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TRENDS IN APPLICATION OF GREEN STAR SA CREDITS IN SOUTH AFRICAN GREEN BUILDING

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ABSTRACT

The South African green building industry is growing towards maturity. Stakeholders need to observe, document, and be informed about trends and development of the industry. This article evaluates whether application trends have emerged of often achieved and seldom achieved Green Star SA credits by all new office buildings that received a Green Star SA rating between 2009 and 2015 in South Africa. Any observed trends are further described by aspects such as the categories of the Green Star SA tool and the Green Star SA rating achieved. The article considers the data of 95 office buildings, made available by the Green Building Council of South Africa (GBCSA). A quantatitive research approach is used to investigate the use frequency of every credit in the Green Star SA tool and to identify trends in credit use. The study finds that 21 of the 67 credits are achieved on average by >80% of the certified projects. Another 14 credits have an average achievement rate of <20%. The nine categories of the Green Star SA tool also varies from average achievements of 84% for Water to only 19% for Innovation. The Green Star SA rating level is also found to be positively correlated to often used credits and negatively correlated to seldom used credits. This article observes industry-wide trends with the potential to negatively affect the ability of green buildings to deliver the required sustainability outcomes expected of them. This finding and the potential outcome thereof need to be monitored and managed by stakeholders such as the GBCSA.

Keywords: Application trends, green building, South Africa, sustainability, trends

ABSTRAK

Die Suid-Afrikaanse groenbou-industrie groei tot volwassenheid. Dit is belangrik dat belangegroepe ingelig bly oor die verskillende fasette en ontwikkelings van die industrie. Hierdie artikel ondersoek die tendense in die toepassing van die Groenster-krediete van die verskillende nuwe Suid-Afrikaanse kantoorgeboue wat Groenster-gradering verwerf het tussen 2009 en 2015. Die studie soek na die bestaan van tendense in die nastreef van krediete wat verwerf is as deel van die groenbousertifiseringsproses. Enige geïdentifiseerde tendense word verder beskryf deur evaluering van aspekte soos die kategorieë van die Groenster-werksdokument en die Groenster-graderingvlak wat verwerf is. Die artikel oorweeg die data van 95 kantoorgeboue, beskibaar gestel deur die Groenbouraad van Suid-Afrika (GBRSA). 'n Kwantitatiewe navorsingsbenadering is gevolg om die gebruiksfrekwensie van elke krediet in the Groenster-werksdokument te ondersoek en om tendense in die gebruik van krediete te identifiseer. Die studie bevind dat 21 van die 67 krediete gemiddeld deur >80% van gesertifiseerde geboue verwerf is, terwyl 14 ander krediete deur <20% van gesertifiseerde geboue verwerf is. Die nege kategorieë van die Groenster-werksdokument wissel ook van 84% gemiddelde benutting vir Water tot 19% vir Innovasie. Die Groenster-gradering was ook positief gekorreleerd met dikwels benutte krediete en negatief gekorreleerd met selde verwerfde krediete. Die artikel identifiseer tendense met die potensiaal om die vermoë van groengeboue om hul verwagte volhoubare resultate te lewer, negatief te beïnvloed. Hierdie bevindinge en die potensiële effek daarvan behoort gemonitor en bestuur te word deur 'n belangegroep soos die GBRSA.

Sleutelwoorde: Groenbou, ontwerpstrategieë, Suid-Afrika, tendense, volhoubaarheid

1. INTRODUCTION

1.1 Background

The adverse effects of global warming, such as rising average temperature and even a possible ice-free winter by 2040 (UNEP, 2007: 1), and an ice-free Barents Sea between 2061-2088 (Onarheim & Arthun, 2017: 1) have been widely published. Birnie, Boyle and Redgewell (2009) stated that climate change might be the most significant environmental challenge of our time. The construction industry carries much of the blame for this situation, as the industry generates 50% of the world's waste, much of the water pollution, and 40% of the world's air pollution. Buildings account for 25% of world wood harvest, one-sixth of the world's freshwater withdrawal, and two-fifths of its materials and energy flows. It is, therefore, important that buildings should become more natural-resources efficient (GBCSA, 2015; WGBC, 2010; Magoulès & Zhao, 2010: 13-15; Toller, Wadeskog, Finnveden, Malmqvist & Carlsson, 2011: 395).

The challenge created by global warming also creates the potential for the construction industry to significantly contribute to ensuring a greener and more sustainable environment (Pekka, 2009: 4,6; CIDB, 2009: 2). The challenge for the green building industry is to ensure that their green rating tools produce buildings that deliver on the promise of increased sustainability.

Energy consumption during the operation phase of the building may consume as much as 80% of total energy used (Junnila, 2004). A study by Jacobs and Ragheb (2010: 21) indicates that the building's operational demands over a 60-year lifespan represent 96% of the total life-cycle energy. Construction methodologies, including construction materials and fittings, must strive to minimize the environmental impact from the operational phase of buildings. Buyle, Braet and Audenaert (2013: 382) support a total life-cycle approach and argue that the choice of materials, construction methods, and end-of-life use deserve more attention from designers and specifiers. Green building rating tools should, therefore, sufficiently allow for concepts of whole life cycle and embodied carbon (Van der Heijden, 2016).

1.2 Importance of the study

With the growing maturity of the sustainability industry, the degree and volume of criticism and calls for introspection on green building issues have also increased. Over a decade ago, a study by Scofield (2009a: 775; 2009b: 1389) questioned data published by the New Buildings Institute (NBI) and the United States Green Building Council regarding energy savings produced by Leadership in Energy and Environmental Design-(LEED-) certified buildings. Scofield found that the data offers no evidence that LEED certification has collectively lowered either site or source energy demands of office buildings.

More recently, Cole and Valdebenito (2013) as well as Van der Heijden (2016) found that green building is often restricted to high-end office buildings in upmarket business districts. Not enough is done to extend green building to existing buildings and to address the behaviour of occupants. In a USA study, Boschmann and Gabriel (2013: 231) also warn against a superficial approach to the credits being pursued, in order to achieve green building certification. Martek and Hosseini (2018) proposed that the performance of green buildings should be independently audited.

