STUDY REPORT

SR 272 (2012)

Review of how Life Cycle Assessment is used in International Building Environmental Rating Tools – Issues for Consideration in New Zealand

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Preface

This is the second of a series of reports prepared to better understand the assessment of environmental impacts of construction materials and products in building environmental rating tools. The work has been undertaken to inform a Plan to move to a more holistic, robust assessment process that considers materials and products in the context of the building in which they are used.

This report focuses on how international building environmental rating tools use Life Cycle Assessment (LCA) and Environmental Product Declarations (EPD) in the assessment process and what features should be considered for a New Zealand scheme.

Acknowledgments

This work was funded by the Building Research Levy. Olivier Muller, Director at PricewaterhouseCoopers in Paris, Michael Dax, Director at DGNB and David Baggs, CEO of Global GreenTag Pty Ltd are thanked for information they have provided for this report.

Note

This report is intended for manufacturers and designers with an interest to understand how environmental profiling techniques are used in environmental assessment of buildings overseas. It is also of interest to the New Zealand Green Building Council (NZGBC).

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BRANZ Study Report SR 272 David C Dowdell

Reference

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Abstract

Life cycle assessment (LCA) is a method that can help deliver the whole of life based environmental profiling tools desired by the New Zealand construction industry in order to provide a fairer basis for comparison. There are already examples of its application in international building environmental rating tools.

It is therefore of interest and timely to review examples of building environmental rating tools that already utilise LCA within their assessment processes in order to understand how its outputs are used and the extent to which they are applied for consideration in New Zealand.

In this report, examples of international building environmental rating tools have been reviewed and a list of desirable attributes for a New Zealand scheme compiled.

Terms and acronyms

ALCAS: Australian Life Cycle Assessment Society.

ASMI: Athena Sustainable Materials Institute, Canada.

ASSOHQE: Association pour la Haute Qualité Environnementale

Athena EcoCalculator: Assessment tool for building assemblies in residential and commercial applications, developed by ASMI.

Athena Impact Estimator: Assessment tool to assess whole buildings in North America a the conceptual design stage, developed by ASMI.

AusLCI: Australian Life Cycle Inventory, a developing life cycle database.

BAU: Business as Usual.

BEES: Building for Environmental and Economic Sustainability – a web based platform developed by NIST for comparison of materials.

BIM: Building Information Management.

BOMA: Building Owners and Managers Association, Canada.

BOMA Best: Rating tool for existing buildings in Canada operated by BOMA.

BPIC: Building Products Innovation Council.

BRE: Building Research Establishment.

BREEAM: Building Research Establishment Environmental Assessment Method, a rating tool developed in the UK by BRE.

CASBEE: Comprehensive Assessment System for Built Environment Efficiency, the building environmental rating tool used in Japan.

CEN: European Committee for Standardisation

CGBC: China Green Building Council.

CSTB: French Secretariat of the Technical Committee of the INIES Base which administers a database of nearly 800 construction products.

DEWHA: Department of the Environment, Water, Heritage and the Arts (now the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC)), Australia.

DGNB: Deutsche Gesellschaft für Nachhaltiges Bauen (the German Sustainable Building Council).

ECD E&E: ECD Energy & Environment Canada Limited.

ECO – EPD: European initiative to provide a platform for standardised EPD.

ELCD: European Life Cycle Database.

EPD: Environmental Product Declaration.

ES CAP: Ecospecifier Cautionary Assessment Process, part of the LCARate assessment process used by Global GreenTag Pty Ltd under licence from Ecospecifier Pty Ltd.

Estidama Pearl: Building environmental rating tool in the Middle East.

ESUCO: European Sustainable Construction Database.

FDES: Fiche de Déclaration Environnementale et Sanitaire (French term for EPD)

GBCA: Green Building Council of Australia.

GBRS: Green Building Rating System, rating tool operated by DGNB.

Green Globes: Rating tool developed in Canada operated by ECD E&E.

Green Star: Suite of green building rating tools managed by Green Building Councils covering various building typologies. Reference to Green Star in this report concerns Green Star Office in New Zealand unless otherwise stated.

HQE: Haute Qualité Environnementale, the French green building rating tool developed by ASSOHQE.

IBU: German Institute for Construction and the Environment, an EPD Registry provider.

iiSBE: International Initiative for a Sustainable Built Environment.

ILCD: International reference Life Cycle Data system.

ISO: International Organisation for Standardisation.

JaGBC: Japan Green Building Council.

JSBC: Japan Sustainable Building Consortium.

LCA: Life cycle assessment.

LCA Design: An Australian building level design tool that uses LCAs of branded products.

LCANZ: Life Cycle Association of New Zealand.

LCARate: A service provided by Global GreenTag Pty Ltd that assesses building materials using LCA.

LEED: Leadership in Energy and Environmental Design, the building environmental rating tool of USGBC.

NIST: National Institute of Science and Technology, USA.

NZGBC: New Zealand Green Building Council.

Oekobau.dat: German building products LCA database.

PCR: Product category rules.

SAC: Sustainability Assessment Category, used in the LCARate assessment process by ecospecifier.

SBTool: Building environmental rating tool developed by iiSBE.

TASC: Thai Association for Sustainable Construction.

USGBC: United States Green Building Council.

EXECUTIVE SUMMARY

Materials credits in green building rating systems have traditionally evolved from a consensus based understanding of environmental issues (Trusty & Horst; 2002). Workshops with the New Zealand construction industry in 2010 showed a desire for more robust, flexible whole of life based environmental profiling tools in order to provide a fairer basis for comparison of materials.

Life cycle assessment (LCA) is a method that can help deliver the whole of life based environmental profiling tools desired by the New Zealand construction industry. There are already examples of its application in international building environmental rating tools. Currently, it does not feature in Green Star NZ although recently in Australia, the Green Building Council of Australia (GBCA):

- Issued a Technical Clarification that recognises an ISO 14040 compliant LCA or an ISO 14025 / EN 15804 compliant Environmental Product Declaration (EPD) issued by a GBCA recognised product certification scheme as evidence of recycled content for as-built projects. Global GreenTag^{CertTM} LCARate (reviewed in this report) is cited as satisfying these requirements.
- Has published a discussion paper requesting comments by 15th August 2012 on using LCA in Green Star.

