TECHNICAL BULLETINS

steelscape

2017 I Rev 1

This issue supersedes all previous issues

Index of Sustainability Technical Bulletins

For more information or other questions not addressed by these bulletins please contact Steelscape's Technical Service Department or your Steelscape Account Manager.

TECHNICAL BULLETIN 1

steelscape

August 2017 I Rev 1

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SUSTAINABILITY

Zero-Carbon and Carbon Neutral Developments

Steelscape has made a commitment to continually improve the company's environmental footprint and the sustainability of its products and services.

This is the first in a series of technical bulletins relating to sustainability issues that directly or indirectly impact the steel value chain. In writing these bulletins Steelscape wishes to inform and educate the market based on the latest available and verifiable information.

INTRODUCTION

As the consequences of climate change become both better understood and more apparent, policy makers and consumers are demanding innovative strategies to reduce carbon dioxide (CO_2) emissions. Zero-carbon and carbon neutral developments are, therefore, becoming more popular and entrenched in legislation. However, the definitions of, and differences between, zero-carbon and carbon neutral remain unclear. The two terms are often used interchangeably and can be confounded by concepts of green design and sustainability. Therefore, there are uncertainties - as well as opportunities - for businesses and industry.

Definitions and Differentiation

There are three important points to note regarding the concepts of zero-carbon and carbon neutral developments, whether dealing with individual buildings or whole communities.

First, there is a subtle but important difference between what zero-carbon and carbon neutral actually mean. Zero-carbon implies that the operation of development does not produce CO_2 emissions. By contrast, emissions produced from the operation of a carbon neutral building are offset. It is the intent of the carbon neutral concept that the building also produce less CO_2 than a conventional building, rather than simply producing - and then offsetting - the same amount of carbon. This is practical as it is likely to be easier and more cost effective to offset the minimum amount of CO_2 while fulfilling environmental and sustainability goals. Offsetting can be achieved by, for example, contribution of renewable energy produced on-site to the main power grid, by extending plantation forests on-site or off-site, or by investment in renewable energy projects off-site.

The second point to note is carbon is calculated as the sum of the emissions produced by the operation of the building (example: the energy required for space heating/ cooling, water heating, lighting and appliance use). The material and energy used in the construction or end-of-life phases of the building are not included in the assessment. The energy required directly or indirectly to produce a product or service within in the building is also excluded from the assessment. Further, the emissions necessary to travel to and from these developments are not generally included either.

The third point is that the most attention and effort to date has been placed on new residential developments. This is not to say that industrial or public buildings, or retrofitted buildings of any kind, cannot achieve zero-carbon or carbon neutral status. It is simply to note that the current focus of policy-makers and the public is on new residential housing stock.

Achieving Zero-Carbon or Carbon Neutral Status

The aim of zero-carbon and carbon neutral buildings can be summarized as the reduction, or reduction and offset, of carbon emissions while maintaining or improving on current living standards. This aim is achieved by employing low- or zero-carbon (LZC) technologies, passive design elements and energy efficient fixtures and fittings.

Low- and Zero-Carbon Technologies (LZC)

LZC technologies operate on two levels: they aim to reduce the amount of energy required to operate a building; and to generate the energy required to operate a building without producing carbon, or by producing much lower levels of carbon than conventional technologies.

LZC technologies can be incorporated into new building designs, installed in existing buildings or can operate at the community/development level. For example, solar photovoltaic (PV) cells and heat pumps are most likely to be installed at the individual dwelling level, while it may be more appropriate for biomass burners and micro-wind and micro-hydro turbines to operate at the community level. Ideally, energy generation systems should also have the capacity to contribute carbon-free energy back into the energy grid.

Passive Design Elements

Passive design elements result in similar outcomes to LZC technologies, and are the logical first steps to achieving a zero-carbon or carbon neutral building.

Design elements include building orientation and shading; roof and external wall material and color; window and door type and placement; insulation type; use and location of thermal mass; and air-tightness. These allow for temperature control via passive solar heating (or cooling) and reduce the amount of additional energy required to regulate temperature in the home.
The use of energy efficient appliances and low energy light bulbs can also contribute to a reduction in operational energy demand.

Carbon Offsetting

Even when zero-carbon or carbon neutral have been defined by policy-makers, there can still be debate as to how to achieve zero-carbon/carbon neutral status.

If carbon offsetting is allowed, the building industry may not seek to increase energy efficiency or to reduce carbon emissions from the operation of new homes, but will simply build to current specifications and purchase carbon credits. This is particularly likely if carbon credits are the less expensive option.

Carbon vs. Green and Sustainable

Many of the technologies and design elements that can be utilized to achieve zero-carbon or carbon neutral status can also be used in sustainable or green building design. However, a zero-carbon or carbon neutral home is not automatically a green and/or sustainable home.

Technologies	Heating Only	Heating and Electricity	Electricity Only
Zero-Carbon	Solar thermal		Solar Micro-wind Micro-hydro
Low Carbon	Air heat pump Ground Heat pump Biomass or waste coiler or stove	Combined heat & power (CHP)	

Table: Low- and Zero-Carbon Technologies

Because the focus of zero-carbon and carbon neutral buildings is on carbon emissions and energy efficiency, other sustainability criteria such as a reduced building footprint; pollution minimization; rainwater harvesting and water-use efficiency; wastewater minimization and reuse; biodiversity protection and enhancement; and affordability and livability can all be neglected. It is theoretically possible that a carbon neutral or zero-carbon home could be highly inefficient in areas other than energy use and, therefore, not be truly green or sustainable.

Further, because the use-phase of a home is the one most often considered in carbon assessments, materials from unsustainable sources or that are not recyclable can be used in the building without changing the status of the development (which is not the case in green or sustainable designs).

Steel Products: Carbon-Reductions

Steelscape products can be utilized in building designs to help improve operational energy efficiency and, therefore, help create zero-carbon or carbon neutral developments.

The high strength to weight ratio of steel allows for wide spans that can be used to create large internal spaces. These spaces can be redefined over the life of the building. Therefore, steel framing and roofing allows flexibility in design that can result in reduced energy consumption. For instance, in warm climates, one-room-thick designs that have windows and/or doors on both sides of the room allow for good cross-ventilation and can help maintain thermal comfort and indoor air quality with reduced need for mechanical air-conditioning. Further, because of the comparatively large glazed areas, the sun can penetrate the building during colder months, increasing the effectiveness of passive solar heating. Good light penetration can also reduce the need for artificial lighting which further reduces energy consumption.

Steel is a low thermal mass material. This means that very little energy is needed to change the temperature of steel. Further, steel does not retain energy. Because of these properties, steel framing and cladding are ideal to use in both reverse mass and lightweight construction.

