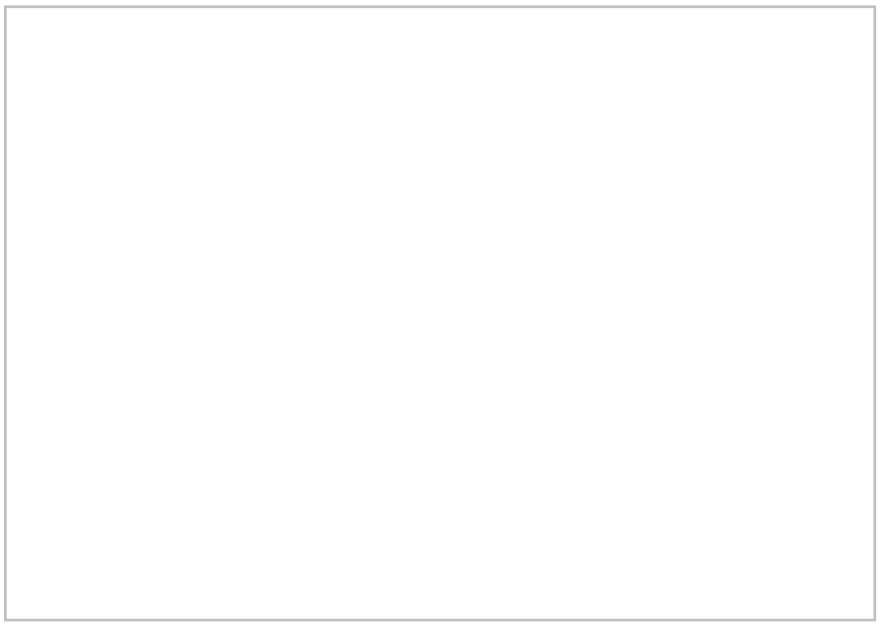
Building LCAQuick Report

in support of an application for Life Cycle Assessment points in Green Star – Design & As Built NZ v1.0 (credit 19A)

Stage: [insert submission stage]



Client: **[insert client company name]**

Building: **[insert building name]**

Assessor: [insert assessor company name]

Verifier: [insert verifier name, if applicable]

Date: [insert submission date]

Report version: [insert report version number]

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Document created using the BRANZ building LCAQuick report template.

How to use this template

This report template has been developed by BRANZ for use with LCAQuick when aiming for the 19A Life Cycle Assessment points in Green Star – Design & As Built NZ v1.0 (credit 19A). It should not be used unless the assessment has been carried out in LCAQuick.

The template contains pre-populated background information about LCAQuick and its reference buildings for the purposes of fulfilling the New Zealand Green Building Council's requirements for transparency and robustness.

As a user of this template who is responsible for assessing the design of a building, you need to complete:

- The title page, by populating highlighted fields and inserting an image of the building design (optional).
- Design specific information about the project where indicated in the template (highlighted in yellow).
- Results of the assessment in LCAQuick. References to specific outputs from LCAQuick are provided in this template to assist you with this.

Further information about specific sections that need completing is provided in Section 2.1.

Other documentation may need to be submitted with this completed report. These accompanying documents are highlighted in green in this template and are likely to be:

- Correspondence with NZGBC, and confirmation from NZGBC, concerning the appropriateness of the reference building used in the assessment.
- Agreement from NZGBC concerning the proposed verifier for the project (if required by NZGBC).
- Report setting out the process and results of the assessment verification (if required by NZGBC).

NZGBC may additionally request other documentation and information.

Appendix D is available for additional text that does not fit into the provided text fields.

Contents

Figures

Tables

Acronyms and terms

BEES	Building energy end-use study. Further information available at www.branz.co.nz/cms_display. php?st=1&pg=17201&sn=317&forced_id=yes
BIM	building information model
building information model	digital representation of the physical and functional characteristics of a building. As such, it serves as a shared knowledge resource for information about a building, forming a reliable basis for decisions during its life cycle from inception onward.
Co	commercial office activity classification (used in BEES and obtained from the PropertyIQ valuation roll). Used for buildings that are entirely offices.
Cx	commercial office mixed classification used in BEES and obtained from the PropertyIQ valuation roll. Used for buildings that are primarily offices but contain other uses (for example, a gym or café).
EcoInvent	proprietary database of materials and processes for use in LCA, developed and maintained by The EcoInvent Centre, Switzerland. See www.ecoinvent.org.
environmental product declaration	voluntary declaration providing quantified environmental data using predetermined parameters and, where relevant, additional quantitative or qualitative environmental information. Also known as a Type III environmental declaration or Type III ecolabel.
EPD	environmental product declaration
GFA	gross floor area – usually measured in square metres (m^2)
Green Star	NZGBC's voluntary environmental rating tool for buildings, which assesses a building at the design and as-built phases in the following areas: management, indoor environment quality, energy, water, transport, materials, land use and ecology, emissions and innovation.
gross floor area	area measured over all the exterior walls of the building, over partitions, columns, interior structural or party walls, stair wells, lift wells, ducts, enclosed roof top structures and basement service areas. All exposed areas such as balconies, terraces, open floor areas and the like are excluded. Generally, projections beyond the outer face of the exterior walls of a building such as projecting columns, floor slabs, beams, sunshades and the like are excluded (NZIQS, 2012).
GWP	global warming potential
HVAC	heating, ventilation and air conditioning.
kWh	kilowatt hour
LCA	life cycle assessment