It is therefore of interest and timely to review examples of building environmental rating tools that already utilise LCA within their assessment processes in order to understand how its outputs are used and the extent to which they are applied for consideration in New Zealand.

In this report, seven international building environmental rating tools (and Global GreenTag^{CertTM} LCARate / LCADesign - a "local" example of a product rating and building design tool) have been reviewed comprising the following:

- North America: LEED, Green Globes.
- Europe: BREEAM, GBRS and HQE.
- Australasia: CASBEE and Global GreenTag^{CertTM} LCARate / LCA Design.
- Global: SBTool.

Recommendations arising from this review to be considered for a New Zealand scheme are summarised as below:

- Reward use of materials for which critically reviewed LCAs (to ISO 21930) and EPD are available (either generic or specific)
- Use weightings to favour third party certified EPD for specific products.
- Report on multiple environmental impacts to be selected from the following list:
    - *Emissions*: global warming, stratospheric ozone depletion, acidification, photochemical oxidant formation, eutrophication.
    - *Resources*: depletion of non-renewable energy resources, depletion of mineral resources, water extraction, waste (total/hazardous), depletion of biotic resources, land use, primary energy (renewable/non-renewable).
    - *Toxicity*: human toxicity, ecotoxicity to water (freshwater/marine), ecotoxicity to land, radioactivity.
- Concentrate on foundation, structure, external envelope and floors.
- Assess whole buildings across their whole life, incorporating materials, in use impacts (energy, maintenance) and end of life.

- Establish a consistent basis for methodological rules.
- Ensure materials data underpinning assessment process are freely available to ensure an open and transparent process.
- Develop whole of life, whole building benchmarks to provide a basis for evaluation of designs. Award points according to how well the designed building performs against an appropriate benchmark.
- Use resulting data as the basis of provision of tools to help designers and specifiers.

These recommendations will be considered further in the New Zealand Environmental Profiling Plan being developed for this project which will be available for consultation later in 2012.

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1. INTRODUCTION

BRANZ and Arup organised environmental profiling workshops with the New Zealand building industry in 2010. Their purpose was to better understand the building industry's perspective and priorities on environmental profiling of construction materials. The results were reported in an earlier BRANZ report (Jaques et al., 2011) and are summarised here:

- There is a desire for whole of life based environmental profiling tools that could be utilised not only by industry but by wider New Zealand stakeholders including Government, the New Zealand Green Building Council (NZGBC), ecolabelling schemes and other initiatives.
- The tools need to be robust enough to ensure unbiased fair comparison, yet flexible enough to encompass the different applications across a diverse and varied design and manufacturing community.

Trusty & Horst (2002) note that defining sustainable materials and encouraging their use seems to be one of the biggest challenges for the developers of green building rating systems, because:

- Material credits have typically evolved from a consensus-based understanding of environmental issues which in some cases have taken on an aura of conventional environmental wisdom that does not always stand up to objective analysis.
- The risk of confusing means and ends, with the means becoming objectives in their own right to the possible detriment of environmental performance.

An example that illustrates both these points is recycling. The use of recycled material is generally assumed to result in reduced environmental impact but this may not always be the case. Recycling is a means to reduce flows from and to nature (with an associated potential reduction in environmental impact arising from the activity) but over time, it has become an objective in its own right (regardless of whether it actually delivers environmental benefit).

Life cycle assessment (LCA) is a tool that can help address these issues and contribute to a more objective basis for decision making within green building rating tools. Indeed, an Australian Government report for DEWHA[1] published in 2006 which looked into ways to improve the environmental sustainability of building materials, recommended LCA as the "most useful approach for the assessment of energy and materials flows impacts in whole building tools" (Woodard, 2011).

It is a tool which is finding increasing application in building environmental rating tools globally. Whilst not yet featuring in GreenStar (in New Zealand or Australia), the Green Building Council of Australia (GBCA) recently published a discussion paper[2], seeking comments by 15th August 2012, about integrating LCA into its Green Star building environmental rating tool (GBCA; 2012). The paper states that incorporating an LCA based methodology into the Green Star materials category may encourage:

- Assessment of the environmental impact of selecting one material over others within a building.
- Selection of materials with a lower environmental impact.
- Reductions in the quantity of materials used.

[1] Department of the Environment, Water, Heritage and the Arts, now the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC).

[2] Available at www.gbca.org.au/green-star/materials-category/discussion-paper-life-cycle-assessment-in-green-star/34051.htm

- Increased reuse of materials, and use of materials containing recycled content; and
- Expansion of the Materials credits to address the impact of materials that go beyond the bounds of the current credits.

The potential benefits are anticipated to be:

- Delivery of better environmental outcomes.
- Continued assistance in the transformation of the Australian materials industry.
- Greater transparency, consistency and cost effectiveness.

Furthermore, in a Technical Clarification issued in June 2012[3], the GBCA acknowledged an ISO 14040 (ISO; 2006a) compliant LCA or an ISO 14025 (ISO; 2006b)/ EN 15804 (CEN; 2012) compliant Environmental Product Declaration (EPD) issued by a GBCA recognised product certification scheme as evidence of recycled content for as-built projects. Global GreenTag^{CertTM} LCARate (reviewed in this report) is cited as satisfying these requirements.

Thinking and development in Australia as a result of the GBCA consultation provide an important reference for New Zealand due to the likely benefits that would accrue from a similar approach to use of LCA/EPD in Green Star across the Tasman. It is therefore useful (and timely) to better understand how international building environmental rating tools use LCA (and public declarations of the environmental impact of products based on LCA called EPD) as part of their assessment processes and provide recommendations for how LCA and EPD can be used as part of an assessment process in Green Star in New Zealand.

2. SCOPE OF THE REPORT

Seven current building environmental rating tools (and Global GreenTag^{CertTM} LCARate / LCADesign – a "local" example of a product rating and building design tool) have been reviewed, two of which have been developed in North America (LEED and Green Globes), three in Europe (BREEAM, GBRS and HQE), two in Australasia (CASBEE and Global GreenTag^{CertTM} LCARate / LCA Design) and one global tool (SBTool).

