

# **Steep-Slope Cool Roofing**

**Asphalt Roofing Manufacturers Association**

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A “cool roof” is designed to stay cooler than a conventional roof through a combination of higher solar reflectance (the ability to reflect solar energy) and thermal emittance (the ability to re-radiate absorbed energy). Although cool roofs are an increasingly popular option, they are only one of the potential approaches to help building owners and homeowners reduce energy consumption and address environmental concerns.

### **MEASURING SOLAR REFLECTANCE, THERMAL EMITTANCE, AND SOLAR REFLECTANCE INDEX**

Several test methods are used to measure solar reflectance and thermal emittance of roofing materials. The standards listed below are employed to determine the associated properties. Values determined by the various methods are generally similar although they may not be identical. Reflectance and emittance differences do not equally affect a roof’s radiative properties. Solar Reflectance Index (SRI) is calculated using measured reflectance and emittance values. By combining both properties, SRI enables comparisons of products and materials with differing reflectance and emittance properties.

|                         |                                            |
|-------------------------|--------------------------------------------|
| Reflectance             | ASTM C1549, E903, E1918, or ANSI/CRRC S100 |
| Emittance               | ASTM E408, C1371, or ANSI/CRRC S100        |
| Solar Reflectance Index | ASTM E1980                                 |

### **STEEP-SLOPE ASPHALT-BASED COOL ROOF OPTIONS**

Cool roof options are available for virtually any roof and any building structure, and they can complement other building modifications to accomplish design goals.

#### **Cool Asphalt Shingles**

The dominance of asphalt shingles in steep-slope applications is driven by a balance of service life, visual appeal, and economic value. The look of asphalt shingles is usually judged to be equal to or better than alternative materials such as metal, wood shakes, and clay or concrete tile. Asphalt shingles remain the preferred roofing material, being utilized on 75-80% of residential roofs in the U.S. <sup>1</sup>

The dominance of asphalt shingles continues in the cool roof arena through development and marketing of asphalt shingles surfaced with cool roof granules. These products maintain a

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<sup>1</sup> Maria Harutyunyan, “Roofing Industry Statistics You Need to Know in 2026,” *Blogs for Roofers SEO* (blog), *Roofex SEO*, December 30, 2025, <https://www.localroofingseo.agency/blog/roofing-industry-statistics>.

varied color palette that allows customers to match shingles to the design and color scheme of their home while offering the benefits associated with higher solar reflectance.

It is important to note that the mineral granules used on highly reflective asphalt shingles are essentially identical to those which have been used on asphalt shingle roofs for decades except for the incorporation of near-infrared reflective pigments. Use of this proven surfacing material assures consumers that cool asphalt shingles will continue to provide all the benefits they have come to expect from conventional shingles.

Solar reflectance values for conventional asphalt shingles range from 0.04 for a black shingle to about 0.25 for a white shingle (the original cool roof). The use of cool granules made with special pigments that reflect most of the near-infrared portion of the solar spectrum has allowed the development of desirable colors with solar reflectance values that exceed 0.27.<sup>2</sup> Both conventional and highly reflective asphalt shingles have thermal emittance values that exceed 0.85.<sup>2</sup>

### **Coating of Asphalt Shingles**

Many asphalt shingle manufacturers do not recommend field coating of their shingles. ARMA strongly advises against the application of any type of field-applied coating over installed asphalt shingles without approval from the shingle manufacturer.<sup>3</sup> Additionally, state or local building codes may prohibit this practice, as field-applied coatings may negatively impact the performance characteristics (e.g., fire classification, algae resistance, impact resistance) of the roof covering. Application of reflective roof coatings to asphalt shingles may be an alternative option to create a cool roof in some cases, if shingle manufacturer approval and a coating product specifically designed for use on asphalt shingles can both be obtained. Typical exterior paint should never be used for this purpose.

### **CONSIDER THE BENEFITS OF THE WHOLE BUILDING APPROACH**

The roofing system is a vital component of a building's moisture and thermal barrier and deserves in-depth consideration when making building feature or design decisions, and when developing policy or incentive programs. However, it is only one component of the building. ARMA asserts that the "whole building approach," which considers all elements of the building and its environment, is the best method for making sound cool roof policy decisions. The selection and use of a steep-slope roof system should be based on the overall building

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<sup>2</sup> "Rated Roof Products," Cool Roof Rating Council, accessed February 4, 2026, <https://coolroofs.org/directory/roof>.

