ALCAS
AUSTRALIAN LIFE CYCLE ASSESSMENT SOCIETY

Feedback from the Australian Life Cycle Assessment Society on the GBCA: Life Cycle Assessment in Green Star - Discussion Paper

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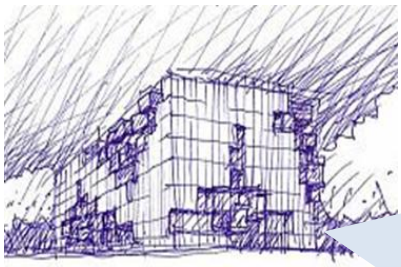

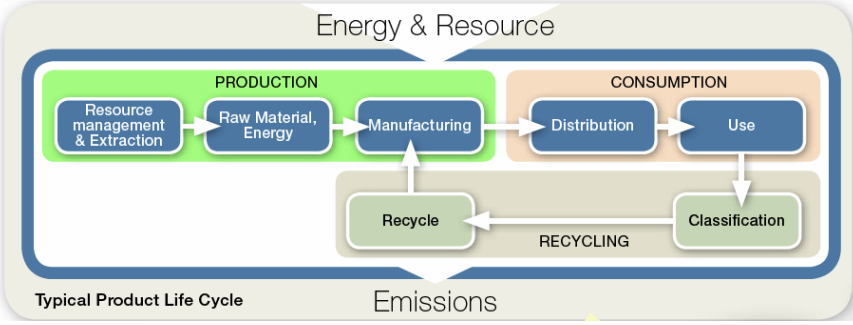

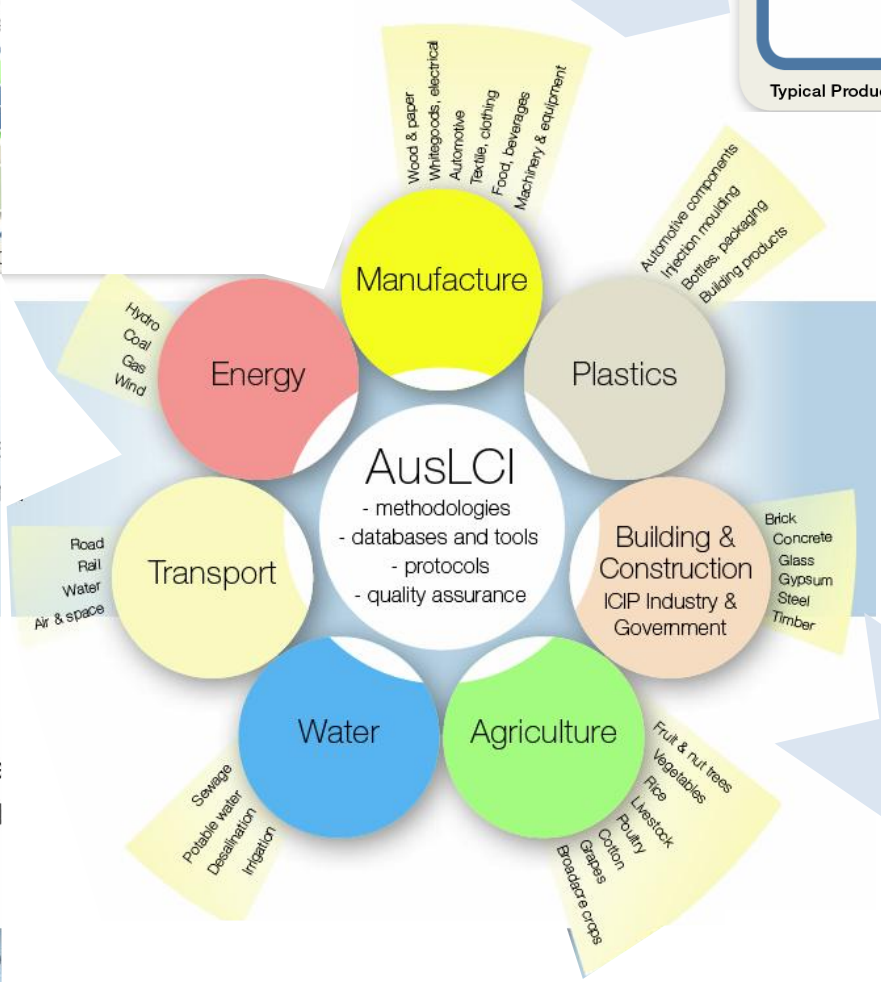

Feedback from the Australian Life Cycle Assessment Society on the GBCA: Life Cycle Assessment in Green Star - Discussion Paper

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Please refer any questions or comments on this submission to Dr Alastair Woodard at woodard@alcas.asn.au

ALCAS
AUSTRALIAN LIFE CYCLE ASSESSMENT SOCIETY

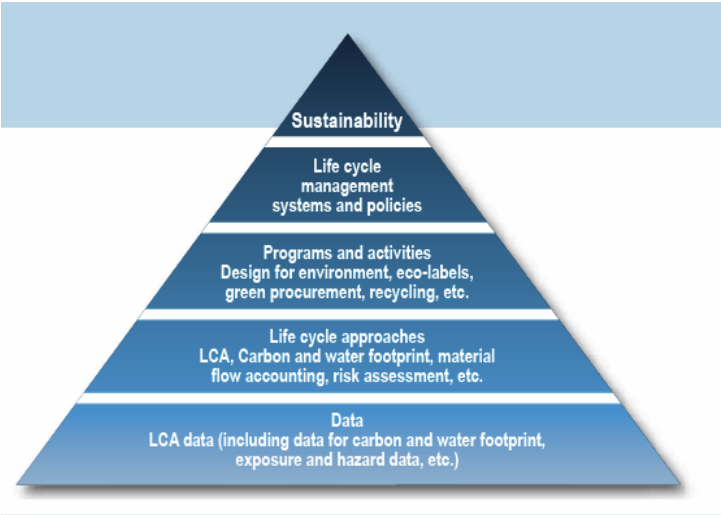
ALCAS and AusLCI

The Australian Life Cycle Assessment Society (ALCAS) is Australia's peak body for the development, promotion and use of Life Cycle practices and processes.

Established in 2001 as a not-for-profit organisation, ALCAS members include organisations and individuals from industry, government, academia and consulting services. ALCAS welcomes members interested in the practice, use, development, education, interpretation of and advocacy for life cycle thinking, management and assessment.

ALCAS represents and advocates on behalf of the 'whole life cycle continuum'. In particular those involved in:

- 'life cycle thinking (LCT)' and life cycle management (LCM)';
- life cycle based 'eco-labels', 'eco-ratings' and 'environmental product declarations (EPD's)' based on consistent Australasian product category rules (PCR's);
- life cycle based design tools and rating schemes;
- 'carbon assessment (GHG LCA)' through to 'full life cycle assessment (LCA)';
- collection and delivery of Australian LCI data.



One of ALCAS' key projects over the past few years has been the development of the initial framework and infrastructure for a single, national life cycle inventory (LCI) database of Australian data - AusLCI. This initiative has been developed to date through extensive voluntary collaborative efforts of university and CSIRO researchers, industry partners and a range of Federal and State Government agencies. Having consistent and correctly collected LCI data is fundamental in delivering level-playing-field life cycle assessment and because of this broad cross-sectoral benefit, having one single national Australian LCI database is paramount. ALCAS has developed and publishes generic '*Requirements for LCI Data Collection'* in Australia and also thorough AusLCI now has the initial on-line framework for storage and dissemination of this Australian LCI data.

AusLCI
The Australian Life Cycle Inventory Database Initiative

ALCAS' vision is
"*to cause life cycle assessment, management and thinking to be the central methods for environmental assessment and decision-making throughout the Australian economy*"

ALCAS also continues to work with and encourage Australian industry sectors, organisations and companies to investigate and integrate life cycle practices into their own systems.

It is gratifying to note that the building sector is one of the most advanced and enthusiastic in this regard.

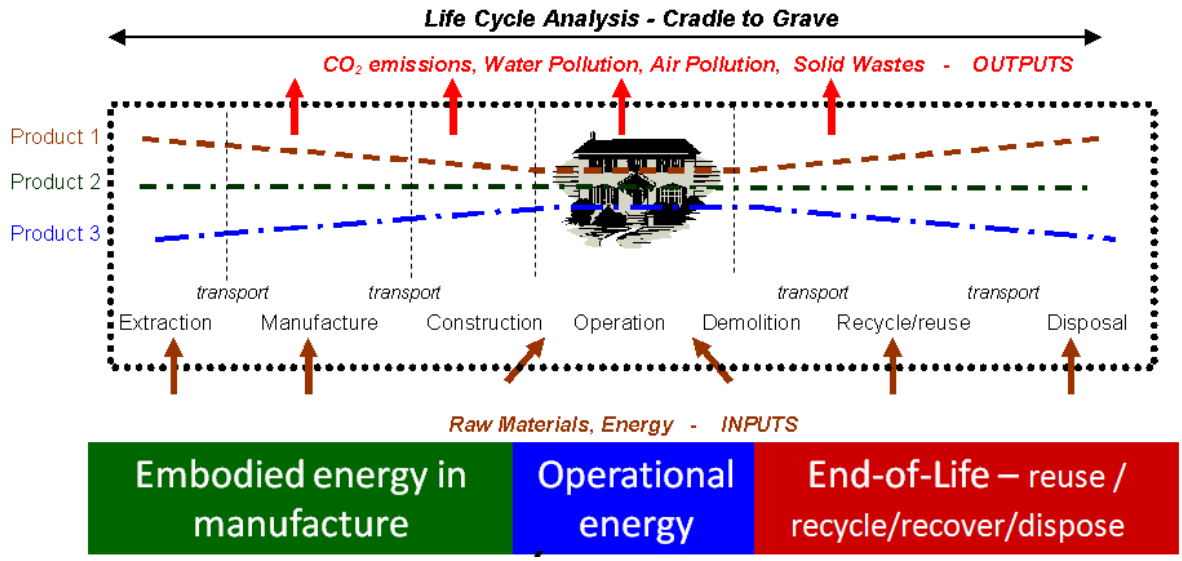
Introduction

ALCAS strongly supports GBCA in the introduction of LCA into Green Star and will be happy to provide constructive input into the process with this document and by taking part in any future processes GBCA considers appropriate.

Life Cycle Assessment (LCA) provides a detailed formal process of quantifying the environmental effects of a product or a construction throughout its entire life (cradle to grave), it accounts for all the material and energy usage (inputs), and subsequent environmental impacts (outputs).

A full LCA includes

- assessment of the amount of energy embodied in individual products during their manufacture;
- the collective impact of the construction process;
- the impact of a building during its operational phase;
- the impact of demolition of the building; and then
- an assessment of the products at end of life - what can be reused, recycled, recovered for energy or what ends up in landfill.



LCA and the Building Sector

The Australian building and construction sector over the past decade has been an active supporter of LCA as the accepted 'level playing field' approach for the environmental assessment of building products and construction. ALCAS has also been a strong commentator and advisor on this to industry, government departments and regulators and to voluntary environmental specifications and tools as they have moved into the marketplace.

