LOW CARBON LIVING CRC

Green Star Communities rating tool

An assessment

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The authors confirm that this document has been reviewed and approved by the project's steering committee and by its program leader. These reviewers evaluated its:

- originality
- methodology
- rigour
- compliance with ethical guidelines
- conclusions against results
- conformity with the principles of the Australian Code for the Responsible Conduct of Research (NHMRC 2007),

and provided constructive feedback which was considered and addressed by the authors.

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Acronyms

GBCA Green Building Council of Australia

GHG Greenhouse gases

BIM Building information modelling

PIM Precinct information modelling

Executive Summary

The report

This report examines various aspects of Green Star Communities v1. The first sections deal with greenhouse gas emissions and building information modelling, and a review of the literature about Green Star Communities. The last sections comprise research which considers the Green Star Communities Submission guidelines, the Calculators, and usability.

Greenhouse gas emissions

In this part we consider the impact that Green Star Communities might have on the reduction of greenhouse gas emissions, through the demand side. This is difficult to quantify. But it is also becoming less relevant as greenhouse gas emissions are being reduced on the supply side, through the move to renewables for power supply. Green Star Communities should take this into account.

Building information modelling

Green Star Communities has parallels elsewhere in the world, notably in the BREEAM and LEED systems. The BREEAM system provides an interconnected hierarchy, from Communities to Products, and it is suggested that Green Star emulates this.

This object hierarchy is paralleled in digital information modelling – PIM, BIM and digital specification systems such as NBS Chorus. The environmental assessment tools offered by Green Star should, like other simulation tools, draw the information they need direct from the digital model. To some extent this is happening already, but should be extended. Parallel hierarchies would help with this.

Literature

There are few published studies on Green Star Communities. This review considers related studies, concerning precinct-level environmental assessment schemes generally, some conducted through CRC LCL.

Submission guidelines

In this part we examine the Green Star Communities v1 Submission guidelines and make quite a few recommendations, mostly minor, as to how they might be improved. Some of these may have been dealt with in v1.1.

Calculators and Guides

Green Star Communities has just the one Calculator, but it is suggested that Calculators developed for Green Star Design & As Built could be used, facilitating the interconnected hierarchy mentioned previously. Accordingly this section explores most of these Calculators, and the associated Guides, and makes a number of recommendations for improvement. Again, minor mostly, and some may have been implemented in v1.1.

Interviews

In this part we consider the usability of Green Star Communities. Suggestions for improvement are made, often similar to those given in the previous sections.

Introduction

This research project had a complex gestation. After several shifts in the academic nature of the proposed research, a post-doctoral researcher, Dr Manju Agrawal, a mathematician with an interest in sustainability, was engaged. At this time the intention was that the project would assess two precinct assessment tools – Kinesis: CCAP Precinct (PRECINX) (Kinesis, 2018) and Melbourne University: MUtopia (Thomas, 2012). For various reasons this did not eventuate, so after some discussion the project switched to assessing GBCA Green Star Communities (v1, 2015) instead. By this point, time had been lost in the project schedule, and the expected mathematical emphasis in the research had been much reduced – while both the original tools use algorithms extensively, Green Star Communities uses just the one Calculator. Nevertheless, the research project continued, and this report is the result.

The research project was led by John Gelder, a lecturer at the University of South Australia's School of Natural and Built Environments, and an architect with an interest in sustainability. Manju Agrawal, a post-doc researcher with UniSA, wrote sections 7 Environment and 8 Calculators. Jeremy Miller, at the time with Sustainability House and now with the City of Charles Sturt, wrote section 5 Literature.

Green Star Communities v1

The GBCA (Green Building Council of Australia) Green Star Communities rating tool evaluates sustainability aspects of the planning, design, and construction of large scale development projects, at a precinct, neighbourhood, or community scale. Green Star Communities assesses projects against a holistic set of categories:

- Governance.
- Liveability.
- Economic Prosperity.
- Environment.
- Innovation.

Each category consists of a group of issues related to a certain sustainability impact; these are known as Credits. A Credit addresses an initiative (or set of initiatives) that has the potential to improve a project's sustainability performance.

The focus of this report is the Environment category, in acknowledgement of the funding through CRC-LCL, and its interest in the reduction of the anthropogenic emissions of carbon dioxide and other greenhouse gases, through energy efficiency in use.

The report is intended to validate and improve Green Star Communities, which is claimed to deliver more sustainable precincts, or communities, than regulation and conventional practice would achieve alone. The tool deals with carbon emissions, but with many other issues as well. Under the heading of Environment, the Greenhouse Gas Strategy Credit is worth up to 6 points, out of 110 across all headings. Carbon emissions would also be picked up by some other Credits, such as Materials (5 points), Sustainable Transport and Movement (3 points) and Heat Island Effect (1 point).

The objective is to gain maximum points against each Credit, but the quantitative amounts of carbon that might be reduced will vary from project to project, even if the maximum number of carbon-related points is accrued, if only because of the various scales of the projects concerned.

The pilot version of Green Star Communities was used in the following projects:

- Alkimos, Western Australia (6 star).
- Barangaroo, Sydney.
- Brisbane Airport, Brisbane, Queensland (4 star).
- Caloundra South, Queensland (6 star).
- Ecco Ripley, Ipswich, Queensland (5 star).
- Greater Curtin, Curtin University, Western Australia (5 star).
- Tonsley Innovation Hub and Bowden renewal project, Adelaide.
- University of Melbourne, Parkville Campus, Melbourne.
- Green Square, NSW.
- Schofields, NSW.
- Willowdale, NSW.
- Waterbank, WA.
- Shenton Park, WA.
- Lawson, ACT.
- West Belconnen, ACT/NSW.

Case studies have been published by GBCA on the Tonsley and Bowden developments in South Australia, on the GBCA website.

Green Star & Greenhouse gas emissions

It is difficult to quantify the greenhouse gas (GHG) emissions that might be reduced as a result of this research, for a number of reasons:

- Green Star Communities is a voluntary rating system for precincts, and so it is not and will not be used in the design of every precinct-scale project in Australia.
- Credits linked to greenhouse gas emissions account for a fraction of the possible Credits in the scheme.
- The scheme provides a range of overall scores, from 6 Stars down to 4. A 4 Star scheme will not perform as well in terms of the various Credits available as a 6 Star scheme.
- Even for the same number of Stars, different schemes will achieve Credits in different ways – some might maximize their greenhouse-gas-emission Credits while others might not, preferring to gain Credits elsewhere.

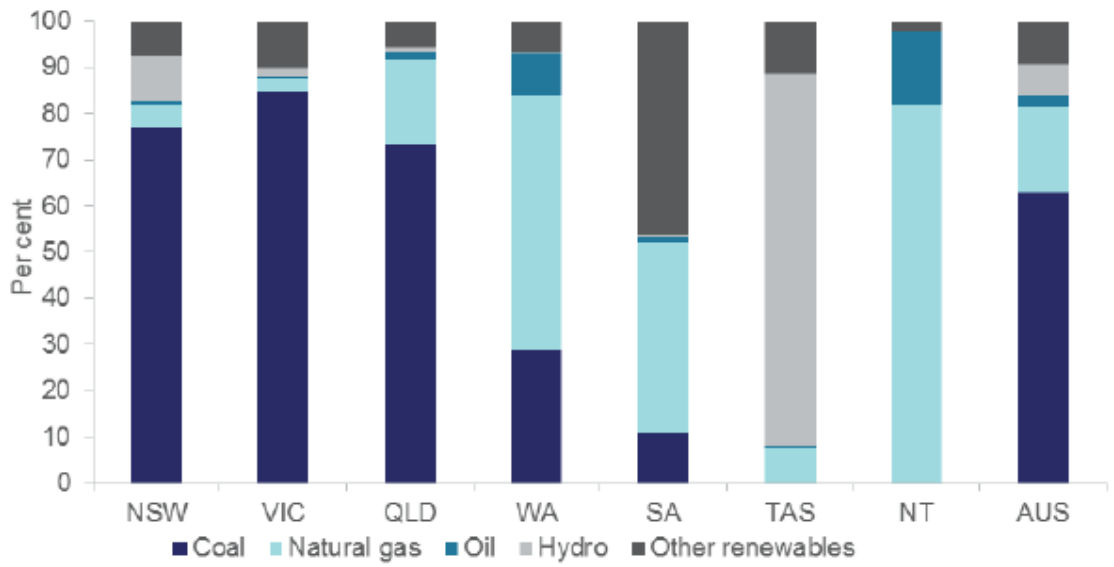
Use of Green Star Communities already, presumably, has had the effect of reducing greenhouse gas emissions, given that the GBCA states that 10 years of data on Green Star-certified buildings shows they can use (up to) 66% less electricity and produce (up to) 62% fewer greenhouse gas emissions than average Australian buildings (GBCA, 2013).

Recommendations arising from this research may not be adopted, but where they are the impact on carbon could be minimal.

However, it could be argued that, if the recommendations made in this research are implemented, and if the research 'validates' Green Star Communities, then the use of the tool could increase, and so the overall effect would be a reduction in greenhouse gas emissions.

Another difficulty is that the nature of the electricity supply is changing quickly. The emission of greenhouse gases can be addressed in two ways – on the demand side, and on the supply side. Green Star Communities tackles the demand side of GHG (mostly CO_2) emissions. Reducing demand makes very good sense for as long as electricity is generated mostly using fossil fuels. But this is a short-term strategy. The long-term strategy, being adopted globally, is to move from fossil-fuels to renewables for electricity supply. Across Australia, some jurisdictions are further ahead in this than others, and most of the rest have plans to change the energy mix substantially within the next decade. Once the energy mix is at, say, 75% renewables, then from an environmental point of view it does not matter much how much energy is consumed – the GHG emissions will be minimal. *Accordingly it is suggested that Green Star Communities incorporates a weighting for the points awarded to reducing GHG emissions.* Where the energy mix is high in fossil fuels (currently NSW, Victoria, Queensland, WA & NT), reducing demand would be worth more Credits than where the energy mix is high in renewables (currently SA and Tasmania) (Figure 1). The picture is changing fast – Victoria intends to get to 40% renewables by 2025, for example (Environment Victoria, 2017), and SA is targeting 75% (Morton, 2018). This weighting could also be adjusted for high-emission fuel (coal) and low-emission fuel (gas). The weighting could range from zero to 100%, considering all these factors. Without such a weighting, the development of sustainable communities in Tasmania, for example, would be unfairly targeted for demand reduction. For them this would be only an economic issue, not an environmental one, and so beyond the remit of Green Star.

Figure 1 Australian electricity generation fuel mix, 2016 (DEE, 2017)



Green Star & Building Information Modelling

This chapter examines Green Star Communities in a broad context – comprising both the Green Star series of environmental assessments, and building information modelling (BIM).

Green Star in context

National environmental assessment schemes include several from Australia, the UK and the USA. Table 1 shows some of these, and the offerings at different levels in the 'object hierarchy' (from Districts or precincts, down to Products).

Table 1 National environmental assessment schemes

Uniclass 2015 classes	Australia		United Kingdom	USA	
	GBCA – Green Star	Non-GBCA	BRE – BREEAM	USGBC – LEED	Non-USGBC
District	Green Star Communities	Kinesis PRECINX UniMelb MUtopia	BREEAM Communities	LEED Neighborhood development	
Complex	-		BREEAM Infrastructure	-	
Entity	Green Star Design & As-built Green Star Interiors Green Star Performance		BREEAM New construction BREEAM Refurbishment & fit-out BREEAM In-use	LEED Building design & construction LEED Interiors design & construction LEED Building operations & maintenance LEED Homes	
Element	-		BRE Green Guide to Specification	-	
System	-		Ditto	-	
Product	-	Good Environmental Choice Australia (GECA) Global GreenTag GreenRate	BRE Environmental Profiles	-	SCS Global Services UL ECOLOGO Green Seal Standards

Green Star is used in Australia (GBCA) and New Zealand (NZGBC). BREEAM is used in 77 countries, including the UK, USA, Netherlands, Spain, Norway, Sweden, Germany, and Austria. LEED is used in 150 countries. The top 10 are USA, Canada, China, India, Brazil, Korea, Germany, Taiwan, UAE, Turkey, and Sweden. Many of the criteria are common, but some are not (Table 2). The point being made here is that Green Star is broadly consistent with equivalent schemes elsewhere.