In an article in *The Australian Financial Review*, the co-founders of the Green Building Council of Australia (GBCA), Maria Atkinson and Ché Wall, warned that the GBCA is risking watering down green building certification by extending the Green Star SA rating system to buildings that fall below the very top tier of sustainable practices and techniques (Bleby, 2014: 2). The above examples of challenges faced by green building and of criticism of the certification process put a high onus on the integrity of the design and the use of green building rating systems.

Green building is still relatively new in South Africa, with the Green Building Council of South Africa (GBCSA) only founded in 2007. In 2009, the GBCSA launched the Green Star SA rating tool, which is based on the Australian Green Star tool but customised to suit the South African context (GBCSA, 2020). The local industry has, however, developed relatively quickly. In 2016, the GBCSA certified the 200th Green Star SA certified building (GBCSA, 2016) and, in September 2018, the milestone of 400 certified buildings was reached within approximately ten years of its existence (GBCSA, 2018).

However, for the South African Green Building industry to keep growing, it is necessary to have a sound understanding of the roles and functions of all primary industry stakeholders. The Green Star SA rating tool plays a critical role in setting the scene of how developers and consultants respond to the challenge of securing green building certification status.

This article investigates whether there exist trends in the credits achieved by green building-certified projects, which is an important facet of the implementation of the Green Star SA tool. Trends in the credits achieved may indicate trends in the application of credits pursued by the consultant teams of the different certified green building projects. If such trends do exist and are significant in scope, the resultant contribution of green buildings towards a more sustainable environment may be skewed, as some aspects of sustainable construction will be over-applied, while other aspects may be lacking. Such development has the potential to negatively affect the ability of green buildings to deliver the required sustainability outcomes expected of them.

2. LITERATURE REVIEW

2.1 The global environmental sustainability scenario

The global construction industry had to respond to the challenge of environmental sustainability. Nine countries founded the World Green Building Council (WGBC) in 1998, namely Australia, Brazil, Canada, India, Japan, South Korea, Mexico, Spain, and the United States of America (GBCA, 2014). The WGBC expanded over the next two decades to now include 80 member countries (WGBC, 2020). The growing market demand for environmentally friendly buildings required changes to building design and operation. Measuring tools were needed for sustainability in the construction industry (Haapio & Viitaniemi, 2008: 469, 470). Although cost was an issue, Nixon (2009: 5) confirmed that people are much more attracted to resource-efficient products and services.

Various green building rating tools were developed and launched to regulate, evaluate, and certify buildings that qualify as green buildings, suited to their local conditions. Some of the most well-known green building rating systems are the Building Research Establishment Environmental Assessment Method (BREEAM) tool launched in the United Kingdom in 1990, and the Leadership in Energy and Environmental Design (LEED) launched in the United States in 2000 (WGBC, 2014). The GBCA (2014) launched the Green Star system in 2003.

According to the United States Environmental Protection Agency (EPA), green building can be defined as the practice of creating structures and using processes that are environmentally responsible and resource efficient throughout a building's life cycle (EPA, 2018: 1)

2.2 Green Building Council of South Africa

The GBCSA was established in 2007. South Africa is still the only established member of the WGBC on the African continent, with Ghana, Cameroon, Rwanda, Mauritius, Namibia, and Tanzania as prospective members and Kenya as an emerging member (WGBC, 2020). The GBCSA launched the South African Green Star SA rating tool in 2009. The tool is based on the Australian Green Star tool but customised for the local context (GBCSA, 2014).

The objectives of Green Star SA can be summarised as follows (GBCSA, 2020):

- Establishment of a common language and standard of measurement of green buildings;
- Promotion of integrated, whole-building designed buildings;
- Creating awareness about the benefits of green buildings;
- Reducing the impact that development has on the environment, and
- Recognition of environmental leadership.

Green Star SA provides a full array of rating tools for the different types of buildings as well as for interiors and existing buildings' performance:

- New Buildings and Major refurbishments v1 & v1.1 (Office, Multi-Unit Residential, Public and Educational, Retail);
- Existing Building Performance v1;
- Interiors v1;
- Sustainable Precincts;
- Green Star SA Custom (e.g. Hotel, Mixed Use, Hospital, Industrial);
- Net Zero Carbon, Water, Waste, Ecology;

- Socio-Economic Category PILOT;
- Energy and Water Performance (EWP), and
- EDGE Residential.

The Green Star SA rating tool is based on the GBCA's Green Star – Office v3 Tool. The Office rating tool version 1 was released in November 2008, and the amended version 1.1 was released in November 2014. The New Buildings and Major Refurbishment rating tools provide for both design and as built phases of new developments (GBCSA, 2020).

2.3 Rating categories and category weights

The Green Star SA rating tool consists of nine different categories that assess the environmental impact resulting from the project's site selection, design, and construction. The nine categories each include a number of credits that address different initiatives that improve a building's environmental impact. Each credit has been awarded a number of points. A project applying for Green Star SA certification may be awarded for each credit to the extent that the project has met the objectives (see Table 1) (GBCSA, 2020).

Table 1: Green Star SA Office v1.1 tool: Categories and weights

Description of categories and credits		*Weighting (score out of 100)*
Management (MAN)		9
Eight credits: MAN 1-MAN 8	Promotes environmental principles through the inception, design, and construction phases of a development and the commissioning, tuning, and operations of the development	
Indoor Environment Quality (IEQ)		15
Seventeen credits: IEQ 1-IEQ 17	Promotes the comfort and well-being of all the occupants of the building. Factors such as the HVAC system, lighting, indoor air pollutants, and some building attributes contribute to a good indoor environmental quality. Comfort factors including external views, individual climate control, and noise levels are also examined	
Energy (ENE)		25
Five credits: ENE 1-ENE 5	Aims to reduce energy consumption, which impacts on the greenhouse gas emissions and other harmful emissions that are related to energy production from fossil fuels	
Transport (TRA)		9
Five credits: TRA 1-TRA 5	Aims at similar principles laid out in the energy category by rewarding the reduction in automotive commuting as well as the use of alternative transportation methods	

Description of categories and credits		*Weighting (score out of 100)*
Water (WAT)		14
Five credits: WAT 1-WAT 5	Aims to reduce potable water through the efficient design of building systems, rainwater collection, and water reuse	
Materials (MAT)		13
Eleven credits: MAT 1-MAT 11	Promotes re-use of materials and efficient management practices; therefore, it considers the consumption of resources	
Ecology (ECO)		7
Four credits: ECO 1-ECO 4	Promotes the reduction of the impact of buildings on ecological systems and biodiversity and initiatives to improve ecological systems and biodiversity surrounding the project	
Emissions (EMI)		8
Nine credits: EMI 1-EMI 9	Targets the impacts of the building's emissions on the environment, including watercourse pollution, light pollution, ozone depletion, global warming, Legionella, and sewerage	
Total		100

Source: GBCSA, 2020: online

Once all the categories have been assessed, a total score is calculated for the project, using category weighting factors. Each category carries a different weighting depending on the importance of the category with regard to environmental performance. A maximum score out of 100 can be achieved (GBCSA, 2020).

