GREEN BUILDING RATING FOR OFFICE BUILDINGS – LESSONS LEARNED

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ABSTRACT

Office buildings constitute a significant proportion of the non-residential building stock. In recent years, various rating tools have been developed to foster green office building development. The Green Building Council of Australia (GBCA) has developed the Green Star - Office rating tools for this purpose. There are an increasing number of stakeholders adopting these tools to showcase their efforts in sustainable development. This research focuses on the challenges and barriers in obtaining GBCA ratings in Australian Office buildings. To accomplish this, the scoring sheets from the rating of 264 certified office buildings were collected and critically analysed. The findings indicated that credits related to the attributes of innovation, ecology and energy are comparatively difficult to achieve. It was also found in this study that a large number of projects did not apply for the specific credits of refrigerant global warming potential, re-use of façade, topsoil and fill removal from site, and individual comfort control. This study provides a useful reference to both the property developer and the Green Building Council of Australia for green building developments in the future. In particular, the findings provide useful inputs to the development of the next generation of green building rating tools.

KEYWORDS

green building rating, office building, GBCA, Australia

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1. INTRODUCTION

Sustainability has been embraced to various extents by an increasing number of organizations and governments globally. It is well recognised that the building sector plays a crucial role in achieving the sustainability goal. For instance, the building sector is one of the biggest energy consumers and greenhouse gas emitters, contributing towards some 40% of total energy consumption in most countries (e.g. WBCSD 2007; Zuo et al. 2012). Indeed, the building sector is identified by the World Business Council for Sustainable Development as one of nine key sectors contributing towards a sustainable future in their strategic document: Vision 2050 (WBCSD 2010). This is further supported by the prediction made by the International Energy Agency that commercial and institutional buildings will grow strongly by 195% by 2050 (IEA 2011). Therefore, the sustainability performance of buildings becomes even more critical.

Office buildings make up a significant proportion of the building stock. Recent years saw a steady improvement of the commercial real estate sector even though it was facing the challenges of the global financial crisis (CBRE 2012; Jones Lang LaSalle 2012). In Australia, the floor area of commercial buildings in major cities is more than 23 million m2 in January 2012 (Property Council of Australia 2012). In response to the requirements of sustainable development, the office building sector is embracing sustainability initiatives (Harrison and Seiler 2011), and an increasing number of green office buildings have been developed to reduce their environmental impact.

In order to assist the industry to develop green office buildings, various building assessment tools have been developed. All major green building rating tools, such as LEED (US) and BREEAM (UK) have a dedicated tool for the office type of buildings. Similarly, the Green Building Council of Australia (GBCA) has released three rating tools for office buildings, i.e., Green Star - Office Design, Green Star - Office As Built, and Green Star - Office Interior. These rating tools consist of nine categories of green building related credits, i.e. management, indoor environment quality, energy, transport, water, materials, land use and ecology, emissions, and innovation. These rating tools have significant impacts on the commercial real estate sector. This is supported by the fact that 11 per cent of Australia's commercial office buildings in the central business districts (CBD) are Green Star certified (GBCA 2010).

There have been studies investigating the benefits and effectiveness of securing the Green Star certification. Kato et al. (2009) surveyed occupants of GBCA certified office buildings and argued that the benefits of green star certification are more psychological than physical, such as health and productivity improvements. They further pointed out that noise and lack of privacy are major concerns about green office buildings from a workplace perspective. Armitage et al. (2011) surveyed 382 occupants of commercial office buildings certified by the GBCA. Their study concluded a high level of tenant satisfaction as the major benefits of a GBCA rated office building. They also found that the employer perceived the improved health and productivity as a benefit of GBCA rated office buildings whereas employees disagreed.

However, securing the Green Star certification for office buildings is not easy for many applicants. Different categories of green office rating tools pose different requirements and challenges to project stakeholders (Xia et al. 2013). In the current literature, few studies have focused on the level of difficulty to obtain credits under each category of the green office rating tool by means of a critical analysis of the rating documentation. Therefore, this research aims to explore the level of difficulty of securing the credits under each category of the GBCA Green Star Office rating tool. Understanding credit acquisitions in each category provides

decision makers with information on credits awarded in the past and insight into credit implementation for future projects with similar goals.

2. LITERATURE REVIEW

A number of studies have investigated sustainability issues associated with office buildings worldwide. Most of these studies have focused on the environmental aspects of the sustainability of buildings such as: energy performance (e.g. Juan et al. 2009), water efficiency (e.g. Zhang et al. 2011) and greenhouse gas emissions reduction derived from construction and demolition (e.g. Dimoudi & Tompa 2008; Gabe 2014). Green office buildings generally lead to better environmental performance than traditional ones. In addition, Kneifel (2010) applied a life cycle approach to new commercial buildings and argued that the benefits from energy efficiency (e.g. energy and cost savings; carbon emission reduction) as part of green building initiatives are long term and will offset the initial cost. This is echoed by Eichholtz et al. (2013) who found that economic returns on green office buildings are substantial and enhanced energy efficiency is capitalized into rents and asset values.