Table 2 Environmental assessment scheme criteria compared

Green Star Design & As Built	BREEAM	LEED
Management	Management	Integrative process
Indoor environmental quality	Health & wellbeing	Indoor environmental quality
Energy	Energy	Energy & atmosphere
Transport	Transport	Location & transportation
Water	Water	Water efficiency
Materials	Materials	Material & resources
Land use & ecology	Land use	Sustainable sites
Emissions	Pollution	-
-	Waste	-
-	-	Regional priority
Innovation	Innovation	Innovation

Mapping between the different levels

It can be seen from Table 1 that BREEAM has a suite of tools at every level in the hierarchy, whereas Green Star and LEED do not. For the BREEAM suite this means that, in principle at least, data from the lower levels can aggregate up to the higher levels, and requirements from the higher levels can disseminate to the lowest. Due to discontinuities, this is not possible for Green Star or LEED, except between Districts and Entities.

For BREEAM, this potential has been partly realized in that data from Environmental Profiles is used in the BRE Green Guide to Specification, and data from this is used in BREEAM New Construction, for example. However, this does not apply in reverse (top down), nor is there a link – in either direction – between the BREEAM tools for Entities and those for infrastructure and Districts.

Links between Districts (Precincts) and Entities in both Green Star and LEED have not been implemented in either direction. The tools are not connected.

One issue with mapping up and down the object hierarchy (Districts to Products) is that the criteria are necessarily different. We have seen that for Green Star Communities they are:

- Governance.
- Liveability.
- Economic Prosperity.
- Environment.
- Innovation.

But at the Product level, environmental product declarations to EN 15804:2012 use the following criteria:

- Global warming potential.
- Depletion of stratospheric ozone.
- Acidification of land & water.
- Eutrophication.
- Creation of tropospheric ozone.
- Depletion of non-renewable energy resources.

The BRE Environmental Profiles add the following:

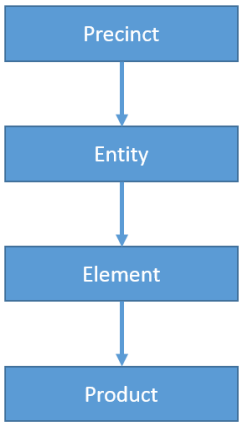
- Human toxicity.
- Waste disposal.
- Nuclear waste.
- Ecotoxicity to freshwater.
- Ecotoxicity to land.
- Mineral resource extraction.
- Water extraction.

All of these taken together might aggregate up to ‘Environment’ at District level, but there is nothing at Product level on governance, liveability, economic prosperity and innovation. Nor should there be (in most cases).

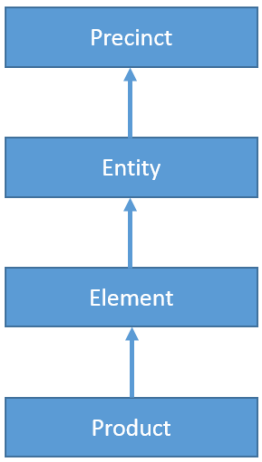
This difference is recognized in unpublished work undertaken by one of the authors (Gelder) in the development of the NBS Create master specification in the UK over 2004-2012, for RIBA Enterprises. The criteria used for the total performance specification of high-level object classes – Regions, Districts, and Complexes – are quite different to those for low-level objects – Entities, Activities, Spaces, Elements, Systems and Products. For the high-level object classes, performance criteria would comprise: functional, social, economic and environmental. These are akin to those for Green Star Communities.

For low-level object classes the NBS Create performance criteria comprise: functional, structural, fire, environmental (e.g. ambient conditions), safety, acoustic, energy, sustainability and non-regulatory. These are much broader than the 13 criteria in the BRE Environmental Profiles, which focus on ‘sustainability’, of course.

What should happen is that decisions made should trickle down through the design stages, to be inherited by the next level.



And actual values should be able to be aggregated up to give actual figures. One can then compare Design (intent) with Execution – identifying the 'performance gap'.



It is suggested that more Green Star tools be developed, to complete the object hierarchy from Districts to Products. It is further suggested that these tools map to each other, at least in terms of content and structure. Ideally there should also be a functional (i.e. digital) mapping to enable automatic aggregation and disaggregation.

For example, Green Star Communities has a credit on light pollution, as does Green Star Design and As Built. Given this, building-by-building responses to light pollution could be aggregated up to District-scale responses, and vice versa. The 2016 introduction by Green Star of the Cross Claim Approach is noted.

Building Information Modelling

The construction industry has been moving towards the adoption of digital information modelling for the last twenty years or so. Recently this has extended from buildings (building information modelling – BIM) to precinct information modelling (PIM) (Plume, Mitchell, Marchant & Newton, 2017) and to digital engineering (DE) for infrastructure (e.g. Transport for New South Wales Digital Engineering, in 2018).

Digital information modelling uses a schema of the kind used in ISO 12006-2:2015 (Figure 2).

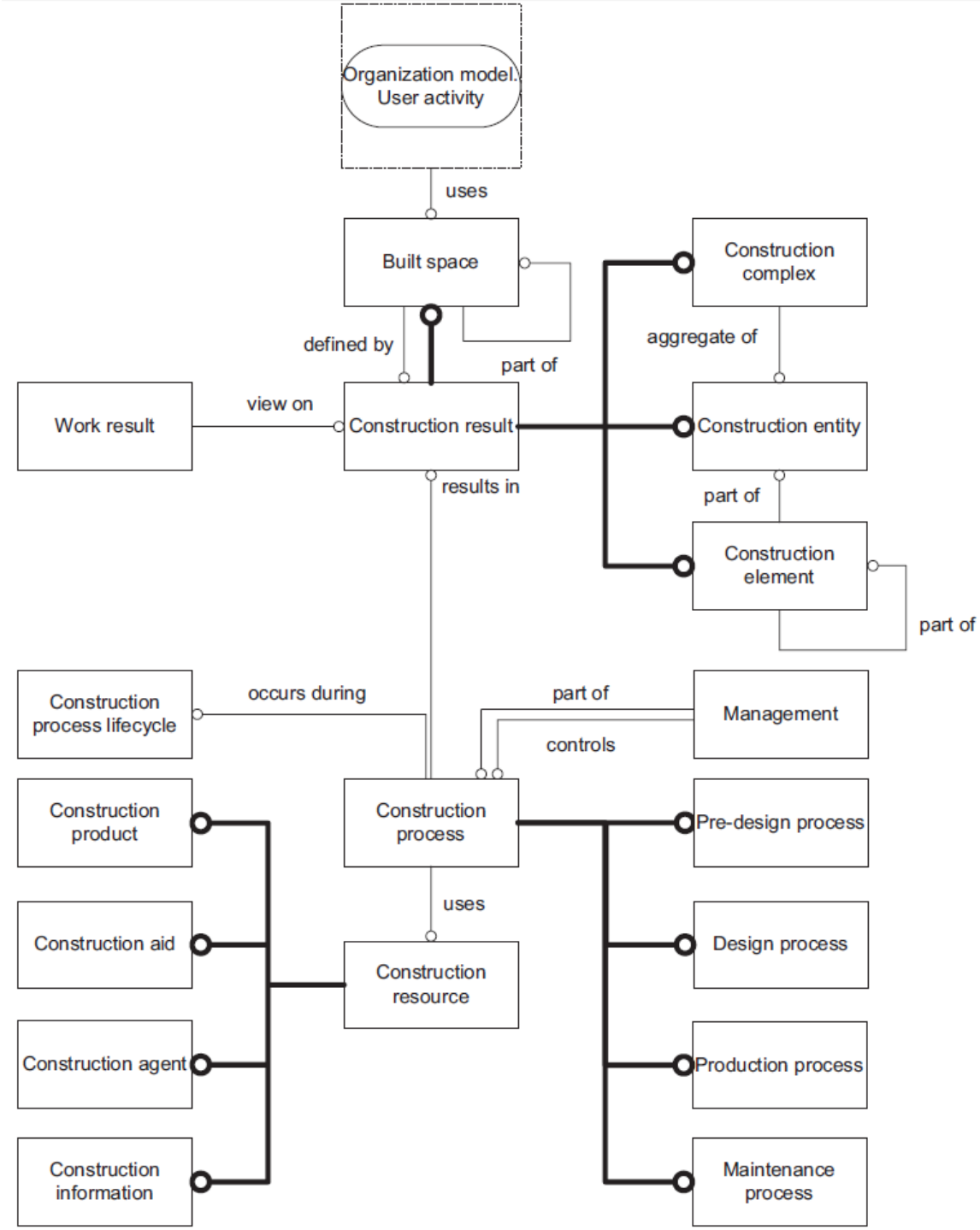


Figure 2 Schema from ISO 12006-2:2015.

A part of this (Complexes – Entities – Elements) has been used in Table 1, i.e. in Uniclass 2015. This is the official UK classification system for the construction industry, and is being adopted by TfNSW (Gelder, 2018), and by NBS in Australia. *It would make sense to consider its adoption, along with the schema, across the Green Star tools.*

The idea of digital information modelling is that all project information is held in a central model. Digital tools that need this information should be able to extract it from the model. This ensures currency and veracity, and saves on rekeying information multiple times for multiple purposes. Currently none of the environmental assessment schemes mentioned can do this, apart from the BRE Green Guide to Specification, which connects to the building information model (BIM) through the

BRE's IMPACT specification and database and compliant tools. *The Green Star tools should do this, and feed design decisions made using the tools back into the model – a bi-directional digital linkage.* This would be a major project as the Green Star tools are essentially manual, apart from some simple Calculators. They will need to be converted into databases.

Environmental assessment schemes and the specification

Part of the digital information model is the specification, or it should be. Accordingly, the various national master specification systems should support environmental assessment, but without becoming 'green specifications' (Gelder, 2003). In Australia, the UK and the USA, the main systems do, to some extent.

For example, NATSPEC TR 01 Specifying ESD (2014) states:

> "This TECHreport outlines the principles of Ecologically Sustainable Development (ESD) and their application to building specifications. ESD-related items included in NATSPEC worksections are listed and cross referenced to BCA and Green Star requirements."

