof access locations, transport and storage availability of water and electricity, and loads imposed by green roof assemblies when fully saturated with water and plants.

➤ Wind uplift: Green roofs must remain stable in high wind uplift conditions. Wind pressures can vary across a roof, depending on location. At the center of the roof, a thin growing media (soil) layer of 15 lbs. per square foot (psf) may be adequate. At perimeters and corners, high winds may necessitate multiple rows of precast pavers to prevent uplift. Taller buildings have a greater risk of wind uplift. Ballasting requirements vary by building height, parapet height, and wind design speed.

➤ Fire prevention: Green roofs that are regularly irrigated are considered to be resistant to sparks and radiant heat. Roofs that are not irrigated are considered fire resistant provided that the growing media is two inches deep, with no more than twenty percent by weight of organic matter; gravel or concrete breaks occur in the vegetation every 100 feet, at least four feet wide; vegetation-free zones occur at all roof penetrations and at perimeter walls with openings; and safety strips are kept free of flammable vegetation.

This rooftop healing garden is used for rehabilitation and horticultural therapy in Chicago. Schwab Rehabilitation Hospital, Chicago, IL. Architect: Stephen Renkin Associates. Landscape Architect: Douglas Hills Associates, Inc. Photo courtesy of American Hydrotech, Inc.

➤ Roof slope: Green roofs can be placed on flat decks, but positive slope to drain is desirable. Conditions should avoid water ponding, as any ponding above the drainage layer will be harmful to plants. Various green roof assemblies can be used on flat decks up to a 3:12 pitch. Higher slopes may require special components, up to a 12:12 pitch.

➤ Roof drainage: Green roofs retain a high percentage of rainwater that falls on the roof, which reduces the strain on surface drainage systems. Excess water must be drained from the roof by surface roof drains, gutters, or scuppers. Roof drainage design should include at least two outlets, or an outlet and an overflow. Outlets must be kept clear of vegetation by installing a vegetation-free zone around the outlet and covering it with an inspection chamber.

➤ Roof penetrations for pipes, equipment, and skylights should be clustered together, to simplify waterproofing details and allow more open planting areas. All roof penetrations and perimeters should be surrounded by gravel or other non-vegetation ballast material. Flashings should be terminated at least eight inches above the finished surface of growing media and pavers.

COOL ROOFS

Energy-efficient roofing systems can significantly reduce roof temperatures during the summer. Selecting cool roofing materials and systems that reflect the sun's radiant energy, before it penetrates building interiors, will mitigate urban heat island effects. Cool roofs encompass several different systems, materials, and installation methods, including built up roofing, coatings, metal, modified bitumen, slate, shakes, shingles, single ply, and tiles.

Cool roofs minimize the transfer of heat to the building below by reflecting and emitting the sun's energy back to the atmosphere. The surrounding environment is cooler, reducing the urban heat island effect and smog formation. Cool roofs benefit building owners and the environment as follows:

➤ Lower rooftop temperatures lead to reduced cooling loads and air conditioning use

➤ Less wear and tear on air conditioning systems and greater efficiency at lower temperatures

➤ Lower ambient air temperatures inside buildings and increased occupant comfort

➤ Increased roof longevity

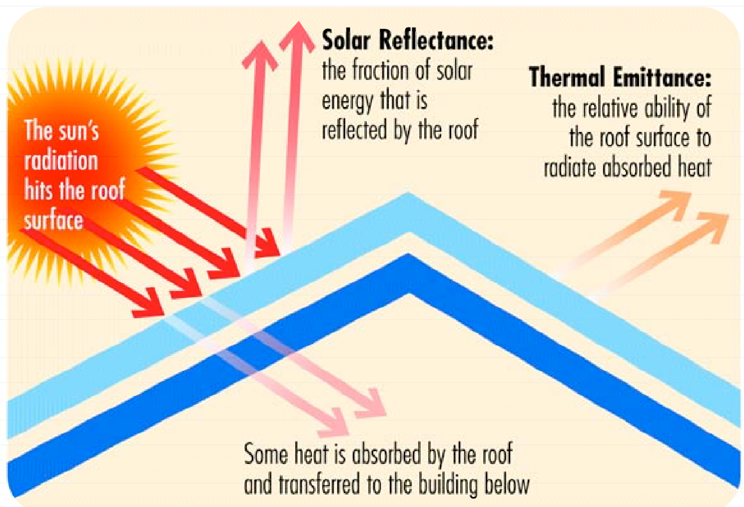
➤ Reduced energy use during peak electricity demand hours avoids the need for rolling black-outs