Energy conservation should not come at the expense of building users' health, satisfaction and productivity (Wedding & Crawford-Brown 2008; Pérez-Lombard et al. 2009; Korkmaz et al. 2010). Other scholars have shed light on the human aspects since the office is a place in which tenants spend a large amount of time and an office building ultimately needs to achieve a high level of occupant satisfaction (Brager & Baker 2009; Thomas 2010; Baird 2010). For instance, Lehmann et al. (2010) simulated and measured the thermal comfort level in a green office building and consequently suggested the range of room temperatures required. Smith & Pitt (2011) pointed out that the potential health benefits expand the traditional scope of environmental sustainability of green buildings to social and economic aspects. Singh et al. (2010) studied two buildings, one conventional and another which had been certified by the Leadership in Energy and Environmental Design (LEED) scheme. Their study indicated that the occupants' health condition and level of productivity is better when occupying a green building (see also Pan et al. 2008). As indoor environmental quality is a critical issue in office buildings (Yu and Kim 2010; Cheong et al. 2003), Hwang & Kim (2011) argued that the enhanced indoor lighting environment (e.g. illuminance/luminance distribution) helps to improve the level of visual comfort and consequently psychological wellbeing and productivity of occupants based on a 1.5 year survey of more than 2700 office workers. Indeed, occupant health and productivity should feature the post occupational evaluation exercise, which helps to bridge the gap between a client's expectation and design solutions for future green building developments (Deuble & de Dear 2012).

However, not all the research findings are positive toward green office buildings. Gou et al. (2012) found that users of green office buildings reported some discomfort with summer or winter temperature, which is statistically correlated with perceived level of health and productivity. A study by Issa et al. (2010) showed that the majority of practitioners were uncertain of productivity and health benefits associated with green buildings as documented in the literature, partly due to a lack of uniform measures of these impacts. A study by Paul & Taylor (2008) also showed that there is no significant difference between green building and conventional buildings with respect to heating, ventilating, and air-conditioning systems in terms of thermal comfort.

Despite a rapid and growing number of buildings certified by various green building rating tools, very few studies have attempted to examine the difficulties of applying varied

credits under different categories. This is particularly the case in Australia. Most of the previous studies offer a general review and analysis of the green building market, such as the distribution of green building projects in various sectors. Silva and Ruwanpura (2009) is one of the very limited number of studies that designed a novel approach (credit frequency indicator) to investigate how frequently a credit has been applied for in Canada. A method is developed in this study to gauge the overall difficulty in achieving credits under the GBCA Green Star Office rating tools.

3. RESEARCH METHODS

To investigate the difficulty of credit acquisition, the scoresheet of certified Green Star projects, ranging from 2004 to 2011, were obtained from the GBCA. Based on the characteristics of these data, the Credit Achievement Degree (CAD), Credit Application Rate (CAR), and Credit Gain Index (CGI), were developed to measure the levels of difficulty.

The Green Building Council of Australia was approached in 2011 for a scoresheet of all green buildings that have been certified. The authors signed a confidentiality agreement with the GBCA prior to the release of the data. The scoresheets were analysed and are discussed in the following sections. There were a total of 388 projects included in the aggregated scoresheets provided by the GBCA and among them there are 333 Green Star office buildings certified under Office Design, Office AS Built, and Office Interiors. As a result, some of credits may not be taken up. For example, Office Interiors do not deal with ecological credits.

A credit frequency indicator (CFI) was used as proposed by Silva and Ruwanpura (2009). This measures the achievements of credits in each project by means of calculating "the frequency of obtaining a certain credit within a category and is calculated based on the total of the previously analysed percentages of points obtained" (Silva and Ruwanpura 2009, p.51). For each certified Green Star project, the credits (points) applied against each subcategory from the applicant, and the corresponding credits (points) obtained by the applicant are recorded in the GBCA score-sheet. The total credits applied (CA) and total credits obtained (CO) for each subcategory/category were retrieved from the scoresheets. Similar to the CFI, the credit achievement degree (CAD) can be calculated by dividing the total number of credits obtained by the total number of credits applied (Xia et al. 2013):

$$CAD=CO/CA*100\%$$

The preliminary analysis of the database showed that for some subcategories, not every single project applied for the same credits (points). Therefore, another indicator called the credit application rate (CAR) was designed to measure the difficulty in achieving the GBCA Green Star credits:

$$CAR= \text{the number of projects that applied for this credit} / \text{total number of projects}*100\%$$

