



# Maximizing the Value From Commercial Roof Systems

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**An Industry Report**

August 2013

Building owners know that their roof is a major investment spanning a long period of time. They also know that the return on their investment depends on a number of factors, including:

- Warranty
- Durability and service life
- Suitability for the building type and climate
- Design and construction
- Maintenance and repair requirements
- Life cycle costs (initial, maintenance, demolition/recycling/disposal, business disruption)
- Energy and environmental performance

A high return from a roof investment comes from optimizing all factors rather than focusing on only a few to the exclusion of others. For example, if primary importance is assigned to the choice of reflective versus nonreflective roofing, then insulation factors with a greater potential impact on performance and lifetime cost can be overlooked. Selecting a roof system is not a black or white decision.

Because a commercial roof is a system of interdependent components, owners should draw on technical expertise to assess a variety of factors. This report will focus on four considerations: 1) condensation risk, 2) insulation values, 3) energy and environmental performance, and 4) maintenance and service life.

## Condensation Risk

We tend to think of roofs primarily as barriers to conditions outside of a building, but they are also barriers to conditions *inside*. This function has significant impacts for the life cycle costs of roofing systems.

For example, buildings with relatively high indoor moisture and large amounts of indoor air moving upward by the stack effect into the roof assembly may be especially prone to condensation. In turn, the condensation can produce wet and moldy roof insulation and deck, leading to costly and premature replacement, especially if a vapor barrier is not correctly specified and installed.

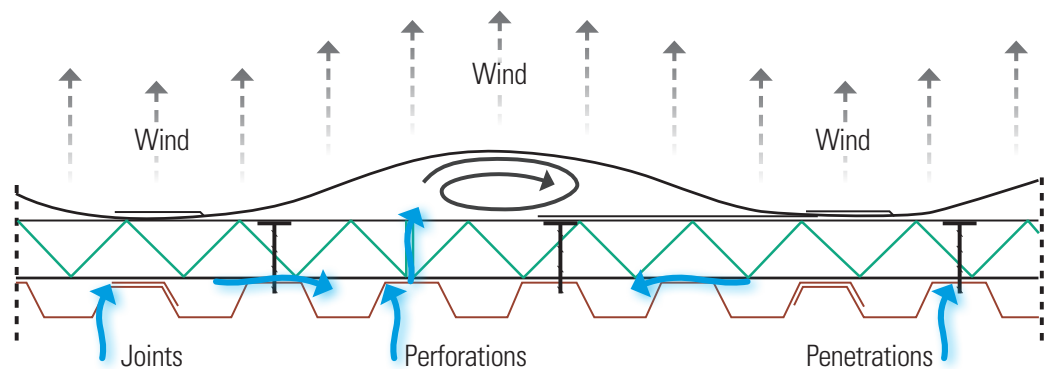
A paper<sup>1</sup> by Manfred Kehrer, senior researcher at the Oak Ridge National Laboratory, and Simon Pallin, of the Chalmers University of Technology in Sweden, describes several factors that can increase the risk of condensation, including roof reflectivity and attachment method. Cool, reflective roofs absorb less sunlight than dark, nonreflective roofs. As a result, reflective roofs have a cooler temperature at night, increasing the possibility of nighttime condensation. The researchers found that a cool roof accumulates approximately twice the moisture below the surface membrane as a black surface.

In cold climates, reflective roofs with mechanical attachments may have an even higher risk of condensation. Penetrations can allow larger volumes of moist indoor air to intrude into the roof components under the membrane.

Kehrer and Pallin also cite research indicating that thermoplastic membranes (PVC, TPO) are prone to indoor air intrusion because the flexibility of the membrane allows a kind of billowing lift that increases the space where moisture can condense. Wind forces that create a fluttering effect, even on roofs properly sealed to the outside, can enlarge the space where moisture can condense under the membrane (see diagram below).

The researchers conclude that climate, solar radiation on the roof surface, indoor moisture levels, and indoor air intrusion should all be evaluated for their impact on condensation risk.

## Indoor Air Intrusion



## Insulation Values

Roof insulation plays a key role in energy efficiency, a fact reflected in codes and standards that have mandated increasingly higher minimum R-values for U.S. climate zones. *ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings*, has steadily increased insulation R-values for all U.S. climate zones through its 2004, 2007 and 2013 [to be published October 2013] editions (see charts). *ASHRAE Standard 189.1, Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*, mandates R-values that are similar to the latest version of *Standard 90.1*. For many buildings, the insulation value has a greater impact on both energy efficiency and sustainability than the choice between a white roof or a black roof.