<sup>3</sup> "Coating of Asphalt Shingles After Installation," Asphalt Roofing Manufacturers Association, accessed February 4, 2026, <https://www.asphaltroofing.org/coating-of-asphalt-shingles-after-installation/>.

performance, taking into account complete and reliable information about its environmental impact during its entire life cycle, its durability, and its economic feasibility, while ensuring consumer affordability and flexibility of choice. Performance as a cool roof is only one of several factors to consider.

There are many building features to consider in the whole building approach to reduce energy use and accomplish environmental goals. The effectiveness of any approach depends upon the other building features and the natural and built environment that surrounds the building. Examples of important building features to consider when applying the whole building approach are discussed in the following sections. It is worth noting that cool roofs are a relatively easy building feature to modify when a roof must be replaced. Some of the other features discussed are less practical to undertake as a modification of or addition to an existing building.

### **Cool Roofs**

Cool roofs reflect more solar energy (solar reflectance) and emit more absorbed heat (thermal emittance) than non-cool roofs. This results in lower roof surface temperatures and less heat transfer into the spaces below the roof. This reduces energy usage during the cooling season but may have the opposite effect for heating loads. Balancing these competing variables is a complex and critical design consideration that is specific to the building, its geographic location and climate, and the relative cost to heat and cool the building. Additionally, a cool roof may help reduce peak power demand, which is a significant concern in some regions. The lower roof surface temperature may also promote a longer roof service life.

### **Insulation**

Attic insulation can be used in lieu of, or in addition to, highly reflective roof surfaces. Insulation is often used as an alternative to cool roofing when estimating building energy usage. A major advantage of insulation is that it works well in both cooling and heating climates. It can help mitigate potential heating penalties in cool climates to reduce energy usage throughout the year. Another advantage is that it does not require cleaning over its lifetime. Additionally, insulation for a steep-slope roof can usually be added without replacing the roof.

### **Attic Ventilation**

Ventilation of attics and enclosed rafter spaces is another technique to reduce heat transfer from the roof system into the conditioned building space. Proper ventilation of these spaces can reduce air conditioning energy usage and improve occupant comfort when air conditioning

is not available.<sup>4</sup> Ventilation reduces the temperature of attics and helps to prevent moisture from being trapped in the attic space. A properly designed roof ventilation system keeps air moving from the eaves to the ridge, where warm attic air is exhausted. The movement of air yields improvements in cooling energy consumption by keeping the attic temperature closer to the outside air temperature and prevents moisture from becoming trapped in and prematurely deteriorating the roof deck and structural wood members. In cold climates, proper ventilation can help prevent formation of ice dams.

### **Sealed and Insulated HVAC Ducts**

Placement of heating and air conditioning ducts in unconditioned spaces such as attics or crawl spaces is a common construction practice in many geographic regions. Significant energy savings can be achieved by ensuring these ducts are properly sealed and insulated.<sup>5</sup>

### **Air Barriers**

Migration of air from the conditioned space of the building into an unconditioned space, such as an attic, reduces energy efficiency and may increase heating and cooling demands. Sealing attic floor penetrations is one simple and straightforward option that can have a significant impact by reducing air transfer between conditioned and unconditioned spaces.<sup>6</sup>

### **Radiant Barriers**

Research has shown that the use of a radiant barrier can reduce the peak day heat transfer and, depending on the attic configuration, can yield year-round energy savings.<sup>7</sup> In cool climates, however, it's usually more cost-effective to install more thermal insulation than to add a radiant barrier. Additionally, the effectiveness of a radiant barrier is affected by its location within the roof system, whether there are ducts in the attic, whether the ducts are sealed and insulated, as well as other factors (e.g., space constraints, storage containers covering the barrier). Finally,

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<sup>4</sup> Yongcai Li, Xiaohan Ta, Yaqin Zhang, and Wuyan Li, "Combining Use of Natural Ventilation, External Shading, Cool Roof and Thermal Mass to Improve Indoor Thermal Environment: Field Measurements and Simulation Study," *Journal of Building Engineering* 86 (2024).

<sup>5</sup> "Minimizing Energy Losses in Ducts," U.S. Department of Energy, accessed February 4, 2026, <https://www.energy.gov/energysaver/minimizing-energy-losses-ducts>.