It is noted that a major life cycle based initiative for the building sector was the Building Products Innovation Council (BPIC) Building Product Life Cycle Inventory Data project, funded through an ICIP grant from the Department of Innovation with matching dollars from industry. This project developed:

- an agreed methodology (based on the ALCAS *Requirements for LCI Data Collection'*) for the collection of LCI data: *"Methodology Guidelines for the Materials and Building Products Life Cycle Inventory database"*, this was used by all building materials sectors to collect the relevant LCI data for their products;
- LCI data (note: some of this data is cradle to gate, some gate to gate) by the individual products sectors *(steel, concrete, brick, timber, plasterboard, insulation, tiles, windows),* around 120 product categories;
- a 'Protocol' agreed by the participating building sectors - providing a set of rules of how to use the LCI data in whole of life and whole of building LCA's: *"Protocol for the Correct Use of Australian Life Cycle Inventory Data for Building and Construction Materials and Products";*
- an internet accessible BP LCI website and database of Australian building product LCI data (accessible at www.bpic.asn.au), note this was developed because 1) AusLCI was not ready to accept data at the time and 2) because BPIC data suppliers desired that users accept certain conditions for accessing the data, particularly adherence to the aforementioned Protocol (Note: data if included in AusLCI will not be subject to these caveats); *and*
- a series of reports providing guidelines and advice on: *Life Cycle Impact Assessment, Weighting of Environmental Impacts in Australia, Maintenance and Replacement Life.* *ALCAS Note:*[1]

The building sectors involved in the Building Product LCI project have recently been invited to submit their data for inclusion in the Australian Life Cycle Inventory National Database (AusLCI) – Australia's national repository of generic life cycle inventory data for all Australian industry sectors. Through this process the building products data:

- can be made publically available with no caveats attached on usage, apart from the terms & conditions of the AusLCI database;
- can be linked to appropriate background data to provide full 'cradle to gate' modules
- can be published as the average industry data for that sector.

It is anticipated that a good proportion of the data will be published in AusLCI within the next twelve months.

ALCAS will also work closely with all the different voluntary environmental specifications and tools as they are clearly one of the major drivers in LCA approaches becoming more widely accepted and used by designers to undertake building assessment.

A variety of tools have been in place for some time and are now converting to an LCA basis additionally a number of new specifically focused LCA tools also exist (LCADesign) are also under development (Envest, E-Tool etc.). These tools include the following (Note: a more detailed summary is provided in Appendix A).

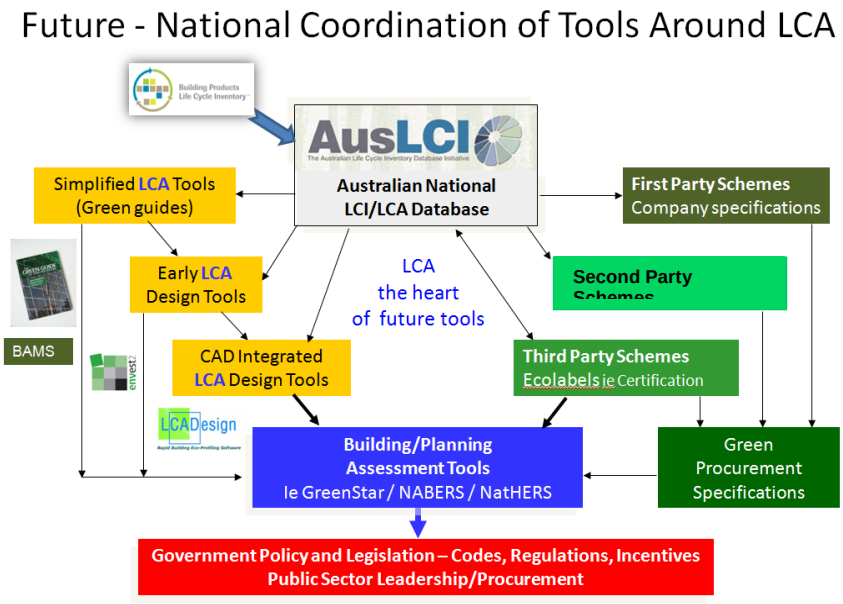
- *Ecospecifier* – a free to access online database of eco and health preferable verified and certified products from all third party sources of, materials and technologies for the built environment construction sector, specifically providing LCA and EPD based information from any source when available - relating to buildings, interiors and surrounds see http://www.ecospecifier.com.au/

[1] Whilst ALCAS was a minor consortium partner to the BP LCI project the reports produced should not be taken as representing the views of ALCAS or is members. ALCAS does however acknowledge that the outputs do represent the views of the participating building product sectors.

- *Global GreenTagCert™ LCARate Certification* - a third party, green building product rating and certification system, underpinned by LCA , that rates products based criteria predominantly based on LCAl. see www.globalgreentag.com
- *LCADesign* - a BIM based and Computer Aided Drafting (CAD) linked LCA tool developed by CRC for Construction Innovation, market ready for small- medium scale projects. see http://www.ecquate.com/
- *Envest Australasia* - a prototype BIM compatible life cycle assessment based design tool for use at the earliest phases of design for buildings (under development). See http://edgeenvironment.com.au/index.php?a=envest
- *eTool* - is a free web based LCA based tool that asses both the "Embodied Energy" and the "Operational Energy" over the total design life of the building or development http://www.etool.net.au/

Through AusLCI and ALCAS new Australian LCI data and methodologies will form the heart of any future building assessment and rating tool frameworks required; available for use at all levels of building design and government and industry strategic planning, including:

- simplified LCA specification tools,
- early LCA design tools,
- sophisticated CAD LCA design tools,
- Company product specifications
- third party schemes such as certification, environmental product declarations, etc
- regulatory, planning and assessment tools such as NatHERS, NaBERS and GreenStar,
- as well as providing a truly scientific basis for assisting government with assessing the impact of environmental policy and legislation.



Adapted from a diagram sourced from BPIC Presentation by EDGE Environment

Ultimately, ALCAS supports the future vision of a fully integrated BIM (Building Information Modelling) based building design process where life cycle assessment becomes an accepted (and automated) component of the design process.

ALCAS however also clearly recognises that a staged approach to introduction is needed and as such fully supports the GBCA's activities at present to develop an LCA methodology for its Green Star rating tools.

Feedback from ALCAS on the GBCA Discussion Paper

Section 3 Provide Your Feedback

The Green Building Council of Australia seeks feedback on the following 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?

The Australian Life Cycle Assessment Society (ALCAS) believes it is totally appropriate for the Green Building Council of Australia (GBCA) to undertake this project but hopes it will do so in close consultation with ALCAS.

ALCAS clearly recognises the Green Building Council of Australia's massive success in transforming the Australian building market in regards to environmentally focused and green design and the broader understanding and education of all stakeholders involved.

ALCAS strongly welcomes the support of the GBCA in investigating the introduction of a life cycle assessment approach in its Green Star materials category and agrees that its introduction will:

- deliver better environmental outcomes;
- continue to assist in the transformation of the Australian materials industry; and
- enable greater transparency, consistency and cost effectiveness

ALCAS also offers all its technical experience and support in the achievement of this goal. Though ALCAS understands the GBCA's process of developing new strategies as much as possible in-house, ALCAS also strongly believes that a better and more effective outcome will be achieved if ALCAS and GBCA can work closely on this as joint stakeholders; particularly, in planning a staged rollout that builds on the GBCA's adopted approach, combined with ALCAS' role as the Australasian EPD & PCR registry for building products and proposed scheme to certify LCA practitioners in due course.

- 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 market is ready; acknowledging and anticipating that any scheme introduced by the GBCA is likely to take one to two years for implementation – this will provide the time needed for full market readiness.

There is already a strong interest from many sectors and government departments in life cycle practices and approaches. The building sector has been one of the most enthusiastic and early-movers in terms of full life cycle assessment through its work with the Building Products LCI Project through BPIC. The building design community has a high degree of market keenness around life cycle approaches and the GBCA's decision to introduce an LCA system into Green Star really is a game changer in getting things moving.

The current state of the market, capability and tools (developed and in development) will support this move by GBCA and be able to deliver the needs of this initiative if a staged approach to implementation is taken in a manner as suggested below:

1. Ideally an absolute reference (ecopoint) value/m^2 would be calculated for each building type and height profile or per storey value allowing for a variety of subsoil conditions. This could be achieved via a Monte Carlo analysis of relevant reference buildings as proposed in the reference building approach proposed by GBCA. This would require a study to be funded by GBCA and prepared by experienced LCA practitioner/s along. A range of reference values would then be available for weighting and calculation of eco-indicator values relevant to each building type. It will not however, until benchmarking of tools has been completed in the future, allow the results to be compared one to another from project to another.

OR If the GBCA chooses not to take this approach, then the reference building approach would be the next solution deemed suitable by ALCAS although it does have well recognised limitations:

2. The reference building approach where a base specification is used to compare a building of the same design and business as usual materials specification, can be an appropriate starting point given the tools in the market have not been benchmarked as a group. The reference building method will allow all current practitioners and tools and their established LCI data sources to be active in supporting this initiative and delivering results that will be a step up from current approaches. It will not however, until benchmarking has been completed in the future, allow the results to be compared one to another from project to another.

TIMEFRAME: ALCAS Suggests that this process be adopted for the next 2-5 years.

3. A possible further development would then be to undertake a benchmarking process once AusLCI has a critical mass of building product 'Gate to Gate' data connected to an Australian and other reference set of 'Background data' and time allowed for this data to be adopted by the various tools. This would then allow a timely and reasonable process to migrate from the reference building approach to an absolute value while giving the industry, LCI data sources and LCA tools developers time to adjust to the process and maximise the potential accuracy during benchmarking.

   TIMEFRAME: Beginning discussions about a Benchmarking process - 1-2 years, undertaking benchmarking 2-5 years, Piloting Implementation 5+ years.

4. An alternative to this would be for GBCA to develop its own LCA tool to standardise the process, <u>but this is not a strategy that ALCAS would support as it would introduce huge duplication and significant cost and complexity.</u>

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

ALCAS believes that some of the main barriers to implementing LCA include:

- **Education of the benefits of LCA**
  Many people simply do not understand what LCA is nor do they comprehend the enormous benefits that LCA can provide in terms of coming up with the best environmental solution and in providing environmental improvements in products and services. More extensive education and training is certainly needed. ALCAS would be keen to assist, or partner with the GBCA in delivery of LCA based education and training programs.

- **Improvement of the building product LCI data**
  Every LCA tool in the marketplace currently has a professional and adequate inventory to commence the program in a non-benchmarked mode.

  Accurate life cycle inventory (LCI) data is fundamental to achieving the most accurate life cycle analysis and for benchmarking of tools common Australian LCI data would be necessary. Whilst the BPIC LCI project achieved some significant outputs, much of the data produced is limited in that it is gate-to-gate, rather than cradle-to-gate in nature.

  AusLCI has commenced discussions with the BPIC sectors and invited them to provide their data for inclusion in the national AusLCI database. As part of this process it is intended that all gate-to-gate data (including BPIC) be hooked up with consistent generic Australian background data to provide true cradle-to-gate outputs. Average industry values for all the major materials will also be published.

- **Funding of LCI development**
  Progress on LCI development has been limited because of funding constraints within ALCAS. ALCAS would welcome the opportunity to work with the GBCA to lobby the federal government for funding to finalise the development of a range of standardised background unit processes (ie; energy, water, transport, etc) to allow the creation of nationally recognised industry average data for benchmarking purposes.

- **Development of an EPD system – PCRs based on Australian criteria**
  The next step beyond average industry LCI data is 'product specific' data. The use of LCA reporting in the form of Environmental Product Declarations (EPD) based on agreed Product Category Rules (PCR's) is increasingly becoming standard practice in developed economies such as EU and USA for business to business (B2B) communication on product LCI information.

  ALCAS is working in conjunction with its sister organisation in New Zealand to develop an Australasian framework and registry for PCR and EPD development *(once a recommendation from the current working group is approved by the ALCAS and LCANZ Boards this will then be articulated to GBCA*).

