

Green Building Council of Australia

09 July 2012

Re: Life Cycle Assessment in Green Star – Discussion Paper

Dear Sir/Madam,

The Centre for Design (CfD) is at the forefront of life cycle assessment (LCA) research in Australia, and has been for over fifteen years. The research interests of the Centre for Design include informing government policy, undertaking LCAs for private and public sector and developing streamlined LCA. We have significant interest in the use of LCA in built environment applications.

It is our understanding that the Green Building Council of Australia (GBCA) are considering the including of LCA in the Green Star Materials Category, which is in turn used as part of Green Star certifications. This consideration is welcomed, as we are aware of concerns within the building and LCA industry, regarding how the existing Green Star Materials credit system reflects actual environmental impacts.

Despite these concerns, the Green Star assessment system is strong in that it is fully transparent and auditable and is written in language which allows for easy implementation. One intention of Green Star is "...to reduce the environmental impact of development"¹. We are not aware of any studies which examine and quantifies if the current Green Star system fulfils this intent. As such, we recommend that GBCA commission an independent review of its existing Green Star system against LCA principles, before recommending LCA as an approach for the materials category. LCA

Such a review could be used to inform an improved Green Star certification system, which utilises LCA results as the basis weightings and credits for not only different materials, but also for the different life-cycles which are accounted for in Green Star (e.g. operational and transport impacts).

We have provided formal feedback on the prompted questions below. We look forward to seeing how GBCA will adopt life cycle assessment in its certification schemes.

Yours sincerely,



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¹ Technical Manual. Green Star Office Design & Office as Built. Version 3. 2008. Green Building Council of Australia

Feedback to prompted questions

Is it appropriate for the GBCA to undertake this project or would any other organisation be better placed to do it. If yes, which organisation?

We are not privy to capacity within GBCA to undertake this project. If GBCA consider their capacity to develop and implement an LCA method as being limited, it is recommended that GBCA partner with an organisation to develop the initial framework and methodology for the tool. An independent body could also oversee or review the methodology to limit vested interests, ensure fairness and transparency, if required. The Centre for Design are well positioned to assist GBCA in this respect.

Is the Australian market ready for LCA as a tool for assessing the environmental impact of materials? If no, in how many years time do you think the market would be ready?

Yes. The Australian building industry has been using LCA to assess construction materials for a considerable period of time. However, it is our understanding that the proposed method uses LCA to compare the material impacts of different building construction materials as a basis for a rating scheme. We consider that the market is ready for such a scheme, however there are methodological issues which need to be resolved and the background data are not sufficiently robust to allow a consistent national approach. We would suggest that resolving the methodological issues and developing consistent, transparent and robust databases could take in the order of 2-3 years to achieve.

What do you see as the main barriers to implementing LCA as an assessment methodology for materials in Green Star?

We consider the main barriers as being:

- Data depth, consistency and availability
- Agreement of LCA methodology across the building and LCA sectors (e.g. how to account for recycling or utilisation of co-products/waste products), which reflect actual environmental performance.
- Potential lack of buy-in and commitment from suppliers of materials to supply life cycle inventory data
- Cost and time associated with undertaking comparative LCAs

If the GBCA decided to introduce the methodology described in this paper, how much notice would you recommend the GBCA give to the market?

We would not recommend introducing the methodology provided in the current paper as it is not yet prescriptive enough to allow for consistent application. Nevertheless, it is important to inform the market at the earliest possible stage to minimise the potential impacts of such an introduction. We would recommend that the GBCA should give notice to the market now of its intentions.

The list of inclusions may be expanded in the future, is it appropriate to start with a limited scope of assessment in order to simplify the LCA?

The current list of construction elements to be included are considered an appropriate start, and to allow for a simplified assessment yet informative assessment. If the GBCA wish to extend the list of inclusions, new items could be assessed on a case-by-case basis to see what effect their inclusion has on the overall environmental impacts. In cases where there is minimal environmental

impact (e.g. less than 1%), this could serve as evidence to exclude them from the formal certification process, thereby simplifying certification.