The overall score is then compared with the rating scale, and a rating is then determined. The rating scale is shown in Table 2.

Table 2: Green Star SA rating tool scores

Overall Score	*Rating*	*Outcome*
10-19	One Star	Not eligible for formal certification
20-29	Two Star	Not eligible for formal certification
30-44	Three Star	Not eligible for formal certification
45-59	Four Star	Eligible for Four Star Certified Rating that was recognized/rewards 'Best Practice'
60-74	Five Star	Eligible for Five Star Certified Rating that recognizes/rewards 'South Africa Excellence'
75+	Six Star	Eligible for Six Star Certified Rating that recognizes/rewards 'World Leadership'

Source: GBCSA, 2020: online

2.4 Critical opinions on the green building industry

Section 1.2 refers to a growing volume of concerns and criticism being raised regarding issues relating to the green building industry. Much of this critical perusal centres around concerns regarding the efficiencies of green building rating tools, about the application of green rating tools, and if green buildings are delivering on their promise.

Recent studies (Cole & Valdebenito, 2013; Van der Heijden, 2016: 575, 584) found that green rating tools are struggling to access much deeper than market leading companies in the high-end commercial office property market. Van der Heijden also found that green building certifications are largely pursued by new buildings, while finding much lower application in existing buildings. Green building tools also focus on technology to reduce carbon load and energy consumption, but does little to change the behaviour of building users. Hayden (2014) speculated that the preference of a technological rather than a behavioural approach to address carbon footprint may be due to the ecological modernisation of many countries supporting green building.

A study by Boschmann and Gabriel (2013: 231) in Colorado, USA, critised LEED for only rewarding incremental solutions towards sustainability. The study proposed a more balanced approach to be pursued between rewarding the more superficial aspects of reduction of energy consumption and pollution through technology and green gadgetry versus a more in-depth approach involving local geographic conditions, natural climate systems, and informed design.

Martek and Hosseini (2018: 3), from Deakin University in Australia, also recently raised concerns regarding the actual performance of green buildings. They advised that sustainability rating tools should be independently audited. Most of the rating tools are predictive, while those few that take measurements use paid third parties. Governments should also be participating in the process.

2.5 Studies on green rating tools and application trends

Very few studies have focused on the difficulty of applying different credits included in green building rating tools. A recent study by Zuo, Xia, Chen, Pullen and Skitmore (2016) did a comprehensive analysis of all the office buildings certified by the GBCA at the time. The study focused on the Green Star SA rating tool to evaluate the challenges of achieving specific credits. The study found that credits relating to water efficiency, management of waste, and providing for alternative transport were relatively easy to achieve. Credits in the categories of Innovation, Ecology and Energy were relatively difficult to achieve.

Another study by Gou (2016: 627) considered the efficiency of green building for office interiors. The study found that very prominent and highly skilled architects and interior designers were often used in the projects considered. Most of the projects achieved high levels of interior sustainability, with low emitting materials and energy-efficient equipment. However, there was much evidence of easily achieved credits or ‘low hanging fruit’ being pursued. The study suggested that more significant green features need to be considered.

Work by Martek, Hosseini, Shresta, Zavadskas and Seaton (2018) places a specific perspective on the role and responsibility of green rating systems if the ideals of green building are to be achieved. Green rating tools were born from the conflict between economic growth, protecting the environment, and providing human well-being and comfort. Each rating tool proposes its own ‘balance’ between these conflicting interests. For green rating systems to work, they must be based on evidence of building performance. The embodied carbon of building products and processes over the full life cycle should also be integrated into green rating tools.

3. METHODOLOGY

3.1 Research method

The main aim of this article is to investigate whether there exist trends in the credits achieved by green building-certified projects. Such trends may indicate similarities in the green-building approach followed by the consultant teams of the different certified green building projects in the application of green building credits. The article considered the accreditation data of 95 Green Star SA-certified office buildings, made available by the GBCSA. The data is quantitative in nature and a quantatitive research approach was used to investigate the use frequency of every credit in the Green Star SA tool and to identify trends in credit use. The study was specifically looking to:

- identify credits achieved very often or achieved very seldom;
- compare the average achievement percentage of the different categories of the Green Star SA tool;
- describe the effect of 4 Star, 5 Star or 6 Star rating on the achievement percentage of credits, and
- analyse if time/the year of certification affected the average achievement percentage of the different credits.

3.2 Sampling

The study population is defined as all new office buildings that have been certified by the GBCSA with a 4, 5, or 6 Star Design or As Built rating, using the Office v1 and v1.1 rating tool from 2009 to 2015. A detailed credit score card also had to be available for each project. A total of 95 office buildings matched all of these requirements. The data of all of these projects was made available by the GBCSA to be included in the study. The fact that all qualifying buildings were included in the study addresses the aspect of validity and required that no further sampling was required.

3.3 Data collection

The data of the 95 buildings was captured on Excel in a matrix consisting of a Y-axis listing all the nine categories and the 67 credits of the Green Star SA tool and an X-axis listing all the 95 projects grouped according to their year of awarding of their green building certification from 2009 to 2015. Every credit achieved by each of the 95 buildings was then captured in the matrix for analysis. At the outset of the study, the GBCSA was contacted to secure their support. The GBCSA data was made available and the findings of the study will be shared with the GBCSA.

3.4 Data analysis

Most of the data analysis required descriptive statistics that were available in Microsoft Excel. The mean or average of data sets was calculated to describe the measures of central tendency of the often used credits (Table 3), the seldom used credits (Table 4), the average credit achievement per category (Table 5), the effect of 4 Star, 5 Star or 6 Star rating on the achievement percentage of credits (Table 6), and if time/the year of certification affected the average achievement percentage of the different credits (Figures 3-11). Descriptive statistics such as the variance, standard deviation and coefficient of variation were used to describe the measures of dispersion of the average credit achievement per category (Table 5) (Berenson & Levine, 2012).