  The ALCAS Board has made the commitment to ensure this framework will be ISO 21930, ISO 14025, and EN15804 compliant and will be adapted to suit the new Eco-EPD standard once it is published. While in general manufacturers in Australia, have been slow to invest in EPD's for their products, there are currently within the Global GreenTag certification system over 60 manufacturers and 250 products (15% base building and 85% interiors) that have either had EPDs produced or are in the process of waiting for the ALCAS/LCANZ EPD process to be finalised before the EPDs are issued. Both Pre and PE International (SimaPro and GABI respectively) also operate EPD programs. ALCAS is also currently in discussions with National Standards about now its planned EPD/PCR process will fit in with this program.

  It is envisaged that the GBCA's movement towards LCA based credits will provide a major encouragement for many companies to continue making this investment.

- **Design Tool development**
  A number of design LCA design tools are currently either available or under development. It is really through these integrated building design tools and the

growth of BIM under the current National BIM Roadmap (BuildingSmart) that LCA will be embraced by the broader design community.

- **Benchmarking**
  If benchmarking of tools is required as a pre-condition to commencement of LCA based credits it will hold the program back. Under the staged approach being advocated by this report some benchmarking of tools will be required in future.

- **Specification of the LCA requirements / decision making**
  With the development and delivery of a new system to market, questions of requirement and usage are expected.

- **Training Green Star users in the use of LCA**
  Training of Green Star professionals in the use of LCA outputs will be critical in ensuring the best outcomes are achieved from this initiative. The automated LCA tools can be easily learnt in a matter of day or so and training courses could facilitate the expansion readily.

- **GBCA setting up their own tool and collecting LCI data should they decide to do so**

- **Differences in international developments – need international consistency**

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

ALCAS believes an 12 – 24 month period is certainly adequate for the initial implementation of the proposed system in pilot form. See also suggestion of a second tier development program – page 7).

The release by the GBCA of this discussion paper has certainly made the building industry aware of the GBCA's intent. Anticipating that the GBCA will utilise an initial pilot program before full implementation, it is believed that an 12 – 24 month period is adequate.

Section 5 Objectives

The Green Building Council of Australia invites feedback from stakeholders on the objectives of the project.

The specific objectives of this project are to:

- *develop a transparent and consistent methodology for assessing the environmental impact of construction materials using life cycle assessment*
- *continue to assist and facilitate the uptake of best environmental practice product and materials selection in the Australian construction market*
- *facilitate the use of ASO14025, Environmental Product Declaration (EPD) for materials assessment in Australia.*
- *deliver better environmental outcomes; and*
- *deliver these outcome in a cost-effective manner.*

ALCAS supports the specific objectives of the GBCA stated above.

It is suggested that several dot-points might be modified as such:

- *develop a transparent and consistent methodology for assessing the environmental impact of construction materials within buildings using life cycle assessment*
- *facilitate the use of ISO 14025 Environmental Product Declarations & EN15804, Environmental Product Declaration (EPD) for building materials assessment in Australia.*

An additional dot-point suggested is:

- ***"to further the evaluation of materials and building design optimisation across the full building life cycle from materials manufacture, construction, operations, maintenance, retrofit, and end of life and re-use and recycling*** "

It is also pointed out that this project will also serve to:

- Encourage Government and other major building owner to better understand the role of LCA in making better decisions about building and materials procurement;
- Enable and require manufacturers to better understand the environmental impact of their own activities – procurement, production, packaging and communicating the environmental benefits of their products;
- Assist in advancing the take up of BIM (Building Information Modelling) of which LCA is an important component;
- Assist in advancing the support for AusLCI and therefore LCA throughout the economy.

Section 6 Methodology

Scope of Assessment

The Green Building Council of Australia seeks your feedback on the following questions.

- 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?

Yes, it is appropriate to start with a limited scope of assessment in order to simplify the LCA but the scope should be less limited than proposed

Appreciating that the GBCA is looking to undertake a logical and structured staged approach to the introduction of life cycle management and assessment, then it does seem appropriate to start with a limited scope of assessment in the first instance in order to simplify the LCA. It is anticipated though that in future developments, that additional elements will be added until all significant elements are eventually covered.

A logical approach might be:

Stage 1: Base Building: structure, core services (not plant) and facade materials (+some extra inclusions - see below)

Stage 2: Interior Fit-out

Stage 3: Full Inclusion of all building elements (anticipated that by this point that BIM will be better established within the sector and more readily used with automated LCA tools)

Note: these stages above might be conducted in parallel if there is enough capacity

- Please provide feedback on the list of inclusions and exclusions.

All elements currently identified as inclusions are supported: *columns, beams, slabs, exterior walls, windows (including framing & glazing), core structure, including load bearing walls, roofs, foundations, cabling, pipes & conduits.*

It is also believed that **the following items are important components of a 'base building' and accordingly should also be included:**

High Priority

- Ceilings
- Partition Walls
- Floor Finishes

Medium Priority

- Mortar
- Sealants
- Formwork

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

The current list of Inclusions & Exclusions appears to cover the basic building products and elements.

Whilst the current list of Inclusions & Exclusions appears to cover the basic building products and elements, structural and reinforcing steel appear to have been left out. Also the use of steel decking which is widespread practice should be included. Also the GBCA propose (p11) that the 'boundary condition used' be '*cradle to constructed, sealed and serviced building*' stating "*taken to mean a finished building structure, including all services such as water, electric, ventilation, air-conditioning, etc installed in common areas*". If this is to be the case then HVAC systems and light fittings should also be included. If this is not the case then reference to these elements in the scope should be deleted.

Also, future approaches may also look to include new and improved products and systems such as: photovoltaic cells, solar panels, wind turbines, co-generation and tri-generation facilities, etc.

Boundary Definition

The Green Building Council of Australia invites feedback from industry stakeholders on the proposed system boundary:

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

Whilst acknowledging GBCA's desire for initial simplicity, ALCAS believes that a whole of life, 'cradle to grave' approach (including use and maintenance) should be the aim for buildings assessment in alignment with international approaches.

ALCAS suggests that the GBCA ultimately aligns its approach to international standards where available and appropriate.

In Europe a harmonised approach is now being pursued through the European Committee for Standardisation (CEN), TC350 and the implementation of EN 15643-2 for the environmental aspects of building sustainability assessment (note this standard supersedes ISO 21931-1:2010)

The following is an extract from the Standard's scope statement:

> *The framework applies to all types of buildings, both new and existing, and it is relevant for the assessment of the environmental performance of new buildings over their entire life cycle, and of existing buildings undergoing refurbishment, renewal or extension, to the end of their life. The environmental dimension of sustainability is limited to the assessment of environmental impacts of a building on local, regional and global environment on the basis of Life Cycle Assessment expressed with the quantitative assessment categories. It excludes the environmental risk assessment of a building on the local environment and it excludes environmental aspects of a building relating to the built environment that extend beyond the area of the building site, e.g. environmental impacts of construction of local infrastructure or environmental impacts resulting from transportation of the users of the building. Other means for measurement of environmental performance of buildings, which are not based on the Life Cycle Assessment methodology, are not considered within this framework.*
>
> *Source: EN 15978 Introduction*

ISO 14044 is a normative reference for this Standard.

Product level standards relevant to this process are:

- ISO21930:2007 (*Sustainability in building construction -- Environmental declaration of building products*) and
- EN15804:2012 (*Sustainability of construction works - Environmental Product Declarations - Core rules for the product category of construction products*)

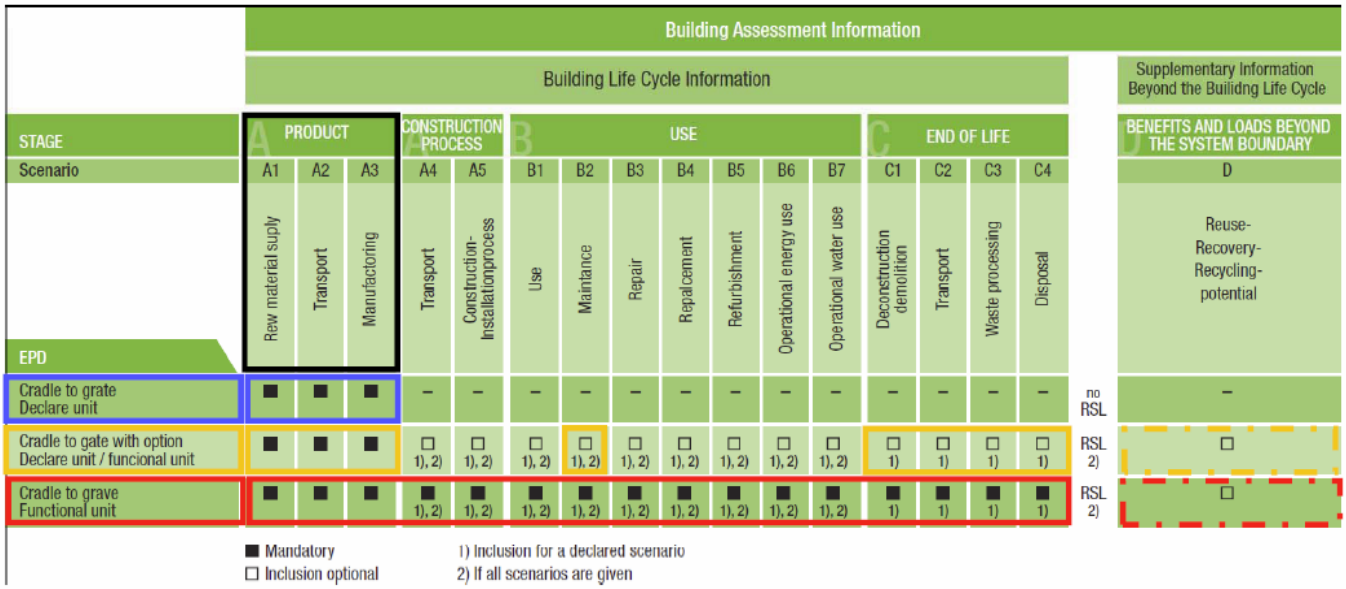
While the EN15804:2012 standard now succeeds ISO21930:2007 in Europe, An ECO-EPD development program is currently underway to harmonise the development of Environmental Product Declarations (EPD) and Product Category Rules (PCR) into a single system EU wide.

The ISO21930 is based on the ISO14025:2006 (*Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures*). These standards apply LCA principles throughout and are therefore considered to be the most appropriate. The ISO21930:2007 standard discusses which life cycle stages need to be included in environmental declarations of building products. The following provides a simplified extract from ISO21930:2007)

	Product stage	Design & Construction Process stage	Use stage / Construction & Use stage / Maintenance	End of life stage
Product related impacts	(Specific)	(Scenario)	(Scenario)	(Scenario)
Operational impacts			(Scenario)	
Cradle to gate declared unit	Mandatory			
Cradle to gate with option declared unit / functional unit	Mandatory	Inclusion optional	Inclusion optional	Inclusion optional
Cradle to grave functional unit	Mandatory	Mandatory	Mandatory	Mandatory

According to EN 15804 the following life cycle stages for building assessment are recognised.

- A1 – A3 Product
- A4 – A5 Construction Process
- B1 – B7 Use
- C1 – C4 End of Life
- D Benefits and Loads beyond the system boundary



GBCA's suggested approach of an initial system boundary of 'cradle to constructed, sealed and serviced' building would incorporate stages A1 – A5 under the above model.

