



Life-cycle cost analysis of green-building implementation using timber applications



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ABSTRACT

Green buildings are gaining popularity in Australia with the applications of Green Star rating scheme. However, the credit for using timber materials in the rating scheme, while timber being a significantly used material in the fast growing residential construction industry, does not adequately guide designers and builders on the selection of the best timber types for residential applications from the life cycle perspective. This research presents the analysis on the life cycle cost of timber materials in their various applications for residential buildings in Australia and thereby provides guidance on how to best meet the requirement set out in the timber credit in the Green Star rating scheme. Structured interviews were used to collect the data on the cost of timber materials in their lifetime from builders, tradesmen and other residential construction professionals. Three sets of cost information were received under each application, for the individual timber species against three conditions (low, medium and extreme weather) with reference to residential buildings. Based on life cycle cost analysis results, the most suitable timbers for different applications are recommended.

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1. Introduction

Greenhouse-gas emissions have become one of the most impacting environmental issues in today's society (Australian Government, 2008; Green Building Council of Australia (2012); Hedberg et al., 2010). Leskovec (2012) stated that an emergence in green buildings has been seen as a response to these environmental concerns. An article by the USGBC (2011) reported that within

green buildings lies a deeper concept of constructing structures using materials and processes that are responsible and efficient towards environmental and resource objectives throughout the buildings life span. The implementation of constructing green buildings is reported by the MGSA (2012), United Kingdom who developed the very first rating scheme, known as BREEAM, to rate buildings on their green/sustainable aspects. As this gathered pace and recognition, a similar scheme was developed in the United States with establishment of the United States Green Building Council.

The Australian Green Building Council began as a not-for-profit organisation, which at a national level encourages the use of green building practices. The organisation also focuses its efforts on developing a sustainable construction industry within Australia (States News Service, 2011). Since the inception of the Australian

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Green Building Council, it was reported by [Ainslie and Robert \(2012\)](#) that as of 2012 there had been 500 Green Star ratings issued within Australia, which depicted the fact that a trend was beginning in accepting sustainable construction within the construction industry and society. This trend is further backed through the implementation of additional schemes such as National Australian Built Environment Ratings System (NABERS), Building Sustainability Index (BASIX) and Nationwide House Energy Rating Scheme (NatHERS). Among these, Green Star is the most widely recognised in Australia.

Sustainable timber is a credit under Material category in the Green Star ratings that is significantly used in Australian residential construction. [Caldwell \(2006\)](#) described timber as a strong and easy to work, which is simply cut, dried and sawn to shape to put it in a workable state. Approximately one-third of the annual worldwide timber harvest is used in construction and timber frame is considered one of the popular methods of construction accounting for approximately 22% of new build housing within the UK ([Lyons, 2014](#)). Further, housing and other residential construction provides a major market for wood products and in 2015–16 it marks the fourth year of consecutive growth use of wood products in residential construction activity in Australia, with the total number of dwelling commencements 58 per cent higher than in 2011–12 ([Australian Bureau of Agricultural and Resource Economics and Sciences \(Abares\), 2016](#)).

About 55% of construction materials used are made up of timber products that are mainly found in applications within residential buildings ([Abs, 2003](#)). It was also reported by the [ABS \(2003\)](#) that over 25 years from 1985 to 2000, the average floor area of residential buildings had increased approximately by 50 m² to a high of 225 m². An environmental sustainability index for timber structures has been proposed for measuring strength-to-weight ratios, insulating properties and encouraging the use of more sustainable materials ([Cuadrado et al., 2015](#)). Timber seasoning in tropical areas has also been studied for different types of products ([Ugwu et al., 2015](#)). The potential for the use of cross-laminated timber which is an engineered wood-based product and made of multiple layers of wood boards and oriented perpendicular to the adjacent layers, for additional applications has also been examined ([Fernanda et al., 2015](#)). These research studies showed the wider use of timber in residential construction and the need to consider sustainable timber that has the least environmental effects.