➤ Lower energy use results in reduced carbon dioxide, particulate matter, and other air pollutants

Radiative Properties

Cool roofs are measured by solar reflectance and thermal emittance. Both properties are measured from 0 to 1, with higher values representing cooler roofs. As the sun's radiation hits the roof surface, some heat is absorbed by the roof and transferred to the building below. Solar reflectance is the fraction of solar energy that is reflected by the roof. Thermal emittance is the relative ability of the roof surface to radiate absorbed heat. When combined, these two measurements comprise the Solar Reflective Index (SRI).

Roof rating programs offer radiative performance data for roofing products. In the private sector, a credible and unbiased third-party rating program measures and reports the radiative properties of roof surfaces. Independent testing laboratories, not manufacturers, are generally best suited to measure relative property values. The two primary values measured are solar reflectance and thermal emittance values.



A cool roof reflects and emits the sun's heat back to the sky instead of transferring it to the building below. "Coolness" is measured by two properties, solar reflectance and thermal emittance.
Image courtesy of the Cool Roof Rating Council.

The U.S. Environmental Protection Agency's ENERGY STAR® program allows manufacturers to rate their products as long as they meet ENERGY STAR's minimum specifications. This government program accepts ratings from the manufacturer's own testing or from a third-party laboratory, uses only solar reflectance as a measure, and only includes products exceeding a minimum reflectance.

The difference in radiative properties of roofing materials can result in large differentials in surface temperatures. A dark colored roofing material may measure 60°F to 100°F above the ambient outdoor temperature, while a cool roof is generally 10°F above ambient temperature.

Energy savings depend on climate, roof performance, insulation, and other design elements. Savings generally average from 10 to 30 percent of the cooling energy needed, and total building electric bill reduction of three to ten percent. These ranges apply to low-rise buildings in regions with significant cooling loads.

FLUID-APPLIED COATINGS AND FOAM ROOF SYSTEMS

During the summer, flat black roofs can reach temperatures ranging from 150°F to 200°F. If dark roofs represent 20 percent of an urban area, shading becomes difficult. Typically, 80 percent of low slope roofs are black. White roofs can average 120°F, significantly cooler than black roofs. White surfaces can be applied on black roofs, but this often results in a short term benefit, where effectiveness diminishes quickly.

TOP RIGHT: The dome roof of the Mississippi Coast Coliseum & Convention Center, in Biloxi, Mississippi was severely damaged after Hurricane Katrina. It was repaired with a fluid-applied coating and foam roofing system. Photo courtesy of BaySystems North America.

BOTTOM RIGHT: White roofs with seamless fluid-applied coating systems provide protection against leaks at roof penetrations and flashing transitions, as seen at the Las Vegas Marriott, Las Vegas, Nevada. Photo courtesy of Jones-Blair Company

White roofs provide several advantages when combined with fluid-applied roof coating systems, including durability, sustainability, low-maintenance, cost efficiency, and reflectivity. Their superior resistance to impact, fire and mildew; flexibility, adhesion, and ease of application make this system an excellent protective elastomeric barrier for extending the life of most roofing substrates. (Elastomeric refers to an elastic substance resembling rubber.) Additionally, white roofs can reflect up to 85 percent of solar rays, reduce temperatures of interior spaces, and mitigate the urban heat island effect. They qualify as a cool construction material.

White roofs can reflect up to 85 percent of solar rays and reduce temperatures of interior spaces.

High-performance Coatings

Roofing systems are available that can leave existing roofs in place, and fix problems after they have been identified, potentially doubling or tripling the service life of existing roofs. This approach decreases energy consumption by 10 to 20 percent, and reduces roof waste that is transported to landfills.