It should be noted (while acknowledging that GreenStar sometimes independently assesses some of these factors) that under this approach:

- 'operational energy' impacts would not be directly assessed (it is noted that this could be independently be done by other means, software, etc) and as such important thermal design benefits such as the use of insulation or thermal mass may be missed;
- 'maintenance, repair and replacement' are not included – some choices often have high maintenance or replacement requirements – it would be counter-productive if high maintenance elements were specified because they were simply cheaper;
- 'end of life impacts; are not included so issues around deconstruction or disposal are missed

ALCAS believes that ultimately a whole of life, 'cradle to grave' (end of life fate) approach in accordance with EN 15643-2 using EPDs in accordance with ISO 14025 and EN 15804 should be the aim for buildings assessment and steps towards this path should be in alignment with international approaches.

- 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?

Yes in most instances it is practical to make qualified assumptions about the origin and the distances that material must be transported in a Green Star design submission.

Transport is can be a significant proportion of the total impact of products especially the mass products likely to be used in a 'base building' analysis and given distances for most mass materials are likely not to be large or travel by air such qualified assumptions can be used. Generic transport data for Australian conditions for road, rail, sea and air are or will shortly be readily available from a variety of sources including AusLCI.

Also, LCA has shown that some recycled materials, when large transport requirements are involved, can be more damaging to the environment than virgin sourced material (ie imported recycled steel products from some sources compared with locally produced materials); for many products 'recycled content' is not a reliable proxy for low impact.

It should also be noted that for some 'Fit-out' materials, particularly high mass materials imported from overseas, transport may also be quite a significant component (ie stonework, tiles etc). These issues would become obvious in a comprehensive LCA. GBCA could distinguish imported products with a different set of assumptions to overcome this issue.

Functional Unit

The Green Building Council of Australia invites feedback from industry stakeholders on the functional unit:

- Is 1m^2 of GFA an appropriate unit?

Yes 1m^2 of Gross Floor Area (GFA) is potentially an appropriate (reference) unit
The functional unit purpose is to quantify the primary function of a building to allow for fairer comparisons and buildings often provide many services to their occupants, so a single unit of measure involves a degree of compromise. It is suggested that a time and function element be added to the 'per m^2 of Gross Floor Area (GFA)' approach for a 'new commercial/mixed use' building (or by analogy the, per m^2 of Net Let-able Area (NLA) unit for 'tenanted space' if a rating tool is addressed to tenancies only)
i.e. /m^{2}GFA.year [office space] or /m^{2}GFA.year [warehouse etc.]

- Are there constraints to using this unit?

The range of commercial buildings varies dramatically in size, function and the numbers of workers or users of the building they accommodate; office buildings include individual work spaces, common work and recreational areas and public zones; shopping centres contain significant public space as well as individual businesses of varying size; schools, hospitals, public buildings – all have different requirements and usage patterns. The appropriateness of using a single 1m^2 of GFA may need to be assessed dependant on the Green Star tool utilised and other factors such as those below may have to be considered

- location / geography – might have to be site relevant relating e.g. to climate
- minimum quality requirements – refer to applicable building codes
- intended design life of the building

Sometimes with some buildings like warehouses and other "large sheds" cubic metres is appropriate

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

An alternative to this functional unit would be per m2 over a consistent 50 year life cradle to grave approach incorporating additionally:

- all operational energy and
- end-of-life (reuse, recycle, recover energy and waste) impacts

Environmental Impact Categories

The Green Building Council of Australia invites stakeholders to provide feedback on:

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

No, ALCAS does not believe that it is appropriate to limit the number of environmental impact categories to six.

Whilst there are differing views on the current approaches to some impact assessment categories and their potential accuracy and usefulness, a fundamental position and strength of true life cycle assessment is that it includes the broad range of environmental impact assessment categories, not simply cherry picks a few of these. This ensures that the broad range of environmental impacts are assessed and known (within the limits of data availability and quality); and in instances where products or processes are trying to improve their impact in a specific area (ie global warming potential) that another potentially more detrimental impact is not in actual fact occurring (ie increased human toxicity, by example).

- 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?

ALCAS believes that environmental impact categories utilised should be in alignment with international LCA, EPD and AusLCI methodological approaches.

In regards to international approaches ISO21930:2007 *Sustainability in building construction -- Environmental declaration of building products* refers to the following:

LCIA impact categories:
- Climate change (greenhouse gases)
- Depletion of the stratospheric ozone layer
- Acidification of land and water sources
- Eutrophication, and
- Formation of tropospheric ozone (photochemical oxidants)

Use of resources and renewable primary energy (Data derived from LCI and not assigned to the impact categories of LCIA):
- Depletion of non-renewable energy resources
- Depletion of non-renewable material resources
- Use of renewable material resources
- Use of renewable primary energy
- Consumption of freshwater

Waste to disposal (Data derived from LCA and not assigned to the impact categories of LCIA):
- Hazardous waste
- Non-hazardous waste

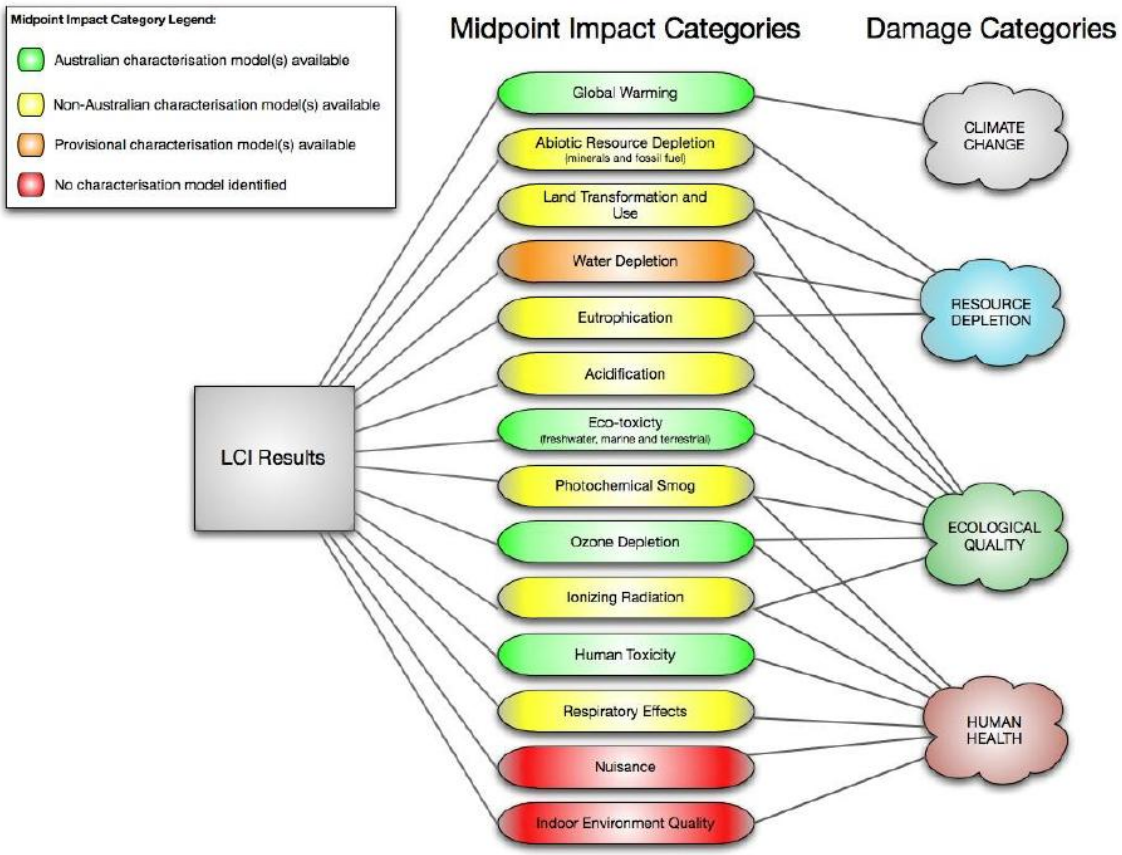
By comparison, the ALCAS *Requirements for development of AusLCI Data sets* document (ver 2, Feb 2012) states that the following impact categories are included in the scope of AusLCI:

- Climate change (also called Global warming or Greenhouse effect),
- Eco-toxicity (air, water and soil pollution),
- Ozone layer depletion,
- Human toxicity (air, water and soil pollution),
- Resource Depletion: Fossil fuel depletion, Minerals depletion,
- Eutrophication,

- Acidification,
- Photochemical oxidant formation (Photochemical smog),
- Land occupation and land transformation
- Water use: water consumption and source, waste water production and destination,

The ALCAS *Best Practice Guide to Life Cycle Impact in Australia*[2] also notes that Land Transformation and Water Use are 'provisional methods that need development'; both use a simple summation approach (total volume of water, total area of land). These two categories are of particular interest in regards to further development for Australian conditions.

Under the BPIC project the following 14 midpoint impact categories (that contribute to four damage categories) were recommended for adoption.



Of the 14 categories described it is noted that:

- 4 have an Australian characterisation model available (those in green): *Global Warming, Eco-toxicity, Ozone Depletion, Human Toxicity*
- 7 have a non-Australian characterisation model available (those in yellow): *Resource Depletion. Land Transformation, Eutrophication, Acidification, Photochemical Smog Ionising Radiation, Respiratory Effects*
- 1 has a provisional characterisation model available (those in orange): *Water Depletion*

[2] Currently undergoing a revision and updating

- 2 have an no characterisation model identified (those in red): *Nuisance, Indoor Environmental Quality*

ALCAS would look forward to further discussion on this matter with GBCA to ensure that the most appropriate set of impact assessment categories are utilised.

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

Not recommended – more categories should be used

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

Not recommended – more categories should be used*[3]

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

Yes, referring to the AusLCI impact categories is appropriate

ALCAS believes it is appropriate to refer to the impact categories described in the ALCAS *Requirements for development of AusLCI Data sets* document (ver 2, Feb 2012) and ALCAS *Best Practice Guide to Life Cycle Impact in Australia*.

Weightings of Environmental Impacts

The Green Building Council of Australia seeks stakeholder feedback on the proposed Weightings and points:

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

ALCAS suggests the GBCA build on the previous BP LCI work and undertake a specific buildings related weighting exercise.

Firstly a text correction, in the GBCA discussion paper page 14, first sentence it states that "*Weightings are essential for LCA results to be calculated*".

This is not actually the case. Weighting is applied after the LCA results for each of the impact assessment categories calculated. Weighting assists when the LCA results are trying to be simplified down to a single score solution.

[3] This represents the majority view from ALCAS. A minority believe a smaller number e.g. 6 is preferable.

Two quite strong (some might say intractable) schools of thought exist with LCA practitioners around weightings. Put quite simply,

- One side asserts that LCA output needs to be presented in its fullest form with outputs from all environmental impact categories presented, thereby providing the richest level of detail for assessment and analysis.
- Alternatively, the other side believes that the detailed output information should be able to be simplified, to a single score, particularly when the final user of the information is less technically skilled; for this to occur a system of weighting needs to be applied. This is of particular interest to design tool developers
-

Both of the positions have merit. The reality is that it is not a simple position of weighting vs non-weighting, rather, it's more a matter of "if you apply weighting, you still need to show the non-weighted results"; this would be in line with ISO14044.

It is important that the GBCA understands the benefits and limitations of weighting.

The introductory paragraph on p14 is also incorrect where it states that

> "*.... - the Building Products Weighting for Environmental Impact Categories which has been developed as part of the AusLCI project*".

The Building Products Weighting for Environmental Impact Categories work was in fact developed under the BPIC ICIP funded project between 2007 & 2010 not the AusLCI project. It should be noted that prior to this work no formal guidance was available as to views from Australian participants on weightings and as such the document provides a valuable initial reference tool.

ALCAS obviously supports the introduction of LCA based credits into Green Star and, acknowledges that in the end these must result in Green Star credits (i.e. the need for a single score), and hence that this means that applying a weighting is essential.