Some of these tools are increasingly being applied outside the region in which they have been developed, and increasingly applied in important growing export markets for New Zealand such as China. Examples include:

- DGNB which developed GBRS has an international arm (DGNB International) that has co-operation contracts with Beijing DGNB Green Building Consulting Company Limited in China and the Thai Association for Sustainable Construction (TASC) in Thailand.
- The first BREEAM assessment in China was carried out in 2010 for a 5 storey shopping mall totalling 109,000 m^2 as part of a 500,000 m^2 mixed use development consisting of a hotel, offices and retail called Wuhan Tiandi[4].
- LEED has been in China since before 2005[5] and in 2010, more than 4.5 million m^2 of gross floor area was LEED certified (IBE; 2011). A Memorandum of Understanding was signed between the United States Green Building Council (USGBC) which developed LEED and the China Green Building Council (CGBC) in 2011 to further joint research work. China has a developing green building rating system called the "three star

[3] www.gbca.org.au/green-star/technical-clarifications-cir-rulings/
[4] www.bre.co.uk/news/First-BREEAM-project-commences-in-China-653.html
[5] www.sustainablebusiness.com/index.cfm/go/news.feature/id/1289

system" which has parallels with LEED and the Japanese CASBEE rating system (IBE; 2011).

- Global GreenTag^{CertTM}, which licenses Global GreenTag^{CertTM} LCARate and LCADesign, has agents in South East Asia and China (as well as The Middle East, South Africa, Europe and South America).

This research provides an overview of how LCA is applied in building environmental rating tools rather than being a comprehensive assessment. Specifically, the research does not include:

- Building environmental rating tools that do not include use of LCA outputs yet, such as Estidama Pearl in the Middle East.
- Software tools that consider materials, assemblies or buildings using only or primarily LCA outputs without assessing other factors, examples of which include:
    - BEES (Building for Environmental and Economic Sustainability), developed by the National Institute of Science and Technology (NIST), USA, which provides a free web-based platform for comparison of materials (www.nist.gov/el/economics/BEESSoftware.cfm) .
    - Athena EcoCalculator for Assemblies, developed by the Athena Sustainable Materials Institute (ASMI), Canada, which provides a free assessment of different assemblies/specifications for residential and commercial applications (www.athenasmi.org/our-software-data/ecocalculator/).
    - Athena Impact Estimator for Buildings, developed by ASMI, which facilitates assessment of whole buildings in North America at the conceptual design stage (www.athenasmi.org/our-software-data/impact-estimator/).
- A comparison of building environmental rating tools to each other. This has been covered by others, including Reed et al. (2009) and LET (2012).

3. METHODOLOGY

Building on earlier work reported by Jaques et al. (2011), building environmental rating tools that incorporate LCA used in different parts of the world are reviewed in this report in order to better understand:

- The scope and extent of use of LCA within the tool.
- The process by which LCA is used.
- The outputs and how these lead to award of credits or points within the assessment process.

Geographically, based on region of origin, the reviewed tools are as follows (illustrated in Figure 1):

- North America: LEED, Green Globes (Section 3.1).
- Europe: BREEAM, GBRS and HQE (Section 3.2).
- Australasia: CASBEE and Global GreenTag^{CertTM} LCARate / LCA Design (Section 3.3).
- Global: SBTool (Section 3.4).

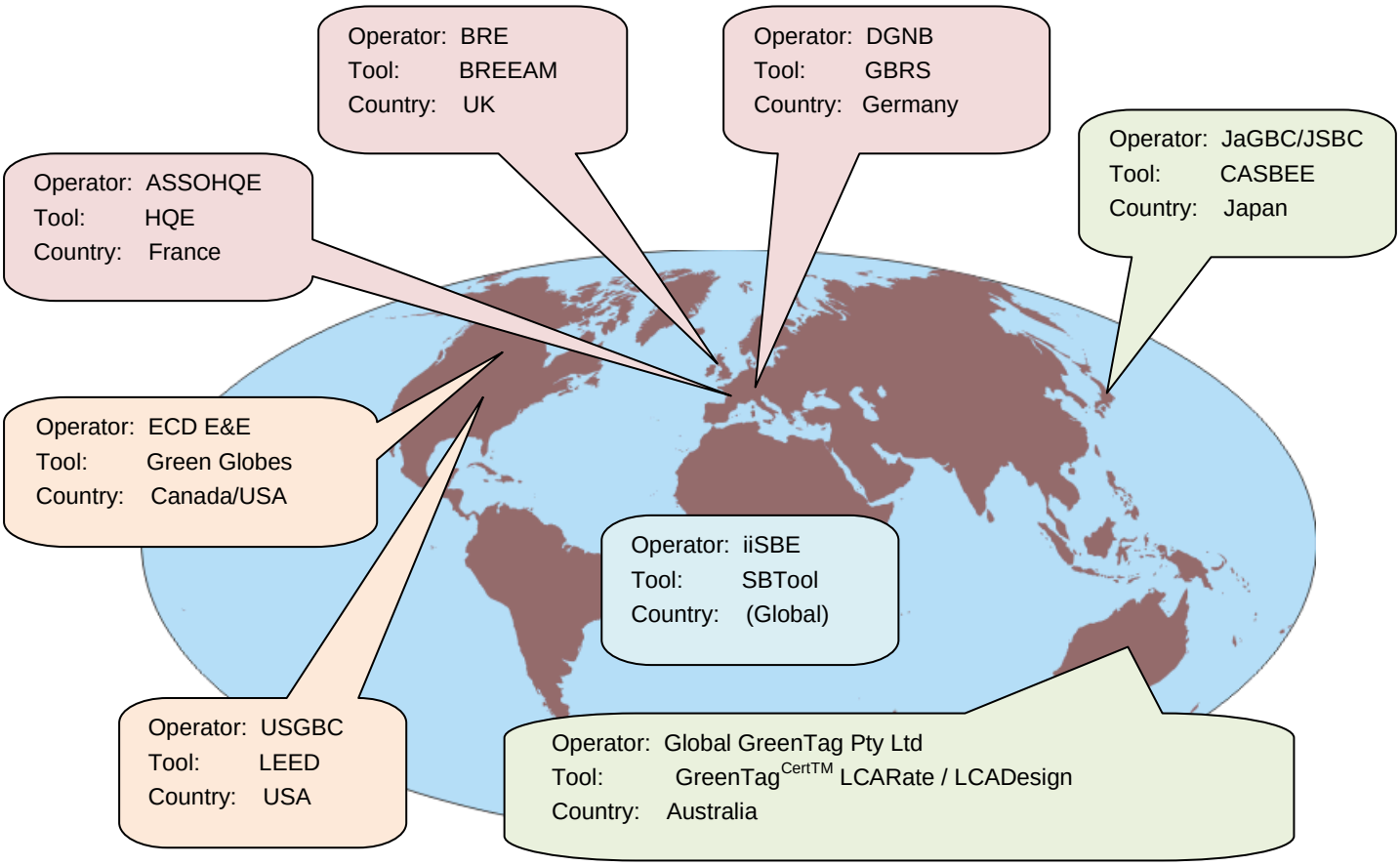

Figure 1. Reviewed Tools by Country of Origin[6]

3.1 North America

Two building environmental rating tools developed in North America are reviewed in this section – these being LEED, initially developed in the USA, and Green Globes, initially developed in Canada.