Inferential statistics, more specifically the Pearson product moment correlation, was used to explore and describe the linear relationships between the average credit achievement percentage and the Green Star SA weighting factor per Green Star category (Table 5). The Pearson product moment correlation was also applied to describe the linear relationships between the Green Star SA certification level and the number of often or seldom achieved credits (Berenson & Levine, 2012; Puth, Neuhauser & Ruxton, 2014).

The number of credits achieved by all the projects per year was totalled and expressed as a percentage of the total number of projects for that year to calculate the average achievement percentage for a credit per year. For example, from the year 2012, a total of 15 projects were included in the study. In the category Management*,* the credit MAN-1 was achieved by eight of the 15 projects, giving MAN-1 an average achievement percentage for 2012 of 8/15 = 53%. After the data of all 95 projects were captured, a total number and an average achievement percentage for every credit for the total period of 2009-2015 were also calculated.

A deeper level of understanding of the credits targeted will be possible by analising the actual number of points of every credit that was targeted as well as the number of credits that was achieved. The data to enable this analysis was not available at the time of the study. A study to explore this aspect of application of Green Star SA credits similar to the study by Zuo *et al.* (2016) is planned for the near future.

Trends of credits achieved very often or achieved very seldom were identified according to the following parameters:

- Credits with an average achievement rate of >80% were defined as “Often achieved” credits that were favoured by the application approach followed.
- Credits with an average achievement rate of <20% were defined as “Seldom achieved” credits that were avoided by the application approach followed.

The effect of the Star rating level achieved on the achievement percentage of credits was calculated by sorting the buildings according to their 4, 5 or 6 Star rating achieved and repeating the sorting within the three groups of buildings to compare the findings with the overall findings to look for relationships. The same approach is used to study the effect of the date of certification on the achievement percentage of credits. The calculations will be done for buildings certified in every year for the period covered by the article: 2009-2015.

3.5 Limitations

Allthough every building that meets the requirements of the study was included and a total of 95 projects were analysed by the article, an even larger number may ensure higher levels of statistical confidence in the findings made. For this reason, the study should be repeated in future when the data of more certified green buildings will be available.

The article did not explore the achievements of Green Star SA credits to the depth of the total number of points available on each credit compared to the number of points targeted and the number of points achieved. This deeper level of analysis will be able to explore the reasons for the existence of trends identified and should, therefore, be considered as a follow-up study.

4. FINDINGS

4.1 Descriptive statistics

4.1.1 Often-used Green Star SA credits

The captured data was analysed to calculate the average achievement percentage for every credit for the period 2009-2015. The analysis revealed the following achievement percentage for the total number of 67 credits of the Green Star SA tool: six credits (0%-10%), eight credits (11%-20%), three credits (21%-30%), three credits (31%-40%), six credits (41%-50%), six credits (51%-60%), seven credits (61%-70%), seven credits (71%-80%), eight credits (81%-90%) and 13 credits (91%-100%). A total of 21 credits or 31.3% were achieved by more than 80% of the office buildings studied. These 21 credits are listed in Table 3 according to categories and are displayed in sequential order from lowest to highest achievement in Figure 1.

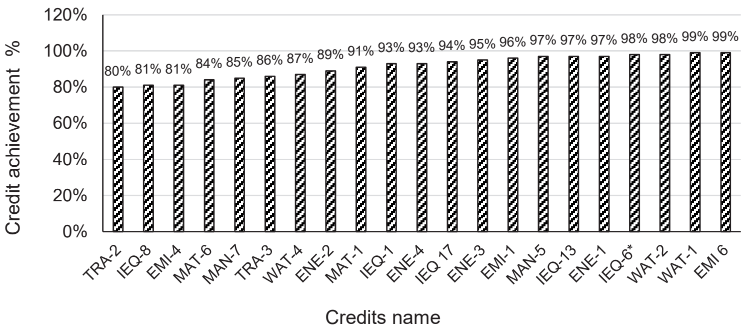

Figure 1: Green Star SA credits with > 80% achievement rate

4.1.2 Seldom used Green Star SA credits

The analysis also revealed that a total of 14 credits or 20.9% of the total number of credits had an average achievement rate of less than 20%. This trend may be due to technical, financial, or other constraints that hinder the frequent use of these credits. The credits are displayed in sequential order

Table 3: Green Star SA credits with >80% achievement rate

Description		*Average % achieved*
Management (MAN)		
MAN-5	Building users' guide	97
MAN-7	Waste management	85
Indoor Environment Quality (IEQ)		
IEQ-1	Ventilation rates	93
IEQ-6*	High-frequency ballasts*	98
IEQ-8	External views	81
IEQ-13	Volatile organic compounds	97
IEQ 17	Environmental tobacco smoke avoidance	94
Energy (ENE)		
ENE-1	Greenhouse gas emissions	97
ENE-2	Energy sub-metering	89
ENE-3	Lighting power sensity	95
ENE-4	Light zoning	93
Transport (TRA)		
TRA-2	Fuel-efficient transport	80
TRA-3	Cyclist facilities	86
Water (WAT)		
WAT-1	Occupant amenity water	99
WAT-2	Water meters	98
WAT-4	Heat rejection water	87
Materials (MAT)		
MAT-1	Recycling waste storage	91
MAT-6	Steel	84
Emissions (EMI)		
EMI-1	Refrigerant/Gaseous ODP	96
EMI-4	Insulant ODP	81
EMI-6	Discharge to sewer	99

* IEQ-6 High-frequency ballasts credit has been removed from the Green Star SA v1.1 tool, as this is regarded as code-compliant standard practice.

from the lowest to the highest percentage achievement in Figure 2 and listed in the category sequence in Table 4.

