BIM and Australian Green Star Building Certification

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ABSTRACT

Nearly 80% of green certified structures in Australia are commercial office buildings. Attaining the highest certification often requires the application of design modelling and analysis tools, demanding greater levels of design coordination and management. Whilst the opportunities for green building certification to benefit from building information modelling (BIM) may be obvious, in Australia the relationship is yet to be validated. This research seeks to address this gap by evaluating the application of BIM for green building certification. The authors present a case study of an Australian commercial office building. Project participants were interviewed and the as-built BIM model audited to analyse data against certification criteria. The results identify gaps in design management and modelling practices, as well as a lack of alignment between design activities and green building certification criteria. Gaps in internal project coordination were more pronounced than with external certification tasks. The study suggests the development of dedicated BIM execution and coordination plans for green building design and certification is required, and discusses the mapping of BIM management requirements with certification standards, criteria and processes.

INTRODUCTION

The construction industry is responsible for more than 30% of carbon emissions (WGBC 2010). Pressures on developers such as rising energy costs, the introduction of carbon taxes, growing awareness of climate change and various other environmental hazards, which can adversely affect health and living conditions, have resulted in the rise of environmentally sustainable design (ESD) methods. In the past two decades national green building certification (GBC) bodies have also emerged around the world. These market-based approaches take the form of voluntary environmental certification systems, such as Green Star (Australia), NABERS (National Australia Built Environment Rating System), LEED (United States, Leadership in Energy and Environmental Design), Energy Star (United States), Green Globes (United States and Canada) and BREEAM (United Kingdom, Building Research Establishment Environmental Assessment Method) (see: BREEAM, 2013, GBCA, 2013, USGBC, 2013, WGBC, 2010).

In Australia, 2014 will see the introduction of a new certification system whereby the Green Building Council of Australia (GBCA) will implement a single streamlined "Design and As Built" rating tool. This tool is designed to be more cost-effective as compared to the two currently separate rating systems. The online tool will comprise a simpler documentation process, support standardized modelling, generate automatic reports, and provide technical information and credit interpretation guidance. The system does not award certification credits until the building is handed over. Consequently it will be critical for projects to consider ESD approaches and environmental management systems from the early project phases, thus demanding higher levels of building systems integration, modelling and simulation during design.

Green building design processes are arguably more complex than conventional design approaches. Multidisciplinary design teams must address ESD and systems integration requirements. Achieving an integrated design solution prior to construction means that the design team must manage reciprocal task interdependencies and address a complex of information sharing requirements surrounding data coordination and exchange across multiple disciplines. Adding to this complexity in new commercial office design, particularly high-rise building design, it is common that one of the main design objectives is to create an 'iconic' design, which results in higher levels of collaboration and coordination due to increased technical requirements surrounding the façade design. Design solutions must be negotiated in interdependent decision networks and design changes (and their knock-on effects) must be tracked across lengthy development periods. Advanced environmental modelling, simulation and analysis tools are therefore required to help manage such complexity. The implementation of information technologies (ITs) to support modelling and analysis during the design stages are increasingly occurring with the use of BIM technologies spreading across the wider project team (McGraw Hill 2012). The opportunities for green building certification processes and outcomes to benefit from these new digital ways of working are obvious. However previous research has shown that BIM for green building design presents new management challenges, and does not necessarily guarantee higher certification ratings (Gandhi and Jupp 2013). This research explores current practices surrounding GBC and the application of BIM for green building design in the Australian AEC industry. This study is therefore aimed at enhancing BIM implementation for green building certification purposes.

BACKGROUND

The GBCA launched the Green Star rating system in 2003 and after a decade reached a milestone of 5.5 million square meters of certified buildings. Figure 1 summarises some significant environmental benefits of Green Star over a 10 year period that is characterized by greener design and construction compared to conventional approaches. There are other benefits that motivate the development of greener buildings amongst clients and developers, some of which include lower overheads, higher returns, lower insurance costs, access to tax credits and incentives, faster lease-up periods, lower renovation costs, increased interest by ethical investment funds, more productive and healthier environments for occupants, and most of all a more competitive industry image.

Nearly 300 of over 425, i.e. almost 80%, of Green Star certified structures can be categorised as commercial office buildings (GBCA 2013). Commercial high rise office buildings represent the highest levels of savings in energy, water and natural gas consumption, as well as in greenhouse gas emissions. Commercial structures built to the standard of a 4.5 Green Star rating (minimum requirement) have a number of benefits in terms of costs, health of occupants, productivity of occupants, life-cycle costs, energy consumption and sometimes have even succeeded in achieving net-zero criteria (GBCA 2013). Table 1 summarizes the rating criteria and certification stages for commercial spaces, as specified by Green Star's Office Design Tool (Version 3, GBCA, 2013).