Lightweight designs are appropriate in tropical and hot, arid climates, and are particularly good for areas occupied predominately in the evening. While lightweight designs do absorb heat during the day, they cool down very quickly at night, meaning that less energy will be needed to cool, for example, bedrooms for comfortable sleeping.

Low thermal mass steel construction also responds quickly to changes in thermal conditions, which is particularly beneficial for homes that are occupied intermittently. The home can be heated or cooled quickly without having to expend a lot of energy to heat or cool the structure.

Reverse mass designs are particularly suited to cool and temperate regions. Reverse mass buildings have high thermal mass materials, such as concrete, brick or tile, exposed inside the structure, which is well insulated with lightweight framing and exterior cladding. The high mass materials absorb heat during the day and release it slowly over the evening. This means that temperatures inside will be lower than outside during the day, and higher inside than outside during the night.

In all climates, it is generally better to have low thermal mass roofs because roofs cannot be shielded from the sun during the hot months the way walls and floors can. Therefore, heat can accumulate during the day and contribute to uncomfortable conditions and increased energy use on supplementary cooling or heat extraction at night.

It must be noted that for thermal mass, passive solar heating and passive cooling to be effective, building orientation, shading, insulation and ventilation must be integral to the building's design.

The range of color and paint finishes produced in steel can also aid passive solar design. Pre-painted steel roofs and walls utilizing "cool" paint systems can be used to reflect energy away from buildings, thereby reducing energy demand for internal cooling. In the coolest climates, where there is minimal need for summertime cooling, darker colored pre-painted steel roofs and walls can be used to absorb solar energy, thereby reducing annual energy demand for heating.

In summary, steel can be used in low- or zero-carbon (LZC) technologies:

- steel has high thermal conductivity, which means that collected heat can be readily transferred to another medium (example - water or air);
- steel has low thermal mass, so is responsive to changes in thermal conditions which is useful for collecting solar heat on days when the sunlight is transient;
- steel can be used to create the water-tight and sealed spaces that are often required with many of the technologies; and
- steel is strong and lightweight, which is an advantage in installation and possibly reducing the need for additional structural support.

222 West Kalama River Road, Kalama, WA 98625-9420 USA I Phone 360-673-8200 I Fax 360-673-8250

TECHNICAL BULLETIN 2

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SUSTAINABILITY

Urban Heat Islands

Steelscape has made a commitment to continually improve the company's environmental footprint and the sustainability of its products and services.

This is the second in a series of technical bulletins relating to sustainability issues that directly or indirectly impact the steel value chain. In writing these bulletins Steelscape wishes to inform and educate the market based on the latest available and verifiable information.

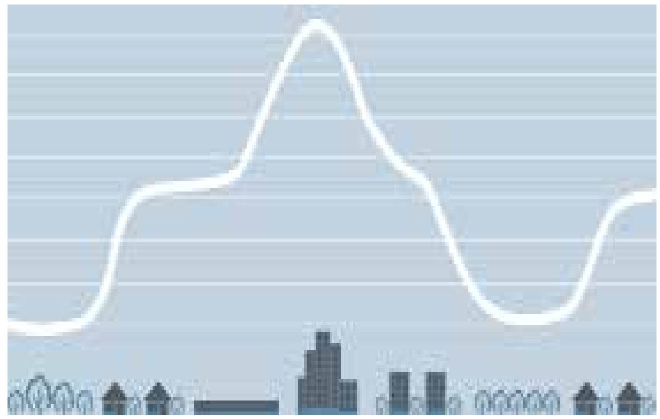

Figure 1: Urban Heat Island - Temperature Profile

INTRODUCTION

The term urban heat island is used to refer to the fact that cities and urban areas are often significantly warmer than the rural or undeveloped areas that surround them. This technical bulletin details why urban heat islands form, the consequences of urban heat island formation, and what can be done to mitigate these effects.

Urban forestry, reflective hard scapes (such as roadways, sidewalks and parking lots) and cool roofs are two of the most effective ways to reduce the intensity of urban heat islands. Pre-painted steel utilizing "cool" paint systems can be used to create cool roofs due to their high solar reflectance and thermal emittance.

Formation of Urban Heat Islands

Urban heat islands are not a new phenomenon. In 1833 Luke Howard, a chemist and amateur meteorologist, presented evidence that the air and surface temperatures in London were often higher than in the surrounding countryside. This is now considered to be the first documented case of an urban heat island. Today, many cities and suburbs record air temperatures warmer than the surrounding natural land-cover (Figure 1). The United States Environmental Protection Agency (EPA) reports that on average US cities are up to 5.6°C warmer than the surrounding countryside[1].

Urban heat islands form when vegetation is replaced with non-reflective, high mass, water resistant, impervious surfaces that absorb a high percentage of incoming solar radiation. There are three main drivers of heat island formation: heating as a result of human activities; reduced evaporation and transpiration due to decreased vegetation cover; and increased absorption and retention of heat due to decreased surface reflectivity.

The formation of heat islands is not necessarily uniform across the city or over time. Heat islands can evolve around a single building, across a small section of the city or over the entire city region. Some researchers have also reported that local and regional climate, and the topographic features of cities, affects the strength and persistence of heat islands.

Surface Reflectivity: Absorption of Heat

All surfaces reflect a proportion of energy that arrives from the sun (solar radiation). The more reflective a surface is, the less solar energy it absorbs and the cooler it stays. Conversely, the less reflective a surface is, the more solar energy it absorbs and the higher its surface temperature will be. Compared to natural landcover, urban environments have lower surface reflectivity, absorb more of the available incoming solar radiation and are consequently warmer. This is the beginning of urban heat island formation.

The solar radiation absorbed by the surface of the Earth is predominantly re-radiated to the atmosphere - and eventually to space - as longwave radiation (Figure 2). Energy also leaves the surface by thermal convection and conduction (sensible heat) and when water is evaporated (latent heat). The amount of energy re-radiated from a surface is dependent on the temperature of that surface. The hotter the surface, the more energy it will emit. Because cities are comparatively warmer, they can emit more longwave radiation than the surrounding countryside.

Re-radiated energy, because of its longer wavelength, can be absorbed by clouds, and particles in the atmosphere such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and water vapor (H_2O_V) - greenhouse gases (GHGs).

These particles emit the energy back to the atmosphere and to the surface of the Earth (Figure 2). Emitted longwave radiation acts to heat both the atmosphere and the surface further.