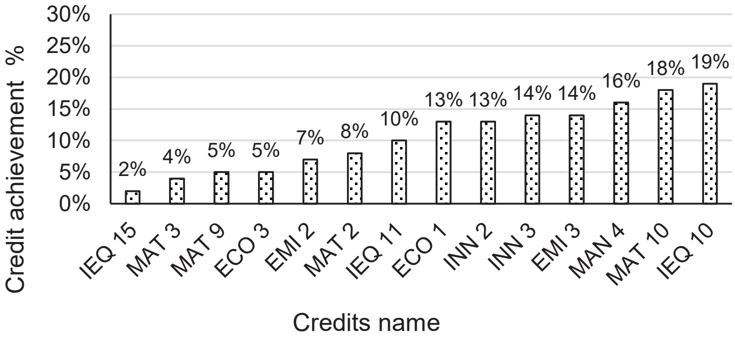

Figure 2: Green Star SA credits with <20% achievement rate

Table 4: Green Star SA credits with < 20% achievement rate

Description		*Average % achieved*
Management		
MAN-4	Independent commissioning agent	16
Indoor Environment Quality		
IEQ-10	Individual comfort control	19
IEQ-11	Hazardous materials	10
IEQ-15	Mould prevention	2
Materials		
MAT-2	Building reuse	8
MAT-3	Reused materials	4
MAT-9	Design disassembly	5
MAT-10	Dematerialisation	18
Land Use and Ecology		
ECO-1	Topsoil	13
ECO-3	Reclaimed contaminated land	5
Emissions		
EMI-2	Refrigerant GWP	7
EMI-3	Refrigerant Leaks	14
Innovation		
INN-2	Exceeding Green Star SA benchmarks	13
INN-3	Environmental design initiatives	14

4.2 Inferential statistics

4.2.1 Average achievement percentage of Green Star SA categories

The average achievement percentage of each credit was used to calculate an average achievement percentage for the credits within every Green Star SA percentage category. This analysis revealed a significant difference in the average achievement percentage of the nine categories. The three categories with the highest average achievement percentage are Water (84%), Transport (79%), and Energy (77%), respectively. The two categories whose credits had the lowest average achievement percentage are Ecology (37%) and Innovation (19%) (Table 5). The large degree of difference in the average achievement percentage of the nine categories is confirmed by the standard deviation (s = 19.8%) and the coefficient of variation (CV = 0.344).

Table 5: Green Star SA categories average credit achievement percentage

Green Star SA category	*Average credit achievement %*	*Green Star SA weighting factor*
Management	64	9
Indoor Environment Quality	56	15
Energy	77	25
Transport	79	9
Water	84	14
Materials	47	13
Land Use and Ecology	37	7
Emissions	57	8
Innovation	19	0
Total weighting factor		100
Average credit achievement %	Variance = s^2	0.039
	Standard deviation = s	0.198
	Coefficient of variation = CV	0.344
Achievement % versus weighting factor	Pearson's coefficient of correlation = r	0.665

The linear relationship between the average achievement percentage and the weighting factor was described by the Pearson product moment correlation (Puth *et al.*, 2014). The Green Star SA weighting factor allocated to the respective categories could only, to some extent, explain this variability in average achievement percentage (r = 0.665). Table 5 also indicates that a category such as Energy with a 77% average achievement also carries a weighted score of 25, which may explain in part why the Energy credits were often included in green building strategies. The category Transport, however, had an even higher achievement of 79%, although the category only carries a weighted score of 9. The category Indoor Environment Quality carries the second-highest weighted score of 15, but only had a 56% average achievement percentage.

The monetary implications or the cost per point scored are most probably a very real issue to consider when evaluating the application trend of Green Star SA credits. For example, credits in the WAT category may be more affordable than credits in the IEQ category.

Aspects such as technical challenges, financial constraints, credits that are not applicable to every project, and so on should also be considered when trying to explain this variability in average achievement percentage.

4.2.2 The effect of Green Star SA rating on the average achievement percentage of Green Star SA credits

The study also evaluated the extent to which the certification level targeted (4 Star, 5 Star, or 6 Star rating) affected the achievement percentage of credits. The findings detailed in Table 6 reveal that higher Green Star SA ratings targeted resulted in significantly higher number of credits being often achieved. A total of 20 credits were often achieved by the 4 Star buildings, but as many as 38 credits had to be often achieved by 6 Star buildings.

Table 6: Credit application versus Green Star SA certification level

Category	*Often achieved*	*Seldom achieved*
Total sample credits	21	14
4 Star rating	20	18
5 Star rating	31	9
6 Star rating	38	5

The linear relationship between the above sets of data was explored with the Pearson product moment correlation (Puth *et al.*, 2014). The weighted points score required for the different certification categories was compared against the credit achievement data (both often and seldom). Table 7 confirms a strong positive correlation between weighted points required and credits with an average achievement of >80% ($r = 0.992$) and also a strong negative correlation between weighted points required and credits with an average achievement of <20% ($r = -0.976$).

Table 7: Green Star SA rating versus average achievement percentage

Category	*Green Star SA rating*			*Pearson's coefficient of correlation*
	4 Star	*5 Star*	*6 Star*	
Weighted score required	45	60	75	
No of credits with achievement >80%	20	31	38	0.992
No of credits with achievement <20%	18	9	5	-0.976

The correlation between Green Star SA rating and the achievement percentage of credits confirms that a relatively large number of credits (18) are left unattended by buildings that apply for a 4 Star rating. This finding may indicate that most of the credits required by 4 Star buildings are sourced from 20 'often used' credits. By comparison, the 6 Star buildings applied 38 'often used' credits, while only five credits were left relatively unattended. When trends in Green Star SA credit use are considered, it is important to bear the certification rating of buildings in mind.

4.2.3 The effect of time/year of certification on the average achievement percentage of Green Star SA credits

The final analysis was to consider the relationship between time/the year of green building certification and the 35 credits that had already been identified as often used or seldom used. Figures 3 to 11 display these relationships graphically. In 2009, only a single green building was certified, and the analysis was, therefore, limited to only display data from 2010 to 2015.

Figure 3 details the Management category with MAN-5 Building users' guide and MAN-7 Waste management as often used credits and MAN-4 Independent commissioning agent as a seldom used credit. MAN-7 has trended lower since 2010, with a 2013 achievement below 80%. MAN-4 has trended higher since 2010, and in 2013 and 2015 exceeded 20% achievement. This trend is significant in light of the recent criticism of green building, suggesting that independent auditing of actual green building delivery should be considered.