In the design development of greener commercial high-rise office buildings sophisticated modelling, simulation and analysis tools must be utilised. The ITs that support BIM must meet the information requirements of Green Star criteria. The provision of this information relies on high levels of multi-disciplinary design coordination and collaboration to undertake the required building simulation activities and demonstrate building performance.

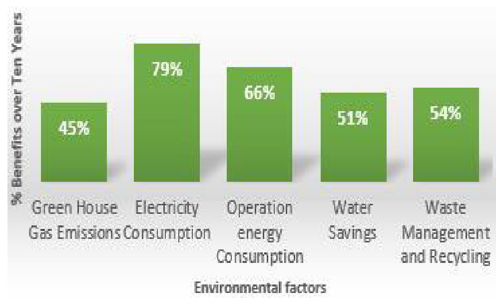

Figure 1. Benefits of Green Star over conventional designs, (source GBCA 2013).

Table 1. Green Star Rating Summary.

Credit Name	Points	Weighting
Management	12	9%
Indoor Air Quality	27	20%
Energy Efficiency	29	25%
Transport	11	8%
Water Efficiency	12	12%
Material Resources	21	14%
Land Use and Ecology	8	6%
Emissions	16	6%
Innovation	10	0

Rating Levels	Points
One Star	10-19
Two Star	20-29
Three Star	30-44
Four Star (Best Practice)	45-59
Five Star (Australian	60-74
Six Star (World Leadership)	75+

From this perspective, BIM has been demonstrated by researches to be able to assist in achieving more than 35% of the credits in the US based LEED rating system (Azhar *et al.* 2011). Bynum *et al.* (2012) have also recently reported that the effectiveness of BIM for sustainable design practices is becoming more prevalent for project management purposes and staging building performance.

Similarly in an Australian context, a data rich semantic BIM model can be utilized to produce the necessary documentation for Green Star certification; such as schedules for parking, detailed object properties specifying energy consumption, day light analysis, etc. Whilst Australia is moving towards its 2020 challenge of achieving carbon neutral buildings it is important to highlight features and elements that assist in achieving neutrality in carbon emissions. Some of the features include passive design, on-site generation of energy from renewable sources, energy efficient appliances and light fittings, purchasing green power, introducing alternative ways to optimize, upgrade or remove HVAC systems.

Current levels of BIM implementation on commercial office building projects are limited in the Green Star certification context; however with the proposed 'Green Star Online' system going live in 2014, the GBCA expects that these project types will increasingly utilise virtual building models in order to meet design and as-built certification criteria. New strategies which can help to minimize gaps between BIM technologies and green buildings will therefore be required (Juan *et al.* 2010, Luthra, 2010, Jupp and Gandhi 2012). In previous research the authors have identified from industry surveys that implementation strategies and management frameworks are important factors affecting BIM adoption for green building design (Gandhi and Jupp 2013). A lack of clarity about process coordination and information exchange requirements also add to the management issues of successful 'Green BIM'. A 'Green BIM' management plan is a vital step that brings to light the mapping between green building requirements and BIM resources throughout the design stages. However, to date no such direct mappings have been created which compare Green Star requirements and the GBCA's Commercial Office Design tool with BIM technologies, processes and protocols.

RESEARCH SETTING, METHOD AND FINDINGS

The scope of this study is limited to commercial high rise office buildings. The object libraries considered for this study were not provided by the GBCA or any other governmental organizations. The research targets issues relating to the mapping of available modelling and analysis resources with Australian Green Star certification requirements.

Methodology. This research design was structured into three stages. Stage 1 included developing a matrix to establish the relationship between BIM technologies and Green Star rating criteria and processes. This matrix was developed using a literature review and analysis of Green Star certification credit requirements for commercial office buildings. Stage 2 involved the validation of this matrix through a case study that targets a commercial office building with a design process that was characterised by: i) integrated multidisciplinary collaboration between the architectural, structural, façade and ESD consultants; ii) the use of BIM technologies for sustainable design analysis; and iii) Green Star certification. The case study focuses on a state-of-the-art commercial office building certified with a 6 Star Green Star rating (highest award) but which achieved only a 4.5 out of a possible 6 Star rating in the NABERS as-built rating system. Twenty seven project participants were interviewed to understand four key aspects of implementing BIM for green building design and certification, namely: i) drivers of implementation, ii) challenges to successful implementation, iii) significance of object libraries, and iv) best or good industry practice. Stage 3 involved the auditing of the as-built BIM model. The process of mapping BIM and the required objects and object properties that were able to support Green Star certification criteria was undertaken by developing a simplified external database. The analysis therefore compared ESD and GBC requirements with BIM resources, focusing on authoring and analysis software and object libraries.