Please provide feedback on the list of inclusions and exclusions.

There is no quantified justification for the excluded elements (this is normally how exclusions are justified in LCA). In addition, the list of exclusions is inconsistent with the proposed functional unit. The functional unit includes servicing, yet some of the excluded items are associated with providing building services (e.g. HVAC and lighting systems). The functional unit also suggests that operational energy is included in the scope, when it currently isn't. Finally, there is conflict between some elements in the list of inclusions and the list of exclusions. For example, ventilation and air-conditioning is included, yet HVAC systems are excluded. Clarification on this list of inclusions and exclusions would be required, together with quantified justification for the exclusions.

Are there additional materials should be addressed by the inclusions and exclusions?

A better distinction needs to be made in the methodology between building/construction elements (e.g. beams) and materials (e.g. structural steel). We would argue that any element which is utilised for energy modelling (e.g. internal walls) would need to be included.

Is the use of a 'cradle to constructed, sealed and serviced' building approach appropriate?

As discussed above, the term "serviced" infers that all service systems and operational loads are included in the scope. It is recommended that this approach could be clarified to better reflect the proposed scope. For example, this could be from "Cradle to the commencement of occupancy" or "Cradle to the final inspection" or "Cradle to completion of construction" to better reflect and distinguish the life cycle stages being considered. The exclusion of elements from the assessment can then be assessed independently. The term may need further refining; depending of the certification is for new or existing buildings.

It must be noted that the environmental impacts associated with the operation and maintenance of a building are generally 3-4 orders of magnitude higher than those associated with construction and embodied materials. As such, we would recommend that the GBCA consider making provision for the broadening the scope of the assessment to include operations and end-of-life impacts. This broadening could be introduced at a later stage and be related to the other assessment categories in Green Star.

Is it practical to make qualified assumptions about the origin and the distances that material must be transported in a Green Star design submission, i.e. at a tender stage when some the specific materials are unknown?

It is only reasonable to make qualified assumptions about the origin of materials and their transport distances if these assumptions do not significantly affect the overall conclusions or comparative outcomes of the LCA. Transport impacts can make a significant contribution to the relative environmental impacts (from cradle to site), depending on the transport route, transport mode(s) and the transported materials' impacts. Any qualified assumptions would need to reflect the regions of production, distances and transport modes which were likely to be used for the final construct. Non-qualified assumptions would be highly unlikely to pass the quality requirements needed for a comparative LCA outlined within ISO 14044:2006. Transport models could be easily developed to allow for a rapid assessment on a case-by-case basis at the tendering stage.

Is 1m² of Gross Floor Area (GFA) an appropriate unit?

The functional unit purpose is to quantify the primary function of a building to allow for fairer comparisons. The primary function of a building is not readily identified, nor quantified. Buildings often provide many services to their occupants, so a single unit of measure involves a degree of compromise. As such, it is considered that the current functional unit could be a good starting point for the assessment, but may require further refining, depending on the type of building being assessed. For example, the functional unit could be refined to include aspects of occupancy per unit area, and time.

Are there constraints to using this unit?

One potential reservation could be the lack of time-element in the functional unit, which essentially could mean that material performance/replacements would not be considered.

If there are constraints or reservations about the proposed functional unit, what are the alternatives?

An alternative functional unit could be one square metre of net lettable floor area (for commercial buildings), or one square metre of net dwellable floor area (for residential buildings).

Is it appropriate to limit the number of environmental impact categories to six?

The environmental impact categories should be selected to reflect the environmental issues associated with the systems being compared. If the categories indicated are reflective of the likely environmental issues, then it could be appropriate to limit the categories to six. We provide the following additional comments:

- The indicators selected need to be supported by all life cycle inventories. If they are not supported, then false or misleading comparisons may eventuate. For example, if an inventory of a material to be certified does not include some toxins, then it will rank favourably against a base case (which would presumably support all impact categories). This outcome would be misleading.
- Land transformation and land use are two separate categories with different units. Land use is typically measured in ha.a (occupation over time), while transformation relates to the transformation of a particular type of land to another (e.g. grassland to industrial). While serving as a useful inventory indicator, both of these do not reflect actual environmental impacts; they are merely precursors to potential environmental impacts. Any comparisons of land use/occupation would need careful interpretation by the LCA practitioner, to account for issues such as biodiversity etc. The transformation indicator is sometimes not well supported by existing life cycle inventories (e.g. Australasian Unit Process Life Cycle Inventory) and as such, care must be taken to ensure that any comparisons are not misleading due to lack of supporting data.
- Ecotoxicity and human toxicity indicators are highly uncertain. The AusLCI Best Practice Guide to Life Cycle Impact Assessment in Australia suggests that “... *these indicators (should) only be used where the systems being studied interact directly with significant toxic systems*” and that “*a difference of at least one order of magnitude or more is needed to conclude that there is significant differences between the systems*”. As such, careful consideration of the inclusion of these indicators is required.

- Mineral and fossil fuel depletion are common indicators which are well-supported by life cycle inventories.
- Water depletion, like land use, is only a precursor to potential environmental impacts. There are more refined water indicators available (e.g. water stress index) which better relate to potential environmental impacts.

If more categories are to be included, which categories do you recommend be included? What method should be applied to determining the impact categories the LCA will take into account?

Eutrophication potential, acidification potential and smog potential could also be categories which could be included. These are common indicators which are often used in LCA in Australia.

If fewer categories are to be included which categories do you recommend be removed?

We suggest that GBCA consider the broader intent of Green Star and which environmental indicators it is seeking to have influence through Green Star, and align these to the materials category. For example, the indicators covered in the other Green Star categories (e.g. ozone-depleting substances, greenhouse gases) should also be covered in the materials category (currently ozone depleting substances are not covered). This would allow for a comprehensive life cycle approach to assessing these emissions.

If six impact categories are appropriate, are the six categories above the most appropriate?

The appropriateness of impact categories will vary, depending on the materials being used. If GBCA commission the development of their own LCA software for the purposes of Green Star, a feature could be incorporated to automatically include/exclude categories, depending on the materials being chosen.

Is it appropriate to refer to the AusLCI impact categories? Is there an alternative which should be used? Why?

The AusLCI categories are a good reference point and are consistent with other impact assessment methods available. There are alternative available (e.g. ReCiPe, eco-indicator, TRACI), however these are tailored specifically for regions other than Australia and there would be argument and conjecture with respect to their applicability.

Is it appropriate to reference the BC LCI weightings? If not, what should be used instead?

No. We dispute the statement that weightings are essential for LCA results to be calculated. Weightings are not always necessary, and as per ISO 14044:2006, weightings are neither mandatory nor essential to fulfil the goal and scope of an LCA. It is also important to note that ISO 14044:2006 explicitly states that weighting should not be used for LCA studies whose results are to be used for comparative assertions which are to be disclosed to the public. The reason for this is that weightings are subjective value choices, i.e. non-scientific judgement.

The value choice component of decision-making cannot be elicited through technical analysis and are best elicited and included in the decision-making process by engaging with those stakeholders whose values are deemed important to the decision at hand. In a decision-making context,

“stakeholders” are considered to be any relevant individual or group that will be affected by the decision.

The BPIC weighting should be avoided due to the reasons outlined above. In addition, BPIC indicated that the weightings presented are not statistically valid². Finally, weightings should be avoided as they mask potential burden shifting in a product system (e.g. reductions in one environmental indicator, leading to increases in other environmental indicators).

An alternative approach is for GBCA to firstly better define what the goal and scope of what both Green Star and the Green Star materials category are and which environmental areas of concern these systems are attempting to address (this can be done through stakeholder engagement). Secondly if multiple environmental categories are defined, then these could be incorporated into a materials rating system which assesses against multiple categories. These categories could then be integrated with other indicators covered by other aspects of Green Star (e.g. water, land use and ODP emissions).

Is it appropriate to have separate credits for each of the environmental categories or should the total score be weighed together and assessed in one credit?

Separate credits for each category, but these categories need to be aligned with other aspects covered in Green Star (as previously discussed). The scope of each environmental category needs to be better defined so as to avoid double-counting or omissions.