<sup>6</sup> Joseph Lstiburek, "Guide to Attic Air Sealing: Identifying and Blocking Air Leakage Pathways Providing Airtight Closure," Building Science Corporation (Somerville, MA), [https://buildingscience.com/sites/default/files/migrate/pdf/GM\\_Attic\\_Air\\_Sealing\\_Guide\\_and\\_Details.pdf](https://buildingscience.com/sites/default/files/migrate/pdf/GM_Attic_Air_Sealing_Guide_and_Details.pdf).

<sup>7</sup> Therese Stovall, Som Shrestha, Rao V. Arimilli, David W. Yarbrough, and Thomas Pearson, "Analysis in Support of the Radiant Barrier Fact Sheet 2010 Update," *ASHRAE* 2010, [https://web.ornl.gov/sci/buildings/conf-archive/2010%20B11%20papers/141\\_Stovall.pdf](https://web.ornl.gov/sci/buildings/conf-archive/2010%20B11%20papers/141_Stovall.pdf).

use of a radiant barrier may increase the average temperature of the asphalt roof covering, which may have a detrimental effect on durability of the product.<sup>8</sup>

### **Glazing and Skylights**

Glazing elements have a significant impact on building energy efficiency, and their proper selection is an important design consideration. Not only must the properties of these elements be considered, but proper installation and integration with other building envelope elements is necessary to ensure that the desired performance is achieved. Many windows are independently rated for energy efficiency following standards of the National Fenestration Rating Council (NFRC).<sup>9</sup>

### **Vegetative Roof Systems**

While infrequently used with steep-slope roofs, vegetative roof systems are a potential alternative steep-slope roof system.

Vegetative roofs are potential energy savers, but the degree to which they do so is highly dependent upon climate conditions and the insulation level of the underlying roof. For the most part, vegetative roofs have very little impact on building energy consumption for a new building built with insulation levels prescribed by current energy codes. Some retrofit applications, however, can result in non-trivial savings of both air-conditioning and heating costs. Vegetative roofs may provide significant cooling savings in the summer and some heating savings in the winter.<sup>10</sup> But the research to date is not clear on the subject of the quantification of savings in real-world applications

If a vegetative roof system is used, the other structures and systems within the building, such as ventilation and roof drainage need to be specifically designed to work in conjunction with a vegetative roof system. In many cases, it will be impractical to add a vegetative roof system to an existing building.

### **Cool Walls**

In climates where energy consumption is dominated by building cooling, reflective (cool) exterior walls may reduce energy usage. This is a relatively new consideration and estimates of the magnitude of energy savings vary widely.

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<sup>8</sup> Joseph Lstiburek, "Understanding Attic Ventilation," Building Science Digest 102, Ventilation," Building Science Digest, 102 (2006), <https://buildingscience.com/documents/digests/bsd-102-understanding-attic-ventilation>.

<sup>9</sup> "Energy Performance Ratings for Windows, Doors, and Skylights," U.S. Department of Energy, accessed February 6, 2026, <https://energy.gov/energysaver/energy-performance-ratings-windows-doors-and-skylights>.

<sup>10</sup> "Extensive Vegetative Roofs," Whole Building Design Guide, National Institute of Building Sciences, accessed February 6, 2026, <https://wbdg.org/resources/extensive-vegetative-roofs>.

## **BENEFITS BEYOND THE BUILDING**

When properly utilized, both cool roofs and the other building features discussed previously may offer benefits beyond the building.

### **Improve Energy Efficiency**

Reductions of total energy consumption and peak energy demand improve energy grid capacity and stability. These benefits may postpone or avoid construction of additional generating capacity and may also provide cost savings associated with the higher cost of supplemental energy.

### **Reduce Urban Heat Island (UHI) Effect**

A localized temperature increase in an area with a high concentration of surfaces that absorb and retain solar energy (e.g., building roofs and walls, streets, sidewalks) is referred to as the “urban heat island effect.” Cool roofs are a viable option to help address this issue. By reflecting a portion of incoming solar energy, cool roofs reduce the heat gain of the roofing surface, resulting in less localized temperature increase. Vegetative roofs provide UHI mitigation in multiple ways. Other approaches to improving energy efficiency (e.g., insulation, ventilation, envelope sealing) can help mitigate urban heat islands as well, primarily by reducing operating demands on HVAC equipment. This reduces the amount of elevated temperature exhaust air released into the local environment.