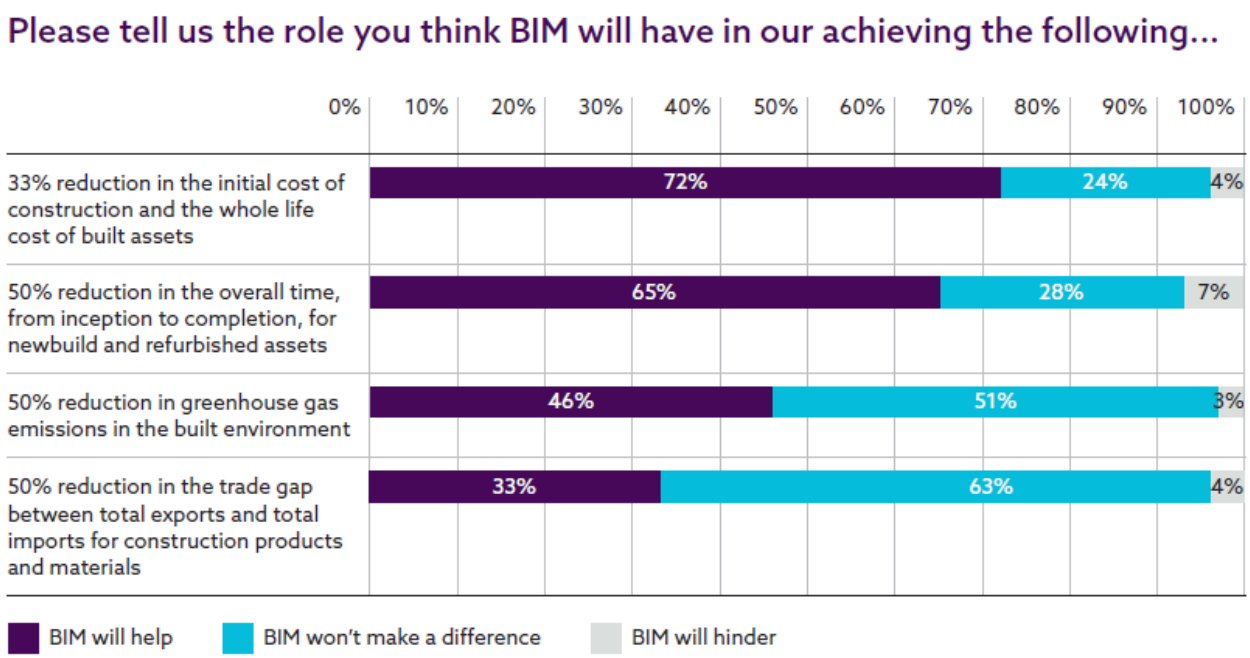
In the UK, for NBS Create and BREEAM, see Clarke (2010). In the USA, for Avitru (formerly ARCOM) MasterSpec and LEED, see Metal Architecture (2013).

However, not all these national master specification systems form a part of the digital information model. For example, NBS Create and the cloud-based NBS Chorus (soon to be released in Australia) do, but NATSPEC does not – it is still an MS Word document, not a database. There is much work to be done. *But in the meanwhile, GBCA should liaise with NATSPEC, and NBS in Australia, to ensure that relevant content is included, as far as practicable.*

BIM and reducing GHG emissions

The NBS National BIM Report has been produced in the UK by RIBA Enterprises every year since 2012. In the 2016 survey, with the experience of BIM among respondents on the rise, it was thought timely to ask about the roles expected of BIM by the UK government in improving project cost, time and GHG emissions, and improving the trade gap. The results for 2018 are summarized in Figure 3.

Figure 3 The role of BIM in reducing GHG emissions



Fewer than 50% of respondents thought that BIM would help the UK achieve a 50% reduction in GHG emissions in the built environment. This is odd given that tools compliant with the BRE's IMPACT specification and database are designed to use the BIM geometry (Revit or IFC or both) to carry out life cycle assessment against a range of environmental impact criteria, including carbon, and are well-known. Providers of IMPACT-compliant software are as follows:

- IESVE 2018 (compatible with BREEAM, LEED v4, Green Mark and OTTV, and in partnership with OneClickLCA).
- The Australian eToolLCD (compatible with BREEAM, LEED v4, CEEQUAL, and with Green Star Communities).

- Bionova's OneClick LCA (compatible with Green Star, BREEAM, LEED v4, DGNB (Germany), HQE International and, for infrastructure, BREEAM Infrastructure, CEEQUAL (CEEQUAL 2018 is replacing CEEQUAL 5.2 and BREEAM Infrastructure), Envision, and PAS 2080:2016 *Carbon management in infrastructure*).

It seems that IESVE 2018 cannot be used with Green Star tools, and that OneClick LCA cannot be used with Green Star Communities. *It is suggested that Green Star should pursue these compatibilities, in order to connect the Green Star entity-level and precinct-level tools to the building information model (BIM).* However, connecting Green Star Communities to the precinct information model (PIM) is not possible at present, since PIM itself is still in development, and so this is something for the future.

Green Star Literature

Green Star Communities has been described as "Australia's leading sustainability rating system for the built environment at a precinct level" (Newton et al, 2013). It is a voluntary tool for assessing the "planning, design and construction of large scale development projects at a precinct, neighbourhood and/or community scale" (GBCA, 2017).

Designed and supported by the Green Building Council of Australia (GBCA), version 1.1 of Green Star Communities was released in mid-September 2016. The GBCA states that the tool provides "a rigorous and holistic rating" (GBCA, 2017) across the five impact categories (being governance, liveability, economic prosperity, environment and innovation) and associated credits. As of 25 October 2018 the online GBCA Green Star Project Directory lists 59 Communities projects. These include both certified projects (having gone through the process to achieve a star rating) and registered projects (those still awaiting certification). Many of the projects were initiated during the pilot phase of the tools development. The breakdown is as follows:

- Pilot v0.0: 8 projects.
- Pilot v0.1: 4 projects.
- Pilot v0.2: 17 projects.
- v1: 11 projects.
- v1.1: 19 projects.

For the researcher looking to unpack the existing literature related to the impact of the Green Star Communities tool on developing and influencing low carbon living, the point that soon becomes apparent is there are few published studies specifically focused on this area.

One obvious explanation for this would be that Green Star Communities, as a voluntary industry adopted tool to drive sustainable development, is not very old and so the number of projects available for a researcher to consider is somewhat limited. However, the question can be asked whether this is the whole picture? Are there other factors to consider, such as what drives adoption of sustainability assessment tools in a competitive market? Are complex voluntary tools with high administrative overheads appealing to industry? How is the adoption of these tools split between projects initiated by government, and private projects? What does Green Star Communities signpost as contributing to this? Finally, can Green Star Communities influence the design and development of precincts to the scope required, particularly in respect to low carbon living?

While specific rating tools that adopt assessment categories to score development may be a recent innovation, designing to structured principles with a focus on outcomes is not a new idea. Several significant urban planning movements characterize the 20th century (Sharifi, 2016). Planning and assessment tools are available to the designer and developer to assess environmental impact from the single building level to the urban / precinct scale (Sharifi and Mirayama, 2013).

Jackson (2016) summarized twelve contemporary tools to assess development at this urban / precinct scale, identifying five tools for use in Australia (the criteria of having local support and presence). These five are: Green Star Communities from the GBCA, the EnviroDevelopment tool from the Urban Development Institute of Australia (UDIA), One Planet Communities associated with One Planet Living, the Living Community Challenge from the Living Futures Institute, and Circles of Sustainability from the UN Global Compact Cities Program.

Other noteworthy and comparable tools identified include BREEAM Communities, DGNB for Urban Districts and LEED for Neighbourhood Development, none of which are (currently) available in Australia. All tools provide for and / or predicted and measured certification strategies. Jackson (2016) comments that a tool's uptake depends on applicability to local conditions and environment, training, technical support, tool and workshop facilitation, with all tools seeking to improve the quality of development.

Sharifi and Murayama (2013) ascribe assessment frameworks like Green Star Communities as "neighbourhood sustainability assessment" tools, equating them to impact assessment. In their analysis of seven such tools they concluded that only tools embedded into the broader planning framework are doing well with regard to applicability. In a research study, Criterion Planners (2014) studied 35 tools used across 22 countries, from which Jackson (2016) concludes that the difference between tools is quite subtle – primarily depending on the operation, phase and format, or how prescriptive the criteria are. In Australia, such assessment tools are voluntary with "Green Star Communities and EnviroDevelopment … playing a leading role across Australia in encouraging the development and application of urban sustainability assessment". (Newton et al, 2013).

Green Star Communities provides a prescriptive framework for developing sustainable communities, and a rating tool to assess them. The tool provides a set of "indicators against each principle" which benchmark associated credits depending on the level of performance achieved (Newton et al, 2013).

Through a series of interviews, Morris (2017) identifies key barriers to the use of Green Star Communities. These include documentation, human resources, evidence of success, complexity, financial outcomes, lack of accredited professionals and certification cost. A level of inequality is highlighted in that smaller developers do not have the same opportunities to embed the principles advocated for by the GBCA – which points to the tool only being used by developers of a certain size and with larger budgets to manage such projects, or to government-initiated projects.

Writing in 2012 Adam Beck (the then Manager for Sustainable Communities at the GBCA) made the case for implementing rating schemes such as Green Star Communities as multi-level operations. Project financiers would gain a framework for sustainable investment while

government policy outcomes would be met and the planning and approval of significant projects streamlined.

Two years before Beck, Martin Musgrave, the then UDIA Deputy Director – Policy, wrote about EnviroDevelopment being a tool that would deliver a scheme to inform homebuyers looking to make purchases in a green field development, giving certainty that they were buying into schemes that had high environmental credentials. These values were seen to translate to homes that addressed affordability in terms of occupancy cost, not just purchase price. Developments need to be "outstanding" and be designed to protect the environment, use resources responsibly and offer benefits to "homeowners, industry and government" (Musgrave, 2010).

Beck (2012) sees schemes like Green Star as facilitators of more efficient development which in turn allow consumers to make more informed decisions. Newton (2017) sees the use of assessment tools as providing "roadmaps" to low carbon development that include mitigation and adaptation pathways. The pathways Newton (2017) describes are required because "the scale of the decarbonisation challenge is now such that change must be transformative, not incremental."

Do Green Star Communities and other such rating tools provide the urgency and "pathways" as seen by Newton (2017), such that they "have a capacity to significantly decarbonise key sectors of an urban system"? One issue highlighted by Rogmans and Ghunaim (2016) is that rating systems put more emphasis on sustainable design than they do sustainable performance. Morris et al. (2017) point out that with few notable exceptions; government-initiated projects have been the main users of the (Green Star) tools and had a clear role in the success of them. Jackson (2016) recognizes that the Green Star tools have come to dominate the Australian market with a well-known brand with "strong support from major developers". However, Sharifi and Murayama (2012) and Haapio (2012), when looking at the impetus to undertake large scale projects with rating tools, suggested that the cost/benefit, ease of use, and return on capital and administrative investment will limit projects, or transfer costs to taxpayers. Newton (2017) points out that "markets can't set policy, but they can deliver on policy". Such tools seek to guide decision making and policy, giving certainty to long term planning and investment (Haapio, 2012; Newton, 2017; Beck, 2012). Further to this analysis, Davidson et al (2012) questioned the common neo-liberal conceptualization of sustainability that places the economy as a core concern and proposes a new typology to categorise indicators of sustainability, one that seeks a social-democratic approach, with an emphasis on social justice and taking a pre-cautionary principle to natural capital.

Perhaps we will see more of a shift in the discourse from sustainability to a discussion of resilience to the shocks and stresses of climate change (Boltz & Granlund, 2014), as indeed the Australian cities of Melbourne and Sydney are approaching through the 100 Resilient Cities program pioneered by the Rockefeller Foundation. Resilient Melbourne (2016) is one such program and expresses this strategy across the four action areas – Adapt, Survive, Thrive and Embed (City of Melbourne, 2016). Within the Green Star suite of tools, particularly Green Star Communities and Design and As Built, there are credits that deal with climate change adaptation (for example Credit 03 in Design and As Built calls on the production of a Climate Adaptation Plan in order to meet the credit criteria). Adaptation and resilience thinking is not unique to Green Star, with sustainability indicators and frameworks such as One Planet Living being used by local government. The City of Subiaco Sustainability and Resilience Strategy (2016) created an Action Plan centered on the ten One Planet Living sustainability principles to create a framework for their strategic response to diagnose, respond and to structured thinking around a sustainability agenda.