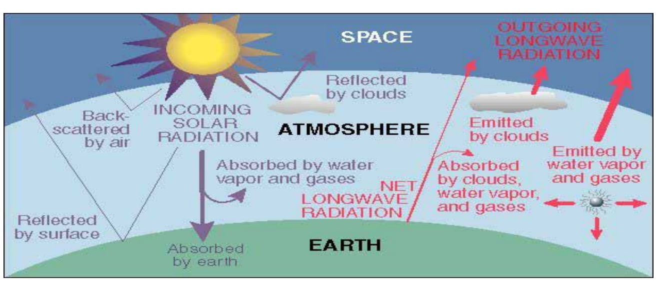

Figure 2: The Earth's Radiation Balance

The increase in atmospheric GHG concentrations have resulted in an overall warming of the atmosphere (the anthropogenic greenhouse effect). Because activities in urban environments are often major generators of GHGs (such as the CO_2 produced by vehicle use and industrial processes), outgoing longwave radiation from cities is more likely to be absorbed and re-radiated in the atmosphere above cities than longwave radiation emitted from the surface in a less polluted environment. The net result is more potential heating of both the city and atmosphere above it.

Reduced Evapotranspiration

Evapotranspiration rates are also altered when vegetation is removed and replaced with an urban environment. Evapotranspiration is the sum of evaporation and transpiration - the sum of water entering the atmosphere from the surface of the earth. Evaporation accounts for the movement of water to the air from sources such as the soil, forest canopy and bodies of water, such as lakes and oceans. Transpiration accounts for the movement of water within a plant and the subsequent loss of water vapor through the leaves.

Evapotranspiration acts to cool the surface because of the loss of latent heat (the energy used during phase change from liquid to gas). Evapotranspiration is generally decreased when vegetation is replaced with a cityscape. When there are less plants there are fewer opportunities for interception and runoff is increased because of the expansion of impervious surfaces. The reduction in evapotranspiration therefore contributes to the formation of a urban heat island.

Anthropogenic Heating

The third factor that causes urban heat islands is the increase in near-surface temperatures that is a result of human activities. For example, the heat produced from industrial processes, electricity generation and building and traffic heat loss.

The combination of heating at the surface and in the lower atmosphere can create an inversion layer which stops heat and other pollutants from dispersing. This enhances the heat island effect and is a cause of smog (ozone) formation at the surface.

Consequences of Urban Heat Islands

In low- and mid-latitude cities such as New York, increased local temperatures often lead to increases in energy demand for air-conditioning, particularly in the summer. This in turn places a strain on power delivery systems and may result in the need for additional power generation sources. If power is generated using fossil fuels, then GHG and particulate emissions are also increased.

Thermal comfort is also reduced inside buildings without air-conditioning and outside. There is evidence that heat-stress mortality and illness are higher in cities during the summer months than at other times of the year.

High pollution levels, particularly under inversion conditions, can also adversely affect human health. Infants, the elderly and those with respiratory or cardiac complaints are particularly vulnerable. High concentrations of pollutants can also affect

the buildings themselves. Deposition of acids (such as sulphur and nitrous dioxides) from the atmosphere, and soiling (black carbon deposition), have a corrosive effect on limestone, sandstone and marble structures. Acid deposition can also adversely affect the water quality of nearby lakes and rivers, and the animal and plants that live in them. The health of forested ecosystems can also be negatively affected. Trees are weakened through leaf damage, nutrient limitation and the uptake of toxins from the soil.

Mitigation of Urban Heat Islands

Increasing surface reflectivity (to reduce the amount of solar energy absorbed and converted to heat), and evapotranspiration (to cool the surface through latent heat loss) are two of the key strategies for reducing the intensity and longevity of urban heat islands.

Potential evapotranspiration can be increased by extending vegetated areas and reducing the amount of impervious surfaces. Urban forestry has been found to produce the greatest reduction in surface temperature per unit area because of the increase in evapotranspiration and the additional shading of buildings and pavements[2].

Urban forestry includes street-to-trees (i.e. curbside planting) and grass-to-trees (i.e. open space planting). Living roofs (i.e. roof-to-grass) also effectively increase evapotranspiration, particularly in areas with limited space at street-level. Green roofs do not, however, have as great an impact on energy demand because they afford no additional shading to buildings.

Replacing dark surfaces and roofs with light surfaces and cool roofs increases the reflectivity of the city. This is a very effective urban heat island mitigation strategy because more surface area can be transformed in this way than can be revegetated. For example, it is estimated that 64% of the surface area of New York City could be redeveloped to incorporate highly reflective surfaces, whereas only 17% of the city's surface could be planted[2].

Cool Roofs

Cool roofs help reduce the intensity of urban heat islands, as well as maintain thermal comfort and minimize energy demand in buildings. Cool roofs can have high solar reflectivity and high thermal emittance.

High solar reflectivity means that less energy is absorbed into the roof initially, thereby reducing the amount of energy that can be converted to heat and re-radiated as longwave radiation (Figure 3). This reduces the heat that can move from the roof to the atmosphere by convection and conduction. The surface temperature of a cool roof can be up to 39°C less than a dark colored roof and limits the amount of longwave radiation that can interact with GHGs and heat the atmosphere.

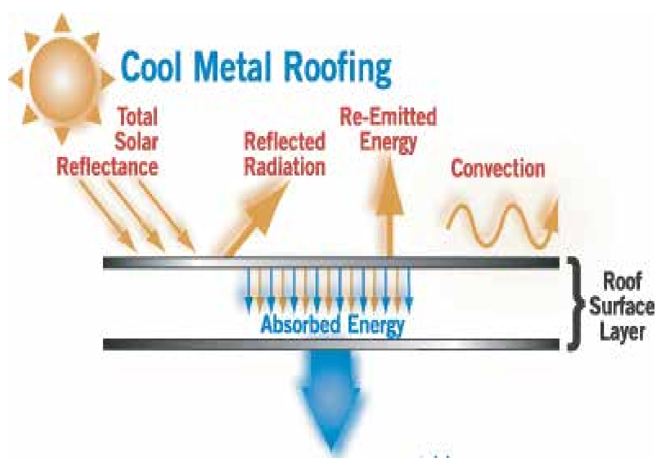

Figure 3: Cool Metal Roofing

High thermal emittance means that any energy that is absorbed into the roof is re-radiated from the building quickly (again increasing thermal comfort and minimizing energy demand).

There are also financial benefits for building owners. Limiting the quantity of absorbed solar energy and reducing daily temperature fluctuations which cause repeated contraction and expansion can extend the life of the roof.

High solar reflectance does not necessarily translate to increased potential for glare. While solar reflectance is important for thermal comfort, and can affect the local radiation balance, it is not always a good indicator of the visual attributes of the surface. The high solar reflectance required to create a cool roof is usually achieved by increasing reflectivity in the infrared part of the color spectrum, which is not visible to the human eye. A surface with high near infrared reflectance will have higher solar reflectance than a surface of identical color with low near infrared reflectance.

Glare is a function of a number of additional surface characteristics (surface roughness, roof pitch, building orientation and configuration) as well as the position of the sun in the sky and observers on ground. Therefore, if glare is a potential concern, mitigating glare should be an important element of the project design process.