3.1.1 USGBC (LEED)

Currently, the LEED Pilot Credit Library[7] is being used as a testing ground for credits involving LCA which are available for project types including new construction, core & shell, retail, hospitality and healthcare, for example.

There are currently two pilot credits involving LCA, these being Pilot Credit 61: *Material Disclosure and Assessment* and Pilot Credit 63: *MR – Whole Building Life Cycle Assessment.*

[6] World map obtained from www.freeworldmaps.net/

[7] Pilot Credits in LEED facilitate the introduction of new prerequisites and credits, and provide an opportunity for stakeholders to engage in the development of the LEED rating system. Projects may register to take part in a pilot involving a specific pilot credit and may earn one point under the Innovation in Design Credit 1 (IDc1) or Innovation in Operations Credit 1 (IOc1) after meeting the credit requirements or demonstrating that the credit is in need of major revision (by completing required documentation and uploading it to the credit in LEED Online for review).

Whilst the exact wording of the stated intent of both pilot credits varies slightly, it is "to increase the use of products and materials with life cycles and ingredients that improve overall environmental, economic and social performance".

Pilot Credit 61: *Material Disclosure and Assessment* provides two options as follows:

- ***Option 1: Assessment and optimisation of non-structural products*:** Use a minimum of 20% by cost, permanently installed non-structural products and elements meeting at least one of the criteria in Table 2.
- ***Option 2: Assessment and optimisation of structure and enclosure:*** Use a minimum of 20% by cost, structure and enclosure meeting one of the criteria in Table 1. Materials contributing to the option must represent at least three product types.

Table 1. Criteria required for Pilot Credit 61

EPD Pathway	Requirement	Weight (applied to cost)
Product Specific Declaration	Products with a publically available, critically reviewed LCA compliant with ISO 21930 (ISO; 2007)	50
Industry Wide (Generic) EPD	Third party certified Type III EPD including external verification, where the manufacturer is explicitly recognised as a participant by the program operator.	100
Product Specific Declaration	Products with a third party certified Type III EPD including external verification.	200

The scope of any EPD must be cradle to gate.

Pilot Credit 63: *MR – Whole Building Life Cycle Assessment* requires that:

- For new construction buildings or additions, a minimum of a 10% reduction is achieved for at least three of the following six impact categories in comparison to a reference building:
    - Global warming.
    - Stratospheric ozone depletion.
    - Acidification.
    - Eutrophication.
    - Photochemical oxidant formation.
    - Depletion of non-renewable energy resources.
- Impact categories not reduced must be maintained at the same level as the reference building in order to achieve the credit.
- The scope is limited to structure and enclosure materials (since these are often the first decisions made on a project and there is greater availability of LCA data for these materials).
- To qualify, the reference and final design buildings must be of comparable size and function, as well as the same orientation and operating energy performance (as defined in Energy and Atmosphere Prerequisite Minimum Energy Performance). Service life of the buildings must also be the same (at least 60 years) to fully account for maintenance and replacement.

- The same LCA tools must be used with the same datasets to evaluate reference and final design buildings.
- Data sets must be compliant with ISO 14040 (ISO; 2006).

Summary of Features	• **Recognises publicly available, critically reviewed LCAs (to ISO 21930) and EPD as mechanisms for providing greater transparency about the environmental impacts associated with materials and products.** • **Specific rather than average, and third party certified rather than critically reviewed are rewarded with greater recognition.** • **Requires reporting on multiple environmental impacts, based on emissions to the environment and use of resources.** • **Requires a target improvement of 10% in at least three impact categories (whilst not increasing impacts in other categories) to be recognised.** • **Limited to structure and enclosure materials.**
Positive attributes for New Zealand to consider	• Rewards use of materials for which critically reviewed LCAs (to ISO 21930) and EPD are available (either generic or specific) • Uses weightings to favour third party certified EPD for specific products. • Requires reporting on multiple environmental impacts.

3.1.2 ECD E&E (Green Globes)

Green Globes began being developed in the mid 1990s based on BREEAM (Section 3.2.1) and became an online rating and assessment tool in 2000. There are two versions:

- A tool for new buildings operated by ECD Energy & Environment Canada Limited (ECD E&E) – reviewed for this report.
- A tool for existing buildings called BOMA Best operated by the Building Owners and Managers Association Canada (BOMA).

In the USA, the Green Building Initiative licenses the tool.

Green Globes uses a points based system broken down as shown in Table 2 (ECD E&E; 2004).

Table 2. Allocation of Points in Green Globes

Assessment Area		Points Score Available	%
A	Project Management	50	5
B	Site	115	11.5
C	Energy	380	38
D	Water	85	8.5
E	Resources	100	10
F	Emissions, effluents & other impacts	70	7
G	Indoor environment	200	20

Under Section E (Resources), 55 of the 100 points available are assessed either entirely or in part by outputs of LCA, meaning that LCA contributes to about 5% of available points. A summary of points available in the Resources section is summarised in Table 3.