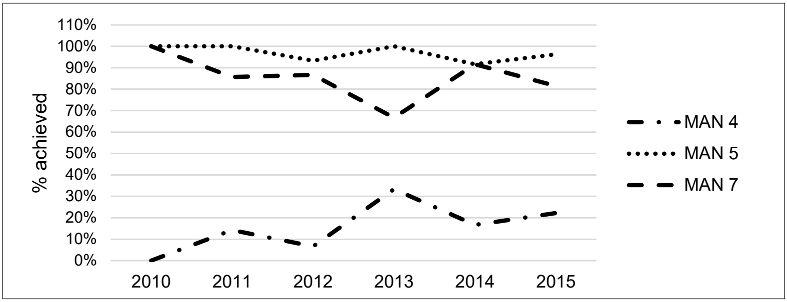

Figure 3: Management category – often used and seldom used credits

Figure 4 focuses on Indoor Environment Quality with IEQ-1 Ventilation rates, IEQ-6 High-frequency ballasts, IEQ-8 External views, IEQ-13 Volatile organic compounds, and IEQ-17 Environmental tobacco smoke avoidance as often used credits, and IEQ-10 Individual comfort control, IEQ-11 Hazardous materials, and IEQ-15 Mould prevention as seldom used credits. The often used credits had regular achievement rates of >80% other than IEQ-8 that in 2011 and 2014 dipped far below 80%. IEQ-10, IEQ-11, and IEQ-15, as seldom used credits, displayed three distinctly different trends. IEQ-15 seldom featured in green application strategies. IEQ-11 displayed an increasing use trend since 2010, and in 2014 and 2015 exceeded 20% achievement. IEQ-10 was constantly declining since 2010 as green building credit and in 2015 scored <10% for the first time.

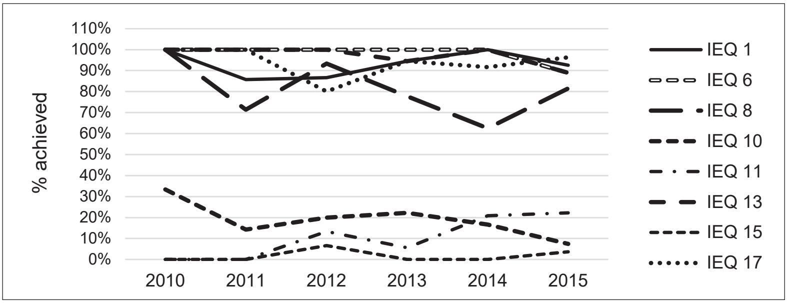

Figure 4: Indoor environment quality category – often used and seldom used credits

The Energy category was detailed in Figure 5 with ENE-1 Greenhouse gas emissions, ENE-2 Energy sub-metering, ENE-3 Lighting power density, and ENE-4 Light zoning as often used credits. In 2010 ENE-2 still had <70% achievement but since then has risen to >90% use. The other three credits had been used very frequently throughout the study period.

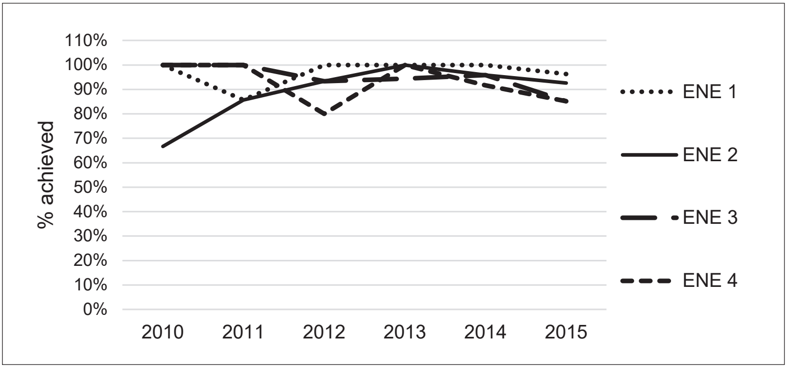

Figure 5: Energy category – often used and seldom used credits

The Transport category detailed in Figure 6 only had two often used credits, TRA-2 Fuel-efficient transport and TRA-3 Cyclist facilities. TRA-2 displayed use frequency varying about the 80% level. TRA-3 started in 2010-2012 as almost always used, but then declined, and in 2014 and 2015 was used by <80% f buildings.

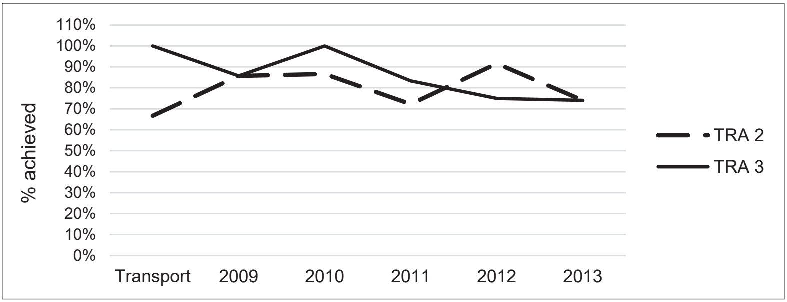

Figure 6: Transport category – often used and seldom used credits

Figure 7 details the Water category with WAT-1 Occupant amenity water, WAT-2 Water meters, and WAT 4 Heat rejection water as often used credits. All three credits were used at around 90% frequency or more, other than WAT-4 that, in 2010, was used <70%.

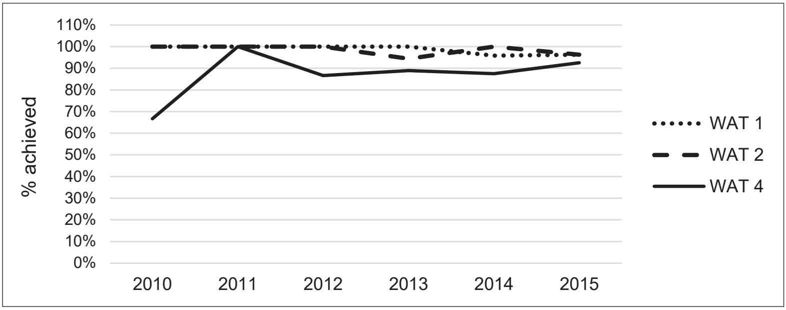

Figure 7: Water category – often used and seldom used credits

The Materials category is detailed in Figure 8, with MAT-1 Recycling waste storage and MAT-6 Steel, as often used credits and MAT-2 Building reuse, MAT-3 Reused materials, Mat-9 Design disassembly, and MAT-10 Dematerialisation, as seldom used credits. Both MAT-1 and MAN-6 were used around 90% of the time other than MAT-1, starting below 70% in 2010 and MAT-6 being used <60% in 2011. The four seldom used credits MAT-2, MAT-3, MAT-9, and MAT-10 were all used around 10% from 2012 to 2015. One point is available for each of MAT-3, MAT-9 and MAT-10, which may in part explain the low use rate. MAT-2 and MAT-9 are also primarily focused on existing buildings and since this study concerns new office buildings, the use factor of these credits can be expected to be low.