Steelscape Cool Roofs

U.S. building codes and regulations most often classify "cool" roof options based on solar reflectivity and emissivity. These values are typically based on as-new (unweathered) product. A value of 0 indicates that a roof reflects none of the incoming solar radiation, whereas a value of 1 would mean that a roof reflects 100% of the incoming radiation. Steelscape offers a wide range of pre-painted steel utilizing "cool" paint systems that when used on a roof may help reduce the amount of solar radiation absorbed and assist with re-radiating heat. This means that the building may be cooler overall, and cool down faster when the sun isn't shining, which helps reduce energy demand.

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222 West Kalama River Road, Kalama, WA 98625-9420 USA I Phone 360-673-8200 I Fax 360-673-8250

TECHNICAL BULLETIN 3

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SUSTAINABILITY

Voluntary Green Building and Product Programs

Steelscape has made a commitment to continually improve the company's environmental footprint and the sustainability of its products and services.

This is the third in a series of technical bulletins relating to sustainability issues that directly or indirectly impact the steel value chain. In writing these bulletins Steelscape wishes to inform and educate the market based on the latest available and verifiable information.

INTRODUCTION

This technical bulletin details the most predominant green building and product programs currently in existence in the U.S., as noted by Steelscape. It is important to mention that there are many green programs in place within the U.S. that deal with green construction that will not be covered here.

U.S. Green Building & Product Programs

There are two primary sustainable building assessment tools used in the U.S. for evaluating and comparing buildings in terms of energy used, water consumed, construction materials employed, quality of the indoor air, and the use of the building site. The US Green Building Council (USGBC) promotes the Leadership in Energy and Environmental Design (LEED) program and the Green Building Initiative provides the Green Globes program.

Both systems have strengths and weaknesses, but they encourage designers and builders to consider how buildings are constructed and how efficiently they are operated. These two systems are pushing the building market to reach for higher and higher goals and will likely remain more ambitious and stringent than government building regulations, codes and standards.

Leadership in Energy and Environmental Design (LEED)

LEED is perhaps the most well recognized green building standard in the world. Developed by the USGBC, a nonprofit organization consisting of building industry leaders, LEED works via third-party certification through the Green Building Certification Institute to promote sustainability, profitability and occupant well-being.

There are several LEED programs for specific types of construction, which include the following:

- New Construction
- Existing Buildings: Operations & Maintenance
- Commercial Interiors
- Core & Shell
- Schools
- Retail
- Healthcare
- Homes
- Neighborhood Development

Within any LEED program the building project is rated and awarded points for achieving performance related to the following categories:

- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality
- Innovation in Design
- Regional Priority

Within each category are pre-requisites and optional credits that award points for compliance. A building project registered in the LEED program is evaluated for its performance against the LEED requirements and can be certified at one of four levels, each based on the points earned. Those levels of certification in the current LEED-2009 program are: Certified (40 to 49 points), Silver (50 to 59 points), Gold (60 to 79 points), and Platinum (80 points and above).

Though there is debate as to whether LEED certified buildings are more expensive to build, it is well-established that LEED buildings offer long-term operational savings, increased asset values, waste reductions, lower greenhouse gas emissions, and safer, healthier spaces in which to live and work.

A LEED registered building that uses metal roof, walls and/or other metal components can potentially qualify for points in all of the categories, depending on the design and products used. The high recycled content, full recyclability, and energy efficiency of metal building products and systems are features that contribute the most points in a LEED project.

Green Globes

The Green Globes environmental assessment and educational tool is promoted in the U.S. by the Green Building Initiative (GBI), a nonprofit organization in Portland, Oregon ,though it is also used in Canada. The goal of the Green Globes program is to promote sustainability and higher environmental performance in commercial buildings using comprehensive measurement protocols, online assessments and software, and third-party certification. GBI is also developing a personnel certification program for professionals working within the Green Globes framework. In contrast to the LEED program, the Green Globes tool was developed as a consensus program and accredited by the American National Standards Institute (ANSI).

An online interactive questionnaire-based approach to the Green Globes makes the program simple to navigate and less costly than LEED to complete. Certification is then verified by third-party trained regional verifiers. Green Globes has two types of certifications depending on project and building type:

- New Construction
- Continual Improvement of Existing
- Buildings

Green Globes also offers professional training through their Personnel Certifications as well as a Life Cycle Assessment (LCA) Credit Calculator to help architects and engineers in their understanding of various environmental impacts.

Buildings are given scores on a 0- 1,000 point scale and must achieve at minimum 35% of the points in order to qualify. Green Globes has several categories for each type of certification:

- Energy
- Indoor environment
- Site
- Water
- Resources
- Emissions
- Project or environmental management

Once assessed, a building will be awarded a number of Green Globes: One Globe (for 35% - 54%), Two Globes (for 55% – 69%), Three Globes (for 70% – 84%), or Four Globes (for 85% – 100%). As with LEED buildings, Green Globes buildings save energy, water, resources, and reduce greenhouse gas emissions.

Cool Roof Rating Council

The Cool Roof Rating Council (www.coolrroofs.org) was created in 1998 as a non-profit independent organization to establish accurate and credible test methods for evaluating and labeling the solar reflectance and thermal emittance (radiative properties) of roofing products. That information is disseminated to all interested parties including building code bodies, energy service providers, architects, specifiers, property owners and community planners.

The mission of the CRRC is three-fold:

1. To implement and communicate fair, accurate, and credible radiative energy performance rating systems for all types of roof surfaces.

2. To support research into energy related radiative properties of roofing surfaces, including durability of those properties.
3. To provide education and objective support to parties interested in understanding and comparing various roofing options.

At the core of the CRRC is its Product Rating Program, in which roofing manufacturers can label various roof surface products with radiative property values rated under a strict program administered by the CRRC. In the labeling program there are no thresholds for criteria that define "cool roofing". The program developed by CRRC has been accredited by the American National Standards Institute (ANSI). Also the CRRC is the sole authoritative entity for cool roof properties used in the California Building Energy Efficiency Standards, Part 6, Title 24.

Energy Star

ENERGY STAR is a joint program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) helping to save energy costs and protect the environment through energy efficient products and practices. In 1992 the U.S. EPA introduced ENERGY STAR as a voluntary labeling program designed to identify and promote energy-efficient products to reduce greenhouse gas emissions. In 1996 EPA partnered with the DOE for particular product categories.

Since its inception, the program has grown to include over 60 different product categories, including roof products. The ENERGY STAR label is now on major appliances, office equipment, lighting, home electronics, building products, and even new homes and commercial buildings. In 2010 a major overhaul to the program took place, requiring third party accredited laboratory testing of labeled products.