Is it practical to establish a standard practice reference case for low-rise, mid-rise and highrise buildings of different classes? If not, what other methods could be used to establish a reference case?

The establishment of a reference case is a good idea for new buildings and green field sites, but the selection and design of the base case would need to ensure that it is reflective of a true best/worst case scenario, such that any star-rated comparisons always reflect environmental benefits. It is important for GBCA to establish this and maintain the dataset and results associated with the base case, to ensure that comparisons cannot be manipulated. For retrofits, the existing building should form the reference case.

Should the reference case distinguish between new building on a green field site, refurbishment of existing buildings and fit outs? How can an equitable system be developed which acknowledges the advantages of the options from an environmental impact perspective?

Refurbishments and fit outs would require the existing building to form the reference case; otherwise the environmental rating of the retrofit could be misleading. The establishment of the existing building as a reference case could then be used to acknowledge environmental advantages. The Centre for Design has undertaken retrofit comparisons using this approach on a number of projects and would be willing to provide guidance in this area, if required.

If the reference case is constructed in a similar manner to that described above, would you be able to provide your interpretation of how this may operate in practice?

² Bengtsson, J. Howard, N., Kneppers, B.. “Weighting of Environmental Impacts in Australia”, Building Products Innovation Council (not dated)

Yes. The reference case could be constructed from a standard bill of materials and the environmental indicators relating to these would need to be assessed and controlled by GBCA. This assessment and control would be needed to ensure that LCA modelling is not adjusted to benefit the comparative case. A standard database and methodology for both the comparative and reference cases would need to be established to ensure that modelling adjustments are not possible (which could potentially favour the comparative case). An online assessment tool would allow GBCA to better-control the assessment database and methodology, and limit variations in modelling and interpretation.

Can LCA methodology in the Green Star Materials category operate without a reference case? If so, how do you see this working?

Yes. A survey of LCA results, or the commissioning of streamlined life cycle assessment, could be used to survey environmental impacts/benefits against the existing Green Star materials credit system. The existing credit system could then be modified to better reflect environmental performance. For example, the credits for reused materials or recycled content could be tested against existing LCA knowledge, and then adjusted to reflect actual environmental benefits.

Is it practical to conduct two iterations of the LCA with different inputs for the project?

Yes. This approach is both typical and essential for comparative LCAs.

How much additional time would it take to do the second iteration of the LCA having completed the first one? Is it 25% more, 50% more, 100% more etc?

We would estimate between 25% - 75% more time for an additional iteration, depending on the LCA modelling technique. Time reductions could be achieved by defining the methodology, database and interface of the LCA modelling software, e.g. through an online interface.

Does the intended content of Table 1 include enough data to determine the input parameters for the standard practice case LCA? If not, what is missing?

Table 1 is a good foundation for the establishment and development of parameters needed for modelling. We firstly recommend that common terminology be used for the reference case as this term varies throughout the discussion paper. Secondly, the term “functional unit” is used in the table. This terminology could be confusing, as the environmental impacts are being assessed at the building level (with functional unit of 1 m² gross floor area), not the material level. Rather, it is recommended that the Table be referred to as a list of “reference flows”. The reference flows are what buildings elements are required to fulfil the functional unit. These are typically modelled from bills of materials. The column “functional unit” should be renamed to “units of measurement”. Some of the units of measurement are not typical for the type of building element. For example, beams would typically be modelled based on mass, not volume. The mass would sometimes need to be calculated based on material density, beam length and cross sectional areas.