Despite insulation's importance, minimum R-values alone do not ensure a given performance level due to the interdependent components in a system. For example, design and construction details have a direct impact on thermal performance. If thermal

bridging occurs at insulation joints or at penetrations for mechanical roof attachments, the overall R-value can be less than the minimum required by code.

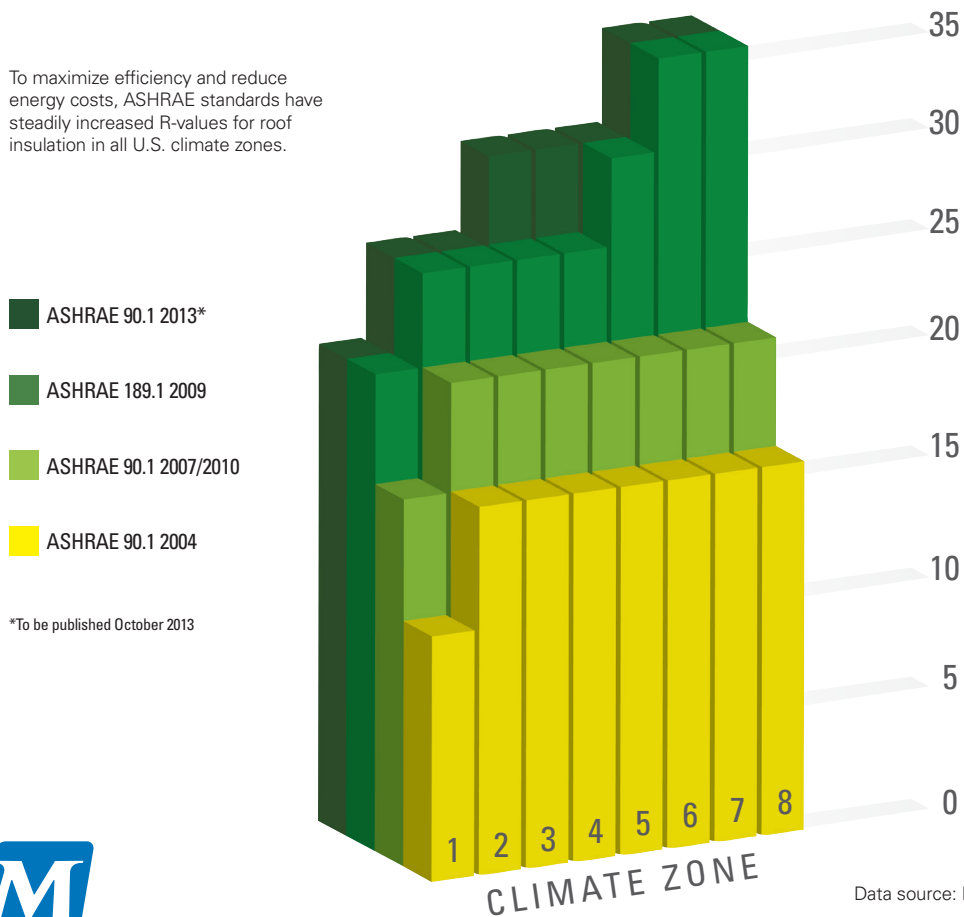
Building owners should also recognize that applying code R-values to insulation without assessing other system components will not lead to optimal performance.

"Insulation is a benefit in all climate zones and it works throughout the life of the roof," says Diana Fisler, Ph.D., environmental construction platform leader for Johns Manville. "Before assessing the relative benefits of white and black roofs, building owners should ensure that insulation values are up to the code's minimum or higher."