Newton (2016) referred to the rapid transition towards urbanization and the growing ecological footprint of human settlements. The challenge in growing cities is one that provides resilience to the array of endogenous and exogenous pressures, the notion of "decarbonising" therefore has to equal regenerative (re)development of the built environment.

Morris et al. (2017) were interested in the concept of sustainable development, specifically in relation to Green Star Communities and the uptake and impact of the rating tool. They drew a focus to the recent introduction of the tool and note that "there has been a lack of research and critical analysis about the rating tool's anticipated influence within the local industry." This is perhaps not unsurprising due to the perceived barriers of cost, time and complexity (Morris et al., 2017) for industry to adopt rating tools to assess communities. Jackson (2016) highlights the number of competing tools available observing that Green Star exists in a market alongside several tools that can be used to assess performance and provide "inspiration for the development and adaption of communities and cities".

In this context Tanya Plant introduced EnviroDevelopment as a planning framework to inspire and deliver sustainable development across a wide range of development typologies. The certification tool was to be used to "distinguish real achievement from any 'greenwash'" (Plant, 2007, p. 14). Designed with a focus on providing a marketing angle for developers to brand their communities, the tool provides for pragmatic flexibility while still protecting the "integrity and credibility of the EnvioDevelopment brand" (Plant, 2007, p. 14). Musgrave (2010) contrasts the marketing of "green projects" against housing affordability, acknowledging that some developers will shy away from adding any additional costs to their projects in the belief that this will effect competitiveness in the market. EnviroDevelopment is promoted as a development industry tool to substantiate environmental claims, noting that a development can be accredited across one, some or all of the EnviroDevelopment elements (Water, Energy, Ecosystems, Community, Materials, Waste).

While the development industry may implement tools or frameworks like Green Star, One Planet Living or EnviroDevelopment, it is in Victoria we see local government, led by the Council Alliance for a Sustainable Built Environment (CASBE) members, using

the planning framework to drive sustainable design (Arnott, 2016). The Sustainable Design Assessment in the Planning Process (SDAPP) framework uses the Built Environment Sustainability Scorecard (BESS). This tool, like Green Star, seeks to improve proposals beyond minimal national standards (Arnott, 2016). It assesses development across a number of impact categories in scale from standalone residential houses to large multi-unit residential and industrial and commercial sites. While it is not a *precinct scale* tool, it uses categories similar to those considered in Green Star, including Management, Water, Energy, Stormwater, Indoor Environment Quality (IEQ), Transport, Waste, Urban Ecology and Innovation. BESS has a focus on "applying Ecologically Sustainable Development (ESD) principles to the built environment through the statutory planning system". The use of the BESS tool does not encompass the whole of Victoria and is primarily focused on inner-city Melbourne Councils who subscribe to it; though in future it could be Australia-wide as more Local Government Areas subscribe (Arnott, 2016).

In Perth, the Western Australian Government's land and development agency, LandCorp, led the White Gum Valley (WGV) project to create Australia's second One Planet Living Community. The development is within Australia's first One Planet Living City, Fremantle and as such is aiming to be a Zero Carbon development with an Action Plan that "aims to achieve a 'One Planet' lifestyle for the council, residents and business community by 2025" (Bioregional Australia, *One Planet Fremantle*, 2016).

Notably, WGV is one of the communities selected by the CRC Low-Carbon Living as part of RP3033: *Mainstreaming Low Carbon Housing Precincts – The White Gum Valley Living Laboratory*, with a "focus on the mechanism used to achieve low carbon outcomes, their acceptance and uptake, with a view to making them mainstream" (LCL CRC, RP3033, 2018).

In one of a number of papers that compares the Green Star Design and As Built tool with others, Roderick el al. (2009) point to a contrast between Leadership in Energy and Environmental Design (LEED), BRE Environmental Assessment Method (BREEAM) and Green Star when used to assess building projects. While not a discussion around community rating, the study found that there was a divergence in results between the tools when compared against a benchmark site. The paper concluded that obtaining similar results is problematic due to the means by which each of the schemes differs in the quantification of energy loads (Roderick el al., 2009, p. 1171).

A more detailed comparison of precinct assessment and rating tools is made in the CRC Low Carbon Living paper – *Performance Assessment of Urban Precinct Design: A Scoping Study* (Newton et al, 2013). In this paper a review of functionality of rating and assessment tools for community development was undertaken. The relevant chapter begins by comparing the alignment of Green Star Communities, LEEDnd (LEED for neighbourhood development) and BREEAM Communities, UK. Following a comparison of key features of these three rating tools and energy and carbon indicators (pp 52 – 54) it then goes on to examine the precinct design and assessment tools that are associated with the CRC partner organizations. This evaluation includes the tools LESS (Hassell), MUtopia (University of Melbourne), PRECINX (NSW Government) and SSIM (AECOM). Not all of these tools are current. The review examines alignment with a carbon-sustainability-resilience (C-S-R) framework, gaps in coverage including data availability, use of benchmarks, information and software platform issues associated with each tool. The paper undertook a detailed gap analysis and comparison also exploring Precinct Information Modelling (PIM) and Lifecycle Cycle Assessment and Inventory. Several conclusions are drawn including recommendations for improving definitions of key indicators, data availability and adequacy, benchmarking and how precinct assessment tools used during design phases are aligned with rating tools (such as Green Star Communities).

Methodology

The following research comprises two parts, an independent assessment of the Green Star Communities documentation and software, and interviews with two users of the tool.

Green Star Submission guidelines

Integrated water cycle

The Submission Guidelines document (Community) has an error in the formula 24A.1.2 (p. 186). The formula written there actually calculates the percentage of total nominated water demand supplied with potable water at the project site with respect to the reference site.

The percent reduction in potable water should be calculated as

> 100 x (1 – Amount of total nominated water demand supplied with potable water / Amount of total nominated water demand supplied with 100% potable water)

However, while it is unlikely that a qualified professional would overlook this kind of error while doing the calculations, this error should be corrected.

Greenhouse gas strategy

Performance Pathway

Predicted annual energy use and corresponding GHG emissions for the proposed project are to be compared to the reference project and the percentage improvement calculated. Points are awarded based on the proposed project's percentage improvements when compared against the reference project's annual greenhouse gas emissions, as detailed in Table 3.

Table 3 Points for percentage improvement

Percentage Improvement	Points Available
5.1 – 20.8 %	**Up to 1**
20.9 – 36.6 %	**Up to 2**
36.7 – 52.4 %	**Up to 3**
52.4 – 68.2%	**Up to 4**
68.3 – 84.0%	**Up to 5**
84.1 - 100%	**Up to 6**

The user is provided with appropriate guidelines regarding the calculations for the reference project as well as for the proposed project. No detailed guidance is provided, though. For the calculations regarding on-site energy generation, the user is referred to the 'Energy Consumption and Greenhouse Gas Emissions Calculator Guide' which is originally developed for the rating tool 'Design and As Built'. However, it is not clear that the user could also be able to use the corresponding 'Greenhouse Gas Emissions Calculator' spreadsheet. It would have been very useful if they could. Even though 'Design and As Built' and 'Communities' have different point allocations and different credit criteria, it would yet still count to the same amount of GHG emissions when it comes to the calculations of emissions of a building of a certain type, irrespective of whether it is an individual building or stands as a part of the community under assessment. For a user, getting 'locked out of the formula cells' could be a big obstacle, and this could be removed. Moreover, it should not be difficult for GBCA to adapt the calculator spreadsheet for each building type, and hence making a suite of the calculator tools available for Communities.

It is suggested that detailed guidance should be provided for the GHG Strategy Performance Pathway. Ensure that Green Star Communities users can use the Design and As Built GHG Emissions Calculator Guide. Users should not be locked out of the formula cells. The Calculator spreadsheet should be able to be adapted for each building type, to create a suite of Calculator tools for Green Star Communities.

The document 'Energy Consumption and Greenhouse Gas Emissions Calculator Guide' is well structured and has in-depth details of the calculation procedure which are much appreciated. Specifically, the Tables in the Appendices have very detailed and informative clear guidelines. However, the Table 72: Greenhouse gas emission factors by fuel type (pp 97-98), was somewhat disappointing. The Table 72 has emission factors listed from National Greenhouse Accounts Factors – July 2013. At the time of release of the document (December 2015), another release dated August 2015 was already available. The current edition is dated July 2018. Proposed projects should be encouraged to use the latest GHG emission factors and the latest carbon intensity of electricity in their modelling performance, not merely because they are the latest, but also because they are supposed to predict their future GHG emissions performance. *It is suggested that the Table move away from past emission factors, so that users can use the most recent emission factors in their calculations.*

As noted above, it may not always be practical because these figures are changing at a fast pace due to the ever-increasing proportion of renewables in the electricity generation grid (see, Clean Energy Australia Report, 2018).

It is quite likely that a proposed project would be disadvantaged in terms of credit points achieved, if older figures are used. To achieve certain points, the Proposed Project has to achieve a better performance by a certain percentage in comparison to a benchmark Reference Project. Both the projects ought to use the same base data. As 2018 emission factors are lower than 2015 emission factors, for example, the Reference Project would certainly be doing better using 2018 emission factors, and then consequently, the Proposed Project would need to work even harder to achieve the better performance by the same percentage.

Then, to be fair for all the proposed projects (past, present and future), GBCA may need to revise the point allocation criteria together with percentage improvement.

For the calculations of energy contribution from photovoltaics the user is referred to 'Green Star Photovoltaic Modelling Guidelines' available on the GBCA's website. Instructions in this guidelines document are provided in a lucid manner and with appropriate technical details.

Prescriptive Pathway

While District Heating and Cooling Connection is a future possibility in Australia, *this point should be given only if the energy is from renewable energy sources, such as geothermal.* The point should not be awarded if, for example, the energy came from coal-fired electricity.

Materials

Life Cycle Assessment (LCA) – Performance Pathway

Eligibility and Compliance requirements appear to be reasonable. "The inclusion of operational energy in the LCA approach in Green Star is a reflection of current international best practice as per EN 15804 Sustainability of Construction Work - Environmental Product Declarations - Core Rules for the Category of Construction Products. The GBCA recognises that there is a 'double counting' by this approach". We totally agree with this statement, and expect that the international experts recognize this fact and for there to be revolutionary change in the LCA approach regarding the inclusion/exclusion of operational energy.

There are two options available for comparison to the project's life cycle assessment, using a standard practice reference project or using an actual reference project. As it is defined, we foresee no issues with the standard practice reference project. However, the actual reference project may lead to ambiguous outcomes. As defined in (26.A.1a.5B):

> "This Actual Reference Project option is only applicable where data for a suitable existing masterplanned development is available to project teams, in accordance with the following requirements:
>
> a. The existing development must have been planned and at least partly constructed in the past 5 years;
>
> b. The age of the reference project must be calculated based on the proposed project's Green Star registration date and the date of planning approval for the reference project; and
>
> c. Where there is no actual reference project that has the same scale as the proposed project, the data of an actual reference project may be adjusted to reflect the scale of the proposed project."

What if this actual reference project was doing very well regarding environmental impacts in most of the impact categories (listed under 26.A.1a.3)? If this is the case, then comparing the LCA of the proposed project with this actual reference project would not allow it to score as many credits as if it had it been compared with a standard practice reference project.

One possibility is that another requirement be added to the definition which would require the actual reference project to be following standard practice (at least for the duration you are using the data from this actual reference project). This may not be a plausible condition to impose, though. If there was indeed such an actual project (or community) during the past 5 years or so, they would not be living entirely unsustainably. This is unlikely given that communities have much more awareness regarding sustainability. *Perhaps, simply remove the option of actual reference project for comparing LCA impacts.*

Life Cycle Impacts – Prescriptive Pathway

Compliance requirements and credit criteria appear to be reasonable. However, we do have a few concerns.