Australian Government in conjunction with the relevant local and state authorities has gone to the lengths of protecting forest ecosystems with the use of forest conversation. The [ABS \(2003\)](#) reported as a result of this, approximately 26.8 million hectares of forest had been protected which makes up about 16% of the remaining native forestry within Australia. However, it has been reported that there has been use of illegal logging of timber within Australia ([Hopkins, 2009](#); [Schaafsma et al., 2014](#)). This would cause forest degradation, which in turn leads to the loss of habitat and biodiversity critical to the environment. It was these issues that lead the Green Building Council of Australia to revise the Green Star Timber Credit in 2010 to recognise timber that is accredited by a forest certification scheme ([Gbca, 2012](#)). It is also noted by [Mellon \(2009\)](#) that the revised timber credit aims to make recognition of certified timber products that are valued as an important part of the Australian timber industry.

Overall, the above background study emphasises the importance of timber materials within the residential construction industry and stresses the need to maintain it as a sustainable resource that can be relied upon throughout the life cycle of a residential building. However, the previous literature lacks in addressing life cycle effects of using sustainable timber in residential construction in Australia. This knowledge gap in the literature was focused in

this research study with the aim to determine the life cycle cost of timber materials in their applications within residential buildings in Australia, which ultimately determines its level of sustainability.

2. Literature review

2.1. Sustainability and green buildings

Sustainability is considered as a greatly important factor in most aspects of our lives as it pursues for meeting the needs of the present without comprising the needs of future generations ([Wced, 1987](#)). It is a term that is used amongst various disciplines within the same context of desired development and environmental management ([Anastas and Zimmerman, 2003](#); [Alexander, 2003](#); [Brown et al., 1987](#)). The definition of sustainability is often quite dependent on the organisation, association or individual defining the term of sustainability ([Hart, 2010](#)). Sustainability can be defined generally as the responsibility of individuals and society to move forth in ways that will sustain life ([Tjpd, 1998](#)). Sustainability surrounds itself around three main principles that are tied together. These include environment, economy and society, which run parallel to maintain the resources we require in this world ([Green Sense, 2012](#); [Honeywell Process, 2009](#); [Alonso-Santurde et al., 2012](#)).

In the context of building sustainability, sustainability involves the management of the limited natural resources that the environment has to offer, whilst also taking into consideration human comfort and living conditions of a building ([Rovers, 2008](#)). Sustainable building design can be commonly referred as green design. The green building forms part of a standard shift toward sustainability being a practice that is commonplace amongst the construction industry. It becomes apparent through a study published by [Bowman and Wills \(2008\)](#) that there are added values that a green building delivers. These are stated to include the value of the building increasing by about 7.5%; the cost associated with operating the building decrease by 8%–9%; an increase of 3.5% in the actual occupancy ratio of the building; an increase of 3% in the buildings rent ratio; and, the owners return on investment is improved by approximately 6.6%.

In conjunction with advantages, there is always the possibility of having disadvantages. In the case of green buildings, it is the cost factor, which can pose the problem to the development of a green building. Cost can be driven by multiple factors and is best reduced through the management and control of these factors during development of a green building ([Ramos et al., 2013](#)). These multiple cost factors included certain costs such as acquisition costs, design and construction costs, operational costs, maintenance costs, refurbishment costs and associated risks ([Ramos et al., 2013](#)) [Yudelson \(2008\)](#) mentioned possible cost-driving factors as type of project, project team experience and Green Building Accredited Technologies.

Recent trends display the movement of green building design from a niche in the market to becoming mainstream. This led to [SBI Energy \(2012\)](#) to report that the residential construction sector represented the swiftest growth segment in green construction, in the period from 2007 to 2011, with the market value of green certified homes rising from \$39 million to \$17.15 billion. More recently in 2013, a survey displayed that 35 percent of Australian building companies are global leaders in sustainability and 95 percent of these companies have internal resources dedicated to managing sustainability, making Australia a global leader in the green building sector ([Gbca, 2013](#)). However, [McGraw-Hill Constructions \(2013\)](#) reported there are challenges in green building sector due to high initial cost and minimal support from a political/government perspectives. To this end, sustainable rating systems help to promote green buildings as discussed next.

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