Table 3. Points from LCA Outputs in Section E of Green Globes

Section E Sub-Assessment Area		Points Score Available	*Objective* and Requirements
E.1	Low Impact Systems & Materials	40	*To select materials with the lowest life cycle environmental burden and embodied energy.* Select materials that reflect the results of a "best run" LCA for the following: • Foundation and floor assembly and materials. • Column and beam or post and beam combinations, and walls. • Roof assemblies. • Other envelope assembly materials (cladding, windows, etc).
E.2	Minimal Consumption of Resources	15	*To conserve resources and minimise the energy and environmental impact of extracting and processing non-renewable materials.* • Specify used building materials and components. • Specify materials with recycled content. • Specify materials from renewable sources that have been selected based on an LCA. • Specify locally manufactured materials that have been selected based on an LCA. • Use lumber and timber panel products which originate from certified and sustainable sources.
E.3	Reuse of Existing Buildings	15	No reference to LCA
E.4	Building Durability, Adaptability and Disassembly	15	
E.6	Reduction, Reuse & Recycling of Demolition Waste	5	
E.7	Recycling and Composting Facilities	10	

Thus, use of LCA outputs in Green Globes is restricted to part of the materials assessment only. The user is required to show that the best materials from an environmental perspective have been selected through iterative use of LCA (similar to the approach for Pilot Credit 63 in LEED).

Summary of Features	• **LCA use restricted to materials only.** • **Around half the points available in this category are based on LCA outputs.** • **Definitions in the Rating System and Program Summary are vague e.g. a list of impacts required to be reported is not provided.**
Positive attributes for New Zealand to consider	• Concentrate on foundation, structure, external envelope and floors.

3.2 Europe

3.2.1 BRE (BREEAM)

The UK based Building Research Establishment (BRE) developed the BRE Environmental Assessment Method (BREEAM) in the late 1990s to assess building environmental performance across 14 criteria (Reet et al.; 2009). Materials are considered separately from operational impacts arising from energy use and the number of credits available varies with the type of building being considered.

BREEAM awards credits based on assessment of the environmental life cycle impact of the following building elements[8]:

- External walls.
- Windows.
- Roof.
- Upper floor slab.
- Internal walls.
- Floor finishes/coverings.

Other parts of the building such as the foundations, building services and some of the fitout eg. ceilings and doors are not included (CPA, 2012).

Under the current BREEAM process, if a material or product that forms part of a building element has an EPD (covering at least part of the whole life cycle), this can be used to increase the contribution that the element makes to the assessed building's material performance (BRE; 2011). This increased contribution or "uplift" is a weighting that favours materials or products with an EPD. The amount of the weighting varies depending on the contribution the product with the EPD makes to a building element, the existing Green Guide rating of the element (A+ and A ratings get more of an uplift) and the scope of the EPD (a cradle to grave EPD gets more of an uplift) (CPA; 2012).

The uplift obtained by using products with EPD reflects the fact that an EPD is available. It does not take into account the impacts described in the EPD (CPA; 2012).

3.2.1.1 The Green Guide to Specification

The Green Guide to Specification[9] or "Green Guide" underpins the LCA component of BREEAM and contributes 6% of the BREEAM score. Materials and components in the

[8] Not necessarily applicable for all building types.
[9] http://www.bre.co.uk/greenguide/

Green Guide are arranged into the following elements to assist designers and specifiers to compare alternative construction systems within each element:

- External walls
- Internal walls and partitions
- Roofs
- Ground floors
- Upper floors
- Windows
- Insulation
- Landscaping
- Floor finishes

Summary rankings for typical constructions categorised under each of the above building elements are provided on a scale from A+ to E, where A+ represents the least environmental impact, and E the most environmental impact of construction systems in a building element category. This summary ranking is based on individual rankings (using the same scale) for the following environmental impacts, reported as outputs of LCA:

- Climate change
- Water extraction
- Mineral resource extraction
- Stratospheric ozone depletion
- Human toxicity
- Ecotoxicity to Freshwater
- Nuclear waste (higher level)
- Ecotoxicity to land
- Waste disposal
- Fossil fuel depletion
- Eutrophication
- Photochemical ozone creation
- Acidification

LCAs on which the rankings are based must be carried out in accordance with BRE's Environmental Profiles methodology (BRE; 2007). The summary ranking is obtained through a process of:

- Normalisation – by comparing the calculated impact of a material, product or assembly against the average impact of a European citizen in 1995, using the comparators in column B in Table 4. Normalisation is carried out in order to calculate an Ecopoints score, which provides the basis for certified EPD provided by BRE. It is also used towards obtaining an A+ to E ranking in the Green Guide (which is used in BREEAM) for assemblies considered across the life cycle.
- Weighting – an additional step used to obtain a summary Green Guide ranking from A+ to E for different assemblies across the life cycle. Weightings are applied to the normalised data, based on the view of a panel of ten international experts whose responses are aggregated to create the weightings in column C of Table 4 (BRE; 2007). Weightings are not used in the publication of EPD at the product/material level.

Table 4. Summary of Normalisation and Weightings used in BRE's Environmental Profiles Methodology

A. Environmental Issue	B. Normalisation (per Citizen Unit)	C. Weighting (%)
Climate Change	12.3 t CO_2 eq. (100 year)	21.6
Ozone Layer Depletion	0.217 kg CFC-11 eq.	9.1
Human Toxicity	19.7 tonne 1,4-DB eq.	8.6
Fresh Water Aquatic Ecotoxicity	13.2 tonne 1,4-DB eq.	8.6
Terrestrial Ecotoxicity	123 kg 1,4-DB eq.	8.0
Photochemical Oxidation	21.5 kg C_2H_4 eq.	0.2
Acidification	71.2 kg SO_2 eq.	0.05
Eutrophication	32.5 kg PO_4 eq.	3.0
Fossil Fuel Depletion	6.51 tonnes oil eq. (toe)	3.3
Solid Waste	3.75 tonnes solid waste	7.7
Radioactivity	23 700 mm^3 high level waste	8.2
Minerals Extraction	24.4 tonnes minerals extracted	9.8
Water Extraction	377 m^3 water extracted	11.7

Summary of Features	• **Underpinned by a published methodology.** • **Assessment of materials based on an LCA database that considers 13 impacts.** • **Industry average LCAs form the basis of Green Guide ratings rather than specific LCAs of products.** • **Individual impacts and a summary impact (obtained using normalisation and weighting) are rated on a scale A+ to E to assist designers.** • **Impacts of typical constructions are used to calculate points (using normalisation and weighting) which determines the credits obtained in the materials assessment.** • **The process underpins a service to provide independently certified EPD.** • **Products with EPD get a credit uplift, the amount of the uplift depends on the impact of the product in the building element, the element rating and the scope of the EPD. This recognises the existence of the EPD and does not consider the impacts reported in it.**
Positive attributes for New Zealand to consider	• Published methodology for consistent application of methodological rules. • Requires reporting across a range of environmental impacts covering environment, toxicity, resources and waste. • Primarily covers building structural and external envelope elements. • Use data to provide tools to help designers and specifiers (the Green Guide). • Recognises and provides an uplift on credits available for products with EPD.