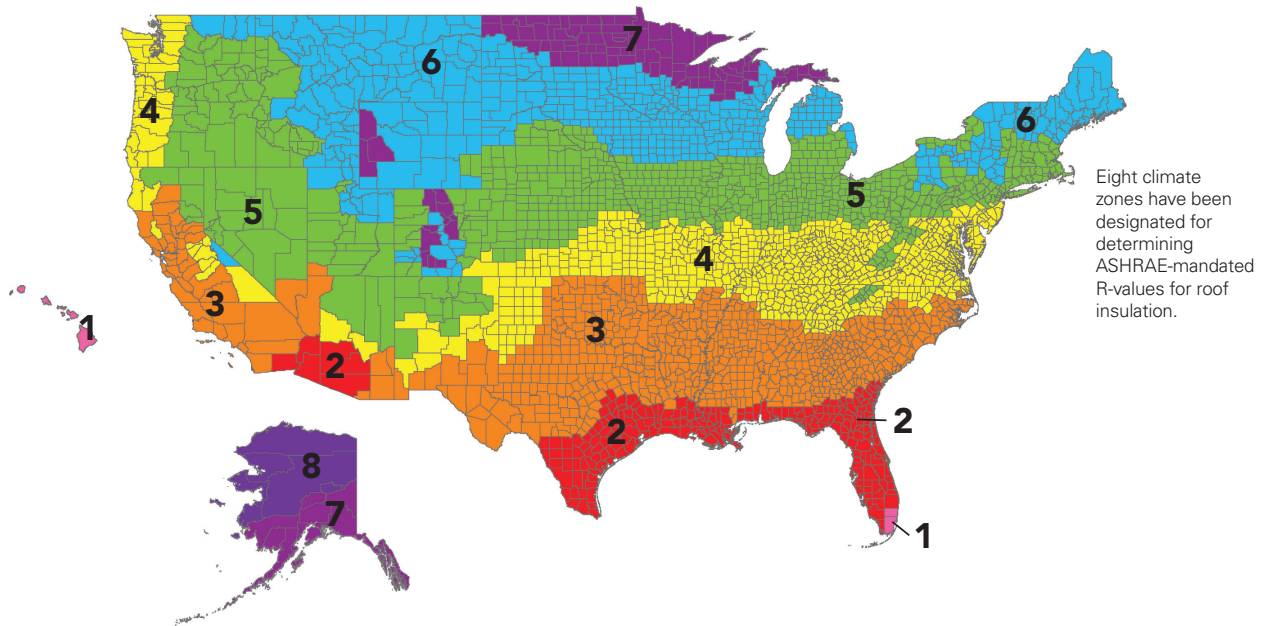
## Energy and Environmental Performance

Durability and service life are significant factors in environmental life cycle analysis. On one level, the service life will determine the period of time before

The Evolution of ASHRAE Insulation Values  
Above deck R-value by zone



## ASHRAE Climate Zones



the environmental impacts of demolition, disposal and replacement occur. For example, an average commercial roof is 300 squares (30,000 ft<sup>2</sup>) and ranges in weight from 100 pounds/square foot (single ply) to 700 pounds/square foot (bituminous, the greater weight of which usually corresponds to greater durability). Membrane removal sends anywhere from 15 to 100 tons of material to a landfill.

The materials used in the roofing system, its manufacture, and its transport also have environmental impacts. Finally, the roof has a variety of energy characteristics. The interaction of all these factors must be assessed in order to optimize roof performance.

A new model developed by the nonprofit Center for Environmental Innovation in Roofing is an example of a tool designed to assess multiple factors.<sup>2</sup> The RoofPoint Guideline uses energy credits as a basis for measuring a roof's impact on three outcomes:

- 1) Net energy savings (insulation, thermal bridges, air and vapor movement, and climate appropriateness)
- 2) Peak energy demand reduction (ability to reduce energy for air conditioning through cool roof strategies)
- 3) Renewable energy production (rooftop PV, skylights, daylighting).

Assessing *net* energy savings versus *peak* energy

savings is important because roofs with the same thermal value but different reflectivity values will have different impacts on energy costs for space heating and cooling. In particular, the savings for cool roofs during periods of peak energy demand are comparatively constant across all climate zones. However, the net energy savings for cool roofs can decline quickly in cooler zones and even become negative, according to Fislser.

"Cool roofs have benefits in hot regions like climate zones 1 and 2, but the benefits diminish steadily in increasingly cooler zones," she says.

Although the performance of cool roofs in northern climates is usually predicted by models and calculations, there are also studies that have compared the real-world performance of reflective and nonreflective roofs in cooler climate zones. For example, a study done on identical buildings at a correctional facility in central New York state found no annual energy benefit associated with a reflective roof in zone 4.<sup>3</sup>

### Maintenance and Service Life

Subject to wind, rain, hail, snow, sleet and UV radiation, the roof may be the most vulnerable component of your building. Clearly, good maintenance and repair procedures have an impact on service life.

It is also important to recognize that the various components of the roof system require different maintenance procedures. For example, insulation in a weather-tight roof system should require no maintenance.

“It is good practice to bring the roof insulation up to current code, which can be done by leaving the old, undamaged insulation in place and adding more layers of polyiso,” says Amy Ferryman, Ph.D., sustainability scientist for Johns Manville.