Finally, the Credit Gain Index (CGI) was developed, which considers both the credit achievement degree (CAD) and credit application rate (CAR) to represent the overall difficulty in achieving the GBCA Green Star credits:

$$\text{Credit Gain Index (CGI)} = CAD * CAR$$

During the time of this study, a total of 333 projects were certified by a suite of GBCA Green Star Office rating tools, i.e. Green Star - Office Design, Green Star - Office As Built, and Green Star - Office Interiors. Green Star - Office Design was the rating tool with the most number of certified projects, accounting for 61%. Take the Green Star-Office Design projects as example, 166 out of 264 projects applied for a total of 498 points against the subcategory IEQ1 (Ventilation Rates: sufficient outdoor air provided to mitigate air pollutants), and 281 points were obtained by the applicants. Therefore, the credit achievement degree (CAD) for IEQ1 is 56% (281/498), the credit application rate (CAR) is 63% (166/264), and the final Credit Gain Index is 35% (=56%×63%). According to this result, it is reasonable to conclude that the subcategory IEQ1 poses challenges to the majority of applicants.

4. RESULTS OF DATA ANALYSIS

This section introduces the results of overall percentages obtained for all 9 categories under the GBCA Green Star Office rating tool; cross-sector comparison of overall percentages between different rating levels (i.e. 4 Star Green Star, 5 Star Green Star, and 6 Star Green Star); and subcategory analysis by utilizing CAD, CAR, and CGI indices.

4.1 Data Characteristics of Green Star Office Buildings

According to the database provided by the GBCA, there have been 333 (86%) projects certified by Office rating tools, i.e. Green Star - Office Design (203), Green Star - Office As Built (61) and Green Star -Office Interiors (69). Considering that Office Interiors have different indicators (subcategories), this research focused on the Office Design and Office As Built tools (264 in total) which share the same rating categories and sub-categories.

For Green star office rating tools (Green Star - Office Design and Green Star - Office As Built), GBCA has launched three different versions, which include slightly different subcategories. As shown in the following Figure 1, more than 87% of rated office buildings are certified under the Green Star - Office v2 rating tool.

FIGURE 1. Certified office buildings within different rating versions.

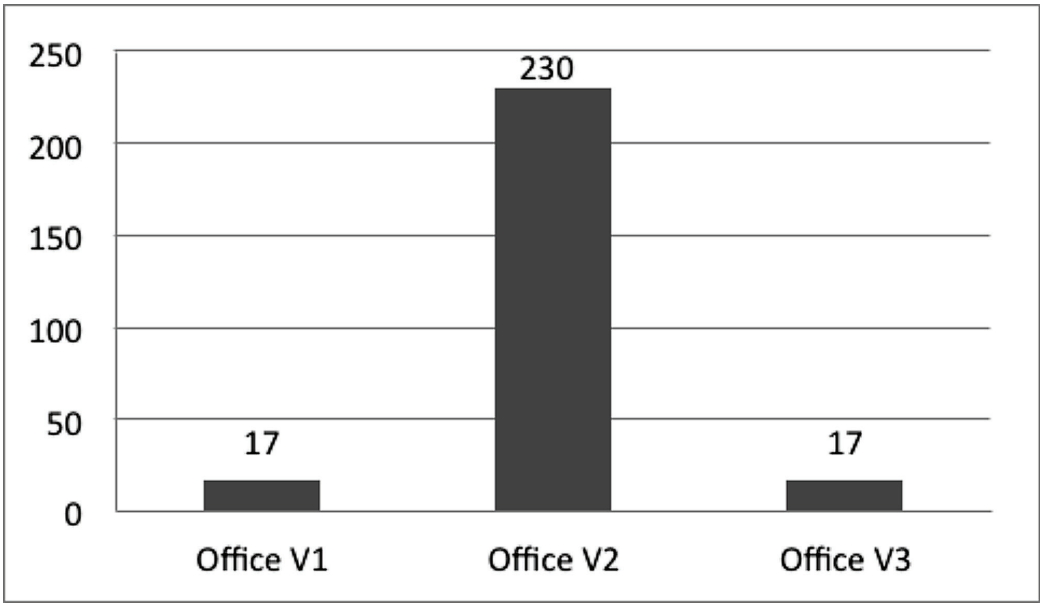


Figure 2 demonstrates that New South Wales (NSW), Queensland (QLD) and Victoria (VIC) accounted for around 74% of the total number of certified green offices.