3.2.2 DGNB (GBRS)

DGNB – the German Sustainable Building Council – launched its Green Building Rating System (GBRS) in 2008. Since October 2010, the system has been available internationally, by adapting the certification system to fit building practices and statutory frameworks of the countries in which the system is being applied.

The scheme assesses different types of new construction and is increasingly being expanded to consider refurbishment of existing building types.

GBRS awards points across the following topics (DGNB; 2010):

- Ecological Quality (22.5%);
- Economic Quality(22.5%);
- Socio-cultural and functional Quality (22.5%);
- Technical Quality (22.5%);
- Quality of the (planning and construction) process (10%).

In total, there are 48 active credits (DGNB; 2011) under these topics (plus Location which is considered separately) each of which has a weighting from one to three to account for differences in importance of the credit to the sustainability of the building.

Criteria under Ecological Quality are as follows, with those based on LCA in bold (DGNB; 2011):

- **Climate change**
- **Stratospheric ozone depletion**
- **Photochemical ozone creation**
- **Acidification**
- **Eutrophication**
- Local environmental impact
- Sustainable use of resources/wood
- **Non-renewable primary energy (on a net calorific value basis)**
- **Total primary energy and proportion of renewable primary energy (on a net calorific value basis).**
- Drinking water demand and waste water volume.
- Land use.

LCA forms an integral part of the GBRS, contributing 13% of the total building rating (Braune & Wittstock; 2011) and much higher than BREEAM and Green Globes. The use of LCA in this way has been made possible by the increasing availability of consistent LCA datasets derived from a framework and calculation rules for the manufacturing stage and other stages in the life cycle.

This has been achieved through the launch of an EPD program by the German Institute of Construction and Environment (IBU) and the German Ministry of Building and Transport, which supported the development of a methodology report and the German building products LCA database (called “Oekobau.dat”) that resulted from this initiative.

The Oekobau.dat database underpins use of LCA within the GBRS (as well as the European Sustainable Construction database ESUCO[10]) and is based on the ELCD[11] format, the fore runner of the globally developing ILCD[12]. It now contains over 850 datasets of construction materials, including data from trade associations and producer specific third party verified IBU EPD.

For the LCA aspects of the certification, the performance of a building is modelled across its life cycle (including manufacture and transport of materials, construction, use of the building (including energy use, replacement of building elements, maintenance, repairs) and end of

[10] Michael Dax, Director International System, personal communication.
[11] European Life Cycle Database
[12] International reference Life Cycle Data system

life (after 50 years for offices and 20 years for industrial units), and compared to target values for benchmark buildings for each of the above impacts.

Benchmarks used for commercial buildings are typically on a net usable floor space – year basis[13] such as:

- Climate change: kg CO_2 eq. /m^2year[14].
- Non-renewable primary energy: MJ/m^2year.

Benchmark buildings are based on materials data meeting ISO 14040 (ISO; 2006) and building performance as required by the German Energy Conservation Regulations for Buildings (BVBS; 2009). The scheme started by defining a benchmark for office buildings and then went on to develop further benchmarks for residential, retail, hotels, schools[10].
Points are then assigned (out of 10) according to how well the building performs against the benchmarks for each of the environmental impacts according to the following scale (DGNB; 2011):

- 1 point – Limit value (legal requirement, construction standard).
- 5 points – Reference value (based on calculated benchmarks, state of the art).
- 10 points – Target value (best practice).

The GBRS uses a whole building, whole of life assessment method based on LCA which does not consider material and operational aspects of a building separately. This approach is in line with the requirements of European standards such as EN 15 804 (NSAI; 2012) and EN 15 978 (NSAI; 2011).

These standards underpin a current European initiative to provide a platform for standardised EPD across Europe (the ECO – EPD initiative) in order to achieve greater cross border consistency. ALCAS[15] and LCANZ[16], of which BRANZ is a member, are currently in discussion to set up an equivalent EPD system for Australia and New Zealand.

[13] Industrial units tend to be on a volume basis (m^3).
[14] This is the unit over the life of the building which is based on an annualised unit of kg CO_2 eq. /m^2/year, as advocated by the World Green Building Council (Madew; no date)
[15] Australian Life Cycle Assessment Society
[16] Life Cycle Association of New Zealand

Summary of Features	• **Outputs of LCA contribute 13% to the total rating for a building, by reporting on a range of impacts related primarily to the environment and energy.** • **Underpinned by a comprehensive construction database of materials, generated in part by an EPD programme (IBU).** • **Materials and operational impacts are considered together with other parts of the life cycle and compared to defined benchmark building values.** • **Units for commercial buildings are on a "net usable floor space * year" basis.** • **Points assigned against each environmental impact according to a scale from "legal requirement" to "best practice".**
Positive attributes for New Zealand to consider	• Uses a whole of life, whole of building approach compliant with EN 15 804 which provides core rules for declaration of environmental performance of building products (aiding consistency and transparency). • LCA is an integral part of the assessment process, in which materials are not separate from the use or end of life of the building – they all contribute to environmental impacts of the assessed building which are quantified and compared to appropriate building benchmarks. • Building benchmarks developed to form basis of comparison, with points awarded. • Range of environmental impacts reported with points awarded depending on whether a designed building meets "legal compliance" or "best practice" relative to the benchmark. • Standardisation of EPD is currently ongoing and should lead to greater international consistency between EPD schemes. • Data underpinning materials are freely available, open and transparent.

3.2.3 ASSOHQE (HQE)

The Haute Qualité Environnementale (HQE) is a French green building rating tool developed by the Association pour la Haute Qualité Environnementale (ASSOHQE). Of the 14 targets under the scheme, one concerns the "choice of integrated products and building materials"[17].

In 2004, a national standard (NF P01-010) for EPD was developed which has subsequently formed the basis for the recently published European Standard EN 15 804 for EPD of construction products (NSAI; 2012).