In order to maximize a roof system’s service life, non-roof maintenance must also be considered. For example, window washing and HVAC maintenance involve foot traffic that can be more damaging to a roof membrane than weathering. White roofs that require cleaning to maintain their reflectivity will also increase foot traffic, Ferryman notes.

Building owners should ensure that suppliers include walkways or pavers as necessary to protect the

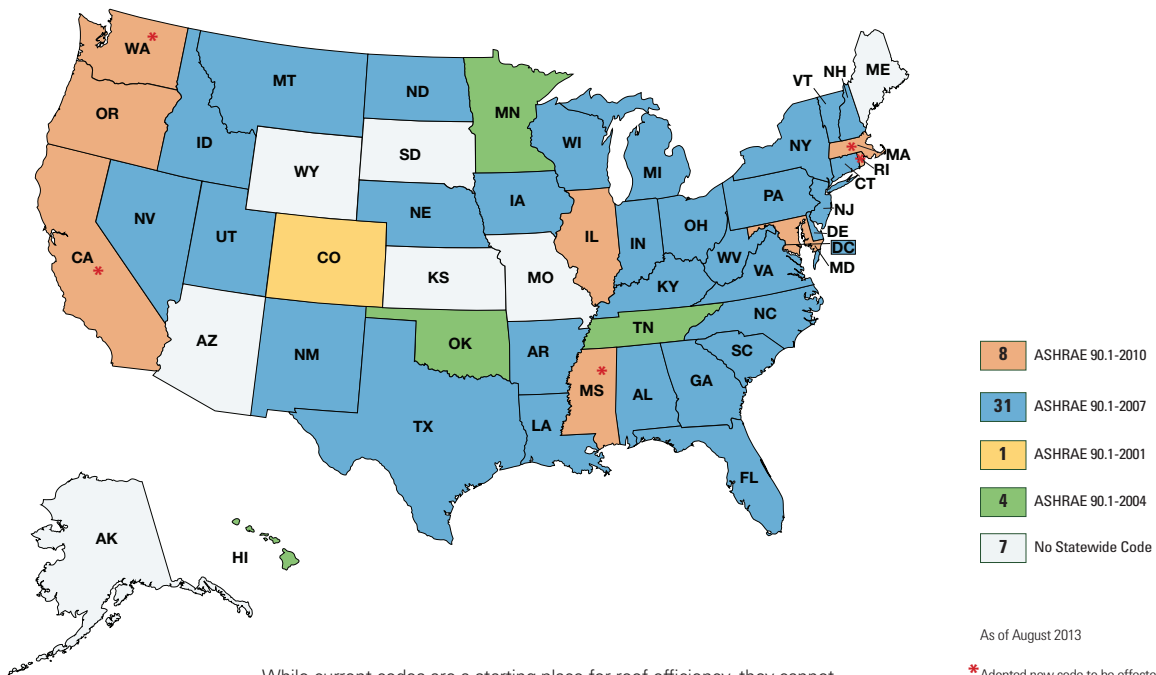
roof. Suppliers should also provide information about maintenance requirements for all system components.

## Conclusion

The greatest return on a roofing investment comes from optimizing the interaction of system components for a given building and climate zone. Because there is no single solution, the roofing industry offers many choices—including white, black, single ply and bituminous systems.

When making a decision on roofing, building owners should ensure that their suppliers have the necessary technical expertise to assess the component interactions that determine service life, sustainability, and life cycle cost. Owners should also ensure that their system is designed by a certified roofing designer or architect and installed by a qualified roofing contractor.

## Current State Code Adoption



While current codes are a starting place for roof efficiency, they cannot ensure maximum performance for a given building and location.

## REFERENCES

- <sup>1</sup> Kehrer, Manfred and Pallin, Simon, *Condensation Risk of Mechanically Attached Roof Systems in Cold Climate Zones*. Paper presented at the RCI 28th International Convention & Trade Show, 2013, Orlando, FL.
- <sup>2</sup> Hoff, James, *Measuring Energy and Environmental Impacts: A New Modeling Tool for Roofing Professionals*. Paper presented at the RCI 28th International Convention & Trade Show, 2013, Orlando, FL.
- <sup>3</sup> *Comparative Roof Testing at Onondaga County Correctional Facility*. A study submitted by CDH Energy Corp. and Ashley-McGraw Architects, PC, to the Onondaga County Dept. of Correction, Jamesville, NY, 2011.