Under the item 26B.0.3.1 Timber Cost, it is stated that "Where the actual cost of reused items is not known then the cost may be estimated on the basis of replacement cost (i.e. the cost of an equivalent new item)." Does this mean that the estimated cost of the reused item is taken to be the same as the full cost of an equivalent new item or should it be a fraction of the cost of an equivalent new item? *This point needs to be clarified.*

Under the item 26.B.0.3.2 Formwork, it is stated that:

"Formwork, made from non-certified timber, that is purchased as new for a project and is reused within the same project, may not be claimed as reused, irrespective of the number of times it is reused on the same project.

Formwork, made from non-certified timber, that has previously been used in another project, and is used again in this project, can be claimed as reused."

If the formwork is already made using non-certified timber, then in terms of GHG emissions, there is apparently no distinction between the two cases, i.e. whether the formwork was previously used in a different project or in the same project. Both the cases should be considered as equivalent. In other words, *allow timber formwork to be claimed as reused irrespective of whether it was previously used in the same project or in a different project.*

The same comments and recommendations are applicable to the criteria 26.A.0.3.1 Timber Costs and 26.A.0.3.2 which fall under Life Cycle Assessment (LCA) – Performance Pathway.

Sustainable transport and movement

Performance Pathway

This pathway is entirely based on the transport assessment (or statement) developed by a suitably qualified professional. The transport assessment or statement is required to at least include recommendations or plans that address certain criteria from a given list (27A.4). This appears to be a reasonable list. However, depending on how it is addressed, the points achieved through this pathway could be different. For example, assessments or

statements prepared by different individuals could lead to different point scores for the same project.

Prescriptive Pathway

The instructions regarding calculation of the points are well explained and supported by a worked example. Everything under this pathway appears reasonable and correct except a few typos found in the Guidance Section under the heading 'Calculating AIBSPP for transport routes (27B.2.2)' (p 246). Table X is referred a number of times; was it meant to be Table 27B.2.2? Another typo is regarding afternoon peak period: it should be commencing at 4:30 pm (not 4:30 am). *These errors should be corrected.*

Sustainable sites

Credit criteria and guidelines are clearly stated and we do not foresee any issues.

Ecological value

There are some instructions on the inclusion of Vertical Gardens and Green Roofs into the credit point calculation (p. 262, Submission Guidelines). However, it is unclear how the weighting is allocated for this land type. Neither the Table 29.1 (p. 262) nor the ecological value calculator (Ecological_Value_Communities v1_r 1.1.xlsx) have any mention of relevant weightings (see Table 4). Also, the dropdown list in the Calculator does not allow any input regarding Vertical Gardens and Green Roofs. *This should be rectified.*

Table 4 (extracted from the Submission Guidelines) does mention of green roof in the parenthesis under item "4. Planted native vegetation". However, if the user included the area of green roof under this category in the 'Calculator', the 'before' and 'after' areas may not match, resulting in an error in the calculation.

This calculation error should be rectified, and the weighting for Vertical Gardens and Green Roofs land type must be clearly stated in the ecological value calculator (Ecological_Value_Communities v1_r 1.1.xlsx) as well in the Submission Guidelines.

Table 4 Table 29.1 from Green Star Communities

Table 29.1: Land Types and Relative Weightings

Land Type	Weighting
1. Hard surface (including building / concreted area and bare ground)	0.00
2. Exotic vegetation (including exotic garden, lawns, weed infestation, non-native plantation forest, crop-farming)	0.05
3. Non-improved pastures (paddocks with minimal cover of native grasses (<25% cover)	0.35
4. Planted native vegetation (including native garden, indigenous native garden, green roof, native plantation forest)	0.50
5. Regenerating native habitat (re-growth) < 5 years old	0.50
6. Regenerating native habitat (re-growth) 5 – 10 years old	0.75
7. Regenerating native habitat (re-growth) > 10 years old	0.90
8. Remnant native vegetation (including indigenous native grassland and indigenous native habitat)	1.00
9. Natural water-bodies (including wetlands, rivers, creeks, billabongs, streams)	1.00
10. Artificial water-bodies (including dams, constructed wetlands, channels, bores)	0.50

Another set of arguable items are the items 5, 6 and 7, in Table 4. For instance, suppose a project site had regenerated native habitat < 5 years old at the date of site purchase (or option contract), and it becomes > 5 years old at the date of project completion. No re-growth was involved; it was simply maintained as it was at the time of purchase. How would the points be calculated in this scenario? Will the project be eligible to claim points for this criterion? If yes, would it be 0.75 weighting to be applied for 'after' and 0.50 for 'before'?

Apparently, if a land type in the project site remains in the same band 7, 8, or 9, before as well as after, then the project is not going to achieve any benefit in terms of credit points for ecological value.

Another, similar situation would be with items 8 and 9, 'remnant native vegetation' and 'natural water bodies'. The land type would have to be only the pre-existing land types. They cannot be created or enhanced 'after' the development. Thus having these land types (8 and/or 9) on the proposed project site and maintaining them 'after' the development is essentially not going to benefit the proposed project in terms of credit points for ecological value.

These ambiguities should be investigated and resolved.

Regarding Biodiversity Management Plan (BMP), It is stated (under 29.2.1.2) that the BMP must include at least 'A brief explanation of how the project applicant can be at least 50% confident that the net gain they are claiming for biodiversity gains is likely to be achievable'. How do you measure "at least 50% confident"? *This should be clarified.*

There are some general issues with hyperlinks. *They should be both relevant and current, or removed otherwise.* For example, there is a reference to Parkes, D., Newell G., & Cheal, D. (2011), 'Assessing the Quality of Native Vegetation: the 'Habitat Hectares' Approach', Victorian Department of Primary Industries. But the given hyperlink did not work. In any case, probably the project team would not need the document, because the documentation for assessment is to be carried out by a qualified ecologist. What was presumably the intended article was found, but it was dated 2003, and published in the journal *Ecological management & Restoration*.

Waste management

Compliance requirements and guidance are adequately addressed. The list of the nominated key questions for the five principles of 'Designing out Waste' is excellent, and the project teams would find it certainly useful.

Heat island effect

Credit Criteria are clearly stated and the guidance is adequately addressed. However, as the vegetation, green roofs and water bodies also contribute to the credits towards Ecological Value, this could lead to double counting. Perhaps, counting twice would not be a big issue (as it is just one point), but different assessors could interpret the criteria differently. Some will consider it as double counting, and some will not. *It is suggested that there should be clear instructions on this aspect.*

Light pollution

Compliance requirements and guidance are adequately addressed.

Green Star Calculators and Guides

The Green Star Design and As Built tool has a number of Credit Calculators and Guides available on the GBCA website. Not every guide corresponds to a calculator and vice versa. Table 5 summarizes the full list of Calculators and Guides.

Table 5 Calculators and Guides in Green Star Design & As Built, and Communities

Green Star Design and As Built			**Green Star Communities**		
Credit	**Calculator**	**Guide**	**Credit**	**Calculator**	**Guide**
12. Visual Comfort	No calculator	Daylight and Views Hand Calculation Guide			
15.Greenhouse Gas Emissions 16. Peak Electricity Demand Reduction	Greenhouse Gas Emission Calculator	Greenhouse Gas Emission Calculator Guide Share Services and Low-carbon Energy Supply Calculator Guide			
17. Sustainable Transport	Sustainable Transport calculator Access by Public Transport Calculator	Sustainable Transport calculator Guide Access by Public Transport Calculator Guide			
18. Potable Water	Potable Water Calculator	Potable Water Calculator Guide			
21. Sustainable Products	Sustainable Products Calculator	No guide			
23. Ecological Value	Ecological Value Calculator	No guide	29.1 Ecological Value	Ecological Value Calculator	No guide
29. Refrigerant Impacts	Refrigerant Impacts Calculator	No guide			
30. Innovation	No calculator	Innovation Category Guidance			

There is only one calculator, the Ecological Value Calculator, associated with both the Green Star Design and As Built and Communities rating systems. *Most of the calculators (and guides) from Green Star Design and As Built should be adapted for the credit calculations for Communities.* With this in mind, they are each discussed briefly in this section, apart from the Refrigerant Impacts Calculator, which is probably not relevant to Communities.

Visual comfort

The guideline notes that “GBCA encourages project teams to use this guide to claim points instead of performing daylight modelling”. For this particular criteria, the prescriptive path is preferred over the modelled path. But what if one performed daylight modelling instead? How would the points be awarded in that case?

Overshadowing Requirements

Projects where external shading does not impinge on the direct 25° line from the mid-height (centre) of the window are deemed to not be overshadowed (Figure 4). External shading includes buildings, cliffs, and any other solid structure. External shading does not include trees.

An obvious question arises (which does not seem to be answered in the calculation guide): *If the building has more than one floor, how is the mid-height window defined?*

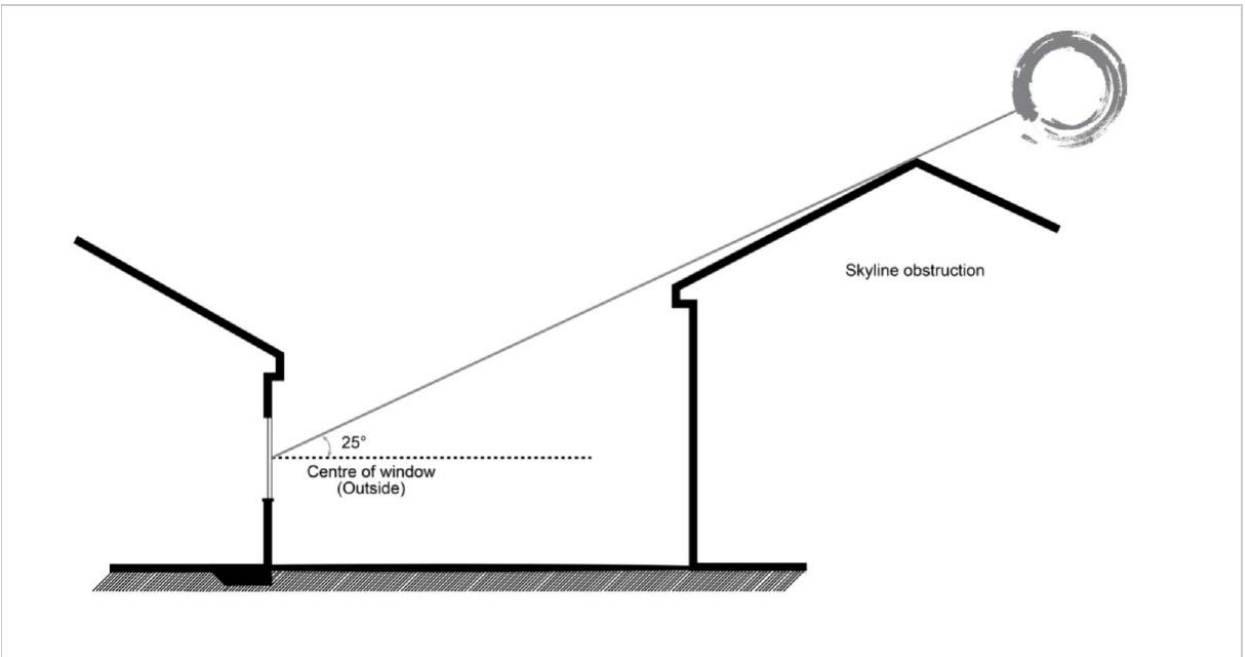


Figure 4 External shading at the centre of the window

Greenhouse gas emissions calculator

Prescriptive Path

15A Prescriptive Pathway (design and as built) calculator worksheet: 15A Prescriptive Path:

If the Comfort Control strategy is selected to be 'Natural Ventilation', then the contents of the cells B31 and D31 (under the heading 'Building Sealing') become invisible. However the embedded dropdown input is still active in the cell D31, and may affect the calculation of credits if inadvertently a 'No' was present in cell D31. The error would be hard to detect due to invisibility of the contents of the cell D31.