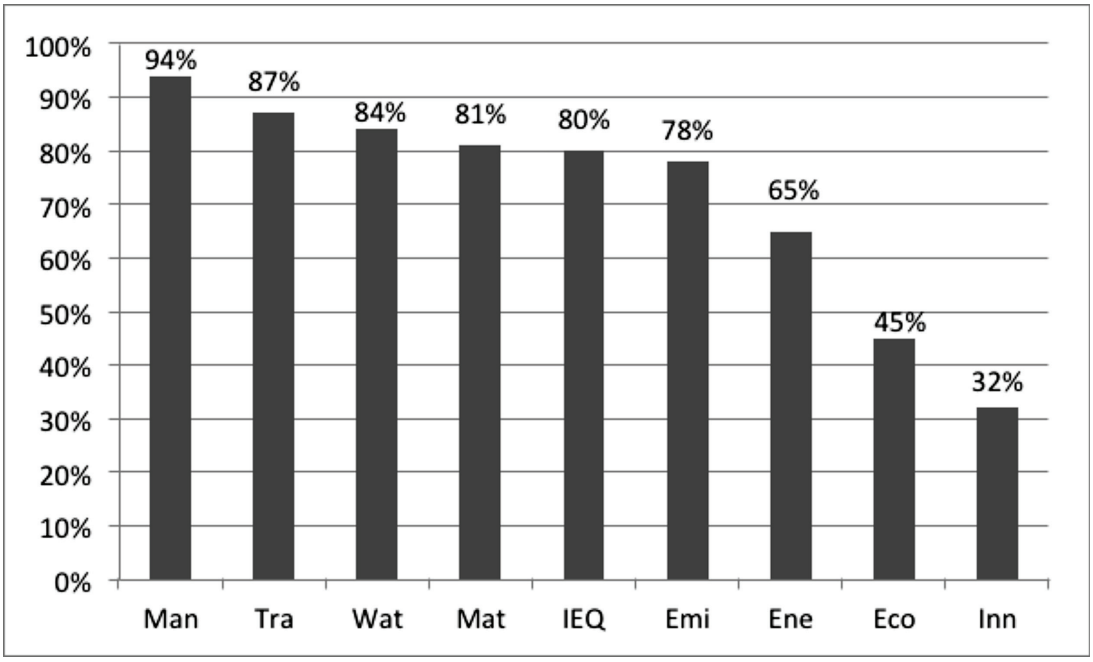
FIGURE 2. Certified office buildings across states and territories in Australia.

4.2 Credit Achievement Degree (CAD) of Categories

The credit achievement degree for each rating category is shown in Figure 3. As can be seen, Management (Man) is the most frequently awarded category, with 94% of the claimed points obtained by applicants. The Management category addresses the adoption of sustainable development principles from project conception through design, construction, commissioning, tuning and operation (GBCA, 2011). It includes 7 credits or sub-categories in Green Star Office As Built and Green Star Office As Design projects with a total of 12 points available. The high award percentage (94%) of Management in this study implies that, on the one hand, almost all the applicants prepared a comprehensive management plan for the Green Star application and on the other hand, it means the credit criteria in the Management category is easier to be awarded.

The categories of Transport (Tra), Water (Wat), Materials (Mat), and Indoor Environment Quality (IEQ) obtained more than 80% of the claimed points. Transportation credits, with 87% obtained in this study, reward the reduction of usage of individual cars by both discouraging car commuting and encouraging the use of alternative transportation. This encourages and recognizes building design that promotes the use of fuel-efficiency vehicles, bicycles, and public transport for work commuting. Water credits (84% obtained) address reduction of potable water consumption of building occupants, landscape irrigation, building cooling systems, fire protection and essential water storage systems. Through efficient design of building services, water reuse and substitution with other water sources (specifically rainwater), the consumption of potable water can be greatly reduced. With 81% obtained, Material credits target resource consumption through material selection, reuse initiatives and efficient management practices. In order to provide a healthy indoor environment and improve occupant

FIGURE 3. Credit achievement degrees of green star rating categories.



wellbeing, IEQ credits (with 80% obtained) address the HVAC system, lighting, occupant comfort and pollutants.

The categories of Emissions (Emi) and Energy (Ene) obtained more than 50% of claimed points. Emissions credits, with 78 percent obtained, address pollution emission from buildings and building services to the atmosphere, watercourse, and local ecosystems. The Emission category encourages and recognizes the reduction of light pollution, water pollution, and the potential damage to the earth's atmosphere. The Energy category obtained a comparatively lower percentage of claimed points, with only 65%. Energy credits award the reduction of greenhouse emissions by addressing energy demand reduction, the use of energy efficiency and generation from alternative sources.

Ecology (Eco) and Innovation (Inn) categories obtained comparatively lower percentages of claimed points, with 45% and 32%, respectively. The category of ecology examines a project's impact on the ecosystem. With only 45% of claimed points awarded, it appears difficult to increase the ecological value of a project site. With only 35% of points obtained, Innovation credits are the most difficult to be awarded. The Innovation category includes three credits, namely, innovative strategy & technologies, exceeding green star benchmark, and environmental design initiatives. Although the innovation credits have only 5 points available in green star rating tools, these credits award marketplace innovation that fosters the industry's transition to sustainable building (GBCA 2011).

