

Improving Building Energy Efficiency with Metal Roofs and Walls

This paper is intended to provide an overview of how metal roofs and walls can improve the energy efficiency in new and existing commercial properties. The information in this document is based on an AIA/CES-approved course that also is approved by USGBC for 1 GBCI CE Hour for the LEED Credentialing Maintenance Program (CMP).

The practice of using the energy, water and materials more efficiently in all phases of commercial building construction has grown dramatically in the last decade. This process, referred to as green building, has shown a positive effect on the planet, people and profit. People living and working in green buildings tend to be healthier and more productive. A green building has low maintenance, reduced operating costs, and less carbon emission, which reduces the building's environmental impact.

In the last six years, the number of buildings incorporating green or sustainable building practices has quadrupled. Today, more than 50 percent of building owners, architects, engineers and contractors now consistently use green building methods.

One of the primary reasons for this phenomenon is our nation's energy situation. The United States currently uses nearly 25 percent of the world's energy. The electricity usage level is expected to grow by more than 1 percent annually so that by 2030 our nation's electricity demand will be 45 percent greater than it is today.

According to the Nuclear Energy Institute, the United States will need to build 50 more nuclear plants, 260 coal-fired plants, 280 natural gas-fired plants and 90 renewable energy plants to meet this increase. Although renewable energy plants are the least expensive to build, a faster, more reliable method to solving this dilemma is to use "the other fuel" -- energy conservation. This has begun to happen as more utilities offer rebates to keep demand low and eliminate the need to build new power plants.

Although a lot of emphasis has been put on reducing fuel usage and emissions in transportation, the building sector is really in the best position to help reduce energy use. Buildings account for

consumption of 39 percent of our nation's energy and 71 percent of its electricity. Many building owners have already taken steps to reduce their energy consumption by incorporating metal roofs and walls into existing buildings and new projects.

A new roof is the ideal place to start that process. Often the roof is the least energy efficient part of a building envelope with R-values frequently as low as R-5 or R-10. According to Oak Ridge National Laboratory, 1/3 of a building's energy is used for heating and cooling and half of that is attributable to heated or cooled air lost through the roof.

Cool metal roofing is a viable solution that offers enormous economic and environmental benefits. It conserves utility use by helping to cool buildings naturally in warmer climates and temperatures. This saves on building operating costs and reduces peak demand for utilities. Cool metal roofing can also mitigate the urban heat island effect, especially in larger cities. Plus, metal roofs have high recycled content and are completely recyclable.

Cool Roofing Guidelines

Because of the many color and style options offered by cool roofing, the design professional can incorporate cool metal roofs into all types of structures. Metal roofs can be used on low slope roofs, which are those with a slope from ¼:12 to 2:12. They also work well for roofs with a steep slope that is 2:12 or greater.

In making decisions about roofing, the building owner and the design professional must first consider what will occur on the building's surface. This involves three primary components of the solar energy spectrum: ultraviolet (UV) rays, which account for only 3% of the total energy striking the earth's surface; visible light (VIS) which is about 40% of the total energy; and infrared (IR), which is the largest of the three at 57%. Although we cannot see the affects of IR, we can feel it as heat.

ROOF CATEGORIES

- **Steep Slope**
Used on roof pitches of 2:12 or greater



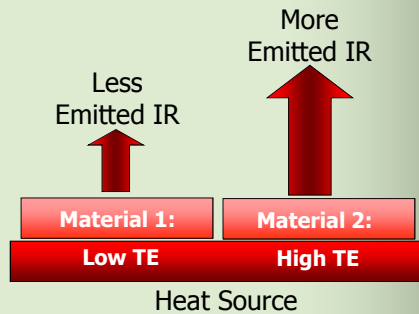
Solar reflectance is one of the important terms used in discussing cool roofing. It describes the portion of solar radiation immediately reflected from a surface and is reported as a decimal or a percentage. The reflectance from a painted metal surface depends on the color and pigmentation used in the coating. Any energy not immediately reflected away will be absorbed by the roof or wall surface, causing it to heat. Some of the heat is removed by air flowing over the surface during the day and some is emitted as thermal infrared energy into the night air. Some heat can be removed through conductive heating to the space below.