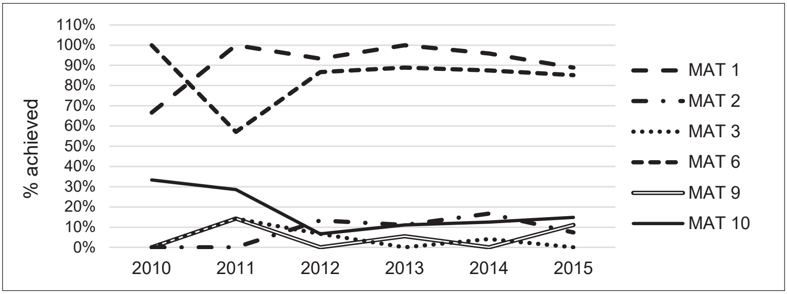

Figure 8: Materials category – often used and seldom used credits

However, any credits focused on reducing the extent of natural resources required by buildings or to extend the use life of resources that have been committed to construction should be regarded as important. This finding indicates that more focus or incentives may be considered to support the regular application of these credits. Studies such as Junnila (2004), Jacobs and Ragheb (2010) as well as Buyle *et al*. (2013) confirm that green building tools must support sustainability over the full use life of buildings.

The Land Use and Ecology category with two seldom used credits in ECO-1 Topsoil and ECO-3 Reclaimed contaminated land is detailed in Figure 9. However, the nature of these two credits that are only applicable to very specific circumstances explains why both credits were used very sparingly, with only ECO-1 used >30% in 2012.

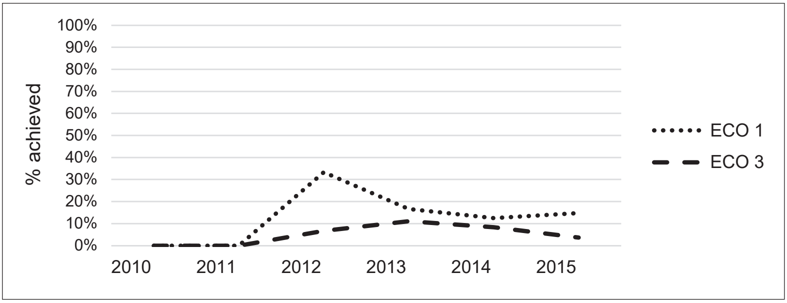

Figure 9: Land use ecology category – often used and seldom used credits

The Emissions category with five trending credits as detailed in Figure 10. EMI-1 Refrigerant/Gaseous ODP and EMI-6 Discharge to sewer were both used >95%, but EMI-4 Insulant ODP only stabilised at >80% use from 2013. EMI-2 Refrigerant GWP was constantly used by around 10% or less of buildings. EMI-3 Refrigerant leaks declined in use from >30% in 2010 to <10% from 2012.

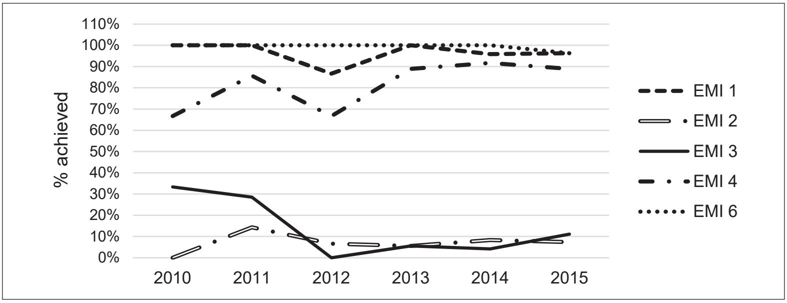

Figure 10: Emissions category – often used and seldom used credits

The last category of Innovation, with only two seldom used credits of INN-2 Exceeding Green Star SA SA Benchmarks and INN-3 Environmental design initiatives, is detailed in Figure 11. Both credits varied between the use of 0%-30%, but since 2013 has stabilised at <20%.

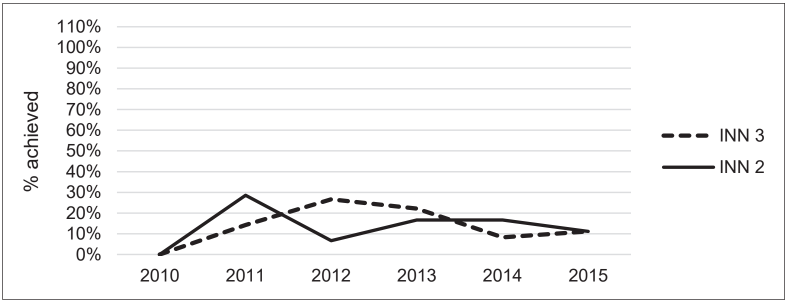

Figure 11: Innovation category – often used and seldom used credits

With the v1.1 version of the Office tool, the number of points in the Innovation category increased from 5 to 10. A wide range of items have been awarded as Innovation credits to date. Green building needs innovative ideas to grow and prosper. A new innovation item recognised by the GBCSA under the INN-3 credit is financial transparency which is worth two points and has no capital cost to the project. This credit should be included in every Green Star SA application. Follow-up studies will be able to confirm if credits in the innovation category will be more often achieved in the futore.

5. DISCUSSION

The study explored potential trends with regard to the application of green credit strategies followed by Green Star SA-rated office buildings in South Africa from 2009 to 2015. The findings revealed which credits are readily accessible and which credits very seldomly achieved Green Star SA. These insights were previously not available.

5.1 Often used Green Star SA credits

The first trend identified was that, out of the 67 credits of the Green Star SA Office v1.1 tool, a total of 21 credits (31.3%) were achieved by an average of more than 80% of the office buildings certified between 2009 and 2015. A total of 13 credits (19.4%) were achieved by more than 90% of these office buildings. This study, therefore, identified that there are specific green credits that are very accessible to the industry and that are included in the green building strategies of almost all South African green buildings.