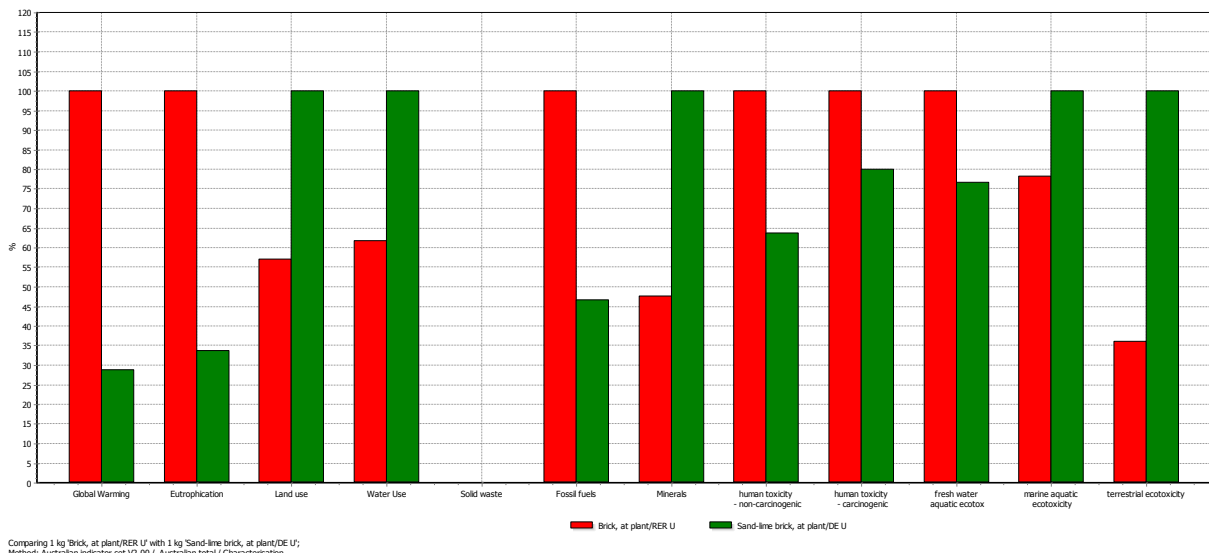
What would be the best way to determine the rules for the input parameters in Table 1?

The reference flows should attempt to capture at least 99% of the environmental impacts associated with the fulfilment of the functional unit. This would be a cut-off rule, further details of which are provided in ISO 14044:2006.

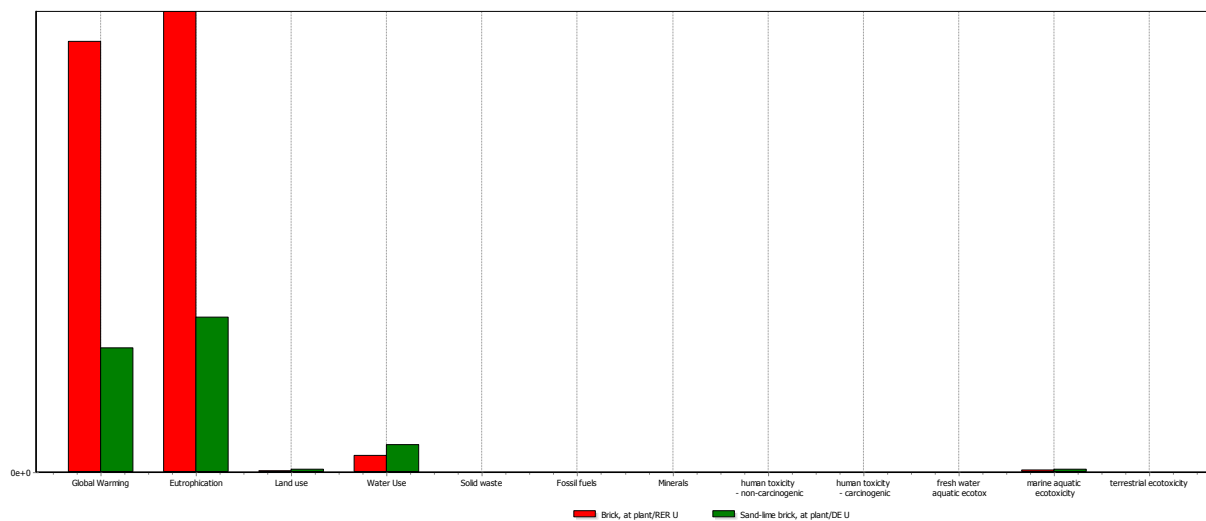
Is percentage reduction in impact an appropriate way to award points for improvement?