The heat energy absorbed in the night air is called thermal emittance and is expressed as a decimal. Materials with high emittance will cool down faster than those with low thermal emittance.

The premise of cool roofing is to find the best combination of solar reflectance and thermal emittance that will keep the surface temperature low enough to be considered “cool.”

THERMAL EMITTANCE

- Percent of absorbed heat energy **emitted** from the surface to the night air.
- Expressed as decimal (0.90).
- Materials with high thermal emittance cool down faster than those with low thermal emittance.



When applying these calculations to metal roofing, designers and owners need to consider whether the surface is painted or unpainted. In broad terms, unpainted or natural metal has low thermal emittance and high reflectance.

When a paint finish is applied through coil coating the characteristics are dictated by the paint formula. This can increase the thermal emittance to .80 or more depending on the coating. Most prepainted roofs are highly reflective and highly emissive, which significantly reduces heat gain into the building.

Cool roofing cannot be defined without taking reflectance and emittance into consideration. For example, in a test comparison of three roof types – a white non-metal roof, a black membrane and an unpainted metal roof – the white roof had a high solar reflectance level and thermal emittance; the black membrane had a much lower solar reflectance and high thermal emittance, giving it the highest heat gain; and the unpainted metal roof had high reflectance and low emittance.

To put this in usable terms, we refer to the Lawrence Berkeley National Laboratory's general rule that states for every 0.01 increment in roof reflectance, the surface temperature decreases by one degree Fahrenheit. For every 0.10 increase in the value of roof reflectance, the building's heating/cooling costs drop 2 cents per square foot per year. Although the figures vary by area, this guide helps building owners realize what can happen.

Building owners also enjoy the added benefit of extended performance from cool paint systems. Roof paint finishes usually are affected by heat, UV rays, and moisture. The coatings in cool roofs help lower the roof's temperature and reduce temperature fluctuation; this decreases expansion and contraction and therefore reduces wear and tear on the roof.

Color consideration is also important, especially with steep slope roofs. New infrared reflective pigments allow darker colors to reflect more solar energy than before without any change to the colors or costs of the systems. The same colors can now have higher reflectance when special infrared reflective pigments are added.



IMPACT OF COLOR

- Dark colors **absorb** more heat than light colors.
- Light colors **reflect** more heat than dark colors.
- **Suggests** color is indication of reflectivity.

Research

Cool roofing has been the subject of many different research studies involving Oak Ridge National Laboratory (ORNL), a facility of the Department of Energy. ORNL has compared the

weathering of low and steep sloped metal roofs in various colors over a 3-year period with other types of roof materials. From these findings ORNL created an energy savings model that uses a black roof as the benchmark and includes variables depending on the type of roof installed.

This has been turned into a calculator available for general use at www.eren.doe.gov/buildings. A new version of the calculator will be online by the 4th Quarter of 2010. By using it, designers and building owners can predict building cooling and heating savings based on different locations, climates, and different types of systems. For example, when three different systems in three different cities were evaluated, the calculator showed that painted roofs do not respond the same in all parts of the country. A painted roof in Phoenix had the highest reflectance and generated the highest savings, while an unpainted roof in Chicago had the lowest reflectance.

The most important value of the ORNL study is the comparison of metal with other types of roofing for degradation. This shows that over a three-year period a white painted roof can lose less than 5% of its solar reflectance because it sheds dirt more readily. A single ply membrane, however, loses more than 40% primarily because it retains dirt.

Incentives

In a crowded city environment an abundance of factors such as dark roads, large parking lots, high density of buildings, flat roofs, and less vegetation increase the ambient air temperature. This raises the demand for building air conditioning, which in turn affects the area's air quality. Taking steps to reduce the outside air temperature in these microclimates can help reduce smog and improve air quality.

Building owners who are creating more energy efficient buildings are often motivated by changes in building codes and standards, and rebates and incentives from utilities and government entities. More incentives exist for cool metal roofs and walls, so it's important to research what's available in each building's locale.