The 5-point scale put forwarded by Silva and Ruwanpura (2009) is adopted in this study to measure the level of difficulty to obtain the Green Star rating tools credits:

- L: low difficulty, 81-100%
- L-M: low to medium difficulty, 61-80%
- M: medium difficulty, 41-60%
- M-H: medium to high difficulty, 21-40%
- H: high difficulty, 0-20%

Based on the result of credit achievement degrees (CAD) of green star rating categories (as shown in Figure 3), the levels of difficulty to obtain claimed points for each category is presented in Table 1. It can be seen that Management, Transport, Water and Materials related credits are comparatively easier to obtain than Ecology and Innovation related credits, which are most difficult to obtain.

TABLE 1. GBCA credit difficulty indicator for each category.

Category	Indicator				
	L	L-M	M	M-H	H
Management	√				
Indoor environment quality		√			
Energy		√			
Transport	√				
Water	√				
Materials	√				
Land use and ecology			√		
Emissions		√			
Innovation				√	

4.3 Cross-Sector Comparison: Green Star Ratings

Among all the 264 green star office projects, the numbers of different certification level, namely, 4 Star, 5 Star, and 6 Star, are shown in Table 2. The credit achievement degrees for 4 Star, 5 Star and 6 Star green projects are 72%, 76%, and 84%, respectively.

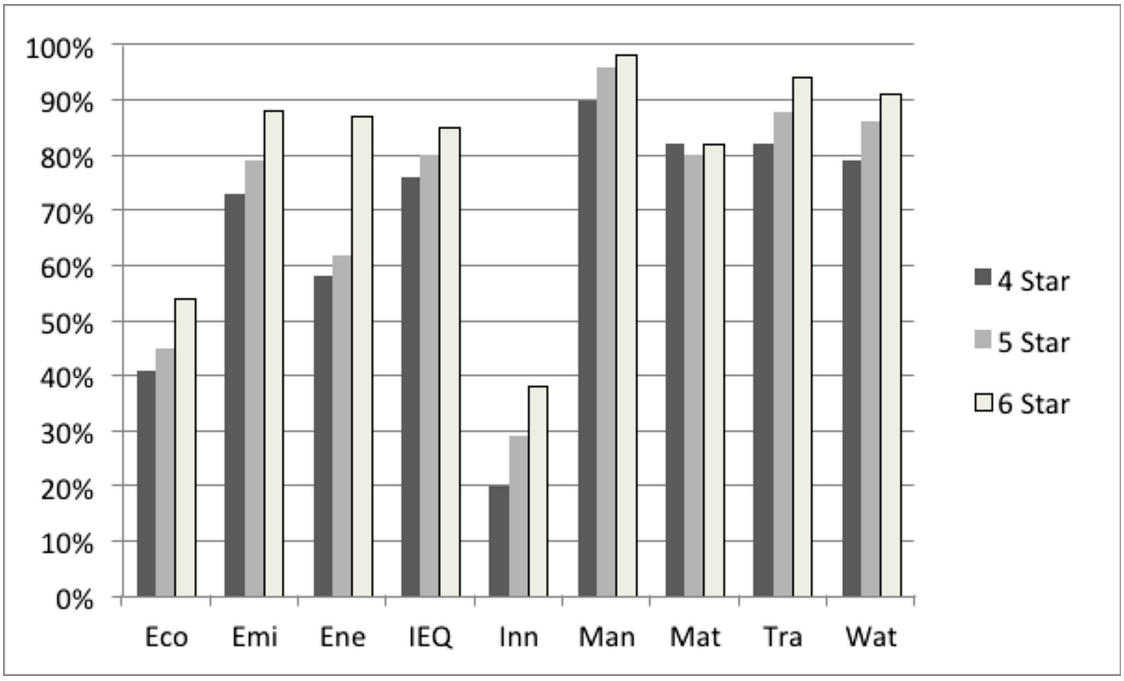
TABLE 2. Credit achievement degrees among different groups of green star rating.

Green Star Rating	Number of projects	Percentage of project number	CADs
4 Star	102	39%	72%
5 Star	120	45%	76%
6 Star	42	16%	84%

The distribution of percentages obtained within different categories for 4 star, 5 star, and 6 star certified green projects is shown in figure 4.

According to Figure 4, projects with higher certified ratings generally have higher CADs within the 9 categories except the Material category in which the 4 Star projects obtained higher CAD than 5 Star ones. It is likely due to the cost-benefit concerns of applicants that triggered their unusual behaviour, which leads to a different trend for the Material category that differs from the other categories and warrants further investigation. Management is still the most frequently awarded category for 4 Star, 5 Star and 6 Star green projects. The Innovation

FIGURE 4. Credit achievement degrees among different groups of rating tools.



category, where all the certified projects obtained less than 50% of claimed points, remains the most difficult to be awarded. For the 6 Star green projects, the percentage obtained for Energy is 87%, which is significantly higher than in 5 Star (62%) and 4 Star (58%) projects.