We are unable to comment on a linear, percentage based award system without understanding what the variation would likely to be over a number of buildings (e.g. variations could be log-normal). A linear percentage system might result in unachievable star ratings, or a lack of distinction between buildings. It is recommended that the award system should be based on a statistical assessment and survey of a number of existing buildings.

The GBCA should be aware that percentage reductions do not necessarily reflect actual environmental differences. This awareness is required because some life cycle impact assessment (LCIA) results are below practical quantification limits, meaning that any comparison on a percentage basis would be misleading. An example of this issue would be to compare the environmental impacts of 1 kg of bricks to 1 kg of a sand-lime brick (from ecoinvent 2.2, using the Australian impact assessment method).



In this comparison, some indicators show that the brick is higher than the sand-lime brick (e.g. global warming), while others show that the sand-lime brick is higher. For example, the land-use impacts of these systems are 7.16×10^{-7} Ha.a and 5.79×10^{-5} Ha.a, respectively. On a percentage basis, this could be interpreted that the brick has approximately 57% the impact compared with the sand-lime brick. However, these results are likely to be under the practical quantification limit (e.g. due to limitations in the inventory data, size of functional unit). Normalisation is useful in this respect, in that it helps to identify which environmental impacts are contributing most to a nations overall environmental load. Normalisation can be used to assist in the selection/limitation of environmental impact categories. In this case, when normalisation is performed, global warming, eutrophication and water use are the three categories which are most prominent, suggesting that percentage comparisons on some indicators (e.g. land-use, toxicity) may not be valid.



Is it appropriate to have separate credits for each of the environmental categories or should the total score be weighed together and assessed in one credit?

Separate credits without weighting.

Should the Aus LCI Building Product inventory dataset be used in a LCA methodology within Green Star rating tools?

AusLCI should be distinguished from BPIC LCI. These are two different datasets which cover different scopes. The BPIC LCI is an important initiative and is a step in the right direction for LCA in Australia, in particular for the building industry. However, we would recommend not using the BPIC LCI in its current form due to:

- The scope of the data is gate to gate, which is not compatible with the proposed approach.
- The data is not readily incorporated into existing LCA software
- There are strong, written rules on the use of the BPIC LCI. These restrictions could limit use in the proposed GBCA LCA rating systems.
- The methodology is at times conflicting with the requirements of ISO 14040:2006 / ISO 14044:2006
- A lack of transparent and independent data-quality checks and missing data

AusLCI, launched in 2011, is a cradle to gate dataset not restricted to building materials. The methodology and format of AusLCI is more consistent with the requirements ISO 14040:2006 / ISO 14044:2006. The current AusLCI dataset is limited to electricity. We anticipate that this will grow over time. It is our understanding that there are moves to incorporate the BPIC LCI into AusLCI. If this integration occurs, the BPIC dataset will be much more useable, however it is unclear at this stage if this integration will release the BPIC restrictions.

The most common LCI currently used in Australia for Australian conditions is the Australasian Unit Process Life Cycle Inventory (AUPLCI). This dataset was originally developed by the Centre for Design at RMIT University, but is now managed by Life Cycle Strategies.

Should a European LCI be used?

European LCI data, such as ecoinvenet, could serve well for materials which are produced in Europe. All LCI datasets are not exhaustive and as such, not all construction materials are available in these datasets. The GBCA should make provision for the inclusion of non-standard materials into the certification system.

European LCI could be used to generate proxies where Australian data does not exist. Likewise, they can be used to validate Australian LCI data. However, if the....?

Are penalties needed?

No. The reasoning behind the proposed penalties is not well understood. All data varies in quality and application, no matter what the source/database. Non-approved data could be higher in quality in application than approved data, and as such it would not be appropriate to penalise for the use of better data.

What data sources would be acceptable for a credible LCA to be conducted.

The data source for a credible LCA would vary case by case. In general, if the data is regionally, temporally, technically correlated with the system under investigation, then the LCA will be well founded. Generally, data directly from the materials suppliers and its supply chain will enhance the credibility of an LCA. When this is not available, secondary data from databases are typically used.