It is suggested that as part of the Green Star LCA pilot process that the GBCA take a leadership role in this area and build on the previous BP LCI work by undertaking a specific *Buildings Related Weighting Exercise* with their broad membership group.

This exercise will also assist in preparing the market for the methods impending introduction and provide an opportunity for initial life cycle awareness training.

- 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?

ALCAS recommends having both separate credits for each of the environmental categories and also a total score

It is suggested that GBCA utilise separate credits for each of the environmental categories (un-weighted) and also a total score (weighted) thereby respectively

- providing the richest level of detail for assessment and analysis, and
- providing a simplified, single score, particularly for the less technically skilled.

This exercise should be undertaken following the proposed new GBCA Building Related Weightings Investigation. The exercise will require some considered thought from an Expert Technical Panel and would benefit highly from representatives experienced in this area participating;

Thoughts from individual member/s include:

- weighting is contentious
- there is no agreed single approach in Australia or anywhere in the world;
- if done, transparency is critical and if possible communicate the make up in the final results
- results should be normalized before weighting.

Section 7 The Assessment Model

Standard Practice Reference Case

The Green Building Council of Australia invites feedback from stakeholders:

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

ALCAS supports an absolute reference value method as a second preference only.

Under this approach reference values would be calculated for each building type and height profile or per storey value allowing for a variety of subsoil conditions. This could be achieved via a Monte Carlo analysis of relevant reference buildings as proposed in the reference building approach proposed by GBCA. This would require a study to be funded by GBCA and prepared by experienced LCA practitioner/s along. A range of reference values would then be available for weighting and calculation of absolute reference (ecopoint) value/m^2 relevant to each building type. It will not however, until benchmarking of tools has been completed in the future, allow the results to be compared one to another from project to another.

If the GBCA chooses not to take this approach, then the reference building approach would be the next solution deemed suitable by ALCAS although it does have well recognised limitations:

Reference Building Approach

It is recognised that the GBCA with this initial move to LCA is looking for a simple and straightforward process to building assessment and as such the suggestion of a 'reference building' approach; it is also recognised that the GBCA is likely to get mixed views from commentators on this approach.

ALCAS would prefer that proper life cycle building assessments be undertaken; however ALCAS also recognises that simple LCA tools for building designers, architects and engineers are not yet currently widely distributed; nor formally benchmarked. Until this is done, ALCAS prefers the reference value method but is prepared to comment on the GBCA's approach in using a 'standard practice reference case' for the first introduction of an LCA 'Base Building' assessment in Green Star.

It should be noted though that consideration needs to be given to

- designers possible 'gaming' the reference case to a high impact so that the actual project appears to perform well;
- GBCA standardising design and specifications aspects to reduce gaming but in doing so increasing the constraint on design innovation;

- how building orientation is recognised; this can be a major factor in operational performance;
- assessing the reference building under the same floor loading and foundation material and National Construction Code climate requirements;
- The additional costs multiple modelling of buildings will have on any application;

ALCAS believes that in terms of a standard practice reference case there is likely to be little differentiation between the per storey impact of low-rise and mid-rise so a single per story assessment could be used for these and a separate case for high rise.

Base building materials (columns, beams, slabs, core) for commercial office buildings and similar structures typically are:

- low-rise (1-4 storeys) – reinforced or precast concrete construction [2]
- mid-rise (5-15 storeys) – reinforced concrete construction [4]
- high rise (16+ storeys) – reinforced concrete or steel frame construction

These may change with building type e.g big box retail, industrial, warehousing, etc.

Most other factors are consistent: windows, foundations, cabling, pipes. External walls would be the only major consideration; use of bricks above 4 storeys is today unusual.

We understand from discussion with GBCA staff, that in regards the 'Reference Building' the GBCA have no fixed position at present on how this might work (or even if GBCA will use one) the current exercise is simply to get ideas and feedback at this point on all the possible opportunities.

- 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?

ALCAS suggests that the reference case should distinguish between new building on a green field site, refurbishment of existing buildings and fit-outs

On a green field site the process is quite straight forward - no consideration is required around demolition or reuse of on-site materials. In refurbishment of existing buildings and fit-outs this is certainly not the case and in many instances demolition costs and impacts can be significant.

There is no doubt however that where a development reuses parts of an existing structure this deserves the commensurate reward of avoiding the use of new materials and products.

It should also be noted that a new-build on a Greenfield site is less constrained and may be more efficient and benefit from new materially efficient structural systems etc. This also needs to be considered

[4] While low & mid-rise construction may be typically concrete in Australia, there are nevertheless many steel framed buildings in these categories in Australia. Overseas, notably in the UK, steel framing is in the majority (over 70%) in these categories. Ie it could be very constraining on design and innovation if the reference buildings were confined to concrete structures.

- 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?

ALCAS Feedback:

A straight interpretation of the information provided on p15 suggests two possible ways that the proposed Standard Practice Reference Case approach might be interpreted and implemented.

GBCA Three Reference Structures

GBCA undertakes and publicises single standard reference cases for 1) low-rise, 2) mid-rise and 3) high-rise buildings.

Designers then undertake an analysis of their own improved building (adjusted for equivalent size) for comparison.

Pros
- Simplicity
- Comparatively cheaper

Cons
- Limited value in assessing true improvements

Reference Building Undertaken for Each Project

Each project first undertakes a reference case of the actual proposed building using standard product use practice advice provided by GBCA.

Designers then undertake an analysis of their own improved building for comparison (either one analysis of final building or an iterative approach)

Pros
- Provides a truer analysis of improvements
- Allows for an iterative design approach
- Builds a detailed library of building LCA's

Cons
- More expensive and time consuming

Examining the second approach: *Reference Building Undertaken for Each Project* our interpretation of the process proposed using a 'reference case' is as follows:

1. Firstly the appropriate standard practice table provided by the GBCA needs to be chosen.

2. Relevant material quantities for each of the building components listed then need to be estimated by a suitably qualified quantity surveyor or estimator for the proposed total building plan and layout (footings based on soil type; building width, depth, number of floors, etc). Appropriate 'distance transported' values need also to be gathered for each building component material.

3. An LCA analysis then needs to be undertaken of this 'standard practice base building' to provide the benchmark impact assessment category results. *Note: this may involve the use of a professional LCA consultancy firm or potentially be undertaken in-house by a suitably qualified staff member using a recognised LCA building design tool.*

4. The design team then either
    - undertakes a second LCA analysis modifying the specified building components with those proposed for the new building and uses the differences between these outputs and the benchmark to determine the 'percentage reduction in impact' points for the proposed building; or
    - undertakes an iterative design process, investigating the benefits of different building component changes until an optimised solution is achieved - differences between these optimised outputs and the benchmark outputs are

then used to determine the 'percentage reduction in impact' points for the building (*Note: this will really only likely to be cost effective if an LCA design tool is used in-house – not an external consultancy firm*)

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

The current state of the market, capability and tools will support this move by GBCA and be able to deliver the needs of this initiative if a staged approach to implementation is taken in a manner as suggested below:

1. The reference eco-point value/m2 is adopted (see strategy below); OR only as a second preference;

2. The reference building approach is adopted;

   While ALCAS prefers the initial approach for its cost efficiency and operational efficiency– either can be adopted as an appropriate starting point and allow all current practitioners and tools and their established LCI data sources to be active in supporting this initiative and delivering results that will be a step up from current approaches. ***It will not however, until benchmarking has been completed in the future, allow the actual LCA results to be compared from one project to another.***

3. A possible further development would then be to undertake a benchmarking process once AusLCI has a critical mass of BPIC Gate to Gate data connected to an Australian and other reference set of Background data and time allowed for this data to be adopted by the various tools.

4. This would then allow a timely and reasonable process to migrate from the reference building approach to an absolute value while giving the industry, LCI data sources and LCA tools developers time to adjust to the process and maximise the potential accuracy during benchmarking.

Eco-point value method

The ALCAS preferred approach is to define absolute threshold criteria for credits in weighted overall Au Ecopoints per m^2 of Gross Floor area. The threshold could be based This could be based on the three GBCA reference structures and specifications mentioned above or alternatively on a wide range of building use mixes, building sizes, shapes, specifications of all major elements, with a range of fit-out alternatives and mixes of open plan to cellular office space. From such a "histogram" the thresholds could be set at any desired level of credit ambition (% of designs likely to achieve any particular Ecopoint/m^2 threshold).

Under this method GBCA would:

- For Each Green Star Tool:
  - Sponsor the LCA of a series of building designs in the sector that span the likely range of designs – large/small, simple, complex, high rise, low rise, in different climate zones…etc. Use the appropriate Working Group of GBCA to decide the mix of buildings to study

        - For each building design calculate the Au Ecopoint per m2 of GFA (or per other reference unit for the particular building type) using the BP LCI methodology and (corrected) data
    - Determine the spread of Au Ecopoint per m2 of GFA for the sector
    - Recommend a linear scoring mechanism between the median (or average) value and the best likely value to match Green Star credit aspirations (decided by the WG). This will result in a number of credit thresholds in Au Ecopoint per m2 of GFA which attract each of the Green Star credits.
    - Write the credit language requiring projects to do their full building LCA and the methodology to be used (AusLCI and BP LCI) and publish the thresholds that they must get for the different levels of Green Star credit.
    - Update each Green Star Tool with the new requirements and criteria.
- Develop the required training and exam materials to include in the GSAP course.

Projects Would

- Commission their whole building LCA's from LCA Practitioners
- Document their results in submissions to win Green Star credits for the projects
- Modify designs to reduce their buildings' impacts

ALCAS Members Would

- Service the demand for buildings LCA and advice to design teams

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

Yes conducting two iterations of the LCA with different inputs for the project is certainly practical

Conducting two iterations of the LCA with different inputs for the project is the necessary minimum iterative design process. One needs to do this to make the assessment of the interactive and interdependent impact of alternatives designs and materials.

- 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?

This depends on the level of optimisation pursued by the design team and the degree of automation and design tools available.

Some possible scenarios and gut-feel on times are as follows:

Scenario 1: No optimisation and using an external LCA consultancy

- a single second LCA analysis is undertaken just modifying the specified building components with those proposed for the new building (no optimisation)
- new quantities need to be estimated and passed on to LCA consultant, consultant undertakes LCA and provides advice back on differences to benchmark – assumed to be reasonably straight forward process perhaps

25% more time. If using an automated tool this time can be reduced to approx 10%.

Scenario 2: No optimisation and using LCA design tools in-house:

- a single second LCA analysis is undertaken just modifying the specified building components with those proposed for the new building (no optimisation)
- new quantities need to be estimated and inputted into LCA tool, tool outputs are then compared to benchmark values and differences determined – again assumed to be reasonably straight forward process perhaps 25% more time. If using an automated tool this time can be reduced to approx 10%.

Scenario 3: Design optimisation using an external LCA consultancy:

- an iterative design process, is undertaken investigating the benefits of different building component changes
- new quantities are estimated and passed on to LCA consultant, consultant undertakes LCA and provides advice back on differences to benchmark
- process is continued until an optimised solution is achieved – if the design team is not skilled in LCA then additional time is likely to be high perhaps 100% more time; if design team, or consultant is skilled perhaps 50-100% more time. If using an automated tool this time can be reduced to 10-20%

Scenario 4: Design optimisation using LCA design tools in-house:

- an iterative design process, is undertaken investigating the benefits of different building component changes using in-house tools
- new quantities are estimated and inputted into LCA tool, tool outputs are then compared to benchmark values and differences determined
- process is continued until an optimised solution is achieved – if the design team is not skilled in LCA then additional time is likely to be high perhaps 100% more time; if design team, is skilled perhaps 50-100% more time. If using an automated tool this time can be reduced to 10-20%

- 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?