A similar but much earlier study by Hoffman and Pienaar (2013) on green building strategies identified that, within the first three years of using the Green Star SA tool in South Africa, all but one of the above 21 often used credits were already identified as very often achieved by green buildings certified. This finding confirms that these credits had been favoured in the vast majority of South African green building strategies from the early days of South African green building certification.

A deeper and more detailed analysis of the credits and the actual points within these credits will add more value to, and insight into the use and application of Green Star SA credits in the South African green building industry. The ENE-01 credit may be of specific interest in this regard to reveal if the green building industry has made a real difference in the past decade.

If all the points of the above 21 often used credits are weighted and added, the sum of 50,78 weighted points, is 5,78 points (or 12.83%) more than is required for a 4 Star rating. In theory, an effective green building strategy that targets all the points of every one of these 21 credits can secure the majority of points to secure a 4 Star green building rating. However, if this process is repeated for 80% and more of buildings, the result may possibly be a less-than-ideal delivery outcome by certified green buildings from a sustainability point of view. The remaining 46 credits of the Green Star SA tool and their contribution to a more sustainable industry may then never be fully realised.

The Green Star SA tool is not designed to have most of the credits achieved by the vast majority of the projects, but to rather offer a wide menu of credits to projects to select from according to the circumstances of each project. However, the current status of a range of credits with very low application may warrant some attention from the GBCSA. It is, therefore, a potential outcome that has to be monitored and managed.

5.2 Seldom used Green Star SA credits

This study also found a second trend of 14 credits or 20.9% of all 67 credits that were achieved by less than 20% of the certified green buildings. A total of six credits (9.0%) were achieved by less than 10% of these buildings. This finding indicates that some credits are very inaccessible to the industry and may be a challenge to implement as part of green building strategies.

These 14 credits were all included in the Green Star SA tool with proper motivation and positive intent. These credits have the potential to make an important contribution to a more sustainable environment. The result of very seldom using these credits may again, as described in section 5.1, be a less-than-ideal outcome from a sustainability point of view. As proposed in section 5.1, this scenario will require monitoring and management.

5.3 Average achievement percentage of Green Star SA categories

The study also made a third finding with regard to the average achievement rate of each of the nine categories of the Green Star SA Office v1.1 tool. The average achievement rate per category varied between 84% for Water and 19% for Innovation. The three categories with the highest average achievement rates were Water (WAT-1 to WAT-5) with 84% (varying between 73%-89%), Transport (TRA-1 to TRA-5) with 79% (70%-83%) and Energy (ENE-1 to ENE-5) with 77% (75%-86%). The three categories with the lowest average achievement rates were Innovation (INN-1 to INN-3) with 19% (varying between 11%-24%), Land Use and Ecology (ECO-1 to ECO-4) with 37% (26%-46%) and Materials (MAT-1 to MAT-11) with 47% (44%-49%).

The weighted points allocated to the respective categories could only, in part, explain this variability in average achievement. Aspects such as technical challenges, financial constraints, credits not applicable to every project, and so on should be explored for a deeper insight to explain this variability in average achievement percentage.

5.4 The effect of Green Star SA rating on the average achievement percentage of Green Star SA credits

The fourth trend identified was a strong positive correlation coefficient of 0.992 found between the Green Star SA rating level of buildings achieved and the number of often used credits as well as a negative correlation coefficient of -0.976 between the Green Star SA rating level achieved and the number of seldom used credits.

Table 7 lends some support to the conclusion suggested in section 5.1 that the 21 credits with a >80% achievement can potentially secure a 4 Star rating. The finding also reveals that the additional credits required by a 5 Star rating needed more credits to be included in the green building strategies, resulting in 31 credits with a >80% achievement. A 6 Star rating requires even more credits targeted in the green building strategy, resulting in 38 credits with a >80% achievement.

Table 6 also details that 4 Star buildings have 18 credits with an average achievement of <20%, while 5 Star and 6 Star buildings only have nine credits and five credits, respectively, with an average achievement of <20%. The above finding supports the hypothesis that most of the credits required by 4 Star buildings are sourced from the ‘often used’ credits and that a relatively large number of credits can be left unattended.

5.5 The effect of time/year of certification on the average achievement percentage of Green Star SA credits

The vast majority of trends by credits that the study identified, either as often used or as seldom used, were apparent for most of the study period from 2010 to 2015. Time was, therefore, not found to have a significant impact on the majority of credit trends. Some of the often used credits such as EMI-4 had increased use, while MAN-7 seemed to be experiencing a decline in use. Among the seldom used credits, MAN-4 and IEQ-11 did experience an increase in use, while IEQ-10 and EMI-3 seemed to be declining even further.

6. CONCLUSIONS AND RECOMMENDATIONS

A young industry such as the green building industry that is starting to grow towards maturity lacks the well-defined descriptors of established industries benefiting from many years of development and analysis. This study explored facets of green building developments to look for possible industry trends in the application of green building credits. The findings revealed overall industry trends that may otherwise have remained hidden from view of individual stakeholders involved with a limited number of projects. The study did find and discussed a number of trends.

After completion of the analysis of the data and the findings made, the following recommendations are made:

- The study regarding green building application trends of green credits should be continued, in order to keep track of this dynamic aspect and to be aware of what is happening as the green building industry matures.
- The trends identified should be studied in more detail to explore the underlying causes of these trends.
- Aspects such as credits with technical challenges, financial constraints and the cost versus point ratio of credits, and credits only applicable to specific project types should be included in the above follow-up study.
- A study comprising the opinions of Green Star SA Accredited Professionals to explore and unpack the findings of this study will add insight into, and credibility to the findings and may be of value to the GBCSA when reviewing or updating the Green Star SA tool.
- Many of the Green Star SA credits are worth more than one point, and these credits should be explored in more detail to reveal the actual percentage of available points targeted and achieved.

One way of managing the trends identified is to, on a continued basis, peruse and consider the Green Star SA tool and, specifically, the points awarded and the weightings applied to the respective categories. New versions of the Green Star SA tool may be amended to move weighted points from often used credits with more modest sustainability contributions in favour of seldom used credits with highly desired sustainability outcomes. The result of such amendments to the Green Star SA tool may be future green building strategies amended to suit the new version of the tool and green buildings with a more substantial contribution towards environmental sustainability.

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