Currently, nearly 800 EPD[18] have been developed covering around 5000 products as the standard allows declarations for individual products or an average of similar products. These are located freely in a database located on the www.inies.fr website which is administered by the Secretariat of the Technical Committee of the INIES Base (CSTB).
These EPD form the basis for the calculation of the impact of materials on the environmental performance of buildings across the life cycle within HQE.

By 2017, it will become a requirement that an EPD is developed if a manufacturer or importer of building products wants to make a public environmental claim about their product. This will help to more closely align NF P01-010 with the European standard EN 15 804[19].

[17] Taken from www.concept-bio.eu/hqe-approach.php
[18] In France, EPD are termed Fiche de Déclaration Environnementale et Sanitaire (FDES)
[19] Olivier Muller, Directeur, Département Développement Durable et Changement Climatique at Pricewaterhouse Coopers LLP, personal communication.

Summary of Features	• **Development of a national standard for EPD has resulted in extensive development of EPD for construction sector products, and a dedicated freely available database.** • **EPD provide the basis for assessment of materials in construction.** • **By 2017 at the latest, it will be a requirement that companies wishing to make an environmental claim about a locally manufactured or imported building product into France will need to provide an EPD.**
Positive attributes for New Zealand to consider	• EPD are driving the process of materials assessment and provide the basis of a freely available database of materials. • Based on EN 15 804 which provides core rules for declarations of environmental performance of building products (aiding consistency and transparency).

3.3 Australasia

3.3.1 JaGBC / JSBC (CASBEE)

CASBEE[20] is the green building rating tool developed by the Japan Green Building Council (JaGBC) and the Japan Sustainable Building Consortium (JSBC) which can be applied to new construction and renovation. In 2008, it was updated to include quantitative evaluation of life cycle carbon dioxide emissions, to help reduce emissions associated with operational energy and embodied emissions arising from manufacture of construction materials. A further update was made in 2010, which includes labelling buildings with superior low carbon performance (JaGBC/JSBC; 2011). The driver for these updates has primarily been:

- Japan's Kyoto Protocol targets (25% reduction in greenhouse gas emissions by 2020 and 80% by 2050, based on 1990 levels) and recognition of the significant contribution the built environment makes to Japan's greenhouse gas emissions.
- The need for tools to quantify this impact and evaluate options for reduction.

The CASBEE life cycle carbon dioxide ($LCCO_2$) method (JSBC; 2010) includes assessment of the carbon dioxide emissions in each of the following stages:

- Construction – including manufacture of materials, transport and construction.
- Operation – Energy use.
- Repair, renewal/demolition – manufacture and transport of materials and components used for maintenance and refurbishment and transport of materials generated during demolition.

Calculated carbon emissions for a building under assessment are compared to a reference building that meets standards as defined by the Japanese Energy Conservation Law, using units of kg CO_2 / m^2. year. A standard assessment may be carried out using data for the building type and size which are linked to reference carbon dioxide values ('quick assessment method') or an individual assessment can be carried out by an assessor who provides a more detailed individual calculation ('accurate assessment method') according to a published LCA method.

Figures underlying the standard assessment method are based on statistical analysis of different sizes of construction works, which provide weights of materials for building and structure type. Quantities of concrete, steel reinforcement, steel frame and formwork are

[20] Comprehensive Assessment System for Built Environment Efficiency

provided (JSBC; 2010) as are carbon dioxide emissions factors, based on industrial input-output tables (from 1995).

Buildings have a defined service life eg. 60 years for offices, hospitals, hotels, schools and 30 years for restaurants and factories.

Reference carbon dioxide emissions arising from energy in use are based on statistical analysis of energy consumption per unit floor area for each building type and a defined mix of energy sources typically supplying each type of building.

The assessed building is given a star rating according to its carbon dioxide emissions relative to the reference building, as shown in Table 5 (JSBC; 2010). The stars are coloured green to complement the red stars that depict building performance based on the CASBEE assessment.

Table 5. Star Ratings used in CASBEE based on Life Cycle CO_2 Emissions for an Assessed Building relative to a Reference Building

Life Cycle CO_2 Saving (%)	Definition (for building operation)	Number of Green Stars
30	Zero energy consumption	★★★★★
60	50% energy saving	★★★★
80	50% energy saving	★★★
100	Current energy efficiency standards	★★
100+	Non-energy efficient	★

Summary of Features	• **Concerned with carbon dioxide emissions and has the ability to undertake a limited assessment.** • **Uses building reference data as a comparator.** • **Uses units of kg CO_2/m^2.year** • **Features supporting data for a standard assessment.** • **Adds the carbon impact of different life cycle stages and the assessed building is compared to a reference building that meets Japanese standards.**
Positive attributes for New Zealand to consider	• Has developed building benchmarks meeting Building Code requirements and covering the whole life cycle to provide a basis for comparison. Supported by a life cycle database of materials and processes.

3.3.2 Global GreenTag Pty Ltd (Green Tag^{CertTM} LCARate and LCADesign)

EcoSpecifier is a commercial company that has developed a suite of services and partnerships to support green building and has now licensed the use of these tools to Global GreenTag Pty Ltd. Whilst not primarily a building environmental rating tool[21], the company offers two products of interest in an Australasian context - these being Global GreenTag^{CertTM} LCARate and LCADesign.

[21] LCA Design provides a weighted ecopoint rating for a whole building.

Global GreenTag^{CertTM} LCARate includes LCA of a product which is compared to a "worst case business as usual product commonly available in the market". To be considered for LCARate certification, a product must exhibit or be a member of a category of products that has unique ecological or health preferred characteristics and pass the ecospecifier ES CAP[22] process.

The LCARate assessment process results in a GreenTag Ecopoint rating based on six Sustainability Assessment Categories (SACs) some of which are informed by LCA. Each of these is scored from 0 to 1[23] (0 being no impact and 1 being equivalent to the worst case Business as Usual (BAU) product) and then weighted as shown in Table 6 (ecospecifier Global; 2010).

Table 6. SACs and Weightings used in LCARate

SACs		Weighting to derive GreenTag Ecopoint when IDS[24] is relevant (%)	Weighting to derive GreenTag Ecopoint when IDS is not relevant[25] (%)
1	Integrated Design Synergy	10	–
2	Life Cycle Assessment – Greenhouse	20	25
3	Life Cycle Assessment – Health	20	20
4	Life Cycle Assessment – Ecospecifier Ecopoints[26]	15	20
5	Biodiversity – Physical Impacts (non-LCA)	20	20
6	Corporate Social Responsibility	15	15

LCARate products also receive a rating based on the tiers in Table 7, and additional requirements arising from the ES CAP process (not reproduced here). An additional "plus" rating is provided if the LCA is based on manufacturer and product specific data (including manufacturing location audit) for processes, manufacturing plants and supply chains.