Findings. The findings of Stage 1 are shown in Table 2, illustrating a mapping between the possible Green Star credits that can be addressed using BIM modelling and analysis technologies. The table also shows the credits attained using BIM in the case study, which resulted in a number of software application based challenges. As the table shows the most often utilised software includes: Autodesk Revit, Autodesk Navisworks, AutoCAD, Graphisoft ArchiCAD, and Ecotect, Stats.

It is clear from Table 2 that BIM modelling and analysis technologies were not utilised to their full potential for Green Star certification, and there is a need to address these gaps so as to align design ratings with as-built ratings. Table 2 also shows that the BIM model did not contain any objects, properties, references or reported outputs for some of the credits required, including Indoor Air Quality, Energy Efficiency, and Innovation The design achieved a 6 Star Green Star rating based on building models, simulations and calculations provided by the architectural, structural, façade and ESD consultants, where building performance was assessed via shadow analysis, thermal performance, fire modelling, lighting, and structural modelling. It is possible that with more detailed object properties defined and further energy modelling and analysis that Indoor Air Quality credits could be addressed more fully which may help assure higher ratings in both design and as-built ratings.

Table 2. Green BIM application Summary.

Credit Name	Points	Weighting	BIM Possible	BIM applied	BIM Tool Applied
Management	12	9%	0	0	
Indoor Air Quality	27	20%	27	19	IES Virtual Environment, Transys, Ecotect, AnTherm,
Energy Efficiency	29	25%	29	15	Ener –Win, Trace 600
Transport	11	8%	10	5	Revit, ArchiCAD
Water Efficiency	12	12%	12	11	Microstation, Revit
Material Resources	21	14%	21	20	Revit, ArchiCAD, Stats, Navisworks
Land Use and Ecology	8	6%	4	2	Revit, AutoCAD
Emissions	16	6%	15	15	Revit
Innovation	10	0	10	0	
Total		**100%**	**88%**	**66%**	

The findings of Stage 2 of this research reveal insights about current AEC practices surrounding multidisciplinary modelling, analysis and simulation. The drivers of Green BIM implementation were varied and the top seven responses included: 1) Improved building design with regard to environmental sustainability (98%)l 2) Improved visualisation (79%); 3) More accurate and efficient simulation, analysis and documentation (78%); 4) Higher levels of certification assurance (77%); 5) Client demand (74%); 6) Contractual obligations (68%); and 7) Cost effectiveness (65%). These results are shown in Figure 2. Interviewees did realise and acknowledge the benefits provided by BIM for improving sustainability analysis, enhancing visualisation and providing greater assurance in the process of attaining expected Green Star certification credits due to increased information accuracies due to modelling, simulation and analysis tools.

Based on an analysis of the interviews, eleven challenges to implementing a Green BIM approach were identified and are shown in Figure 3. The graph shows that the five main challenges are: 1) Required changes to traditional workflow (93%); 2) Lack of involvement of ESD consultants in early project phases (94%); 3) Lack of implementation strategy (91%); 4) Required changes in data management (89%); 5) Required changes in tendering process (88%).

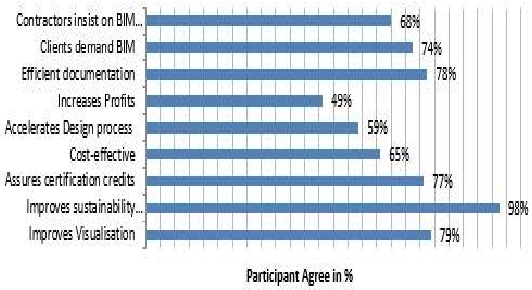

Figure 2. Factors driving Green BIM in Australian AEC industry.

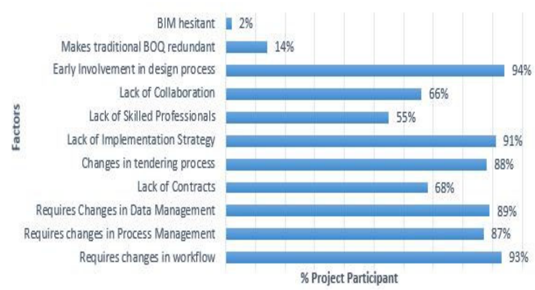

Figure 3. Challenges to a Green BIM approach in Australian AEC industry.

It was also revealed that despite the lack of contractual detail and client funding, interviewees agreed that commercial office projects are steadily moving towards higher levels of multi-disciplinary collaboration with mutual co-operation and increasingly incorporating BIM tools. In particular the younger AEC professionals (25-35) appeared to have a greater appreciation for integrated design processes and actively extended their responsibilities and scope (irrespective of contractual agreements) to achieve greater levels of design integration.