Fluid-applied coating systems provide roof protection for low slope roof applications over various systems, including spray polyurethane foam, EPDM/single ply, modified bitumen, built-up roofs, metal, and concrete. They can increase and extend the life of existing roofs, and provide a cost-effective, sustainable alternative to traditional roofs that require expensive and disruptive tear-off and replacement.

Fluid-applied roof coating systems are appropriate for commercial, industrial and institutional uses. They don't have seams or fasteners, the two major sources of roofing failure. A base coat optimizes adhesion, bond strength, and fire retardant properties. A top coat provides high-reflective coating. Seams are often found at flashing transitions, and when the slope changes, causing leaks to occur. Fluid-applied roof coating performance properties include:

- Seamless, fully adhered: Provides a one-piece finished roof and protection from leaks.
- Lightweight: Goes over existing roof without tear-off, reduces reroofing costs and weather exposure.
- Elastomeric: Accommodates thermal expansion and contraction, no cracking or splitting.
- Light reflective: Keeps buildings cooler, reduces urban heat island effect, lowers energy costs.
- Insulation: Highest R-value, continuous insulated surface reduces energy consumption.
- Sustainable: Renews, not replaces, systems; reduced recycling costs, less landfill waste.
- Hail and wind up-lift resistant: Performs in adverse weather conditions, fewer repairs, reduced insurance claims.
- Environmentally friendly: Low odor, no hazardous waste disposal costs.

Foam Roofing Advantages

With the proper surface coating, polyurethane foam is a re-roofing option with several advantages:

- Thermal insulation: Foam roofs can provide energy cost savings of up to 33 percent.
- Light weight: A finished application weighs about 50 lbs. per 100 square feet, compared to as much as 2,000 lbs. for conventional roofing systems.
- Reduced thermal shock: The insulating properties of foam roofing systems reduce substrate cracking caused by thermal expansion and contraction.
- Seamless: No laps or joints to expand, contract, crack or tear, and no seams to fail.
- No migration: Water will not migrate through the closed cell foam. Damage is quickly repaired.
- Adaptable: For re-roofing or new construction, polyurethane foam is adaptable to most substrates.
- Fast and economical: No costly, inconvenient tear-off of existing roofing.
- Design flexibility. Polyurethane foam adapts to any slope and shape.

SLATE ROOFING

Slate is a dense, natural stone that is ideally suited for roofing. Known for its strength, durability, fire resistance, water resistance, and minimum maintenance, slate is practically non-absorbent, with porosity between 0.15 to 0.4 percent. Additionally, slate is impervious to fungus and mold, dimensionally stable, and resistant to climate change inherent in the freeze-thaw cycle. Slate roofs are chemical-resistant, easy to repair, and are classified as cool roofs. Three common types of slate roofs depend on the type and thickness of slate used:

- Standard Slate Roofs are sloping roofs utilizing commercial slate with one uniform length and width, generally rectangular in shape. Standard roofs differ from other types in texture and appearance. The corners of each slate may be trimmed to give a diamond, hexagonal or Gothic pattern. Patterns can be achieved by laying two or more standard commercial slate over the same area. The appearance of this roof is flat, even, and uniform.
- Textural Slate Roofs are sloping roofs that utilize slate of various

sizes, thicknesses, textures, and colors. They are composed of textural slate, which is rougher than standard slate. Textural slates are produced in different sizes and thicknesses. Various shades of textural slate are often used to enhance roof colors. Compared to standard roofs, textural roofs display more character, due to pronounced shadow lines and color variations.

➤ Graduated Slate Roofs combine the artistic features of the textural slate roof with variations in thickness, size, and exposure. The thickest and longest slates are placed at the eaves. As the slate courses progress to the ridge, slates of gradually diminishing size and thickness are used, creating a graduated effect. Graduated slate roofs are often customized in various patterns.

TOP: Semi-weathering slates complement a stone façade, with random widths for a traditional application. Photo courtesy of Evergreen Slate.