[22] Ecospecifier Cautionary Assessment Process

[23] This information is based on the 2010 Global GreenTag Program Standard. At the time of writing, there is also a draft 2011 Program Standard (ecospecifier Global; 2011) which features some differences, if adopted in the proposed form. For example, SAC 2 and SAC 5 can allow for scores below 0, where -1 becomes the "best possible positive impact". This additionally has an impact on the tier levels provided in Table 7.

[24] Integrated Design Synergy

[25] For example, for fitout components or internal finishes (ecospecifier Global; 2010)

[26] Weighted result of the LCA over the potential life of a product, typically over a 60 year cycle of use in a building including maintenance, cleaning and replacement. The life cycle impacts considered include energy and fuel use, water use, air pollution, ozone depletion, human health (from emissions not directly generated by the product's constituents), ecosystem quality, eco-toxins and waste, resource depletion, recycled content and water pollution. Building life is likely to be revised to 50 years in 2012 (David Baggs, personal communication).

Table 7. LCARate Tier Levels based on GreenTag Ecopoints Score

LCA Rate Tier Level	GreenTag Ecopoints Score Range
Platinum	<0.35
Gold	≤0.5 > 0.35
Silver	≤0.75 > 0. 5
Bronze	> 0.75

LCADesign is another service that uses LCA data in commercial software to conduct a whole of life environmental profile assessment of buildings using LCAs of branded products[27]. Originally developed by the CRC for Construction Innovation, it provides real-time environmental assessments from CAD and virtual Building Information Management (BIM) models.

The LCA outputs are underpinned by an existing Australian National Life Cycle Inventory Database with the intention to enhance and integrate with BPIC and AusLCI data when available without economic allocation. Databases for other countries include Germany, Netherlands, USA and Canada (Ecospecifier Global; 2010). These data allow users to investigate the sources of environmental impacts by design element, individual product, assembly or component. Comparative profiles are also provided.

Since Global GreenTag^{CertTM} LCARate / LCA Design is primarily aimed at facilitating design, only a summary of features is provided below.

Summary of Features	• **LCA of assessed products compared to a worst case equivalent product.** • **LCA outputs contribute to at least 55% of available weightings to derive an ecopoint for an assessed product.** • **These (and other) LCA data underpin a whole building assessment tool called LCADesign, which provides a weighted ecopoint score for whole buildings.** • **Comparative profiles are available.**

3.4 Global

One tool – SBTool - has been developed with the intention of an international focus from its inception. This is contrary to the spread of other tools, examples of which are provided in Section 2.

3.4.1 iiSBE (SBTool)

The International Initiative for a Sustainable Built Environment (iiSBE) is an international non-profit organisation whose overall aim is to actively facilitate and promote the adoption of policies, methods and tools to accelerate the movement towards a global sustainable built environment. Its main objectives include:

- Mapping current activities and establishing a forum for information exchange so that gaps and overlaps may be reduced and common standards established.
- Increasing awareness of existing initiatives and issues amongst the international buildings and construction community;

[27] Ecospecifier Global – Corporate Brochure.

- Taking action in areas not covered by existing organisations and networks.

iiSBE has developed the SBTool which has derived from the GBTool launched by Natural Resources Canada as part of an international collaborative effort (called the Green Building Challenge) to develop a building environmental assessment tool as early as 1996. The tool provides a framework which is adaptable.

Part of the tool requires determination of the building structure, for which it provides a link to the Athena database to facilitate this assessment. It provides for a basic assessment of embodied energy for the main structural and envelope components of a building and allows inputting of values from external LCA studies.

Summary of Features	• **Some use of quantitative data on materials** • **Considers structure and envelope and uses a single indicator (embodied energy).**
Positive attributes for New Zealand to consider	• Based on an assessment of structure and envelope.

4. SUMMARY OF FINDINGS

Table 8 summarises attributes to be considered for the development of LCA as part of the assessment process of green buildings, based on approaches used in assessed international building environmental rating tools.

Global GreenTag^{CertTM} LCARate / LCADesign is not included in Table 8 as it is primarily used to inform green design rather than being used as a rating tool (like Green Star in Australia and New Zealand). It is understood to incorporate many of the attributes listed below, although the method and extent to which these attributes are implemented has not been reviewed in this work.

Table 8. Summary of Positive Attributes for New Zealand to Consider

Attribute	Derived from
Reward use of materials for which critically reviewed LCAs (to ISO 21930) and EPD are available (either generic or specific)	• BREEAM • GBRS • HQE • LEED
Use weightings to favour third party certified EPD for specific products.	• BREEAM • LEED
Report on multiple environmental impacts to be selected from the following list: • *Emissions*: global warming, stratospheric ozone depletion, acidification, photochemical oxidant formation, eutrophication. • *Resources*: depletion of non-renewable energy resources, depletion of mineral resources, water extraction, waste (total/hazardous), depletion of biotic resources, land use, primary energy (renewable/non-renewable). • *Toxicity*: human toxicity, ecotoxicity to water (freshwater/marine), ecotoxicity to land, radioactivity.	• BREEAM • GBRS • Green Globes • HQE • LEED
Concentrate on foundation, structure, external envelope and floors.	• BREEAM • Green Globes • SBTool
Assess whole buildings across their whole life, incorporating materials, in use impacts (energy, maintenance) and end of life.	• BREEAM • CASBEE • GBRS • HQE
Establish a consistent basis for methodological rules	• BREEAM • GBRS • HQE
Ensure materials data underpinning assessment process are freely available to ensure an open and transparent process.	• GBRS • HQE
Develop whole of life, whole building benchmarks to provide a basis for evaluation of designs. Award points according to how well the designed building performs against an appropriate benchmark.	• CASBEE • GBRS • HQE
Use data to provide tools to help designers and specifiers.	• BREEAM

These attributes will be incorporated into and inform an LCA Plan for New Zealand being developed by BRANZ as an accompanying document to this research.

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