In the ENERGY STAR Roof Products program, the minimum solar reflectance values are established for steep slope and low slope oriented products. An ENERGY STAR labeled metal roof product, in the steep slope category (> 2:12 slope), would require a minimum initial solar reflectance of 0.25 and three-year aged solar reflectance of 0.15. For low slope metal roof products, the criteria are a minimum solar reflectance of 0.65 and three-year aged solar reflectance of 0.50. Although there are no criteria for thermal emittance, ENERGY STAR partners are required to submit the measured emittance values as part of the program requirements. Currently, the performance data submitted to ENERGY STAR needs to be developed through the use of a Certification Body who works with the Partner and the laboratories to ensure that the test methods and procedures are properly followed.

Through its partnerships with more than 20,000 private and public sector organizations, ENERGY STAR is providing technical information and tools that promote energy efficient products and practices. In recent federal legislation, tax incentives have been linked to ENERGY STAR labeled prepainted metal roof products as an example of an energy efficient improvement to a residence. The ENERGY STAR for HOMES program also references ENERGY STAR labeled roofing requirements in the warmer climate zones of the United States.

222 West Kalama River Road, Kalama, WA 98625-9420 USA I Phone 360-673-8200 I Fax 360-673-8250

TECHNICAL BULLETIN 4

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SUSTAINABILITY

Recycling

Steelscape has made a commitment to continually improve the company's environmental footprint and the sustainability of its products and services.

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INTRODUCTION

This technical bulletin details the two aspects of steel recycling: recyclability and recycled/recovered content. Steel is 100% recyclable, without downcycling, and is one of the most recycled materials globally by volume. There are two types of recycled content - pre-consumer and post-consumer - as well as reutilized scrap.

Recyclability

Recyclability refers to how effectively and efficiently a product or material can be recycled into a new product. Steel is theoretically 100% recyclable: if recovered at the end of each use phase, the life cycle of steel is potentially endless. Recycling prevents the waste of potentially useful materials, reduces consumption of raw materials and energy (thereby reducing greenhouse gas (GHG) emissions) as compared to virgin production, and reduces pollution.

Recycling must be clearly differentiated from downcycling. Recycling indicates that a material can be recovered and reprocessed into the same material of the same quality again and again, as is the case with steel. Downcycling occurs when a material is recovered, but can only be reprocessed into another material of lesser quality. For example, the recycling of plastics turns them into lower grade plastics.

Reuse of individual building components can perhaps be considered the most preferable form of recycling as there is no reprocessing energy whatsoever. In this case, a building component (or entire structure) is simply moved from one location to another.

Steel is also easy to recover from waste streams because of its magnetic properties. This, coupled with its economic value, makes steel the most recycled material in the world by volume[1]. Globally, over 80% of all scrap steel is captured and is either re-used or recycled.

There are two factors that account for the difference between the actual (>80%) and potential (100%) recycling rate of steel scrap. As with all recycling, it is a choice whether to send waste to landfill. Even though there are clear economic and environmental benefits of recycling steel, some scrap inevitably ends up in landfills. Logistics also plays a part. For example, in remote locations the cost of transporting equipment to recover building components, and the cost of transporting scrap back to a main center for recycling, may be prohibitive. Some treatments, coatings and building practices can also increase the cost and complexity of recycling steel. For example, steel reinforcing in concrete can be difficult to extract due to the concrete crushing equipment required.

Recycled Content and Reutilization

Recycled content denotes that proportion of a product that is generated from pre-consumer and/or post-consumer material. The recycled content of a building material is often used as a benchmark in some green buildings rating tools.

Pre-consumer (sometimes also referred to as post-industrial) material is recovered from the manufacturing process before it is sold to end consumers. Examples of pre-consumer material might be scrap from a car manufacturer sold back to the steel industry.

Post-consumer material is generated by end-users (including households, businesses, industries and institutions) from products that can no longer be used for their intended purpose. Examples of post-consumer material include tin cans, old car bodies and decommissioned building scrap. In order for a product to be technically "recyclable", there needs to be a fully established recycling program in place in a given area for that specific product.

Reutilized material is rework, regrind and/or scrap material created during a process that is "reused" within that process. Examples of reutilized material might be scrap generated during the steel making process that is remelted and reused back within that same process. However, to reiterate, reutilized material is not considered recycled content by most green rating programs.

The Recycling Process: Steel Production

These two production methods mean that steel is one of the only materials in the world to have guaranteed recycled content[2].

Naturally, there are small process losses in both BOF and EAF steelmaking. It is unavoidable that some iron units in the steelmaking furnace are oxidized during refinement and float into the slag layer on top of the liquid steel bath. A small percentage of iron units also escape the furnace during charging and oxygen blowing. These are captured in off-gas cleaning systems. Most steel manufacturing processes recover these materials and return them to the steelmaking process if at all possible (reutilization).

From a sustainability point of view, the proportion of steel that is recovered for recycling at the end of each use phase is more relevant than the recycled content in any one product at a particular point in time. Further, consideration should also be given to economic and environmental costs associated with transporting the higher recycled materials from greater distance versus using locally manufactured products.

Literature Cited:

1. *World Steel Association (2008) - 2008 Sustainability Report of the World Steel Industry.*

2. *Steel Recycling Institute (2009) - Steel Takes LEED with Recycled Content.*

222 West Kalama River Road, Kalama, WA 98625-9420 USA I Phone 360-673-8200 I Fax 360-673-8250

TECHNICAL BULLETIN 5

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steelscape

SUSTAINABILITY

Sustainable Building Solutions: Thermal Mass

Steelscape has made a commitment to continually improve the company's environmental footprint and the sustainability of its products and services.

This is the first in a series of technical bulletins relating to sustainability issues that directly or indirectly impact the steel value chain. In writing these bulletins Steelscape wishes to inform and educate the market based on the latest available and verifiable information.

INTRODUCTION

Thermal mass is the term used to describe the ability of materials to absorb and store heat. There are a number of ways that both high and low thermal mass materials can be used to help create energy efficient buildings. In many climate zones thermal mass construction can be a sustainable choice, while in hot, arid or tropical regions, lightweight construction may be more appropriate. Regardless of climate zone, a low mass roof is usually preferable.

Steel is a lightweight, low thermal mass material. Therefore, steel can be used in both low and reverse mass designs.

Energy Efficiency and Thermal Mass

Increasing energy efficiency, which reduces energy demand, is one of the easiest and most effective ways to increase environmental, social and economic sustainability. Reducing GHG concentrations is key to slowing climate change and its associated effects such as increased species extinction rates, changes to rainfall patterns and sea-level rise. A reduction in particulates in the air may positively affect the health of local communities, particularly infants, the elderly and those predisposed to asthma or bronchial complaints.

Energy efficient buildings should provide occupants with thermal comfort with reduced dependence on mechanical heating and cooling systems, which not only saves energy but also saves money.