It is suggested that the formula in cell D41 should be rectified to ignore the content of D31, in the case if the Natural Ventilation is selected in the cell D12. Alternatively, some logical statement could be used to disable the input of cell D31 if the case 'Natural Ventilation' is selected for 'Comfort Control Strategy'.

D23-D26 become invisible too (but these cells have dropdown input options Yes/No/NA). Once again, it would be safer to use a remedy similar to that suggested for the cells D31, D41 (above) instead of merely making the relevant cells invisible.

Modelled Path

As noted above, GHG emission factors being used are not current. There is also a multiple pathway calculator worksheet, and it appears that the user is allowed to use multiple pathways for each part of the floor area of the single project site. The impact of unsynchronized assumptions could be significant, e.g., if GBCA is using 2015 emission factors, and NatHERS is using 2018 factors, and the NABERS energy path and BASIX using some other version. This could lead to different outcomes or inconsistent results using different pathways, given the inherent lack of transparency regarding the underlying assumptions in the black-box of the software being used.

We did not look into the details of the three worksheets, namely 15B NatHERS Path, 15C BASIX Path, and 15D NABERS Energy Path.

Peak electricity demand reduction

We don't foresee any specific issues in this regard, as the peak electricity demand reduction calculations are based on the modelled scenario and the calculations of peak electricity demand for the Reference project.

Sustainable transport calculator

Points awarded in the 'Sustainable Transport' credit can be achieved using the Performance Pathway or a

Prescriptive Pathway (Figure 5). While this Calculator determines the number of points awarded out of the available points under the Performance Pathway for the 'Sustainable Transport' credit, there is a separate calculator, namely, 'Access by Public Transport calculator' to determine the number of respective sub-points under the Prescriptive Pathway. The latter is discussed in the subsequent section, although it is a subset of the former.

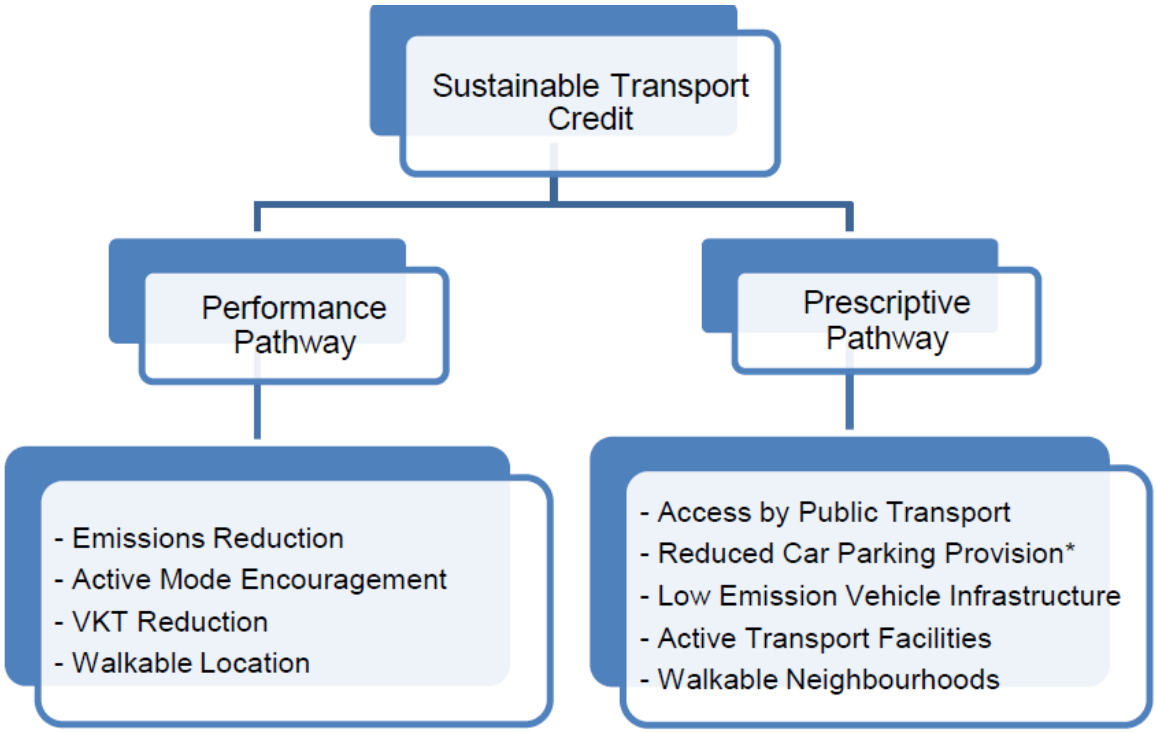


Figure 5 Sustainable transport: Roadmap of two alternative pathways

The Sustainable Transport Calculator works by comparing the Proposed Project with a Reference Project against the criteria listed in Table 6.

Table 6 Green Star points for Sustainable Transport

Green Star – Design & As Built	Points Available					
	0.5	1	2	3	4	5
1. Emissions Reduction	-	10-15%	15-25%	25-35%	35-45%	>45%
2. Active Mode Encouragement	> 50%	100%	-	-	-	-
3. VKT Reduction	> 10%	> 20%	-	-	-	-
4. Walkable Location (Walk Score®)	-	71 - 80	81 - 90	91 - 100	-	-
Total						**10 points**

The Reference Project characteristics are automatically calculated within the Calculator. Mode share data is determined using SA2 level data from the ABS 2011 Census *Method of Travel to Work* (MTWP) data. Average trip length for the Reference Project is also determined using the same data. Emissions intensity is estimated using a report prepared by SKM MMA (2011) while the local electricity grid's emission intensity factors are sourced from National Greenhouse Accounts Factors, 2013. Points are achieved by comparing the performance of the Proposed Project with the Reference Project. This all sounds reasonable assuming that the emission intensity factors would remain unchanged for a time window of 2-5 years. However, the recent fast growing proportion of renewable energy into the electricity grid (to achieve Australia's Renewable Energy Target by 2020) would require faster updates on the grid emission intensity factors in the calculator. *Again, energy data for the same year should be used across the Calculator.*

The 'Walkable Neighborhoods' criterion considers the walkability score of the location of the project being rated. Points are achieved using outputs from the Walk Score® website (Walk Score, 2018). *The walk score on this website should be updated as soon as new amenities and services develop near a location.*

Access by Public transport calculator

The Access by Public Transport calculator was developed by GBCA and AECOM to determine how well a particular destination is served by public transport. This Calculator is only to be used for projects undertaking the Prescriptive Pathway under the Sustainable Transport credit in Green Star Design & As Built rating tool. The Prescriptive Pathway is an alternative to the Performance Pathway in the Sustainable Transport credit. The Calculator determines the number of points awarded out of the three points available for the Access by Public Transport criterion. This involves use of a uniquely developed Public Transport Accessibility Index (PTAI) to determine the project's accessibility, which reflects how well a particular destination is served by public transport.

The measure of the accessibility relates to the number of project occupants that can access the nominated destination through the use of public transport within a 45 minute travel time threshold during morning peak hour.

The 45 minute travel time threshold includes the following:

- Walk time to and from the public transport stop at both ends of the trip.
- In-vehicle time.
- Wait/transfer times.
- "Dead" time – the difference between the desired arrival time and the actual arrival time.

The Calculator works by:

- using Google Maps to search for the nominated project address and allocate a statistical area (SA2);
- querying data sourced from Google Transit to determine which other SA2s contain a population of residents that can access the nominated destination through the use of public transport within a 45 minute travel time threshold during morning peak hour, with the exception of Victoria. The analysis for Victorian based locations is based on AECOM's analysis of existing public transport services databases. Dynamic data is not currently available for Victorian based public transport networks;
- using 2011 Census data to determine the population of the SA2s that meet the design parameters; and
- comparing the total population that can access the location within a 45 minute travelled time to the total population in the Australian Bureau of Statistics, Greater Capital City Statistical Areas (GCCSA).

Points are assigned according the following proportion percentages:

Table 7 Points against GCCSA proportions

Number of points	**0**	**1**	**2**	**3**
Proportion of GCCSA population	< 5%	5 to 10%	10 to 15%	> 15%

Due to the data being sourced from Google Transit servers, there is a limit of three complete spreadsheet calculations that can be run from any given IP address per day.

Critiques and recommendations

We ran the calculator for a number of randomly chosen locations Australia wide, and the output was excellent and very informative. The underlying program code might have much greater scope of application, e.g. in other relevant research areas. However, the calculator algorithms triggered a few concerns.

Does Google Transit still use the 2011 data? This is certainly not the case (e.g. Adelaide Metro has updated timetables and frequency of public transport several times since 2011, and it is observed that the Google Transit is actually using the most recent data feed). In view of this, it is not reasonable to use SA2's population figures from 2011 Census data for the credit point calculations. *We recommend that the most recent population estimates (or projections) should be used in the calculations.*

Another concern is that the sparsely populated SA2 region might be unfairly represented in comparison to their densely populated counterparts. For example,

suppose that project site A is located in the vicinity of sparsely populated SA2 regions and project site B is located in the vicinity of densely populated SA2 regions, and that site A and site B both fall under the same Greater Capital City Statistical Area (GCCSA). Then despite having a similar level of public transport availability, site A might be missing out on credit points, while site B would have achieved a good score.

The following advice is given in the calculator guide:

> "For locations with lower populations, or less access to public transport infrastructure it is not possible to achieve a score above zero. Project teams should consider using the 'Performance Pathway' to demonstrate improvements in sustainable transport for their project."

Users should be advised of this somewhere near the beginning of the Calculator Guidelines.

Potable water calculator

The Potable Water Calculator spreadsheet (Design and As Built) appears to have very detailed structure and analysis regarding all types of water resources. However, as the formulae in the cells are invisible (hidden), we were unable to detect flaws (if there were any) in the Calculator spreadsheet.

The Potable Water Calculator Guide (Design and As Built) is excellently documented with well explained formulae and clear user guidance. Run-off coefficients for different roof surface types are sourced from BS 8515:2009 *Rainwater harvesting systems – Code of practice* (now replaced by BS EN 16941-1:2018), and is assumed to be the same in the Australian context. *The standard should be updated.*

Application efficiencies of common irrigation systems are assumed (no source mentioned). They appear to be reasonable, though. Where the irrigation efficiency is different from any of the pre-allocated values, the user is allowed to alter the efficiency values manually, and in that case, the user is required to submit additional compliance documentation to prove that such efficiency can be achieved.

The user is required to purchase certain climate data (specific to the project site) from the Bureau of Meteorology. The data required are the monthly average dry-bulb temperature, monthly average humidity, daily average rainfall and point potential evapotranspiration data for the project location. While some of these data are freely available at the BoM site, some might require a purchase. The data sets purchased from the BoM must form part of the project's Green Star submission documentation.