### **Improve Occupant Health and Comfort**

For buildings without cooling in hot climates, cool roofs help keep the top floor of a building at a lower temperature, which has a positive effect on occupant health and comfort. Insulation may provide a similar effect.

### **Reduce Greenhouse Gas Generation**

Any building enhancement that reduces building energy use can contribute to a reduction in greenhouse gas generation. However, the magnitude of this benefit depends directly on the fuels used to cool and heat the building. In areas where utilities generate energy primarily from fuel combustion, energy efficiency improvements, including cool roofs, may help reduce greenhouse gas generation. This may not be the case if energy is generated using methods that do not produce greenhouse gases (e.g., wind, solar, hydroelectric).

## **Offset Carbon Dioxide**

Cool roofs have been shown as one mechanism to offset carbon dioxide emissions and potentially delay climate change.<sup>11,12,13</sup>

## **Improve Roof Durability**

By design, reflective asphalt shingles reflect solar energy away from the roof surface, leading to a reduction in the average surface temperature of the shingles. Since heat is one factor that accelerates shingle aging, the reduction in surface temperature is expected to have a positive—although possibly not easily measurable—impact on asphalt shingle durability.

## **COOL ROOF LIMITATIONS AND UNINTENDED CONSEQUENCES**

While cool roofs may offer immediate and long-term savings in building energy consumption and costs, as well as environmental benefits, there are potential drawbacks to consider.

### **Potential Loss of Reflectivity**

Cool roofs may be more likely to show dirt, algae and stains than traditional asphalt shingles due to their typically lighter color and may require cleaning and maintenance to retain their high reflectivity. If it is not properly performed, cleaning can damage the roofing products. To address this issue, many reflective asphalt shingles are formulated to resist algae growth to help maintain their reflective quality even in humid climates.

### **Potential Winter Heating Penalty**

Recent research has confirmed that the use of cool roofs can result in an increase in total energy consumption as a result of increased energy consumption for heating the building (winter heating penalty).<sup>14</sup> This can be substantial and can increase energy usage even in the moderate climate associated with DOE/ASHRAE Climate Zone 4. Baltimore, St. Louis, and Portland are examples of major metropolitan areas in Climate Zone 4. The magnitude of the increased energy usage is expected to be greater in cooler climates (Climate Zones 5 through 8). The potential for and magnitude of increased energy usage for winter heating depends upon climatic circumstances, as well as other building features and components, such as the amount

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<sup>11</sup> H. Akbari, S. Menon, and A. Rosenfeld, "Global Cooling: Increasing World-wide Urban Albedos to Offset CO<sub>2</sub>," *Climatic Change* 94, 275-286 (2009), <https://doi.org/10.1007/s10584-008-9515-9>.

<sup>12</sup> K.W. Oleson, G.B. Bonan, and J. Feddema, "Effects of White Roofs on Urban Temperature in a Global Climate Model," *Geophysical Research Letters* 37:3 (2010), <https://doi.org/10.1029/2009GL042194>.

<sup>13</sup> "Cool Science," Heat Island Group, Lawrence Berkeley National Laboratory, accessed June 3, 2026, <https://heatisland.lbl.gov/coolscience/cool-roofs>.

<sup>14</sup> Niraj Kunwar, André Desjarlais, Som Shrestha, Stacey Weister, and Jeffrey Steuben, "Retrofitting Buildings with Solar-Reflective Roofs and Exterior Walls and their Impact on Energy Savings and Peak Power Demand," U.S. Department of Energy (2024), <https://doi.org/10.2172/2324016>.

of insulation and style of the building. Once again, the whole building approach needs to be considered.

### **Geoengineering**

Increasing the reflectivity of the built environment is a form of geoengineering intended to reduce the average temperature of the planet, and cool roofs can play a part in this effort. However, application of this concept on a wide scale raises serious questions about unintended consequences that continue to be discussed in research literature<sup>15</sup> and are beyond the scope of this paper to address.