BOTTOM: Varied slate colors, sizes and textures allow many architectural effects, and contribute to the overall building appearance. Photo courtesy of Evergreen Slate.

Slate Colors

Slate roofing tile is available in many rich and varied colors, sizes, and textures that enhance design flexibility and aesthetics. Slate roofs are commonly used for residences, churches, libraries, universities, and government buildings. Colors are determined by the slate's chemical and mineralogical composition.

Exposure to weather causes all slate to change slightly in color. Slates with minimal color change are classified as permanent or unfading. Those which show a more obvious color change are called weathering slates, which offer designers another variation in roof color. When color is important, designers and owners should consider the slate source, its capacity for color change, weathering effects, and specify unfading or weathering preferences. Slate color nomenclature includes black, blue black, gray, blue gray, purple, mottled purple and green, green, purple variegated, red, and weathering green (changes to buff or brown).

Slate Texture

Slate has a natural cleavage, which allows it to be split in one direction. Grain is the second direction of fracture, occurring at right angles to the cleavage. Roofing slates are commonly split so that the length of slate runs in the direction of the grain. The texture of slate after it is split for commercial applications depends on the nature of the rock from which it is quarried. Some slates split to a smooth, even, uniform surface, while others are rough and uneven, providing a range of available roofing surfaces.

Some slate contains narrow ribbons of rock that are different in chemical composition and color from the rest of the slate. If chemical composition of the ribbons doesn't weaken the slate and the color is not objectionable, ribbon slates are acceptable. Clear slate is trimmed to eliminate ribbons. Slate with acceptable ribbons is called ribbon stock.

Slate Standards and Testing

There is no single slate classification in the U.S. because slates vary widely, from ribbons and clear, to smooth and rough surfaces. The American Society for Testing and Materials (ASTM) has developed tests for material characteristics and physical requirements, to measure slate quality used in roofing, including ASTM Designation: C 406-00, the Standard Specification for Slate Roofing.

ASTM classifies slate by the expected service life of three grades, based on geographic location and environmental exposure. Service life refers to the period of time over which the slate material may be expected to require no repair or replacement due to weathering. Grade S1 has a service life of over 75 years, and is highly recommended for roofing. Grade S2 is rated for 40 to 75 years; Grade S3 is rated for 20- to 40-year service life. Three ASTM tests measure qualities of slate:

➤ ASTM Designation: C 120-90 Standard Test Method of Flexure Testing of Slate, addresses determination of the modulus of rupture and modulus of elasticity of slate by means of flexure testing. S1 minimum: 9,000 pounds per square inch (PSI).

➤ ASTM Designation: C 121-90 Standard Test Method for Water Absorption of Slate, addresses determination of the water absorption of slate. S1 minimum: 0.25 percent.

➤ ASTM Designation: C 217-85 Standard Test Method for Weather Resistance of Slate, addresses two procedures for weather resistance of slate in all outdoor installations by determining the depth of softening by an abrasive or by hand scraping. S1 maximum: 0.002 inches.

This article continues online at
http://construction.com/CE/articles/0707roofing-1.asp

See Quiz on the Next Page

Roof Maintenance Tips

Maintenance is an essential part of ensuring long-term roof performance. Basic maintenance for all roofs should include inspections at least twice yearly, depending on climate and location. White roofs may need seasonal cleaning because they will show soot and dirt, which causes a loss of emissivity properties. Inspections should occur at least once in the spring and once in the fall, after major storms, to clean out leaves, clear drains, and cut nearby overhanging trees. Contractors, owners, or consultants can perform roof maintenance. During inspections, workers should be careful about walking on roof surfaces and avoid dropping tools and equipment, which can puncture materials and cause leaks.

At Arizona State University, the Performance Based Studies Research Group investigates and tests roofing systems, including fluid-applied coatings and foam roofing systems. This non-profit research group has identified effective roofing techniques and ways to reduce risk, along with other studies that benefit the building industry. They have partnered with many public and private organizations to advance knowledge and educate building owners on the long range value of high-performance roofing systems.