Further, because meeting peak demand is already a challenge for many supply grids, if energy demand at peak-time can be reduced, the need to develop additional power stations, which are expensive and potentially sources of GHGs and pollutants, may also be deferred.

There are numerous design features, fixtures and fittings that can be utilized to gain energy efficiency in new buildings, significant retrofits or renovations. Thermal mass is one of these tools.

Thermal mass is the ability of any material to absorb and store heat energy, and can be thought of in terms of how much energy is needed to change the temperature of a material. High thermal mass materials include concrete, bricks and tiles.

Lightweight materials such as steel and timber have low thermal mass and store very little heat energy. Low thermal mass materials respond to temperature changes comparatively quickly, whereas high thermal mass materials take longer to heat or cool (Table 1).

Property	Low Thermal Mass	High Thermal Mass
Heats up quickly	Yes	No
Cools down quickly	Yes	No
Takes a lot of energy to alter temperature	No	Yes
Stores thermal energy	No	Yes
Lightweight	Yes	No

Table 1: Properties of low and high thermal mass materials

The total thermal mass of a building, and where thermal mass is located within the structure, is important to managing the discomforts and associated energy demands of climate extremes. Local climate, such as average temperature, humidity and diurnal temperature*, is the most important factor in determining how thermal mass should be used. Designs and materials that may assist in providing thermal comfort in cool regions may be less suited for the hot, humid conditions experienced in other regions.

**The difference between minimum & maximum temperature over a day.*

General Guidelines for the use of Thermal Mass in Buildings

here are basic principles about using thermal mass to gain thermal benefits in a building. Climate is the most important factor. Specifically, diurnal temperature variation and average summer and winter temperatures are to be considered.

Diurnal temperature influences the ability of the thermal mass to absorb heat and assist in cooling the building or to release heat to assist in heating the building. In general, in regions where the diurnal temperature range is less than 43ºF, thermal mass has little benefit. Where the range is between 44ºF and 50oF, thermal mass may be beneficial (depending on the climate). The most benefit is likely to be gained in regions that experience a diurnal range of more than 50ºF.

Appropriately located thermal mass acts to regulate indoor temperatures around the average daily temperature. If the average summer temperature is above or near the upper comfort range, then thermal mass may be detrimental. If average winter temperatures are below or near the lower comfort range, then thermal mass can be beneficial if it is warmed by solar radiation or another heat source. When thermal mass is utilized to capture winter solar radiation, it must also be protected from summer sun; otherwise the benefit may be limited.

An Integrated Approach

As indicated in the previous section, to help maintain thermal comfort, thermal mass cannot be used in isolation. Insulation, ventilation, passive solar design techniques, and the color, texture and finish of materials can all affect the performance of thermal mass.

For designs to be effective, insulation must be included in the building. Insulation stops heat flowing into or out of buildings and, therefore, compliments thermal mass. Bulk insulation is good for keeping heat in or out of the building envelope, while reflective insulation is most effective at stopping heat entering the building. A combination of both types may be appropriate depending on the climate zone. An airtight building envelope can also enhance the effectiveness of insulation.

Ventilation is key to removing the heat stored in buildings in the evening, which is vital in many climate zones across the U.S. in the summer. One of the most energy efficient solutions is to design to create, or take advantage of, natural air movement. This means orienting the building to the prevailing summer wind direction to take advantage of natural breezes, and integrating them with breeze paths through the building. Existing or proposed vegetation, landscape or topographic features and the location of windows and doors should all be considered when deciding on building orientation and room configuration. For example, blocks of tall vegetation can act as a barrier and reduce wind speed while more sparsely planted shorter trees can create turbulence and enhance wind flow. One-room-thick designs, which have windows and doors on both (or all) sides of the room, optimize opportunities for capturing the breeze and removing heat from a room during the evening. In private homes, high ceilings and overhead fans can enhance air circulation with minimal additional energy use. If mechanical extraction is necessary, as may be the case in commercial buildings that are unoccupied at night, the energy efficiency of the system selected becomes very important to the overall sustainability of the building.

Orientation and room configuration also affect passive solar heating and passive cooling. In cooler climates, passive heating on winter days is important to ensure that high thermal mass materials are able to absorb energy to reradiate at night. If there is no passive solar heating, high thermal mass may increase winter energy requirements. This is because each time supplementary heating is used, the internal thermal mass needs to be heated before the internal air temperature will rise. Therefore, a high internal thermal mass design does not take advantage of passive solar heating can increase the overall energy required to maintain thermal comfort. In particular, window-area should be maximized to capture winter sun. However, eaves should also be incorporated into the design to exclude summer sun and minimize the heat absorbed during summer days, which will be reradiated at night.

In cool and temperate climates, deciduous trees can provide effective shading during the summer, and allow sun to enter the building and heat the thermal mass during the winter.

The color, texture and finish of the floor and wall coverings selected affect the ability of internal thermal mass to absorb heat. For example, carpets or cork tiles laid over concrete slab floors insulate the thermal mass of the slab from incoming heat, which delays the receipt and release of energy into and out of the slab. This can result in an increase in internal temperature of 33-35ºF. In winter this may improve the thermal comfort and partially offset any increase in heating energy requirements due to absorption of heat by the thermal mass. However, in summer an increase of 33-35ºF may cause discomfort to occupants and increase the need for supplementary cooling. In warmer climates, hard floor finishes may be a better choice. Ceramic tiles, slate or vinyl on a slab floor increases the thermal mass of the floor and its ability to store heat and cool the room in summer.

Dark colored finishes absorb more solar radiation than light colored finishes. Dark finishes on high thermal mass can increase the temperature of a room by 35-37ºF year-round.

The effect of choices to maximize thermal comfort and the efficiency of thermal mass must be balanced with other aspects of energy efficiency and sustainability. For example, in cold climates, the thermal storage gained by incorporating dark, textured walls in a building should be balanced against the affect on internal light levels, and a potential increase in artificial light as dark surfaces absorb light.

The intended occupancy of the building should also be considered, and often influences how thermal mass can be used most efficiently. For example, if a building is to be occupied intermittently, lightweight construction may be the best choice. Because low thermal mass materials respond to changes in thermal conditions quickly, the home will heat up or cool down swiftly, without expending energy on heating or cooling the structure.

How Steelscape Products Can Help Create Thermal Comfort

Steelscape products can be used to compliment high thermal mass materials in construction and to achieve many of the additional design elements necessary to gain the full benefit of using thermal mass to achieve year-round thermal comfort. Steelscape products can also be used in low mass, lightweight designs such as those particularly suited to warmer climates and buildings that are occupied intermittently.