Is it appropriate to exclude fitouts based on the lack of an agreed functional unit for fitout items?

It is unclear as to why there is a need for a different functional unit for fitouts. The function of a fitout is related to other aspects of the services provided by a building (e.g. thermal comfort). As such, fitouts should be assessed on a broad basis and not just against the function of the fitout material. The lack of an agreed functional unit is not a strong basis for the exclusion of fit outs.

Will the proposed LCA methodology accommodate existing LCA systems and tools?

Yes for methodology, and to some extent for tools. The Centre for Design could assist GBCA in developing a tool specifically for this purpose, if required.

What constitutes an LCA practitioner, what qualifications should be required, and should the system ALCAS be developing be referenced?

There is no agreed consensus in Australia or internationally on what an LCA practitioner is, or what qualifications are required. The Centre for Design is actively involved in Australian Life Cycle Assessment Society's (ALCAS) development of the certification system for Australian LCA practitioners. It is recommended that the system ALCAS are developing be referred to, but not mandated, until the details of the system are better established and implemented.

How much would you estimate it would cost to complete the assessment outlined in this paper? And how does that cost compare to the cost of demonstrating compliance with the current Materials Category in Green Star?

The cost is dependent on the final method, the required data sources, etc. A certification could cost between \$5,000 to \$50,000 or more, depending on the methodology and tools used.

Which are the relevant standards that Green Star related LCAs should adhere to?

ISO 14040:2006 and ISO 14044:2006 are the benchmark standards for performing comparative LCAs. ISO 14025 Type III environmental product declarations (EPDs) could also be used, but it should be noted that the goal and scope of these EPDs may not align with the proposed approach.

Is the requirement to use recognised software necessary?

Perhaps. It may be necessary for GBCA to develop or commission the development of software which it recognises. The Centre for Design specialises in the development of such commercial LCA tools and would be interested in discussing this further with the GBCA, if required.

Should the GBCA recognise particular software?

LCA software serves only as an interface to perform calculations based on pre-existing databases. As such, there is no need to recognise particular LCA software. That being said, the most common LCA software in Australia is SimaPro and GaBi. These “full LCA” tools can be used to develop streamlined tools which allow for more rapid and cost-effective life cycle assessments. Examples of these tools include PIQET and Greenfly (developed by the Centre for Design at RMIT University), or e-tool.

Which software should be recognised, and why?

No specific LCA software should be recognised. The recognition of particular software does not enhance quality or consistency of LCA outcomes.

The requirements of the Energy category within Green Star rating tools, stipulate that any energy simulation software used are BESTEST compliant. Does equivalent software exist for LCA?

We are not aware of any BESTEST compliant full-LCA software, however there are moves to integrate some thermal modelling software with LCA indicators for materials. The results of thermal modelling software are typically fed into LCA models, to present results over the full life cycle.

Is the requirement for peer review necessary?

We consider peer-review as important, but may not be necessary. Under ISO 14044:2006, any LCAs which are used for comparative assertions must be subject to peer-review. It is important to note that ISO 14044:2006 further defines a comparative assertion as an “*environmental claim of superiority or equivalence of one product versus a competing product that performs the same function*”. Under this definition, it could be argued that the proposed methodology (whereby results are compared to a fictitious reference building which will not compete against the comparison building) does not require a peer review. That being said, the peer-review process is important to ensure that the LCA methodology is scientifically sound, transparent and consistent with the goal

and scope of the study. The peer-review process increases credibility and decreases the likelihood of misunderstandings or negative consequences arising from the LCA. A peer-review of the proposed method and any online interface tools would assist GBCA in establishing the credibility of the claims arising from the Green Star materials LCA ratings.

What other requirements are necessary to ensure best practice LCA modelling?

We recommend and endorse the requirements of ISO 14040:2006/14044:2006 to ensure best-practice. There are some industry critics who cite these standards as flawed and not prescriptive enough. In our experience these standards are robust and allow for a consistent, best-practice approach, whilst also providing the flexibility to apply LCA.