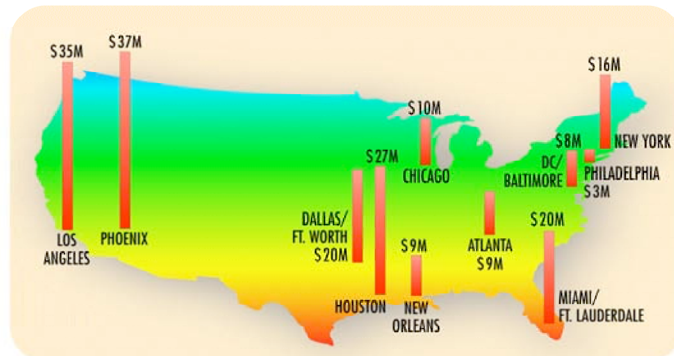
LEED® AND ENERGY PROGRAMS

The U.S. Green Building Council's Green Building Rating System, Leadership in Energy and Environmental Design (LEED®), is a voluntary certification program for sustainable buildings. LEED for New Construction and Major Renovations (LEED-NC) Version 2.2 allows credit for several roofing types and related strategies.

Green roofs can contribute up to 14 credits with LEED-NC, Version 2.2. Between one and two points can be earned in the following categories: Storm Water Management, Landscape and Exterior Design to Reduce Heat Islands, Recycled Content, Reduced Site Disturbance, Water Efficient Landscaping, Local/Regional Materials, and Optimized Energy Performance. Typically, plant choices for green roofs are native to the area, and the growing media is locally sourced, so that soil is not shipped far.

North Park 400, Atlanta, GA. This accessible public green roof is a popular gathering place. Architect: Thompson, Ventulett, Stainback & Associates. Photo courtesy of American Hydrotech, Inc.

Cool roofs can receive credits under LEED-NC Version 2.2, Sustainable Site Credit 7.2; Heat Island Effect: Roof. LEED-NC credits roofs with an SRI value greater than or equal to 78 for low-slope roofs, and 29 for steep-slope roofs. LEED for Existing Buildings (LEED-EB) Version 2.0 provides credit for a cool roof under Sustainable Site Credit 6.2: Heat Island Reduction: Roof.



Nationwide implementation of cool roofs could mean an annual savings of $1 billion in cooling costs. Values in this diagram reflect 1997 energy prices; current values are higher. Courtesy of Lawrence Berkeley National Laboratory.

Various energy codes, green building initiatives, and public agencies have adopted cool roof measures. Several electrical utilities offer rebates for installation of cool roofing materials in new construction or major roof retrofits, as incentives to save energy and reduce peak demand. As of 2007, utility rebate programs include Pacific Gas & Electric Company, Southern California Edison, Idaho Power, and the City of Austin.

Two building industry organizations, the International Code Council (ICC) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) have developed National Model Energy Codes. These documents are not mandatory or enforceable until a jurisdiction adopts them. In the U.S., many states and jurisdictions have adopted these organizations' codes, while California and the City of Chicago have developed their own.

The California Energy Commission's Building Energy Efficiency Standard, Title 24 includes a cool roof prescription for low-sloped (less than 2:12) nonresidential roofs for new construction and major re-roofing, and requires that cool roofs be tested and labeled by a third-party rating program. Title 24 defines a cool roof as any roofing product with an initial thermal emittance greater than or equal to 0.75 and a minimum initial solar reflectance of 0.70. Title 24 makes limited exceptions for clay and concrete tiles and products with low thermal emittance and comparatively high solar reflectance.

Cool roofs are not mandatory under Title 24. Nonresidential buildings with low-sloped roofs can comply by choosing one of the available compliance options, regarding performance, envelope component or overall envelope approach.

The City of Chicago's Energy Conservation Code includes a requirement for cool roofs as a way to mitigate the urban heat island effect. Chicago requires cool roofs in low-sloped roofing applications. Roofs installed before December 31, 2008 must meet a minimum solar reflectance of 0.25 for initial and aged values. After that date, roofing products must meet ENERGY STAR criteria.