4.4 Subcategory Analysis

This section reports the level of difficulty to obtain the Green Star credits for each subcategory within the nine major rating categories. However, although different rating tools use the same nine categories, some subcategories are not the same. For example, Eco-1 denotes:

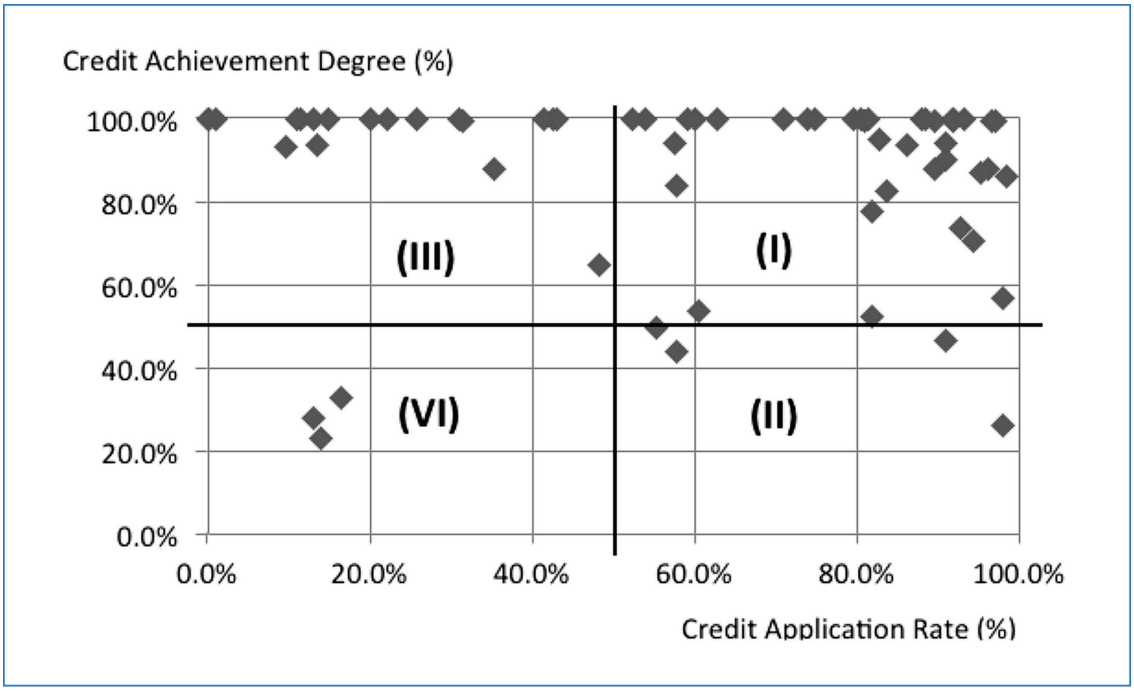
- 'Ecological Value of Site' in Green Star-Office Design and Green Star-As Built rating tools
- 'Green Star - Office As Built Certified Building' in Green Star-Office Interiors rating tool
- 'Topsoil' in other rating tools

Similarly, some subcategories in Green Star Office rating tools are different in different versions. For instance, in the Green Star -Office v3 tool, the scope of the Man-5 credit, Building Users' Guide, was expanded to require monitoring and targeting for water, waste and indoor environment quality apart from energy.

Considering that office buildings constitutes the biggest share of the certified building stock, and that most of these buildings were certified by the Green Star - Office v2 tool, it was decided to focus on Green Star - Office Design and Green Star - Office As-built v2 for further analysis as these two rating tools share the same subcategories.

Figure 5 presents the credit application rate (CAR) and credit achievement degree (CAD) for each subcategory.

FIGURE 5. CAR and CAD performance of subcategories.



The subcategories can be divided into four groups according to the performance of CAR and CAD as shown in Table 3. For those with a high application rate and a high credit achievement degree (type I), they are regarded as the easy-to-obtain indicators for the applicants. For type II category, the credits of subcategories have been sought in the majority of projects but the success rate is low. As a result, the overall Credit Gain Index (CGI) is low. For instance, 97.8% of certified office buildings have applied for the credit change

TABLE 3. Summary of different groups of subcategories.

Subcategory type	Subcategories included
Type I (High CAR, high CAD)	Eco-2, Emi-1, Emi-3, Emi-7, Emi-9, Ene-2, Ene-3, Ene-4, Ene-5, Ene-6, IEQ-1, IEQ-3, IEQ-6, IEQ-7, IEQ-8, IEQ-9, IEQ-12, IEQ-13, IEQ-14, IEQ-16, Man-1, Man-2, Man-3, Man-4, Man-5, Man-6, Man-7, Mat-1, Mat-4, Tra-1, Tra-2, Tra-3, Tra-4, Wat-1, Wat-2, Wat-3, Wat-4, Wat-5.
Type II (High CAR, Low CAD)	Eco-4, Emi-6, IEQ-4, Mat-5.
Type III (Low CAR, High CAD)	Eco-5, Emi-4, Emi-5, Emi-8, Ene-7, IEQ-2, IEQ-5, IEQ-10, IEQ-11, IEQ-15, Mat-2, Mat-3, Mat-6, Mat-7, Mat-8.
Type VI (Low CAD, Low CAR)	Inn-1, Inn-2, Inn-3.

of ecological value (Eco-4) with only 25.9% of credits being granted, which leads to a CGI value of 25%. Similarly, for type III subcategories, they have low application rates but high credit award degrees, which also results in a low CGI. The type VI subcategories are the most difficult to secure credits. With low application rates (ranging from 13% to 16.5%) and low achievement degrees (ranging from 23.1% to 16.5%), the Inn-1, Inn-2 and Inn-3 have less than 5% CGI.