Daily rainfall data (10 years' average) for a few selected locations is provided in the calculator worksheet. It is given for Melbourne (1998 - 2007), Sydney (1996 - 2005), Brisbane (1997 - 2006), Adelaide (1996 - 2005), Hobart (1996 - 2005), Perth (1997 - 2006), Darwin (1996 - 2005), Canberra (1997 - 2006), Mackay (1991 - 2000) and Townsville (1994 - 2003). *Given that the climate is changing, this data should be as current as possible.*

It can be seen that the 10 year range in the parentheses varies across the locations. It might be robust enough in itself. But if the user decided to use another set of 10 year data for averaging (for example most recent data for 10 year daily average rainfall, say 2008-2018), it could be very different to the daily average rainfall obtained using a previous decade. Southern Oscillation Index (SOI) values and other climate drivers (e.g. El Niño and La Niña events) affect the rainfall patterns across the continent. There is no clear mention in the calculator or in the calculator guidelines about which 10 years to be selected. Should those be necessarily any 10 consecutive years? Selecting a decade having more wet years than dry years might be beneficial to the project in terms of credit score, because there would be more rainwater/storm water available for use and reuse. *A particular decade should be specified.*

Sustainable products calculator

Points are awarded based on the percentage value of the products that meet one of the specified initiatives. This is established by calculating the Project Sustainability Value (PSV) and comparing it with the Project Contract Value (PCV).

For each individual product, its Sustainability Value is obtained by multiplying its dollar cost by a Sustainability Factor (SF) that reflects the weighted benefit of the initiative.

The projects' overall Project Sustainability Value (PSV) is then calculated as the combined value for all compliant products on the project.

The only possible concern here was that the dollar value of the individual products was taken into account. Accordingly, the proposed project is better off using recycled material for the costliest items than using recycled cheaper items. This concern, however, is ruled out after noting that the other sustainable aspects e.g., 'Life Cycle Impacts', 'Responsible Building Materials' , 'Construction and Demolition Waste' have been adequately addressed under the Materials Category. The calculator spreadsheet is available for the subcategory 'Sustainable Products' only.

Ecological value calculator

In our first attempt, we evaluated the October 2015 version (Ecological Value Calculator 07102015.xlsx). The calculator did not enforce the upper bound threshold of the full available points (i.e. it was possible to obtain more than three points calculated in some instances). However, this issue has been fixed in the newer version (Ecological Value Calculator_20160115.xlsx), which is excellent. The logical test in the cell C22 for checking Area Match is good, thus accordingly the points will not be awarded where areas (Before and After) do not match. It is acceptable for an increase in area, for example, where vertical gardens are provided on the site.

There are a few other issues present, though. One of the issues is the criteria 'Remnant Native Vegetation'. If it was already present on the project site, it will either

remain the same (or could be reduced) but certainly cannot be further added on the same site. One cannot grow it (has to be original existing vegetation on the site). A logical/conditional checking statement should be inserted in the calculator spreadsheet which ensures user input (After) is the same as or less than the user input (Before).

There is a nice worked example given in the Ecological Value Calculator. We simulated a similar example using exactly the same data except that it had 'Remnant Native Vegetation' absent throughout. Surprisingly, it achieved full allocated points. This might suggest, somewhat counterintuitively, that you are better off not having 'Remnant Native Vegetation' at all on your project site than having it on the site and maintaining it as it is. Interestingly, the presence of 'Remnant Native Vegetation' up-to 12 m^2 would still allow the calculator to award full points.

Land Type	Weighting	Before			After		
		Area (m^2)		Score	Area (m^2)		Score
		Plan area	Green wall		Plan area	Green wall	
Hard surface	0.00	220	-	0.00	180	-	0.00
Exotic vegetation	0.05	100		5.00			0.00
Non-improved pastures	0.35		-	0.00		-	0.00
Planted native vegetation	0.50			0.00	100		50.00
Artificial water-bodies	0.50		-	0.00	40	-	20.00
Regenerating native habitat (re-growth) < 5 years old	0.50		-	0.00		-	0.00
Regenerating native habitat (re-growth) 5 – 10 years old	0.75		-	0.00		-	0.00
Regenerating native habitat (re-growth) > 10 years old	0.90		-	0.00		-	0.00
Remnant native vegetation	1.00		-	0.00		-	0.00
Natural water-bodies	1.00		-	0.00		-	0.00
Total		**320**	**-**	**5.00**	**320**	**-**	**70.00**
Ecological Value Score				**0.02**			**0.22**
Check Areas Match	**TRUE**						
Total Change in Ecological Value	**0.203**						
Points Achieved	**3.0**	**Full points achieved.**					

Figure 6 Simulated example showing that one is better off not having remnant vegetation at all on the project site

Land Type	Weighting	Before			After		
		Area (m^2)		Score	Area (m^2)		Score
		Plan area	Green wall		Plan area	Green wall	
Hard surface	0.00	220	-	0.00	180	-	0.00
Exotic vegetation	0.05	100		5.00			0.00
Non-improved pastures	0.35		-	0.00		-	0.00
Planted native vegetation	0.50			0.00	100		50.00
Artificial water-bodies	0.50		-	0.00	40	-	20.00
Regenerating native habitat (re-growth) < 5 years old	0.50		-	0.00		-	0.00
Regenerating native habitat (re-growth) 5 – 10 years old	0.75		-	0.00		-	0.00
Regenerating native habitat (re-growth) > 10 years old	0.90		-	0.00		-	0.00
Remnant native vegetation	1.00	100	-	100.00	100	-	100.00
Natural water-bodies	1.00		-	0.00		-	0.00
Total		**420**	**-**	**105.00**	**420**	**-**	**170.00**
Ecological Value Score				**0.25**			**0.40**

Check Areas Match	**TRUE**
Total Change in Ecological Value	**0.155**
Points Achieved	**2.5**

Figure 7 The example provided in the Ecological value calculator

Land Type	Weighting	Before			After		
		Area (m^2)		Score	Area (m^2)		Score
		Plan area	Green wall		Plan area	Green wall	
Hard surface	0.00	220	-	0.00	180	-	0.00
Exotic vegetation	0.05	100		5.00			0.00
Non-improved pastures	0.35		-	0.00		-	0.00
Planted native vegetation	0.50			0.00	100	600	200.00
Artificial water-bodies	0.50		-	0.00	40	-	20.00
Regenerating native habitat (re-growth) < 5 years old	0.50		-	0.00		-	0.00
Regenerating native habitat (re-growth) 5 – 10 years old	0.75		-	0.00		-	0.00
Regenerating native habitat (re-growth) > 10 years old	0.90		-	0.00		-	0.00
Remnant native vegetation	1.00	100	-	100.00	100	-	100.00
Natural water-bodies	1.00		-	0.00		-	0.00
Total		**420**	**-**	**105.00**	**420**	**300**	**320.00**
Ecological Value Score				**0.25**			**0.44**
Check Areas Match	**TRUE**						
Total Change in Ecological Value	**0.194**						
Points Achieved	**2.9**						

Figure 8 Adding the Green wall with extensive native vegetation did not help achieve full points.

Another simulation was done (based on the same example data, again) to explore how additional Green Wall area affects the points. Interestingly, even if you increase Green Wall with Native Vegetation, hypothetically, by 600 m^2 (this is quite unrealistic as the horizontal area is much smaller; 420 m^2), full points still cannot be achieved (Figure 8). The same number of points is awarded whether there is 500 m^2 of Green wall or 600 m^2 of Green wall. This is because the denominator in the ratio is increasing more rapidly than the numerator, hence the ratio increases very slowly. This might be discouraging to those who wish to enhance the ecological value of their project site by creating green roof or wall with growing Native Vegetation on it. They might have some other constraints on their floor area which might restrict them to grow enough native vegetation there but they were optimistic and enthusiastic for creating a green wall full of native vegetation. *Perhaps, re-allocate the weighting, or re-define the formula which fairly takes into accounts the Green Wall with native vegetation.*

Ecological Value calculator (Communities)

This calculator requires significant improvements. Perhaps, the similar layout as its counterpart in 'Design and As Built' has would be helpful and transparent to the user. There is no Green-wall input currently allowed in the calculator worksheet, while it is mentioned in the instruction worksheet.

Biodiversity Management Plan

As noted above, it is stated (under 29.2.1.2) that the BMP must include at least a brief explanation of how the project applicant can be at least 50% confident that the net gain they are claiming for biodiversity gains is likely to be achievable. But how do you measure "at least 50% confident"?

Interviews

Two users of Green Star Communities, both qualified GSAPs (Green Star Accredited Professionals) for Communities, were interviewed (Green Building Council of Australia, 2018). They had used the tool on separate projects – in one case the use of the tool was complete at the time of the interview (for the time being) and in the other the project was mid-process. Their responses follow.

Why was this tool chosen?

For one project the decision to 'go green' preceded the decision to use Green Star Communities by 2 years, and was made because the project was to be a demonstration project, leading to better and widely adopted sustainability practices. The use of Green Star Communities was seen as a way of demonstrating this leadership.

For the other project several reasons were given. The developer's director of sustainability was involved in the development of Green Star tools and advocated their use. The project's masterplan, which preceded the decision to use Green Star Communities, revolved around green technologies, and broader issues of sustainability, so the tool was seen as a good fit. Use of the tool could be used for marketing. The tool provided a neat way of integrating sustainability into the project processes. The independent third party, and thorough, recognition that certification to Green Star Communities gives suited the client's objectives.

Were you seeking a particular rating, and why?

The minimum rating available is 4 Star (Best Practice) and the maximum is 6 Star (World Leadership). Both project teams actively targeted the middle of the range – a 5 Star rating (Australian Excellence) – in one case as a result of a project-team round-table, and in the other because of the project team's desire to be seen to be leading other projects in SA by example.

One of the projects has achieved a 6 Star rating, partly because announcement of the 5 Star minimum target led to public and team pressure to do even better.

The other project had not been rated at the time of the interview.

What other assessment tools were considered?

For both projects, Enviro Development was considered. One Planet Living (OPL) was also considered for one of them, because the project's original 'feasibility report' referenced the ten principles of OPL.

Neither the UK's BREEAM Communities (BREEAM, 2017) nor the USA's LEED Neighborhood Development (USGBC, 2018) were considered, if only because GBCA claims to have cherry-picked the best parts of both for Green Star Communities. Of course, these schemes are also geared to conditions in the UK and USA respectively, rather than to those in South Australia, and so would need to be adapted for use here, as they have been adapted for use in other jurisdictions.

Is the site using PIM (precinct information modelling)?

Neither project has used PIM. For one of the projects, BIM (building information modelling) has been used for many of the buildings and there had been engagement with the Low Carbon Living CRC project *RP2011: PIM – An open digital information standard throughout the urban development lifecycle* (2014-2017), but this was discontinued due to the amount of data required by that team (Plume et al, 2017).

At what stages has the tool been used on the projects so far?

For one project the early stages were carried out before Green Star Communities was brought in. These stages included feasibility and master-planning. Instead the developer's own sustainability framework was used, feeding into the masterplan. This was all compatible with Green Star Communities, training for which was carried out during master-planning, and the project documents needed to be organized for certification. This took 18 months. The tool was used in all subsequent stages.

For the other project, which has seven (mostly) residential zones, Green Star Communities has been used throughout master-planning, and beyond. At the time of the interview, 1 zone was occupied, 2 were under construction, and 3 were at initial design. One third of the credits were ready for certification, with around 20 points achieved.

For the first project is was observed that recertification of the project will be required every 5 years, until the project is complete. Precinct-scale projects will often have extended timelines, and so face this recertification issue. By way of example, for this particular project, a residential component has been recently approved, and the issue of contaminated land has consequently been raised – this may affect recertification.

Which version did you use?

Both projects picked and mixed from the various versions of the tool that were issued during the design process. In one case Pilot versions v0.0, v0.1 and v0.2 were all used, and in the other Pilot versions v0.0, v0.1 and v0.2, and release Version 1 have been used. For this project, Green Star Communities was still being used, as the interview was conducted mid-process.

What kinds of organization have used the tool on this project?

One user told us that the consultant architects were not familiar with Green Star, whereas the consultant services engineering were. Various developer

departments also contributed, as did the consultant contractors.