Steel cladding and roofing made from TruZinc® or ZINCALUME® steels can be used in conjunction with steel framing to create both reverse mass and low mass designs. Because steel building components are produced with consistency and tight tolerances that are maintained over the life of the building, they can be used to create extremely airtight building envelopes. A steel envelope can therefore help enhance the effectiveness of insulation in all climate zones.

TruZinc and ZINCALUME steels can also be used to create lightweight, low thermal mass roofs which, with climate appropriate insulation, allow heat to move in and out of the building as necessary. It must be remembered that because roofs cannot be protected from solar heating in the summer the way walls and floors can, low thermal mass is generally preferable. Low thermal mass roofs are especially advantageous in the residential sector. They allow any heat accumulated in the home during the day to be re-radiated quickly once the sun sets, reducing the need for mechanical air-conditioning and creating comfortable conditions for sleep.

High strength, lightweight steel building products allow large central spaces to be enclosed with minimum material use. This material efficiency makes one-room-thick and high ceiling designs more sustainable and potentially less costly. If oriented correctly, one-room-thick buildings can also be effective designs for maximizing passive solar heating, such as adding large glazed areas.

Lightweight steel construction can also increase the design flexibility of the decking and/or eaves required to shade high thermal mass materials from the sun in the summer.

Steelscape's Spectrascape® pre-painted steel comes in a variety of "cool" colors that also help the reflectivity and emissivity of the building envelope further ensuring thermal comfort.

222 West Kalama River Road, Kalama, WA 98625-9420 USA I Phone 360-673-8200 I Fax 360-673-8250

TECHNICAL BULLETIN 6

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SUSTAINABILITY

Steel in Sustainable Buildings

Steelscape has made a commitment to continually improve the company's environmental footprint and the sustainability of its products and services.

This is the first in a series of technical bulletins relating to sustainability issues that directly or indirectly impact the steel value chain. In writing these bulletins Steelscape wishes to inform and educate the market based on the latest available and verifiable information.

INTRODUCTION

This technical bulletin demonstrates how steel products can be used to improve the sustainability of the built environment over the whole life of a development.

Sustainability in the Built Environment

Sustainability is about more than energy use or carbon dioxide emissions. While how a product is created is important, it is also important to consider how it is used over its life, and how it is disposed of at the end of that life - a life cycle approach.

Sustainability is also about more than the natural environment - individuals, communities and economies are also important to consider. The sustainability advantages of including steel products in sustainable designs are manifest at every stage of a development's life - from construction to use to eventual decommissioning.

Construction

The advantages of using steel may start before materials even reach the construction site. Steel is lightweight compared to many other materials used for the same purpose. This means that more flat steel can be transported in each load than many other materials used for the same purpose.

Because steel building components - and entire building envelopes - can be cut to precise specifications or prefabricated off-site, on-site waste is minimized. Any waste that is created as components are cut to specification can be reused in the steelmaking process. No off-cuts need to be disposed of in landfills, as may occur when waste is produced by contractors on-site.

As prefabrication is a semi-automated process, it may also be safer than working on a construction site, and may reduce the time that contractors are exposed to building hazards such as working at heights. Prefabricated or pre-cut components may be assembled faster than other materials used for the same purpose that are not prefabricated, or that have to be cut to size on-site. This can reduce construction time and construction costs.

The lightweight nature of steel can also create advantages on-site. Because it is so light, sections may be more easily lifted into place. The need for heavy cranes may be reduced, or even completely avoided, depending on the scale of the project and the particulars of the site.

Choosing pillar construction instead of slab-on-ground may also reduce the amount of heavy machinery on-site, and may offer increased design flexibility on sloping sites. There are many positive environmental, economic and social effects.

Minimizing the use of heavy equipment on-site can help protect the surrounding natural environment by reducing soil compaction and/or loss of vegetation. Keeping as much of the existing vegetation in place as possible helps to reduce erosion. When deposited in local rivers, lakes or estuaries, eroded sediment can change flow patterns and affect the animals, fish and plants that live in the receiving-water environments.

Minimizing the extent of foundation work and the use of heavy machinery may also reduce the cost of a project. The cost of using the equipment is avoided; less erosion and/or soil compaction may result in reduced landscaping costs; and the time to completion may be less. The latter results in savings on labor, and potentially a quicker return on the investment.

High strength, lightweight steel can also help improve the material efficiency of a building (i.e. less steel by volume may be required to perform the same function as other products used for the same purpose). The strength of steel means, for example, less framing may be required to support a structure than would be required of an inherently weaker material. Because steel is lightweight, it also requires less support. For example, a steel roof would likely require less roof framing than a heavier roofing material. Material efficiency is one measure of the sustainability of a building: using fewer resources has environmental advantages and may reduce the overall cost of the building.

The high strength to weight ratio of steel can also be used to solve unique design problems. Steel framing can be used to add volume to existing buildings, particularly heritage buildings, which are weight sensitive. Projects of this nature not only reuse existing structures, which equates to materials and cost savings, but can also help to preserve the aesthetics of heritage precincts.

Use

In the use phase of a building, steel products can help improve energy efficiency and thermal comfort, and reduce energy and water demand.

The high strength to weight ratio of steel allows for the creation of economical wide spans that can be used to create large open spaces that can be redefined over the

Building Life Cycle Attribute	Properties of Steel	Key Advantage
Transportation		
	Lightweight	Potentially reduced transport costs
Construction		
Waste	Prefabricated and pre-cut components	Less waste on-site; waste produced off-site can be recovered and reused
On-site safety		Safer building sites
Construction time and cost		Easier to assemble; reduced construction time; may reduce construction costs
	Lightweight	Reduced need for heavy lifting equipment; may reduce construction time and cost
Foundations		Option to use pillar construction; leads to less damage to site and potentially reduced landscaping costs
On-site disturbance		
Off-site disturbance		Less disruption of nearby built and natural environments (noise, traffic, sedimentation)
Materials use	High strength	Material efficiency - fewer resources required; cost effective
	High strength-weight ratio	Potential reuse of existing structures
	Dematerialization	Innovation has allowed downgauging and increased manufacturing efficiency
Use		
Adaptability	High strength-weight ratio	Large internal volumes are more easily redefined
Ventilation		One-room thick designs; good cross-ventilation; improved indoor air quality (IAQ); good light penetration
Thermal comfort and energy consumption		Passive solar heating and passive cooling
	Design flexibility	Appropriate decking and eaves for shading
	Low thermal mass	Reverse mass and lightweight construction
	Solar absorptance	Light colors reflect energy; dark colors absorb energy. Low solar absorption can help meet legislative requirements
		Helps reduce the intensity of urban heat islands (UHIs)
	Prefabrication	Tight envelopes minimize air leakage
Maintenance	Durability	Fewer resources spent on maintenance and replacement
Internal air quality (IAQ)	Likely to emit less VOCs and formaldehyde than other materials used for the same purpose	Better IAQ; health benefits for occupants
Water harvesting	Food grade polymer lining	Reduces pressure on main supply for irrigation, toilet flushing, etc; water may be suitable for potable use
		Reduces storm water flows
End of Life		
Reuse	Long lifespan	Designs for disassembly and reuse
Recycling	100% recyclable	Necessary for new steel production
	No downcycling	

Table 1: Potential key advantages of incorporating steel products over the life cycle of a development

life of the building. This adaptability can reduce retrofit costs and may actually extend the useful life of the structure.