No, more information is likely to be required from that given in Table 1

Table 1 provides a good initial foundation for establishing base parameters however comprehensive specification/design details and dimensions would be needed for every component to allow alternative solutions to be designed and estimated for a true comparison with the reference case.

Other comments on the table 1 information as provided include:

- Second Column is headed ‘functional unit’ – this is really a unit of measurement and the heading should be adjusted
- Column, Beam, Slab, Core & Foundation building component materials are all defined as ‘reinforced concrete’ with a ’m^3’ measure – impact of reinforcing steel needs also to be included
- In Australian mid-high rise construction columns and beams might also be typically constructed from steel

- Roof – also typically constructed from structural steel (rafters, purlins & columns) also metal deck roofing

It is also unclear how other optimised design factors might be included: ie modifying the building orientation, the building shape, the number of stories, or the window performance. Every item that remains common improves the consistency of the assessment but is removed from the designer's palette to innovate for environmental improvement.

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

ALCAS would recommend the use of an Expert Technical Reference Panel

Reporting Mechanism

The Green Building Council of Australia invites feedback from industry stakeholders on the use of ISO 14025 EPDs:

- Is it appropriate to nominate ISO 14025 as the reporting mechanism?

ISO 14025 is a reporting guideline for general product reporting. However as noted previously ISO 21930 is specifically for Building Products and has recently been superseded by EN 15804. Building LCAs should be reported to ISO 15643-2.

Source: [5]

When product manufacturers and suppliers look to become involved in life cycle assessment of their products they generally do this through the utilisation of a life cycle based ecolabel or by issuing Environmental Product Declarations. It should also be noted that a range of national EPD schemes exist globally. Some differences between the different EPD programs can cause considerable variation in results for the same product. This is due to differences in the underlying assumptions, boundaries and scope. At present, by example a manufacturer selling the same product in several different European regions cannot use a single EPD program; and may have to produce a separate EPD for each region, which can be at considerable expense.[5] In Europe harmonisation of all EPDs systems is being undertaken via a new pan-EU ECO EPD program.

In Australasia, ALCAS and ALCANZ are currently examining the best approach for EPD and Product Category Rules (PCR) development through a dedicated EPD Working Group which includes all key stakeholders including representatives with an understanding of: National Standards, Global GreenTag, ALCAS, LCANZ, BRANZ and LCA consultants. An assessment will be made by the EPD Working Group of the most suitable system for Australasia and a recommendation will then be made to both the ALCAS and LCANZ Boards for consideration. Once a position and framework is agreed for Australasia then ALCAS and

[5] 2012, "A Guide to Understanding the Embodied Impacts of Construction Products", Construction Products Association – *and excellent overview of EPD systems in a European context – available at* http://www.constructionproducts.org.uk/sustainability/products/sustainability-of-products/

LCANZ will engage with all the key sector representatives, including the GBCA, in regards to implementation.

- Is there an alternative that is preferred or should be considered?

Building LCAs should be reported to ISO 15643-2.

Allocation of Green Star Points

The Green Building Council of Australia seeks stakeholder feedback on the proposed Allocation of points:

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

ALCAS supports a 'percentage reduction in impact' approach in the initial adoption of the project

Whilst ALCAS supports a 'percentage reduction in impact' approach in the initial adoption of the project some thought needs to be given as to how this will work in practice.

The concept makes sense where changes result in positive environmental improvements – accordingly a level of points based on percentage reduction can be applied (ie 1 point for each 5% improvement as suggested).

However these changes may also result in a greater environmental impact in another category; this may end up being a worse environmental outcome overall. This is where weighted scores benefit the scoring outcome.

The current system only allows for positive change, not negative change. Perhaps a negative point system is also needed. Using the GBCA's own example on p18, this might work as illustrated opposite.

- 30	-6
- 15	-5
- 20	-4
- 15	-3
- 10	-2
- 5	-1
Predicted percentage reduction in greenhouse gas emissions	Points awarded
0	0
5	1
10	2
15	3
20	4
35	5
30	6

The discussion paper advises that "*The actual number of points available will be determined at a later date. At a minimum, the points available will be no less than the sum of the relevant points currently available in the Materials Category of Green Star Rating tools*"; this currently is around 22 points

This approach works best when a single weighted eco-point approach is used.

- 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?

ALCAS recommends a weighted eco-point approach but have the projects declare and publish the separate (unweighted) impacts for each of the environmental categories.

Thereby respectively

- providing the richest level of detail for assessment and analysis, and
- providing a simplified, single score, particularly for the less technically skilled.

This exercise should be undertaken following the proposed new GBCA Building Related Weightings Investigation. The exercise will require some considered thought from an Expert Technical Panel and would benefit highly from representatives experienced in this area participating. ***Any resultant weighting method should be thoroughly tested (and the results should be transparent to the LCA community) before it is implemented it into a scheme as influential as the GBCA's Green Star tools.***

Section 8 Data Inventory

Standard Practice Reference Case

The Green Building Council of Australia seeks stakeholder feedback on the proposed Data inventory:

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

ALCAS strongly supports the use of AusLCI datasets be used in a LCA methodology within Green Star rating tool

ALCAS has developed the AusLCI database to be the single national publically available repository for LCI data. Its aim is to consolidate existing LCI data and remove the need for multiple databases (where data might have varying levels of quality). All data included in AusLCI will have been developed in a consistent and uniform manner and will link to generic Australian background data providing accurate cradle to grave information.

Whilst it is true as the discussion paper suggests that: AusLCI "*has yet to release complete LCI datasets at the time of writing*" ALCAS is confident that appropriate building product LCI will be available through AusLCI by the time the Green Star LCA Pilot is released.

As mentioned previously all the building sectors involved in the Building Product LCI project have also recently been invited to submit their data for inclusion in the Australian Life Cycle Inventory National Database (AusLCI) – Australia's national repository of generic life cycle inventory data for all Australian industry sectors. Through this process the data

- can be made publically available with no caveats attached on usage, apart from the terms & conditions of the database;
- can be linked to appropriate background data to provide full 'cradle to gate' modules
- can be published as the average industry data for that sector.

It is anticipated that a good proportion of the data will be published in AusLCI within the next twelve months.

- Should a European LCI be used?

ALCAS suggests overseas data should only be used as a last resort to fill data gaps in Australian data (as it would be in any ISO 14040 compliant data quality hierarchy) unless the product in question comes from that area.

ALCAS do not believe that there will be a need to turn to overseas data sources to fill data gaps for the majority of common Australian LCI needs for the GBCA LCA Project. ALCAS is confident that the appropriate Australian LCI data will be available through AusLCI prior to the release of the Green Star LCA Pilot.

ALCAS also acknowledges though that if products used in projects actually come from overseas and specific LCI data is available, then it is appropriate that this real product data be used.

As in any LCA however, when data gaps exist the best next available data set can be adapted to required local conditions or processes and EU, US or other datasets can be used in this way. It is appropriate to ensure this approach remains available as an option especially for novel materials.

- Are penalties needed?

ALCAS believes penalties are not needed

ALCAS does not believe that penalties need to be applied to 'non-approved data'. ALCAS believes that the major sectors that produce the vast majority of building products (particularly by mass) will make available accurate Australian data for their products through AusLCI. If any sector chooses not to do this it will be quite obvious. ALCAS is confident it can provide conservative Australian data for any sector that is recalcitrant in supplying its own.

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

ALCAS encourages the use of the following LCI data hierarchy

1. From AusLCI (this data will comply with the AusLCI Data Guidelines and be highly compatible with BPIC/ICIP data).
2. From the BPIC/LCI database whilst this continues to operate (this data will comply with the BPIC/LCI *Methodology Guidelines*).
3. From other acknowledged Australian data sources (documented for source, age, representativeness and data quality assessment).
4. From other authoritative sources (e.g. Ecoinvent, USNLCI, GABI, Boustead, Athena Institute, Plastics EU, Franklin Institute etc.) adapted for relevance to Australian conditions (energy sources, transport distances and modes and so on, and documented to show how the data is adapted for relevance in Australia).
5. From other sources with sensitivity analysis reported to show the significance of this data for the results and conclusions drawn.

Section 9 Applicable Green Star Rating Tools

The Green Building Council of Australia seeks feedback from industry stakeholders:

- Is it appropriate to exclude fit-outs based on the lack of an agreed functional unit for fit-out items?

ALCAS believes that whole building LCA should be engaged to include fitout as otherwise the major impacts of the fitout will be lost but understands GBCA's approach to exclude fit-outs in the first release of the GBCA project on a 'walk before you run' basis.

A logical approach might be:

Stage 1: Base Building: structure, core services and facade materials plus additional suggested inclusions above.

Stage 2: Interior Fit-out (should be undertaken concurrently):

Stage 3: Full Inclusion of all building elements (anticipated that by this point that BIM will be established and in use with the appropriate integrated LCA design tools)

ALCAS looks forward to working with the GBCA in the logical evolution of an LCA approach particularly assisting with developing a relevant functional unit to cover building fit-out.

Section 10 Other Matters of Discussion

The Green Building Council of Australia invites feedback from stakeholders on the issues listed in section, as well as any other matter you believe should be addressed:

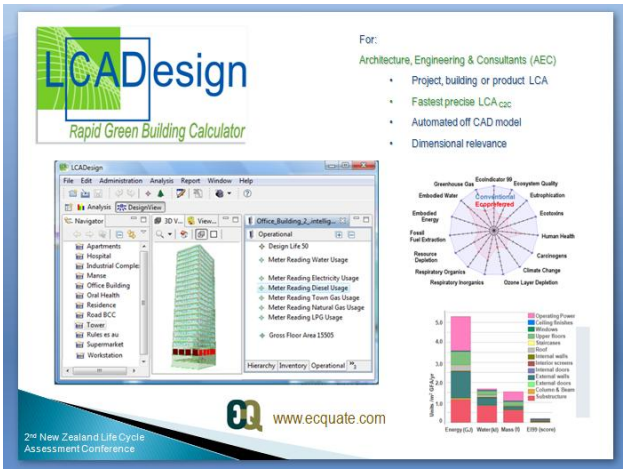
- Will the proposed LCA methodology accommodate existing LCA systems and tools?

ALCAS believes that the proposed LCA methodology will accommodate existing LCA systems and tools

The current proposed LCA methodology using the standard reference model and a 'base building' is quite straight forward and should be easily achieved through current LCA approaches which could be as simple as utilising an aggregated spreadsheet approach or a full Gabi or SimaPro simulation. These approaches would however require the assistance of a qualified professional LCA practitioner.

Additionally, there are a wide range of LCA based tools which could be used by trained building designers. Some of these tools are available now, some are under development but may be available by the Pilot launch time (see Appendix A, page 27 for a full summary of tools relevant to the building sector including contact details, web links, etc).
Two of these tools are described on the following page:

- LCADesign, and
- Envest Australasia



LCADesign: is the world's first BIM based LCA calculator that allows semi-automated whole building simulations as part of the design process. *LCADesign assesses the actual building that has been designed by the project team* and can be simply and quickly modified as the building or specification changes or to scenario play for optimisation- it can changes materials or element by 'click and drag' from the materials libraries on the right hand side to the 3D elements in the BIM model on the left

Designers simply tag the building elements and link with generic LCI data and the system undertakes automatic quantities take-off, LCI attribution and then calculates the LCA environmental impact assessments or eco-profiles for the building. 14 (selectable) environmental impact categories are available as well as a composite weighted ecopoint indicator and a variety of graphical output information is available to assess comparative changes between different LCA scenarios.