Table 4 and Table 5 describe the credits that are easier and more difficult to obtain based on the CGI in the GBCA Green Star - Office rating tools.

TABLE 4. GBCA credits easier to obtain (above 75%).

Credit Ref.	Title	CAR	CAD	CGI
IEQ-6	High frequency ballasts	97.0%	99.6%	96.5%
Ene-4	Tenancy sub-metering	96.5%	99.5%	96.1%
Man-5	Building user guide	93.0%	100.0%	93.0%
Man-1	Green star accredited professional	91.7%	100.0%	91.7%
Emi-1	Refrigerant ODP	91.7%	99.8%	91.5%
Ene-3	Electrical sub-metering	91.7%	99.5%	91.3%
IEQ-14	Formaldehyde minimisation	89.6%	99.5%	89.1%
Man-3	Commissioning-Building tuning	88.3%	100.0%	88.3%
Ene-6	Office lighting zoning	87.8%	100.0%	87.8%
Wat-2	Water meters	90.9%	94.0%	85.4%
Wat-1	Occupants amenity potable water efficiency	98.3%	85.8%	84.3%
IEQ-13	Volatile organic compounds	96.1%	87.6%	84.2%
Man-6	Environmental management	95.2%	86.9%	82.8%
Man-2	Commissioning-Clauses	90.9%	90.0%	81.7%
IEQ-16	Tenant exhaust riser	81.3%	100.0%	81.3%
Man-7	Waste management	86.1%	93.7%	80.7%
Emi-7	Light pollution	80.4%	100.0%	80.4%
Emi-9	Insulant ODP	80.9%	99.5%	80.4%
Eco-2	Re-use of land	79.6%	100.0%	79.6%
Tra-4	Commuting public transport	89.6%	87.8%	78.6%
IEQ-12	Internal noise levels	82.6%	95.0%	78.5%

Overall, high frequency ballasts (IEQ-6) and tenancy sub-metering (Ene-4) are the easiest credits to obtain, with a high application percentage and high success rate. By contrast, refrigerant GWP (Emi-2) is the most difficult credit to be obtained. It is also worth noting that even though there are only a few projects that made efforts to apply for this credit (applied project percentage is 0.9%), the success rate in obtaining this credit was 100%. There are another 10 credits that fell into the same category where a small number of projects applied the credit but the success rate was very high. These include: re-use of façade (Mat-2), topsoil and fill removal from site (Eco-5) and individual comfort control (IEQ-10). Further investigation is warranted into what prevents the project team applying

for this credit. A possible explanation is the lack of clarity of this credit together with its high requirements for applicants.

TABLE 5. GBCA credits more difficult to obtain (less than 30%).

Credit Ref.	Title	CAR	CAD	CGI
Mat-5	Recycled content of concrete	55.2%	49.6%	27.4%
Emi-4	Refrigerant recovery	25.7%	100.0%	25.7%
IEQ-4	Daylight	57.8%	43.9%	25.4%
Eco-4	Change of ecological value	97.8%	25.9%	25.3%
Eco-3	Reclaimed contaminated land	22.2%	100.0%	22.2%
Ene-7	Peak energy demand reduction	20.0%	100.0%	20.0%
IEQ-15	Mould prevention	14.8%	100.0%	14.8%
IEQ-11	Asbestos	13.0%	100.0%	13.0%
Mat-3	Re-use of structure	13.5%	93.5%	12.6%
Eco-5	Topsoil and fill removal from site	11.3%	100.0%	11.3%
Mat-2	Re-use of façade	10.9%	100.0%	10.9%
IEQ-10	Individual comfort control	9.6%	93.2%	8.9%
Inn-2	Exceeding green star benchmarks	16.5%	32.6%	5.4%
Inn-1	Innovative strategies and technologies	13.0%	28.0%	3.7%
Inn-3	Environmental design initiatives	13.9%	23.1%	3.2%
Emi-2	Refrigerant GWP	0.9%	100.0%	0.9%

5. DISCUSSION AND IMPLICATIONS

The findings of this study which are broadly in line with Silva and Ruwanpura's (2009) are as follows:

- It is comparatively easier to obtain water efficiency related credits;
- The level of difficulty to obtain indoor environmental quality related credits is similar according to these two studies;
- It is not hard to secure a credit for managing construction and demolition waste;
- Both studies found that it is comparatively easy to claim the credits for reuse or recycling of construction waste to minimize the load to landfill;
- Both studies found that it is comparatively easy to obtain a credit to award for alternative transportation, i.e. providing bicycle storage, changing facilities and security locker; and
- The majority of projects in both studies (in the Silva and Ruwanpura's Canadian study it was 100%) have engaged accredited professionals in project design to provide sustainability related inputs and to prepare the certification documentation. Furthermore, 91.7% of projects have applied for this credit (Man-1) with a success rate of 100%.

