Sustainability

BLUESCOPE STEEL

Zero-Carbon and Carbon Neutral Developments

BlueScope Steel Ltd. (BlueScope Steel) 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 BlueScope Steel wishes to inform and educate the market, based on the latest available and verifiable information.

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 are already entrenched in legislation in some nations. 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 business and industry.

This technical bulletin aims to define and differentiate the two terms, and to illustrate how steel products can be used to help create zero-carbon or carbon neutral developments.

Other technical bulletins in this series related to zero-carbon and carbon neutral developments include:

2. Urban Heat Islands
3. Voluntary Green Buildings Ratings Tools in Australia;
7. Sustainable Building Solutions: Thermal Mass; and
8. Steel in Sustainable Buildings.

1. Definitions and Differentiation

There are three important points to note regarding the concepts of zero-carbon and carbon neutral developments*.

First, there is a subtle, but important, difference between what zero-carbon and carbon neutral actually mean: *zero-carbon* implies that the operation of a 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 – and fulfil environmental and sustainability goals. Offsetting can be achieved by, for example, contribution of renewable energy produced on-site to the main power grid, by carbon sequestration† on- or off-site or by investment in renewable energy projects off-site.

* *Developments* can be thought of along a spectrum from individual buildings to whole communities.
† Sequestration includes non-point source strategies, such as extending plantation forests, and point source solutions, such as carbon capture and storage underground or undersea.

The second point is alluded to the previous: for both sorts of developments, carbon is calculated as the sum of the emissions produced by the operation of the building e.g. the energy required for space heating/cooling, water heating, lighting and appliance use. The materials and energy used in the construction or end-of-life phases of the building are not included in the assessment. The embodied energy‡ in the building is therefore also excluded from the assessment. Further, the emissions necessary to travel to and from these developments are not generally included in the assessment.

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

2. Achieving Zero-Carbon or Carbon Neutral Status

The aim of zero-carbon and carbon neutral buildings can be summarised as to *reduce, or reduce and offset, 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.

Table 1: Low- and Zero-Carbon Technologies[1].

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

2.1 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 (*Table 1*).

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 grid.

2.2 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 colour; 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.

‡ Embodied energy is the energy required directly and indirectly to produce a product, which may be a physical entity or service.

2.3 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. For example, in the UK, where it will become mandatory for all new homes to be zero-carbon§ by 2016, the government is still yet to define the range of mechanisms that can be employed to achieve compliance, and in particular is still considering if, and to what degree, carbon-offsetting can be utilised.

Some fear that if carbon offsetting is allowed, the building industry will 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. However, a business-as-usual scenario is unlikely in the long-term, as the market is likely to demand real change; but it is realistic to expect that allowing offsetting will reduce the potential for innovation in the near-term.

3. Carbon v Green and Sustainable

In practice, zero-carbon or carbon neutral homes are likely to cheaper to live in – because they often have better natural thermal comfort – and have a smaller ecological footprint (as well as a smaller carbon footprint). Many of the technologies and design elements that can be utilised 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.

Because the focus of zero-carbon and carbon neutral buildings is on carbon emissions and energy efficiency, other sustainability criterias such as a reduced building footprint; pollution minimisation; rainwater harvesting and water-use efficiency; wastewater minimisation and reuse; solid waste minimisation and reuse; biodiversity protection and enhancement; and affordability and liveability 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 the 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).

4. Steel Products in Zero-Carbon and Carbon Neutral Developments

BlueScope Steel products can be utilised 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 volumes that 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, and that it 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 predominantly 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, to allow occupants to sleep comfortably. Low thermal mass steel construction also responds quickly to changes in thermal conditions, which is

§ The UK government has defined zero-carbon to mean that, *over a year, the net carbon emissions from all energy use in the home would be zero*[2].

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, but can also be used to create cool refuges for daytime occupation in tropical areas. 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 at night. Reverse mass buildings will therefore be comfortable on hot days, potentially without using air-conditioning. As long as there is ventilation to allow the heat to escape at night, summer evenings are likely to be within the comfortable range. Winter evening temperatures are also likely to be comfortable because of the release of the heat absorbed during the day and – with correct orientation and design to allow passive solar heating during winter – supplementary daytime heating requirements may also be minimal.

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. Reducing energy use on summer evenings is particularly important in Australia: meeting peak summer loads is increasingly difficult for most supply grids.

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 design.

The range of *colour* and *paint* finishes produced in steel can also aid passive solar design. In temperate and warm climates, light coloured COLORBOND® steel roofs and walls – incorporating Thermatech® technology – can be used to reflect energy away from buildings, thereby reducing energy demand for internal cooling. In the coolest Australian climates, where there is minimal need for summertime cooling, darker COLORBOND® steel roofs and walls can be used to absorb solar energy, thereby reducing annual energy demand for heating.

Draughts account for up to 25% of heat loss from Australian homes[3]; 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 heat loss and reduce energy demand.

Steel can also be used in the creation of *LZC technologies*:

- steel has *high thermal conductivity*, which means that collected heat can be readily transferred to another medium, e.g. air or water;
- 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.

Literature Cited

1. **Boardman, B. (2007)** Table 6.2: Low-and zero-carbon technologies. In, *Home Truths: A Low-Carbon Strategy to Reduce UK Housing Emissions by 80% by 2050. A research report for The Co-operative Bank and Friends of the Earth.* Environmental Change Institute, University of Oxford, Oxford, UK. pp 59.
2. **Department for Communities and Local Government (2007)** Building a Greener Future: Policy Statement. London, UK. 28pp.
3. **McGee, C., Mosher, M. and Clarke, D. (2008)** Passive Design: 4.7-Insulation. In, *Your Home Technical Manual. 4th ed.* Department of the Environment, Water, Heritage and the Arts, pp 101-107.

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