Sustainable Cities and Society 23 (2016) 105–113

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

Potential carbon emission reductions in australian construction systems through bioclimatic principles

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ARTICLE INFO

Article history:
Received 10 August 2015
Received in revised form 9 March 2016
Accepted 10 March 2016
Available online 19 March 2016

Keywords:
Construction carbon emission
Sustainable construction processes
Emission reduction
Embodied energy
Construction materials
Australian construction systems
BIM

ABSTRACT

The building sector responsible for 40 per cent of energy use (UNEP SBCI Sustainable Buildings and Climate Initiative, 2010); by 2030, a total of 60 Mt of carbon-reduction opportunities can be found in the Australian building sector (McKinsey, 2008). Reduction in the carbon emissions from Australian buildings is thus a priority for the Federal government. In Australia the government recently announced plan to cut emissions by 26–28 per cent by 2030 (Federal Politics, 2015). This study concerns energy use in building construction and the degree of carbon emissions reduction that can be achieved through use of bioclimatic principles.

Criteria of the model proposed in this research have been developed through analyzing *bioclimatic principles* to measure the potential construction carbon emissions that can be reduced in pre-construction and construction (cradle to site) stages during the lifecycle stages of a building. The developed model examines six case studies from Australia and the UK.

The outcomes of this research clearly shows that by use of bioclimatic principles up to 65 per cent reduction in construction carbon emissions can be achieved for a whole building systems (floor, wall and roof), while current best construction practice (i.e. a graded by Green Star) at the highest level achieve less than 32 per cent reduction.

However the future of the green construction industry lies on taking into account the bioclimatic principles- such as replacing conventional building materials with more energy efficient materials (i.e. replacing Portland cement with geopolymer based cement); reusing the recycled construction materials; reducing transportation and other similar initiatives.

1. Introduction

Climate change and global warming are recognized as major concerns of sustainable development. Based on a UN report, the building sector is responsible for 40 per cent of energy use (UNEP SBCI Sustainable Buildings and Climate Initiative, 2010), and produces 25 per cent of solid waste. The building sector also generates more than one third of global greenhouse gas (GHG) emissions, and is the largest emission source in most countries of the world. The UN believes we need to reduce our greenhouse gas emissions by at least 50 per cent within the next forty years (UNEP SBCI Sustainable Buildings and Climate Initiative, 2009).

The Australian building sector is reported to be one of the largest contributors to Australian greenhouse gas (GHG) emissions (building sector is responsible for 40 per cent of energy use (IPCC Intergovernomental Panel on Climate Change, 2007)); it is estimated a total of 60 Mt of carbon-reduction opportunities can be found in the Australian building sector by 2030 (McKinsey, 2008), and thus has the largest potential for significant reduction of greenhouse gas emissions as compared to other major emitting sectors. Reduction in the carbon emissions from Australian buildings is consequently a priority both for the federal government and also for the Green Building Council of (Green building Council of Australia, 2008). The Australian government has thus announced plans to cut emissions by 26–28 per cent by 2030 (Federal Politics, 2015).

This study concerns the degree of carbon emissions reduction due to building construction that can be achieved through use of bioclimatic principles. It is proposed that the use of bioclimatic principles can reduce construction carbon emissions (energy consumption) by five to six times (Treloar, 1998). The UK government has already undertaken steps towards reducing the GHG emissions of buildings by commissioning studies from four leading university groups with interests in reducing embodied energy and

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http://dx.doi.org/10.1016/j.scs.2016.03.006
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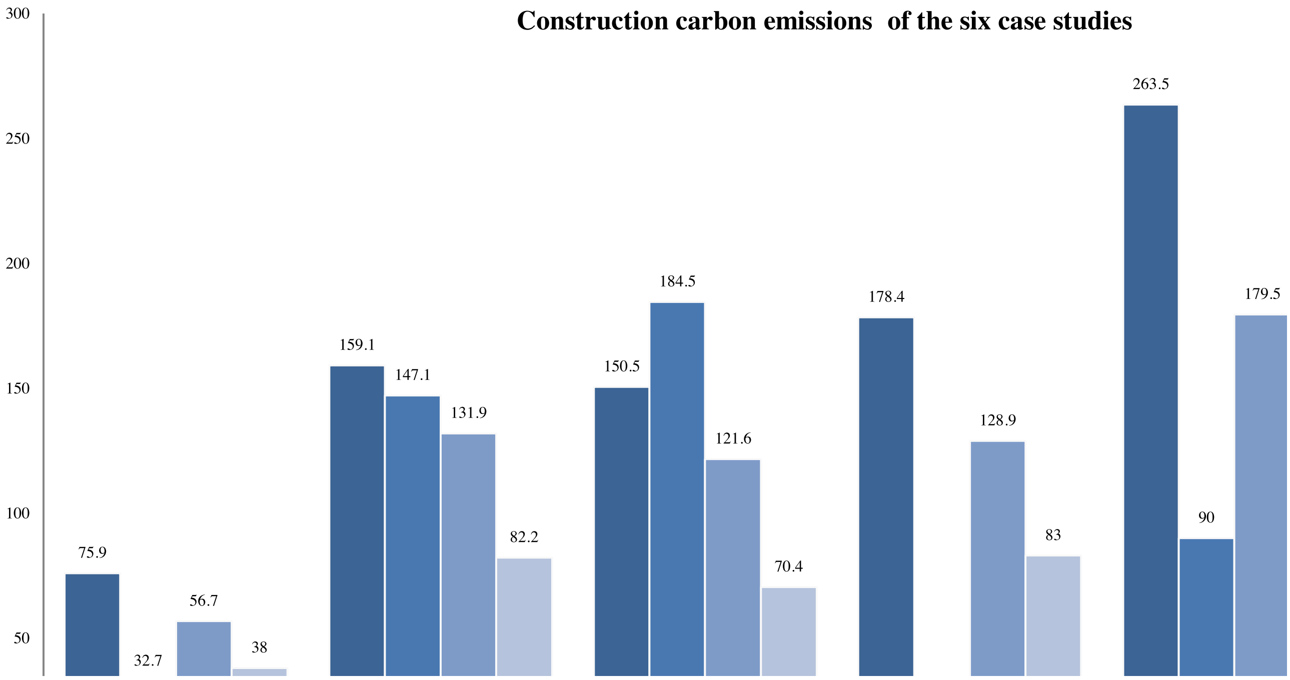