Asphalt Roof Disposal

Older roofs use up natural resources, such as asphalt and oil-based components for installation, tear-offs, disposal, and reroofing. Upgrading existing roofs can utilize existing components, such as insulation, if total roof replacement isn't needed. With carefully chosen materials and installation, high-performance, low-maintenance systems can restore original performance levels to existing roofs, and minimize deterioration over time.

Asphalt roofs with coal tar pitch and gravel surfaces are typical of tear-offs that are disposed in landfills. According to the Asphalt Roofing Manufacturing Association, two million tons of asphalt coated membrane roofing has been sent to the waste stream, representing 11 million tons of roofing waste per year, and seven to 10 percent of landfill space over the last 40 years.

Used or Salvaged Slate Roofs

For older roofs, problems with flashing or other deteriorating components may necessitate partial or major roofing replacements. A used or salvaged slate roof is one in which the designer or owner has chosen to reuse slate that has already been installed on a roof, such as for reduced material costs. The aesthetic appeal of an aged roof, with colors unlikely to change, and the interest in retaining historic materials may be considerations. All slate ages differently, so used slate should be evaluated carefully, since salvaged slate may come from several sources.

Reuse of salvaged slate roofs may qualify for one point under LEED-NC for New Construction and Major Renovations, Version 2.2, Materials and Resources. Credits 3.1 and 3.2 offer one point each for Materials Reuse, based on five or ten percent, respectively, of total project material costs.

The intent of MR Credit 3.1 Materials Reuse, Five Percent, is to reuse building materials and products to reduce demand for virgin materials and reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources. The requirements call for salvaged or reused materials, so that the sum of these materials constitutes at least five percent, based on cost, of the total value of materials on the project. MR Credit 3.2: Materials Reuse: Ten Percent, is similar to Credit 3.1, based on ten percent of the total value of project materials.

LEFT: In 2005, after Hurricane Katrina destroyed the roof, the New Orleans Superdome was repaired in record time, with a fluid-applied coating system and foam roof. Photo courtesy of BaySystems North America

CASE STUDY: NEW ORLEANS SUPERDOME

Foam roofing systems with proper coatings perform in adverse conditions, such as hurricane-force winds and steady rain. After Hurricane Katrina in 2005, the New Orleans Superdome was severely damaged by high winds which lifted the bladder-like covering and rivets off the structure, creating a vacuum that left holes in the roof. The damage was extensive, down to the steel deck.

Special coatings, which fully adhered to the roof surface, fixed the problem. The damage was further repaired using metal covered with foam, and topped with coatings to protect the roof with a seamless system. The membrane was added to the large opening at the top of the Superdome, primed, and topped with a spray coating, providing superior wind uplift resistance. The New Orleans Superdome replacement was completed in record time. Damaged areas below the dome were recoated with a fluid-applied coating system and spray polyurethane foam. This high-performance design solution has proven to be very effective for coastal areas prone to hurricane conditions, especially along the Gulf Coast, from Biloxi to New Orleans.

SUMMARY

Energy conservation and energy cost reductions have become primary concerns to building owners, architects, and building industry professionals, as well as American mayors and public officials concerned about the environment. Raising public awareness about the urban heat island effect, and ways to mitigate its negative impact, remain increasingly important for all those who live and work in cities, and rely on thriving urban environments to enhance the quality of life.

Sustainable roofing design strategies have taken on greater importance in recent years. Owners and architects have many sustainable roofing options to choose from, whether for new construction, major renovation, or reroofing projects. The growing interest in cool roofs has lead to renewed interest in green, or garden, roofs; white roofs, foam roofs with special coatings, and slate roofs. These varied approaches are among the most prudent roofing strategies available for reducing energy costs, advancing sustainability, and achieving environmental goals.

Barbara A. Nadel, FAIA, principal of Barbara Nadel Architect, in New York City, frequently writes about design and technology. She is the author and editor-in-chief of Building Security: Handbook for Architectural Planning and Design *(McGraw-Hill, 2004).*

To receive AIA/CES credit, you are required to read the additional online text, which can be found at http://construction.com/CE/articles/0707roofing-1.asp
The quiz questions below include information from this online reading.