However, this study indicated some differences from the previous study which focused on LEED certification in the Canadian context (Silva and Ruwanpura 2009). These are the following:

- Innovation related credits are most difficult to obtain under GBCA rules. However they were frequently awarded in LEED certified projects in Canada;
- More Australian projects have applied commissioning related credits in this study with a considerable success rate compared with the Canadian study;
- The success rate of materials related credits under GBCA rating scheme is similar to the LEED scheme. However, very few projects have applied for this credit. This results in the low level of Credit Gain Index of materials related credits under GBCA Green Star rating tools, particularly for reuse of façade and structure;
- LEED certification encourages the use of local or regional materials, with 98% of certified Canadian buildings being awarded this credit. By contrast, there is no such requirement under the GBCA rating tools.

In the GBCA rating tools, there are three credits under the Innovation category:

- Inn-1: innovative strategies and technologies to encourage and recognise pioneering initiatives in sustainable design, process or advocacy;
- Inn-2: exceeding green star benchmarks to encourage and recognise projects that achieve environmental benefits in excess of the current Green Star benchmarks; and
- Inn-3: environmental design initiatives to encourage and recognise sustainable building initiatives that are currently outside of the scope of this Green Star rating tool but which have a substantial or significant environmental benefit.

The level of difficulty of Inn-3 is even greater than the other two indicators under the innovation category. This indicates that: (1) few projects attempted environmental sustainability features that are beyond the scope of the Green Star rating tools; (2) even though a small number of projects put forward these efforts and application, very few of them succeeded. The GBCA started assessing Innovation at round 1 of the assessment process approximately 1 year ago. Prior to this, Innovation was assessed at round 2 only. As a result, there were fewer claims made and less success because the majority of Green Star - Office v2 applications had only 1 round of assessment as opposed to the other credits which had two. This may have an impact on the number of times it has been awarded.

Indeed, innovation has been highlighted by Häkkinen & Belloni (2011) as one of the key barriers to sustainable building development. They further emphasized that the communication and engagement of all stakeholders (e.g. users, designers, contractors, etc.) plays a key role in the innovation process. Love et al. (2012) revealed that the adoption of sustainable innovation is hindered by a conservative market, inappropriate regulations and standards. However, the client's attitude is the key to break down these barriers.

6. CONCLUSIONS

The past decade has witnessed the strong growth of green buildings from both the theoretical and practical perspectives. Various rating tools have been developed by the Green Building Council of Australia (GBCA) for different types of buildings. This study critically analysed the scoresheets of all commercial building projects certified by the GBCA.

The results showed that Management, Water and Transport related credits are the most frequently obtained in GBCA Green Star rated office buildings. This indicates that these categories are comparatively easier to be obtained. However, Innovation remains the least frequently obtained credit. In other words, it is hard to achieve this credit in practice and poses a challenge to most of the applicants.

A contribution of this study has been the critical review of the GBCA database of green building assessments. As far as is understood, this is one of the very first studies that has assessed the full list of certified buildings. Prior studies chose to review the information available from the public domain, which presents some 60-70% of the total amount of certified green buildings (e.g. Silva and Ruwanpura 2009; Warren 2010). With the support from the Green Building Council of Australia, it has been possible to access the full list of 264 green office buildings certified by the GBCA at the time that this research was undertaken. This mitigated the validity risks associated with assessing just a proportion of buildings.

Another contribution of this study was to assess the credits application rate (CAR) in addition to the credit achievement degree (CAD). Past studies, which focused on the identification of challenges of green building certification, have only calculated the credit frequency in terms of the points that been awarded out of the total of number of points claimed (cf. Silva and Ruwanpura 2009). It was argued that it is another key indicator of level of difficulty to calculate how frequently the points were applied. With the combination of the credit achievement degree (CAD) and credit application rate (CAR), the Credit Gain Index (CGI) was developed to represent the overall difficulty/challenge to achieve the GBCA Green Star certification.

These findings provide useful inputs to the development of the next generation of green building rating tools. Most of green building rating tools worldwide share similar structure, i.e. categories, credits and points. Therefore, the methodology developed in this study and its ability to inform decision making make it applicable beyond the Australian context. They also help both the policy makers and the industry in further promoting green building development in the future. Future research opportunities include the verification of these findings by means of interviews or case studies.

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