It is compatible with interoperability standards IFC2 and IFC3 BIM software such as Revit and ArchiCAD and is most suitable for advanced concept design, design development or construction stages as project documentation needs to be developed sufficiently to distinguish between different key elements and systems. LCADesign already includes some significant BPIC LCI supply chain data and is committed to including full use of the BPIC LCI. Operational Energy and Water can be manually added from either simulation tools or GBCA calculators to achieve whole of life building LCA. See www.ecquate.com.au.

A variant of this software is used by Global GreenTag to undertake their eco-label certification process and hence digital libraries of GreenTag Certified products are available for use under separate licence in the 'LCADesign powered by GreenTag' software variant. This maximises the accuracy of the LCI and LCA as it then becomes a product specific building analysis.

Envest Australasia: currently under development by Edge Environment, provides a different approach.

ENVEST adopts the philosophy is that many of the key design decisions about a building are made in the early phases of the design process and that often the remainder of the time is spent only refining the design and concerned with relatively minor details.

Edge Environment believes that the whole design is usually based on just 4 pieces of key information – the Location (Postcode), Building size (M2 GFA), Mix of building uses (%) and Budget ($).

After entering these details ENVEST adopts a default bland rectangular plan building design that would meet this brief and fit the site.

This building is comprehensively detailed. ENVEST adopts common default specifications for everything. The building is assessed for both materials' embodied impacts and operational energy and water performance using 14 (selectable) environmental impact categories as well as the composite weighted ecopoint indicator. Financial $ initial and life cycle costs are also estimated. As the design team go to work, they substitute default values for design choices and can see context relevant data about performance and tradeoffs. They can change shape, dimensions, glazing areas, shading, rooflights and atria and materials specifications for all major elements – substructure, frame, floors, external walls, internal walls, ceiling, floor and wall finishes to approximate their building design.

Building services and controls and structural systems can also be changed and detailed. The building can be spun on its axis to find the best orientation. At any point, the design team will then be able to press the BIM button to export a compatible BIM file for use in other BIM compliant software.

These tools illustrate how the building designer can/will become more intimately and naturally involved in the future in including a seamless life cycle assessment as part of their normal design process.

With the more widespread adoption of BIM (Building Information Modelling) in the future all of these computer based tools allow the full design team to share in understanding the impact of their actions and understand the most appropriate tool used for the stage of development of the building process.

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

ALCAS is developing a certification scheme for qualified LCA practitioners. Given the 1-2 year timeline proposed by the GBCA ALCAS will have certified practitioners in the market by the time the GBCA LCA model is introduced.

ALCAS is developing a certification and professional recognition scheme for both

1) Full LCA Practitioners undertaking
   - Comparative marketing claims
   - Inventory development
   - EPDs
   - LCA design tool development

2) LCA GHG Practitioners undertaking
   - Carbon footprinting
   - Carbon neutral assessment
   - Supply chain GHG

An ALCAS Certified Practitioner, will:
- Possess defined LCA competences that employers, stakeholder and peers value
- Receive a nationally recognised certification of competence, benchmarked against best-practice in the field of LCA
- Have demonstrated competence which has been formally assessed by ALCAS and tested by senior LCA professionals in Australia

- Have confirmed a commitment to currency of knowledge through professional development.

A full list of identified competencies (draft) is supplied in Appendix B.

It is anticipated that the certification and professional recognition schemes will be launched in early 2013.

- 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?

As an estimate between $10 - $50k initially, less than $10k in future with design tools

The cost of an LCA for a whole building depends on the complexity of the building and the quality and relevance of the data provided by the design/development team or owner and would range $30,000 to $100,000, with the majority lying in the $30,000-$50,000 range for practitioners specialised in buildings' LCA.

Utilising appropriate LCA automated software tools the cost of assessment can (subject to BIM use) be dramatically reduced possibly to around $2,000-$10,000 for complete assessments of a large range of buildings.

- Is the requirement to adhere to international standards necessary?

Yes. ALCAS believes that international standards are a key to consistency across LCA practitioners and regions.

ALCAS in principle supports alignment with international standards where available and appropriate. Suppliers and manufacturers that operate across international markets typically tend to requests alignment across these markets as well; as this reduces the work they need to do to service their markets (and thus reduces the costs for industry). Adhering to international standards will support this objective and make Australian businesses able to communicate their environmental performance to international markets..

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

ALCAS believes that the most relevant standards for products are ISO21930:2007 and EN15804:2012. These standards are strongly linked to ISO14025:2006 and ISO14040:2006 & ISO14044:2006, which form the generic basis for Type III Environmental Product Declarations and Life Cycle Assessment.

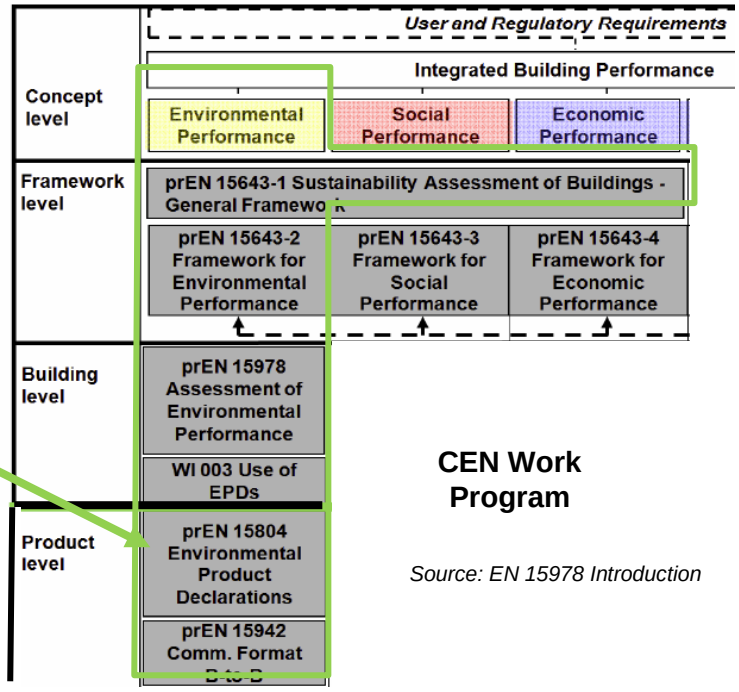
The appropriate standard for buildings is ISO 15643-2 Framework for Environmental Performance of Buildings.

ALCAS suggests that the GBCA ultimately aligns its approach to international standards where available and appropriate. In this case, the relevant documents include:

- ISO21930:2007 (*Sustainability in building construction -- Environmental declaration of building products*) and
- EN15804:2012 (*Sustainability of construction works - Environmental Product Declarations - Core rules for the product category of construction products*)

In Europe a harmonised approach for EPDs is now being pursued through the European Committee for Standardisation (CEN), particularly around the harmonising of the development of EPDs and Product Category Rules (PCR).

The EN15804:2012 standard succeeds ISO21930:2007.



CEN Work Program

Source: EN 15978 Introduction

- Is the requirement to use recognised software necessary?

No, there is not a requirement to use 'recognised' software, practitioners can undertake assessment using spreadsheets and data from EPDs but it is cumbersome and not without technical issues that require careful consideration.

LCA is certainly aided by purpose built software, but this is not essential and does not need to be a requirement. If software is used however it needs to include processes and calculations that reflect recognised international standards and practices and to ensure that EPDs are using consistent PCR Scope, Boundaries and Assumptions.

- Should the GBCA recognise particular softwares?

Yes, just like practitioners, LCA software ideally needs to be recognised

It is believed that there would be benefit in ensuring that proprietary LCA software meets a certain level of basic operational, functionality and output generating criteria, to ensure that consistent processes are being used and that output is relevant and where possible comparable between tools. It is suggested that in Phase 1 any whole spectrum LCA tool should or spreadsheet system should be able to be used. A benchmarking exercise would then be undertaken as Phase 2 of the project.

- Which software should be recognised, and why?

To be determined, after benchmarking but in the meanwhile….

LCA Software:
Two major commercial life cycle assessment software packages are used in Australia and internationally to undertake life cycle assessments.

- SimaPro, developed by PRé, and
- GABI, developed by PE International.

These software tools today generally provides the foundation for LCA work and often the LCA impact assessment and eco-profile output for other LCA based tools and assessment schemes but require manual quantity/volume inputs.

Building LCA Design Tools:
These tools are design focussed and incorporate LCA impact assessment approaches and eco-profile output in addition to other design tasks. They may draw on the LCA Software Tools or use LCI data directly from various databases. A number of tools either exist or are under development these include: Envest, eTool (both under development) and LCADesign.

It is suggested that a benchmarking exercise be undertaken of commercially available LCA tools as Phase 2 of the GBCA project;

- 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?

BESTEST type compliance is not needed for LCA software

LCA software handles large quantities of data but the manipulations that the software does are not complex. Energy modelling by contrast is much more with different approaches and algorithms used to translate theory and empirical data into energy performance. LCA analysis often utilise existing energy simulation software tools to provide inputs that are then used within the LCA design tools or the LCA process.

BESTEST compliance is needed for Energy Modelling but the equivalent is not needed for LCA software. All that is required to be demonstrated is that the tools provide acceptable similar results when assessing the same buildings.

- Is the requirement for peer review necessary?

Yes ALCAS believes that the requirement for peer review is necessary in principle

In LCA, it is the underlying methodology and data that needs to be verified. The key issues are scope, boundaries, product and functional unit definition, co-product and recycled material impact allocation, upstream and downstream data modelling. Expert or panel peer review conventionally provides the mechanism for this data quality assurance and details of the peer review are provided with the data.

However with LCA design tools this opportunity is not really feasible as the scope, boundaries, product and functional unit definition, co-product and recycled material impact allocation are predefined. Hence the benchmarking will really undertake the same function.

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

- **It is once again reinforced that all activities undertaken under the GBCA program be in compliance with relevant international standards and local Australasian approaches as defined by ALCAS via AusLCI in collaboration with groups such as National Standards.**

- **Ensuring high quality Australian LCI data is available is fundamental. It would be hoped that the GBCA would assist ALCAS in calling on government and industry to facilitate delivery of a high quality LCI background data and product data including transfer of the BPIC data into AusLCI with the connection to Australian background data.**

- **Comprehensive training is also critical for GBCA assessors and the broader building and design community. It would be hoped that the GBCA would assist ALCAS in developing and delivering appropriately tailored training packages and courses.**