Program title: **"Sustainable Roofing Strategies: Lowering Energy Costs, Advancing Environmental Goals" (07/07, page 95)**. AIA/CES Credit: This article will earn you one AIA/CES LU hour of health, safety, and welfare credit. (Valid for credit through July 2009). **Directions**: Refer to the Learning Objectives for this program. Select one answer for each question in the exam and fill in the box by the appropriate letter. A minimum score of 80% is required to earn credit. **To take this test online, go to: construction.com/CE/**

1. Urban heat islands occur when:
- ❑ **a.** dense available shading from urban parks, trees and vegetation is available.
- ❑ **b.** global warming increases the sea level of coastal cities in warm climates.
- ❑ **c.** a city is hotter than the surrounding areas.
- ❑ **d.** rooftops reflect more solar heat than nearby suburban areas.

2. Which statement best describes solar reflectance?
- ❑ **a.** a measurement that is not used by ENERGY STAR program
- ❑ **b.** the fraction of solar energy reflected by a roof
- ❑ **c.** the relative ability of a roof surface to radiate absorbed heat
- ❑ **d.** lowest index values represent cooler roofs.

3. Design strategies to obtain LEED® credit for cool roofs should
- ❑ **a.** Achieve an SRI value greater than or equal to 78 for low-slope and steep-slope roofs.
- ❑ **b.** Provide an SRI value of less than 28 for steep-slope roofs.
- ❑ **c.** Utilize used or salvaged roofing materials.
- ❑ d. Meet or exceed an SRI value of 78 for low-slope roofs and 29 for steep-slope roofs.

4. Which of the following statements is true regarding storm water run-off?
- ❑ **a.** Impervious conventional roofs, parking lots, and roads reduce flooding risks after heavy rains.
- ❑ **b.** Storm drains and sewers become overloaded in cities because of vegetation clogging the system, which reduces storm water run-off.
- ❑ **c.** Continued urban development reduces storm water run-off problems by 20 percent.
- ❑ **d.** Green roofs reduce peak flow of storm water run-off by as much as four hours, minimizing impact on sewer systems.

5. Which roofing assembly consists of insulation placed on top of the waterproofing membrane?
- ❑ **a.** Traditional roof
- ❑ **b.** Protected membrane roof
- ❑ **c.** Graduated slate roof
- ❑ **d.** White roof

6. Which of the following is true about asphalt roofing materials?
- ❑ **a.** Seven to ten tons of asphalt coated membrane roofing has been sent to the waste stream in the last two years.
- ❑ **b.** Asphalt roofing materials can be recycled and have no impact on landfills.
- ❑ **c.** Asphalt roofing waste occupies up to two percent of landfill space in the last 20 years.
- ❑ **d.** Asphalt coated membrane roofing represents 11 million tons of roofing waste per year, and seven to ten percent of landfill space over the last 40 years.

7. Which is the best roofing option for mitigating urban heat island effects and reducing storm water runoff?
- ❑ **a.** Extensive green roof
- ❑ **b.** Graduated light colored slate roof
- ❑ **c.** Domed roof
- ❑ **d.** Modified bitumen roof

8. Which roofing system is well suited for coastal areas prone to the high winds and heavy rains associated with hurricane conditions?
- ❑ **a.** Standard white roof
- ❑ **b.** Fluid-applied coating systems and spray polyurethane foam roof
- ❑ **c.** Intensive green roof
- ❑ **d.** Standard slate roof

9. Which is the recommended grade and service life for slate that may be expected to require no repair or replacement due to weathering?
- ❑ **a.** Grade SRI greater than or equal to 78 years for low-slope roofs, and 29 years for steep-slope roofs
- ❑ **b.** Grade S1 for 75 years
- ❑ **c.** Grade S3 for 75 years, applies only to graduated, steep-sloped roofs
- ❑ **d.** Grade PSI for 90 years

10. ASTM tests measure slate for all of the following qualities except:
- ❑ **a.** water absorption.
- ❑ **b.** weather resistance.
- ❑ **c.** solar reflectance.
- ❑ **d.** flexure.

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Material resources used: Article: This article addresses issues concerning health and safety.

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