Large internal volumes also allow for one-room-thick designs that have windows and/or doors on both sides of the room, which allows for good cross-ventilation and can help maintain thermal comfort and indoor air quality (IAQ) with less need for mechanical air-conditioning. If oriented correctly, one-room-thick buildings can also be effective designs for maximizing passive solar heating: large areas of glass allow the sun to warm the building during colder months. Good light penetration can also reduce the need for artificial lighting, which further reduces energy consumption. However, windows must be shaded from the sun during the summer months, otherwise, despite good airflow, overall mechanical air-conditioning demand may be increased. Shading can be achieved by incorporating eaves, or overhanging balconies on second and subsequent floors, into designs; erecting shade sails; or planting deciduous trees, which provide shade in summer but not in winter. Lightweight steel construction allows flexibility in the design of decking and eaves, and may improve the material efficiency of the design. For example, steel can be made into curved shapes that are not as easily or cost effectively made with other materials, which can be used to create eaves to block the harshest summer sun, while still allowing winter sun to penetrate the building.

Steel is a low thermal mass material. This means that steel does not store energy effectively and that very little energy is needed to change its temperature. Because of these properties, steel framing and cladding are ideal to use in lightweight construction. Lightweight designs are well suited for tropical and hot, arid climates, and can be used to create comfortable conditions in areas occupied predominantly in the evening across all climate zones. While lightweight designs do absorb heat during the day, they cool down very quickly at night, meaning that less energy will be needed to cool, for example, bedrooms, to allow occupants to sleep comfortably.

In all climates, it is generally better to have low thermal mass roofs because, unlike walls and floors, roofs cannot be shielded from the sun during the hot months. Therefore, heat can accumulate during the day, and contribute to uncomfortable conditions, and increased energy use on supplementary cooling or heat extraction, at night. Reducing energy use for cooling on summer evenings is particularly important for the sustainability of U.S. energy supply.

It must be noted that for thermal mass, passive solar heating and passive cooling to be effective, appropriate building orientation, shading, ventilation and insulation must be integral to the design.

The range of color and paint finishes produced in steel can also aid passive solar design. In warmer climates, light colored steel roofs and walls can be used to reflect energy away from buildings, thereby reducing energy demand for internal cooling. "Cool" pigments within paint finishes can also provide darker color options that still provide the cooling affects. In cool climates, where there is minimal need for summertime cooling, dark roofs and walls can be used to absorb solar energy, thereby reducing annual energy demand for heating.

Steel roofs made with Steelscape products that provide low solar absorption can also help developers and owners meet various requirements within federal and state-based legislation, while allowing a wide range of color options.

Reflection of energy away from buildings during the day also helps reduce the intensity of urban heat islands (UHIs), the localized heating of cities caused in part by the increased absorption of solar energy by surfaces that are darker than the land-cover that existed prior to urbanization. Heat islands not only increase energy demand for cooling in most climates (especially in the summer), but they can also lead to the formation of an inversion layer in the atmosphere above the city. Inversion layers can trap pollution, further reducing air quality and increasing the probability of smog events.

Draughts can also cause heat loss from homes, so weather-proofing and draught sealing can potentially make a big difference to energy use. Because steel building components are produced with consistency, and tight tolerances that are maintained over the life of the building, they can be used to create extremely airtight building envelopes. A steel envelope can therefore help limit air loss and reduce energy demand.

Steel products have a long lifespan and require minimal maintenance, which can further increase the overall sustainability of a building. Fewer resources may need to be expended on maintenance of steel products when compared to alternative, less durable or shorter-lived, materials used for the same purpose. As such the lifespan of steel products is likely to match that of the building, which is a sustainability benchmark.

Volatile organic compounds (VOCs) and formaldehyde can also adversely affect internal air quality. VOCs may have short- and long-term adverse human health effects, including triggering headaches and respiratory distress, and have been linked to some cancers. Formaldehyde has been linked to eye and throat irritation, nausea, asthma attacks in predisposed individuals and some cancers. Steel products are likely to emit less VOCs and, in particular, less formaldehyde than other products performing the same function. Using steel products is therefore likely to result in better indoor air quality, protecting the health of building occupants.

Rainwater can be harvested from roofs and stored in tanks, which can then be used to supply water for irrigation, toilet flushing, and other non-potable water needs. Creating alternatives to potable water supply reduces the need for new dam construction, protects the remaining flows in rivers and streams, and reduces infrastructure operating costs, which all increase regional and national sustainability. Rainwater harvesting also helps control stormwater flow rates. Minimizing, or slowing the release of stormwater generated reduces on-site erosion and prevents the loss of valuable topsoil. It also contributes to regional sustainability by relieving pressure on infrastructure, potentially negating the need to create new pipelines, and may help to stop erosion of the land around receiving waterways. Further, because stormwater is often discharged into lakes, rivers or the ocean untreated, any contaminants, sediment or debris carried along with the water directly impact discharge environments.

End-of-Life

Although steel products have long life spans, and can be used to create adaptable spaces or to add volume to extend the life of existing buildings, eventually most buildings will be decommissioned. Reusing and recycling building components is inherent to sustainability at this phase of a development's life.

One of the emerging strategies to increase sustainability is to design for disassembly. High-grade, durable materials, such as steel, work best in designs for disassembly, where building components, or entire buildings, are removed and reused.

Steel is theoretically 100% recyclable. If recovered at the end of each use phase, the life cycle of steel is potentially endless. Recycling prevents the waste of potentially useful materials, reduces consumption of raw materials and energy (thereby reducing greenhouse gas emissions) as compared to virgin production, and reduces pollution. Therefore, ensuring that any steel components that cannot be reused are recycled is a meaningful contribution to resource sustainability.

Recycling must be clearly differentiated from downcycling. Recycling indicates that a material can be recovered and reprocessed into the same material of the same quality again and again, as is the case with steel. Whereas downcycling occurs when a material is recovered, but can only be reprocessed into another material of lesser quality. For example, the recycling of some plastics turns them into lower grade plastics.

Scrap steel is also an important ingredient in the new steel produced by Basic Oxygen Furnace (BOF) steelmaking processes.

222 West Kalama River Road, Kalama, WA 98625-9420 USA I Phone 360-673-8200 I Fax 360-673-8250