Fig. 1. Construction carbon emissions from the six case studies based on data in Table 3 (Standard/Basic construction carbon emissions compared with Implemented; Green tool (Green Star) and from application of the Research Model).

carbon emission in the UK building sector (Allwood et al., 2012; UK Indemand, 2014). It is hoped to eventually achieve 80 per cent reduction in construction carbon emissions in the UK by 2050.

As the Australian building sector represents the greatest contributor to Australian greenhouse gas (GHG) emissions, reducing construction emissions in this sector is of great importance to the Australian government and building designers. Thus, the future of the green construction industry lies on taking into account bioclimatic principles- such as replacing conventional building materials with more energy efficient materials (e.g. replacing Portland cement with geopolymer based cement); reusing recycled construction materials; reducing transportation and other similar initiatives.

2. Carbon emissions (embodied energy) of building

Construction, renovation and maintenance of buildings are significant economic activities contributing to between 10 and 40 per cent of the Gross Domestic Product (GDP) of many counties. The environmental footprint of the building sector includes 40 per cent of energy use, 30 per cent of raw materials use, and 25 per cent of solid waste. The building sector is also responsible for more than one third of global GHG emissions, and in most countries is the largest emissions source. Furthermore, significant energy is used in transporting occupants, goods and services to and from the building (UNEP SBCI Sustainable Buildings and Climate Initiative, 2010). An IPCC report concluded that the building sector has the largest potential for reducing GHG emissions (IPCC Intergovernmental Panel on Climate Change, 2007). The energy consumption in both new and existing buildings can be cut by an estimated 30–50 per cent without significantly increasing investment costs (Nuttall, 2015).

Australia generates about 1.5 per cent of global greenhouse gas emissions; and on a per capita basis is one of the world's largest polluters (Carbon Neutral, 2014). In fact, the energy used by buildings in Australia contributes approximately 20 per cent of the country's greenhouse gas emissions (Australian Government, 2014), and the Australian building sector is reported to have one of the largest impacts on such emissions (Hyde, 2012). Energy reduction in the Australian building sector is thus a priority both for the federal government and also the city councils of Australia (Green Building Council of Australia, 2010; City of Melbourne, 2014). This Australian study identifies methods that can assist in this goal, and could also be used as a pilot for other countries, thus increasing the potential to reduce GHGs beyond just the Australian context.

3. Bioclimatic design principles

The twin Olgyay brothers from Hungary defined bioclimatic principles as the principles that bring together the disciplines of human physiology, climatology and building physics (Olgyay & Olgyay, 1963). Victor Olgyay (1910–1970) is best known today as the author of "*Design with Climate: Bioclimatic Approach to Architectural Regionalism*" (1963)—a book often referenced in the environmental building design field. As leaders in research in bioclimatic architecture from the early 1950s to the late 1960s, the Olgyay brothers can be considered the fathers of contemporary environmental building design (Leather & Wesley, 2014).

Pereira (2012) believes that building design should be inspired by nature, and aim to minimize environmental impact (Pereira, 2012). This goal can be achieved through use of bioclimatic principles which can be used to identify criteria to measure potential reduction in carbon emissions generated by building construction. There are two main aims in bioclimatic construction—first, to ensure that the constructed building is able to function satisfactorily within current and future climatic conditions; and, second, that the environmental impact of existing buildings is reduced through reduction in their energy use and GHG emissions. Use of these principles has been integrated into building design in the context of regionalism in architecture, and in recent years has been seen as a cornerstone for achieving more sustainable buildings (Hyde and Yeang, 2009). Research has found that appropriate bioclimatic design can reduce energy consumption in a building as compared with conventional building design (Jong and Rigdon, 1998).

The following is a summary of the bioclimatic principles that have been used in the model proposed in this paper. They focus