On the national level, the commercial building energy incentive for metal roofing in the Energy Policy Act of 2005 was extended to 2013 via the American Recovery and Re-Investment Act of 2009. This allows a tax deduction of up to \$1.80 per square foot if the building conserves

energy. It also identifies energy efficient building envelope components that fit the criteria; a cool roof is one of them.

Regionally, California has been the leader in this and other states are beginning to mimic its Title 24 programs. California's current Title 24 that went into effect in January 2010 now addresses residential and non-residential steep and low slope roofs and contains language specific to cool roof requirements. Compliance is driven by tying building permitting to meeting California's energy requirements. All building permits must include an energy budget that has a baseline value for all building components. It includes a cool roof value.

Because cool metal roofing reduces energy consumption and improves air quality by reducing heat island effect, it helps building owners comply with energy codes and qualify for tax deductions.

Engineering Options

Metal roofing offers a great deal of flexibility in the engineering, which allows designers and owners to achieve both design and performance objectives. The products can be engineered to perform optimally in different environments. In cooler climates where heating dominates, cool roofing objectives may be met with unpainted metal roofs. In warmer climates where high reflectance and emittance are desirable, a pre-painted metal roof is the best solution.

Another benefit of a metal roof is its excellent compatibility with solar energy systems. Solar panels can be mounted on a metal roof without penetrating the roof surface. Because metal is highly durable, it will outlast most solar systems that will degrade and wear out faster than the roof.

Wall Systems

Cool metal applications are not limited to roofing. The same paint systems used for cool roof systems are used for metal wall systems and these energy efficient wall systems are beginning to gain more visibility in the market. Energy provisions in codes and standards now also mention cool or energy efficient wall systems. The draft of ASHRAE's High Performance Building Standard, for example, contains provisions for cool metal wall systems.

Cool wall systems have also been tested by ORNL; preliminary results show a minimum of about a 10% reduction in cooling energy with some reductions as high as 20%. As the call for total building performance and Zero Energy buildings continues to increase, the use of metal wall systems also continues to grow.

Walls also can help achieve higher building performance when insulated metal panels (IMPs) are used. An IMP is a strong, single unit constructed of a rigid core of polyurethane or polyisocyanurate insulation foam adhered between two sheets of metal.

IMPs have proven to be sturdy, time saving building elements for more than 30 years, but the growing interest in improving building performance has brought IMPs to the forefront.

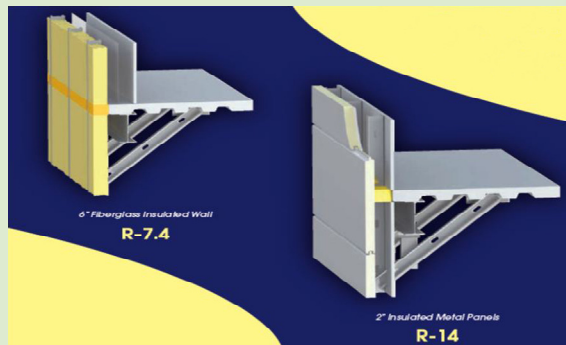
Although individual products have slight variations, all IMPs typically consist of an insulated core, metal skins for both exterior and interior walls, double tongue-and-groove joinery, and concealed clips and fasteners

IMPs are installed outside the metal stud cavity or other structural support mechanism. This minimizes thermal bridging while efficiently incorporating a water, air and vapor barrier with a single-unit wall assembly that eliminates the need for other materials and construction trade coordination. Normally, insulation placed within a building's stud cavity can be as little as 33 percent effective. In contrast, IMPs can provide up to 95 percent thermal efficiency. This high level of field performance is verified by their compliance with ASTM C-1363-05 dealing with thermal performance and ASTM C 518 related to steady-state thermal transmission properties.

IMPs also reduce airflow in and out of the building envelope, which helps improve HVAC performance. This enhancement may potentially qualify for up to 10 points for Optimized Energy Performance if the building is aiming for certification in the USGBC's LEED program. IMPs also help the environment by reducing or eliminating field cutting and material waste.