The auditing of the as-built BIM dataset revealed four shortfalls in the model and thereby the modelling and analysis practices that were used to produce it. The first shortfall surrounded gaps in the modelling conventions. This includes a lack of standardised naming conventions across project participants. Often objects in the model were named in relation to their location, level, or type to indicate elements in the model. This makes it difficult for managers to retrieve information during the design phases. Standardised object-libraries were also not implemented to regulate item codes and easy identification of elements in the model throughout design stages. In addition, the creation of element and object sets or groups were often irregular as they were created according to information specified by external consultants. Such an approach to modelling makes it difficult for core design team members to review building services at different levels individually. The second shortfall relates to the specification of the purpose or function of the BIM model. The function of the model did not explicitly target Green Star certification, nor was the central model consistently updated to include ESD modelling outcomes. Rather independent ESD models were generated from the central model but not fed back into it. This makes it difficult to keep track of changes which may directly or indirectly impact on the sustainability of related building systems. Thirdly, in the as-built model, detailed asset information was not embedded into all assets contained in the model as installed. The asset information was found to be ineffective for both Green Star and facilities management purposes. Finally, whilst not evident from within the as-built model, the fourth shortfall can be attributed to inconsistencies in the file exchange formats used during design. Whilst this problem was initially identified in the interviews it is evident from the as-built dataset that it has caused model coordination difficulties.

DISCUSSION

The results of the case study reveal gaps in the design and model management strategies surrounding Green BIM and shortfalls in modelling and analysis practices. as the findings also demonstrate a lack of alignment between the processes, activities and tasks that support modelling and analysis and those that support the fulfilment of green building certification criteria. Figure 2 illustrated the demand and uptake of BIM in industry and project participants appear to understand its benefits for ESD and Figure 3 suggests there are various factors that pose challenges to a Green BIM approach; amongst which the required changes to traditional workflow and absence of ESD consultants in early project phases coupled with the lack of implementation strategies are three key concerns.

Developing an accurate virtual building prototype for green certification purposes depends on various factors such as greater detail and clarity surrounding a 'greener' BIM coordination and execution plan, identification of participant capabilities in modelling and simulation processes, development of appropriate object libraries that can address Green Star criteria, advances in modelling guidelines and standards suitable for certification processes, and increasing levels of design process coordination and information exchange. Table 2 mapped Green Star credit requirements and the BIM technologies capable of addressing them relative to the case study's BIM model. From the table it is evident that nearly 90% of Green Star credits can be assisted by BIM ITs, but even in a state-of-the- art project only 65% of the possible credits were addressed using the building performance analysis capabilities provided by these technologies. This indicates that despite the available ITs, skills, contracts and guidelines that the capabilities of BIM technologies were not leveraged to their full potential on this commercial office design project in relation to meeting Green Star criteria, and therefore not realising the prospective sustainability benefits over the building's lifetime.

The auditing of the as-built BIM model revealed the four potential causes. Despite the relatively detailed BIM execution and coordination plans, the identification of modelling conventions and specification the model's purpose for Green Star certification, together with the lack of detailed asset information and agreements for file exchange formats were not agreed prior to commencing design, nor were capabilities of project participants assessed before project execution.

CONCLUSION

Australian AEC organisations participating on commercial office building projects are beginning to exploit BIM for green building certification purposes. This study shows that whilst BIM technologies are able to support Australian Green Star certification and (as demonstrated by the case study) achieve the highest (6 Star) rating, due to shortfalls in design and data management these outcomes do not necessarily translate into as-built ratings. Thus the further potential to leverage the IT capabilities of BIM so as to realise higher as-built ratings on project completion lay in the implementation of new process and policy coordination and data management capabilities. Development of Green BIM execution and coordination plans that can address the requirements of green building certification are therefore essential. It is necessary to introduce new approaches to managing modelling and simulation tasks that address reciprocal task dependencies and data exchange requirements of building simulation and performance analysis. Decisions regarding the functional requirements of virtual building prototypes for Green Star should be pre-defined to avoid unexpected results and information shortfalls; such requirements include a planned list of models mapped to analysis and simulation requirements. Agreed modelling conventions across disciplines must be supported by detailed guidelines providing greater clarity on all modelling tasks and elements. Assessment of BIM capabilities required by green building design projects should be conducted during tender processes to avoid uncertainty at later stages. A detailed Green BIM implementation strategy must also therefore be developed to address these internal requirements and align design processes with external Green Star certification procedures. This latter issue is the topic of future work that will be conducted by this research.

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