Appendix A: Comparison of LCA Based Design Tools

Tool	Supplier	Description	Status
GABi 	PE International Barbara Nebel 3 9015 9455 b.nebel@pe-international.com	Gabi is one of the world-wide LCA software tools. The software is packaged and sold together with a range of life cycle databases these include *PE's own Professional Database* , the complete ELCD database as well as data from Plastics Europe (includes almost 1000 processes)	Over 200 users, widely used in Europe, North America and Australia
SimaPro 	Life Cycle Strategies (Aust rep) Tim Grant 3 8669 2048 tim@lifecycles.com.au	SimaPro, developed by PRé is one of the world's leading LCA software tools. It includes databases with a broad international scope, including the 'ecoinvent' database, and a library with 17 impact assessment methods.	Widely used by industry, research institutes, and consultants in more than 80 countries in Australia and internationally (over 100 users in Aust & NZ)
Green TAG *LCA Rate* 	Global GreenTag Pty Ltd under licence to Ecospecifier Pty Ltd David Baggs 0418 232 827 david.baggs@globalgreentag.com	Provides a detailed 'beyond LCA' rating of products compared to the worst case business as usual (BAU) product commonly available on the market. This rating is reflected by a Bronze, Silver, Gold or Platinum tier attainment. Also delivers product eco-labels, EPD's and Product Library Branded BIM modules for LCA Design.	LCARate systems is finding good market take-up at present with over 60 manufacturers and 250 products certified or undercertification
LCA Design 	LCA Design Del Jones *04 3856 0212* delwyn@evah.com.au	LCA Design provides rapid automated environmental impact assessments or eco-profiles of new and refurbished building designs directly from BIM models (whole or part buildings)- in Generic (BAU) and Eco-preferred options. Branded Product Libraries are imported from LCADetail under licence when LCA is available from Global GreenTag LCARate certification..	Early days- a number of major commercial, govt & university licenses for generic version– looking to have a branded product version out next year
LCA Detail	LCA Design Del Jones *04 3856 0212* delwyn@evah.com.au	LCADetail delivers environmental impact assessments for products. It can be customized e.g. by Global GreenTag for various products and sectors (ie flooring, paint, textiles, etc).	Customised only for specific clients at present
Envest 	Edge Environment Nigel Howard 0401 241 489 nigel.howard@edgeenvironment.com.au	An LCA based design tool that will be suitable for use at the design inception stage that reveals both the operational impacts and the materials embodied impacts of a building as the design evolves. Will use CO_2 coefficients, resource depletion, eco-point score through SimaPro.	A pilot tool has been developed in Excel, this is now being road tested. Next step is to take it into a commercially funded phase for a more professional software version.
BIM 	BuildingSmart John Mitchell 410 318 131 john.mitchell@cqr.net.au	*Building Information Modelling (BIM): BuildingSmart is the industry association supporting BIM- BIM* Provides a 3-D digital representation of a building. It can be used to calculate, analyse or predict building performance of thermal, embodied energy cost, environmental impact, etc over its full life	In manufacturing BIM uptake is high but in terms of building design and modelling the uptake is still quite slow, needs a demand from commercial operatives. Federal government is currently showing an interest –National BIM Roadmap underway.

eTool	eTool Richard Haynes, Alex Bruce 08 6364-3805 richard@etool.net.au	eTool is a free, web-delivered LCA based residential focused 'whole of house' carbon & energy assessment tool for private homeowners, designers, builders, developers & Government. Assists in quantifying the total environmental footprint of building designs (also includes a cost analysis). Recently (August 2012) received a Federal grant to expand LCI scope beyond GGEs..	Tool was launched 25th May 11. Staff currently work part time developing tool and undertaking assessments for home owners, designers, developers & Govt
BAMS	RMIT Centre for Design Usha Iyer-Raniga & Enda Crossin 9925-9066 usha.iyer-raniga@rmit.edu.au	A simplified design tool - 2008 LCA based scorecard system of typical building materials and assemblies . 1st stage: methodologies & process – complete-	Has been referred back to Sustainability Victoria to see if they want to proceed (No further funding to date)
GECA	GECA 02 8284 7781	The Good Environmental Choice Label indicates the environmental performance of a product from a whole of product life perspective. The label is awarded to products that meet voluntary environmental performance standards which have been created and assessed in conformance to international environmental labelling standards (not LCA based standards or product assessment).	LCA is used to inform Standards development not in product assessment. GECA Announced recently a liaison with RMIT to produce LCA of products for manufacturers who choose to undertake an LCA.
AGIC	AGIC Antony Sprigg 0414 454 723 asprigg@agic.net.au	AGIC has developed a an Infrastructure Sustainability (IS) rating tool for infrastructure that will measure governance, social, economic and environmental factors to be applied across the design, construction, operation and decommissioning stages of infrastructure delivery	Sustainability (IS) rating tool was released in February 2012 and includes an LCA calculator developed by Edge Environment under contract.

Appendix B: Summary of Life Cycle Practitioner Competencies (DRAFT)

Topic	Competency	Full LCA	Single-stream LCA (e.g. carbon assessment, water footprint)	Streamlined LCA	Life Cycle Management / Life Cycle Thinking
Introduction to LCA	Understand history of LCA	✓	✓	✓	✓
	Describe key principles of LCA	✓	✓	✓	✓
	Explain role of LCA more broadly	✓	✓	✓	✓
	Understand past applications of LCA	✓	✓	✓	✓
	Explain the 4 step LCA procedure	✓	✓	✓	✓
	Identify main LCA standards	✓	✓	✓	✓
	Define life cycle concepts, as per ISO 14040:2006 (needs better definition)	✓	✓	✓	✓
	Outline ISO requirements for comparative assertions against ISO 14040:2006 / 14044:2006	✓	✓	✓	✓
	Define the strengths and weaknesses of different LCA approaches	✓	✓	✓	✓
Goal & Scope	Explain the importance of defining the goal of the LCA study	✓	✓	✓	✓
	Describe the elements to be included in goal definition	✓	✓	✓	✓
Key elements of scope	Outline what's included in LCA scope	✓	✓	✓	✓
	Describe the relevance of scope definition	✓	✓	✓	✓
	Explain the structure of scope definition	✓	✓	✓	✓
	Define function and functional unit	✓	✓	✓	
	Describe reporting options	✓	✓		
	Describe critical review process	✓	✓		
Functional unit	Describe the linkage between function of the product system and functional unit	✓	✓	✓	
	Explain the criteria for selection of the appropriate functional unit	✓	✓		
	Explain the concept of reference flow	✓	✓		
	Relate reference flows to functional unit	✓	✓		
System boundary	Explain the concept of process flow diagram and unit process for a product system	✓			
	Describe elementary material and energy flows (inputs and outputs) for a unit process	✓	✓		
	Explain the criteria for exclusion and/or inclusion of flows, unit processes and life cycle stages	✓	✓		
	Draw a system boundary diagram	✓	✓	✓	
Cut-off criteria	Explain the need for cut-off criteria	✓	✓		
	Describe the types of cut-off criteria	✓	✓		
	· Mass	✓			
	· Energy	✓	✓		
	· Environmental significance	✓	✓		
Input output	Explain the difference between EIO LCA and process based LCA	✓		✓	
	Explain the key advantages and disadvantages of both approaches	✓		✓	
Inventory	Structure and undertake a data collection exercise	✓	✓	✓	
	Determine data quality requirements, based on goal and scope	✓	✓	✓	
	Assess data quality against goal and scope requirements	✓	✓	✓	
	Relate inventory data to reference flows and functional unit	✓	✓		
	Outline the difference between environmental flows and economic flows	✓	✓		
	Undertake a carbon or other mass/energy balance on a unit process	✓	✓		
	Calculate inventory data elements and report calculations	✓	✓	✓	
	Validate inventory data	✓	✓	✓	
Uncertainty & data quality	Explain principles of uncertainty analysis	✓	✓	✓	
	Assess data quality using qualitative indicators	✓	✓	✓	
	Assess uncertainty using LCA tool	✓	✓		
	Apply uncertainty analysis in an LCA report, and explain the significance of results obtained.	✓	✓	✓	
Impact assessment	Explain the difference between the LCI and the LCIA	✓	✓	✓	
	Define Impact Categories, Category indicators and Characterisation	✓	✓	✓	
	Complete LCIA using first principles	✓	✓		
	Explain difference between midpoint and endpoint approaches	✓			
	Describe the difference between the individualist, hierarchist & egalitarian perspectives and their relevance	✓			
	Determine when to apply different impact assessment methods	✓	✓	✓	
	Explain potential issues with using other impact assessment methods in an Australian assessment	✓		✓	
	Complete midpoint and endpoint LCIA using full LCA software	✓			
	Explain the concept of normalisation	✓			
	Explain the meaning of normalised results	✓			
	Select an appropriate normalisation factor	✓			
	Report normliased results	✓			
	Apply different approaches to carbon accounting (e.g. minus in, plus out and zero flow approach)	✓	✓		
	Explain concept of weighting and grouping	✓		✓	

Appendix B: Summary of Life Cycle Practitioner Competencies (DRAFT) - continued

Topic	Competency	Full LCA	Single-stream LCA (e.g. carbon assessment, water footprint)	Streamlined LCA	Life Cycle Management / Life Cycle Thinking
Attributional & consequential	Describe the difference between attributional and consequential perspectives	✓	✓	✓	✓
	Explain the concept of marginal supply	✓			
	Discuss the three situations that deviate from standard assumption	✓			
	Apply consequential modelling in LCA	✓			
Co-products	Describe co-production	✓	✓	✓	
	Explain attributional method of allocating co-products - economically, by mass, by energy content etc	✓	✓		
	Describe the two methods of system expansion - full/not full utilisation of dependent co-product	✓	✓		
	Identify allocation methods used in background data	✓	✓	✓	
	Apply all ISO 14040:2006 allocation methods to multi-output, multi-input or multi-output & multi-input process	✓	✓		
Recycling	Explain how recycling is a form of co-production	✓	✓	✓	
	Explain how both allocation and system expansion can also be used for recycling	✓	✓		
	Apply different allocation approaches to recycling (e.g. PAS 2050 100:0/0:100, Ekvall models, loop models)	✓	✓	✓	
	Apply allocation to a recycling scenario	✓	✓	✓	
Interpretation	Apply triangulation. Relate environmental flows to process and environmental indicator	✓	✓		
	Assess audience and modify interpretation accordingly	✓	✓	✓	
Completeness	Describe the objective of the completeness check (all relevant info and data is available and complete)	✓	✓	✓	
Sensitivity	Apply sensitivity to LCA study	✓	✓	✓	
	Describe the objective of the sensitivity check (assess how the final results are affected by data uncertainty, allocation, or impact calculation)	✓	✓	✓	
Scenario analysis	Undertake scenarios analysis in order to illustrate a range of possible results	✓	✓		
Consistency	Describe the objectives of the consistency check (whether assumptions, methods and data are consistent with goal and scope)	✓	✓	✓	
	Explain other the elements of consistency that should be addressed (impact assessment, allocation, regional/temporal differences)	✓	✓	✓	
Conclusions, limitations, recommendations	Describe and apply a sequence for determination of conclusions (identify significant issues, evaluation, preliminary conclusions - taking into account goal and scope, data quality requirements, methodological and study limitations; if results are consistent, report as final conclusions)	✓	✓	✓	
Reporting	Apply LCA reporting requirements, as per ISO 14044:2006	✓	✓		
	Be aware of alternative report presentations	✓	✓		
	Present inventory data in a coherent and transparent fashion	✓	✓		
	Interpret characterisation results and present in a coherent and meaningful fashion.	✓	✓		
Peer review and ethics	Describe the ISO 14040/14044 peer review processes	✓	✓	✓	
	Identify when an ISO 14040/14044 peer review is required	✓	✓	✓	
	Describe the importance of integrity and objectivity	✓	✓	✓	
	Explain the difference between professional judgment and personal values	✓	✓	✓	
Application of LCA	Apply LCA in a decision making framework	✓	✓	✓	✓
	Describe approaches to economic and social assessment	✓		✓	✓
Life cycle management	Name and define the principal sustainability elements (i.e. social, environmental, economical)	✓	✓	✓	✓
	Distinguish between life cycle thinking, LCM, LCA and LCC	✓	✓	✓	✓
	Identify relevant life cycle and environmental standards	✓	✓	✓	✓
	Identify the project's environmental hot spots	✓			✓
	Investigate the root causes of the identified hot spots	✓			✓
	Develop strategies to mitigate the hot spots				✓
	Quantify the life cycle costs of each developed strategy				✓
	Identify the social impacts of each developed strategy				✓
	Develop decision criteria				✓
	Weight the decision criteria				✓
	Perform multi-criteria assessment of the developed strategies				✓
	Select the best performed strategy				✓
	Estimate the effect of limited data availability on outcomes and decision-making	✓			✓
	Evaluate the trade-offs and burden-shifting of the selected strategy	✓			✓