INSULATED METAL PANELS

- In commercial applications, **3-inch-thick panel** meets most buildings' insulating requirements.



IMPs can be made in various widths and thicknesses, in curved and formed shapes, and a wide selection of high performance coatings or surface textures. They also can be applied horizontally and vertically. For designers and building owners, this means unlimited design options along with the highest insulating value per inch of any wall on the market today. The most widely used IMPs range from 1 to 4 inches thick, but manufacturers can provide panels up to 10 inches thick.

Sustainability

Beyond the multitude of applications for metal are the environmental aspects of the basic material. Metal roofs and walls have high recycled content, and are recyclable or reusable at the end of the building's useful life. This lowers the demand for raw materials and reduces construction waste. Steel, for example, is the most recyclable material on the planet.

Metal roofs are also designed to last between 30 and 50 years, depending on the substrates, paints and coatings. Natural metals such as zinc and copper that have no added exterior paint or coating will form a natural patina that inherently protects the surface and maintains its aesthetic appeal.

Good air quality is also ensured with metal roofs and walls because they are inert and do not create off-gassing or VOCs. This helps mitigate the heat island effect and reduce smog.

Metal roofs can also be installed over old flat roofs. This eliminates putting the existing roof material into the landfill and can create a ventilation cavity to help cool the building. This above sheathing ventilation (ASV) creates a chimney effect that can be used to vent out heated air through ridge vents or direct it down for heating air spaces as needed. Because any heat is dissipated out through the air space it also removes excess moisture and in cool weather blocks heat loss out of the space. This works especially well in areas that experience both warm and cool temperatures because it can yield energy savings throughout the year. With ASV, the heat is dissipated out through the air space in hot weather, and in cold weather the air space acts as added insulation to prevent heat loss.

The benefits of ASV combined with cool metal roof surfaces have been documented by ORNL in studies that show ASV can help reduce heat gain through the roof assembly by up to 45%.

Benefits in LEED

For projects that are seeking certification in the USGBC's LEED program, metal roof and wall components can qualify for specific points in this process.

A cool metal roof can qualify for a LEED point under Sustainable Site Credit 7.2, Heat Island Effect-Roof if the roof meets minimum solar reflectance index (SRI) values and covers a minimum of 75% of the roof surface area. A low slope roof (<2:12) must have a minimum SRI of 78; a steep slope roof (>2:12) must have a minimum SRI of 29. To qualify for these SRI values, prepainted metal roofs must have a reflectance of 66% or greater for a low slope and 30% or greater for a steep slope.

Typically the metal used in roof and wall installations contains at least 25% recycled content and up to 80% depending on the metal and how much scrap content it has. This can raise the building's overall average recycled content and help qualify for up to 2 LEED points under Material and Resources Credit 4, Recycled Content.

Additionally, the steel, aluminum, copper and zinc in metal panels is 100% recyclable at the end of the building's service life. This can qualify for up to 2 LEED points under Materials and Resources Credit 2, Construction Waste Management.

When a building is renovated, an existing metal roof can help qualify for up to 2 LEED points under Materials and Resources Credit 1.1, Building Reuse.

Metal roofs also help improve water efficiency in buildings. Because water easily drains off the roof surface, they are excellent for rainwater catchment. This allows the building to capture and reuse rainwater inside the building or for landscape irrigation. This can qualify for up to 7 LEED points under the Water Efficiency Credits 1, 2, and 3.

Cool metal roofs and IMPs are also part of the energy simulation calculations and can qualify for LEED points under Energy and Atmosphere Credits, Optimize Energy Performance.

All members of the metal industries are working on the embodied energy in cool roofs and are updating this information to provide a more accurate representation of LCA calculations.

Summary

Metal roofs and walls offer an unbeatable level of environmental performance and aesthetic appeal. They are sustainable, have low impact on the environment, reduce solid waste in construction, help reduce energy usage in all climates, and improve the air quality and water efficiency in buildings and their surroundings. They can be applied to all types of buildings in any climate and offer designers and building owners a variety of visible options and behind the scene operating benefits.