### **Potential Impact on Adjacent Surfaces and Buildings**

Prior to installation of a cool roof, consider the potential effect on adjacent surfaces or buildings that will be exposed to concentrated reflected heat. This reflected heat has been shown to increase the temperature of surrounding building surfaces and may damage or accelerate the aging of materials such as plastics, masonry and rooftop equipment.<sup>16</sup> The same higher reflectivity may affect occupants of nearby buildings by reflecting light into the interior of adjacent buildings.<sup>17</sup>

### **Moisture Condensation and Accumulation**

Another issue is the potential for moisture condensation within the roof assembly, which is a special concern when replacing an existing roof with a more reflective roof. The lower surface temperature of cool roofs reduces heat transmission into the roof assembly relative to traditional roofing materials. This leads to an increased risk of moisture accumulation within the roof assembly, especially in cooler climates, because there is less heat available to dry out roof assembly materials.<sup>18,19</sup> "If a reflective cool roof is designed for a temperate or cold

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<sup>15</sup> Yu Cheng and Kaighin A. McColl, "Unexpected Warming From Land Radiative Management," *Geophysical Research Letters*, 51:22 (2024), <https://doi.org/10.1029/2024GL112433>.

<sup>16</sup> Elizabeth J. Grant, Kenneth A. Black, and Stephen R. Were, "The Influence of Roof Reflectivity on Adjacent Air and Surface Temperatures," *Architectural Science Review* 60:2 (2017), <https://www.tandfonline.com/eprint/abUI5JS65apniscUTEJe/full>.

<sup>17</sup> "Cool Science," Heat Island Group, Lawrence Berkeley National Laboratory, accessed March 30, 2026, <https://heatisland.lbl.gov/coolscience/cool-roofs>.

<sup>18</sup> Bryan Urban and Kurt Roth, "Guidelines for Selecting Cool Roofs," U.S. Department of Energy (2010).

<sup>19</sup> Chetan Aggarwal and Sudhakar Molleti, "State-of-the-Art Review: Effects of Using Cool Building Cladding Materials on Roofs," *Buildings* 14:8 (2024), <https://www.mdpi.com/2075-5309/14/8/2257>.

climate, its moisture behavior should be analyzed by hygrothermal simulations in order to avoid critical water content in the construction.”<sup>20</sup>

Balancing these potentially competing variables, limitations, and unintended consequences is a complex and critical design consideration that is specific to the building, its geographic location, and the relative cost to heat and cool the building. A combination of features and options may provide the best design solution. As an example, cool roofing is an excellent choice to reduce building cooling needs resulting from solar heat gain but is an incomplete solution in climates where heating costs predominate. Combining reflective roofing with insulation is one approach that may be more appropriate. Once again, the whole building needs to be considered.

### **RESPONSIBILITY AND CONSUMER CHOICE**

Cool roofs are required by code or regulation in some jurisdictions. In others, incentive programs are used to drive consumers to choose cool roofs. In many cases, third-party verification of product solar reflectance and thermal emittance is specifically required by these programs. Unfortunately, some jurisdictions (e.g., California) have limited this verification function to a single organization. Allowing competition in the third-party verification arena will positively affect the cost of compliance. ARMA encourages and supports the availability of multiple verification agencies.

Importantly, ARMA believes that the cost of a cool roof must not outweigh its benefits over its lifetime. Building owners and consumers selecting cool roofing options must be confident in the economic value initially and over time.

In some cases, energy efficiency goals are not computed solely based on cost effectiveness but may include the consideration of social goals such as reducing greenhouse gas emissions. Society has limited resources to address issues like reducing greenhouse gas emissions, and it makes sense to consider the tradeoffs and alternatives of the whole building approach to achieve these broader goals in the most effective manner.

### **CONCLUSION**

While a roof’s primary function is to keep water out of the building, today’s environmentally conscious agencies and consumers have made “cool” an increasingly important consideration in the roof selection process. Some groups are promoting cool roofs as the best solution to

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<sup>20</sup> Christian Bludau, Daniel Zirkelbach, and Hartwig M. Künzle, “Condensation Problems in Cool Roofs,” 11th International Conference on Durability of Building Materials and Components – Globality and Locality in Durability (2008).

achieve energy efficiency and environmental goals for buildings. ARMA recommends consideration of the potential benefits, limitations, and unintended consequences of all cool roof options when making roof selection decisions and encourages designers to remember that a combination of strategies may provide the most suitable option. Finally, ARMA believes the best solution will be achieved when cool roofs are recognized as but one option within the “whole building approach” that is available to accomplish energy efficiency and environmental goals.

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*The Asphalt Roofing Manufacturers Association (ARMA) is the trade association representing North America’s asphalt roofing manufacturing companies and their raw material suppliers. Committed to advances in asphalt roofing, ARMA produces white papers and technical bulletins to educate consumers and industry stakeholders about the benefits of asphalt as the roofing solution.*

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