For the other project, of around 15 consultants on the project, some have contributed to the Green Star certification process, e.g. the consultant traffic engineers. Others have not.

Familiar parts of the tool

Familiarity was a function of the position in the project process at the time of the interview. For one user, with the process complete, familiarity was with all parts, but for the other, with the process unfinished, there was no familiarity with the Submission Templates, Ecological Value Calculator and Submission Checklist. These had not yet been used.

Accordingly, the first user could answer questions about all parts of the tool, but the other could not.

Categories and credits

Both users felt that the allocation of Credits across the main categories, and the subcategories, was skewed, both with respect to the number of credits available, and to the effort involved. Both felt that Governance credits reward accepted practice, and so achieving them is more of a formality. Green Star ratings begin with 4 Stars, which is meant to be Australian Best Practice, not 'average practice'. *Governance – accepted practice – should not be worth so many points.*

Table 8 summarizes the perceived priority and ease across the main categories.

Table 8 Priority and ease of use of Green Star Communities categories

Category	Green Star: Priority (by Credits)	User two: Priority	User one: Priority	User two: Ease	User one: Ease
Environment	1 (29)	1	-	Not known yet	Difficult
Governance	2 (28)	4	-	Easy	Easy
Liveability	3 (22)	2	-	Easier for a big project	-
Economic prosperity	4 (21)	3	-	-	-
Innovation	5 (10)	5	-	Credits too high, too undefined	Too undefined

Submission guidelines

One interviewee observed that these Guidelines are the 'bible' – users of the tool must understand them. But at 300 pages long (v1.1 is over 400 pages long), for both users the use of the guidelines was largely self-taught. However, there was some interpretation provided from GBCA – including a workshop in the early stages of one of the projects with other users of the tool in Adelaide – and technical clarifications and responses to Credit Interpretation Requests.

It was noted that the credits can be hard to find in the Guidelines, and *colour coding was a suggested solution*.

Scorecard: Excel spreadsheet

It was noted that some credits require experts to be involved, which is to be expected. It was also noted there were issues with the formulae – they were 'clunky' to use, with the result that the assessors returned one as it had not been filled out correctly, due to 'human error'.

Both agreed that the Input sheet is adequate, that the Instructions are clear, and that the Scorecard has given expected results, and is fair.

One user said that the process is transparent, but the user more experienced in the Scorecard said that it was not, and did not like being locked out of the formulae, for example.

Submission templates

These first became available during the project process, so were not used in either project. Instead the two project teams developed their own templates. However, one of the users had tried to use one of the Green Star Communities templates, but found it too much of a straight-jacket, constraining the response. It was thought that the templates might help assessors, but they made the process harder for the users. It did not help that the GBCA kept changing them once they had been introduced – presumably they have now stabilized.

However, one interviewee noted later that he 'found the templates good when completing the later credits'.

Calculator: Ecological Value

One interviewee had not used this yet, but noted that it was compulsory. The other had used it, but considered it a flawed credit. The user is locked out of the formulae. The hidden formulae were wrong – GBCA rejigged the Calculator, but it did not work. It was not clear what GBCA was trying to achieve through this credit. In spite of the effort put into it, the team only managed to score 0.1 out of 1 possible credit. *Errors in this Calculator should be rectified.*

Did you expect other Calculators to be a part of the tool? If so, which ones? If not, why not?

Both users thought that there should be more Calculators in the tool. One user thought most of those available for Green Star Design & As Built could be adapted, and that they were not flawed. The other specifically suggested the use of the Greenhouse Gas Emissions Calculator, and perhaps the Sustainable Transport Calculator. In any event, *more Calculators should be added.*

However, it was noted that because Kinesis PRECINX deals with energy consumption and greenhouse gas emissions, and since this tool can be used to report for Green Star Communities (according to the PRECINX website), there would be no need to adapt the Green Star Design & As Built calculators for these topics. But, Green Star Communities v1.1 makes no mention of PRECINX.

Toolkit components

One of the interviewees characterized the various components of Green Star Communities as shown in Table 9.

Table 9 An assessment of the Toolkit components

	Checklist: Project inception	**Categories & credits**	**Submission guidelines**	**Scorecard**	**Submission templates**	**Calculator: Ecological value**	**Checklist: Submission**
Did the Toolkit have no influence at all?	Yes	Yes	Yes	Yes	No	Yes	No
Did it have a beneficial influence?	Yes	Yes	Yes	Yes	Yes	No	Yes
Did its use backfire in some ways?	Yes	Yes	Yes	Yes	No	Yes	No
Did the Toolkit encourage a tick-box approach in lieu of good design?	Yes	No	No	Yes	No	No	No
Did it encourage good design?	Yes	Yes	Yes	No	No	Yes	No
Did it facilitate good design?	Yes	No	Yes	No	No	No	No
Did it encourage designers to consider issues that wouldn't otherwise be considered?	Yes	Yes	Yes	No	No	No	No
Did it encourage designers to obtain data they might not have otherwise obtained?	Yes	Yes	Yes	No	Yes	Yes	No
Did it encourage designers to ignore some issues or data they would normally not have ignored?	No	No	No	No	No	No	No

Recommendations

Changes to Green Star Communities

This research has led to a number of recommendations for improvement to the GBCA Green Star Communities tool. These are generally presented in the sequence they are made in the report, as follows:

- Green Star Communities should incorporate an energy-mix weighting for the points awarded to reducing GHG emissions. Where the energy mix is high in fossil fuels, reducing demand would be worth more Credits than where the energy mix is low in fossil fuels (and high in renewables).
- In terms of these recommendations, consider how they have been addressed by other environmental assessment schemes, such as BREEAM and LEED, if at all.
- More Green Star tools should be developed, to complete the object hierarchy from Districts to Products.
- The tools adjacent to each other along the object hierarchy should map to each other, at least in terms of content and structure. Ideally there should also be a functional (i.e. digital) mapping to enable automatic aggregation and disaggregation.
- Consider the adoption of Uniclass 2015, and its schema, across the Green Star tools.
- The Green Star tools should be able to draw the information they need from the digital information model, and to feed design decisions back to the model – a bi-directional digital linkage.
- In particular, GBCA should pursue compatibility with IESVE 2018 and OneClick LCA, in order to connect the Green Star entity-level and precinct-level tools to the building information model (BIM).
- GBCA should liaise with NATSPEC, and NBS in Australia, to ensure that relevant Green Star content is included in Australian national master specification systems, as far as practicable.

Environment and Calculators

- Correct the error in Integrated Water Cycle formula 24A.1.2.
- Detailed guidance should be provided for the GHG Strategy Performance Pathway. Ensure that Green Star Communities users can use the Design and As Built GHG Emissions Calculator Guide. Users should not be locked out of the formula cells. The Calculator spreadsheet should be able to be adapted for each building type, to create a suite of Calculator tools for Green Star Communities.
- Table 72, Greenhouse gas emission factors by fuel type, should use, or enable the use of, current emission factors.
- The Proposed Project and the Reference Project should use the same base energy mix data. Then, to be fair for all the proposed projects (past, present and future), GBCA should revise the point allocation criteria together with percentage improvement.
- The point for District Heating and Cooling Connection should be given only if the energy is from renewable energy sources, such as geothermal.
- For the Life Cycle Assessment Performance Pathway, remove the option of the Actual Reference Project for comparing LCA impacts.
- Under 26.A.0.3.1 and 26B.0.3.1 Timber Cost, clarify the meaning of ‘the cost of an equivalent new item’.
- Under 26.A.0.3.2 and 26.B.0.3.2 Formwork, allow timber formwork to be claimed as reused irrespective of whether it was previously used in the same project or in a different project.
- Under Sustainable Transport and Movement, correct a couple of errors: Under ‘Calculating AIBSPP for transport routes’ Table X should be Table 27B.2.2 (?). The afternoon peak period should commence at 4:30 pm, not 4:30 am.
- Under Ecological Value, the dropdown list in the Calculator should allow input regarding Vertical Gardens and Green Roofs. The weighting for Vertical Gardens and Green Roofs land type must be clearly stated in the ecological value calculator as well in the Submission Guidelines. The calculation error in the ‘Calculator’, whereby the ‘before’ and ‘after’ areas for Planted native vegetation may not match, resulting in an error in the calculation, should be rectified.
- Under Ecological Value, investigate and resolve the various ambiguities identified in the text about Table 29.1 Land Types and Relative Weightings.
- For the Biodiversity Management Plan (BMP) 29.2.1.2, clarify how one is to measure “at least 50% confident”.
- Hyperlinks should be both relevant and current, or removed otherwise.
- Under Heat Island Effect, clarify the issue of possible double counting for vegetation, green roofs and water bodies also in Ecological Value.
- Most of the calculators (and guides) from Green Star *Design and As Built* should be adapted for the credit calculations for Communities.

- For overshadowing, how is the mid-height of the window defined for buildings with more than one floor?
- GHG Calculator – Prescriptive Path: It is suggested that the formula in cell D41 should be rectified to ignore the content of D31, in the case if the Natural Ventilation is selected in the cell D12. Alternatively, some logical statement could be used to disable the input of cell D31 if the case 'Natural Ventilation' is selected for 'Comfort Control Strategy'. Ditto for cells D23-D26.
- For the GHG Calculator Multiple pathway calculator worksheet, the energy mixes assumed for each pathway must be the same.
- For the Sustainable Transport Calculator, energy data for the same year should be used throughout.
- The walk score on the Walk Score website should be updated as soon as new amenities and services develop near a location.
- The Access by Public Transport calculator should use the most recent population estimates (or projections) in the calculations.
- The advice regarding locations with lower populations should be located somewhere near the beginning of the Calculator Guidelines.
- Replace BS 8515:2009 *Rainwater harvesting systems – Code of practice* with EN 16941-1:2018, assuming this applies in Australian conditions.
- Rainfall data in the Potable Water Calculator should be as current as possible, particularly given that the climate has been changing over the last decade or so, and will continue to do so. The decade should be specified.
- For the Ecological Value Calculator, perhaps, re-allocate the weighting, or re-define the formula which fairly takes into accounts the Green Wall with native vegetation.

Interviews

- The Governance category should not be worth so many points.
- Colour coding for Credits is suggested in the Submission guidelines.
- Errors in the Ecological Value Calculator should be rectified (echoes recommendations above).
- More Calculators should be added, particularly the Green Star Design & As Built Greenhouse Gas Emissions Calculator, and perhaps the Sustainable Transport Calculator (echoes recommendations above).

Further research

As for further research, similar studies of parallel tools used in Australia could be carried out, forming a suite of critiques – in effect extending Jackson (2016). These tools are:

- UN Global Compact Cities Programme: Circle of Sustainability (Circles of Sustainability, 2018).
- UDIA: Enviro Development (EnviroDevelopment & UDIA, n.d.).
- Living Future Institute of Australia: Living Community Challenge (LFIA, 2017).
- BioRegional: One Planet Communities (Desai, 2009).

A press release on 2 March 2016 announced that the GBCA, the Living Future Institute of Australia, and the International Living Future Institute will be working to align relevant Green Star credits and Living Building Challenge Imperatives, but this does not appear to extend to alignment between Green Star Communities credits and the Living Community Challenge (GBCA, 2016). Perhaps it should.

The tools originally intended to be studied in this research project – Kinesis: CCAP Precinct (PRECINX) and Melbourne University: MUtopia – could also be studied in this way. Both serve Green Star Communities. Other such tools include Energy Inspection: AccuRate (Energy Inspection, 2018) and BERS Pro (Energy Inspection, 2018), though these have been reviewed on several occasions, as part of their own improvement cycles (see Delsante 2005, for example).

Finally, other tools in the GBCA Green Star suite could be studied, with a view to assessing the extent to which they operate as a consistent family.

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