LCAQuick	Excel-based early design support tool developed by BRANZ to help architects and other professionals involved in design to better understand what LCA is, how to incorporate it into workflows and how to use LCA outputs to inform design decisions. Performs an environmental evaluation of a design and compares it to one or more reference New Zealand buildings.
LCI	life cycle inventory
life cycle assessment	compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle (ISO, 2006a, b).
life cycle inventory	outcome of a life cycle inventory analysis that catalogues the flows across the system boundary and provides the starting point for life cycle impact assessment (ISO, 2006a,b).
MBIE	Ministry of Business, Innovation and Employment (www.mbie.govt.nz)
MfE	Ministry for the Environment (www.mfe.govt.nz)
module	discrete part of the building life cycle that encompasses all the processes that occur. For example, modules A1, A2 and A3 cover production of materials whilst module B6 covers operational energy use in a building. The modules in the life cycle of a building are set out in EN 15978 (CEN, 2011), and further information is provided in BRANZ Study Report SR349 (Dowdell & Berg, 2016).
net lettable area	sum of the floors of a building measured from the exterior faces of the exterior walls or from the centrelines of walls separating two uses within a building, excluding all common areas such as hallways, elevators, voids and unused parts of buildings. Usually measured in square metres (m^2).
NLA	net lettable area
NZBC	New Zealand Building Code
NZGBC	New Zealand Green Building Council (www.nzgbc.org.nz)
PCR	product category rules
product category rules	Set of specific rules, requirements and guidelines for developing environmental product declarations for one or more product categories.

Executive summary

Populating NZGBC's tool entitled "19A_life-cycle-assessment-calculator-NZ v1.0" (available on NZGBC's web-site) with LCAQuick assessment results, the following number of points are being sought for credit 19A:

19A.1 Comparative LCA	[insert LCA points]
19A.2 Additional LCI reporting	[insert LCA points]
19A.2 Material selection improvement	[insert LCA points]
19A.2 Construction process improvement	[insert LCA points]
Innovation – Exceeding Green Star benchmarks	[insert LCA points]

1. Introduction

In 2016, BRANZ, with project partners, completed development of an initial set of resources that comprise the New Zealand whole-building whole-of-life framework.

The framework's focus is to facilitate use of building Life Cycle Assessment (LCA) in design in order that environmental implications are iteratively considered. Using building LCA in this way increases opportunities for future environmental impacts to be designed out, ensuring that our buildings contribute to meeting our needs, in terms of our transition to a low-carbon economy and a more sustainable society.

Framework resources can be freely accessed at www.branz.co.nz/buildingLCA and include a free Excel-based building LCA software tool called LCAQuick. YouTube training videos in the use of LCAQuick are available on the BRANZ Media Channel[1], as well as other videos about building LCA and its recognition in Greenstar (for example).

The framework is needed because it:

- Provides more of a level playing field for assessment, with a focus on environmental performance of buildings across the life cycle.
- Enables evaluation of the environmental performance of buildings according to their function.
- Provides a basis for comparing building designs in order to better understand the sources and scale of environmental impacts across the life of a building.
- Aligns with ongoing developments in building environmental assessment according to international standards.
- Provides a holistic assessment that does not focus on single issues or specific parts of the life cycle of a building, both of which risk problem shifting from one impact to another or one stage of the life cycle to another or one medium to another.
- Measures continuous improvement through recognition of innovation based on reduced environmental impacts.
- Facilitates a stronger connection between supply and demand for construction products. Architects and designers who use LCA to evaluate their building designs rely on LCA-based data for construction products, which can be provided by manufacturers and importers in the form of environmental product declarations (EPDs). By making data about their products publicly available, manufacturers and importers can ensure data for their products is accurate and representative of current production as well as demonstrating a willingness for robustness and transparency.
- Can integrate well with quantitative design tools that are finding increasing application, such as Building Information Modelling (BIM) and energy simulation, thereby making the process of evaluation quicker and easier. For example, provision of LCA-based indicators as metadata in BIM objects freely downloadable for construction products provides opportunities for direct calculation of environmental impacts of building designs in BIM.

Further information about the framework is available in Dowdell & Berg (2016).

[1] www.youtube.com/playlist?list=PLQeYTsvZ7o2yOIYdXCGYD27n6PCowu_te

1.1 Building LCA

LCA is a systematic process that maps the life cycle of a product in terms of a defined level of function. This mapping requires setting out the processes within the life cycle that are needed to maintain functionality and significantly contribute to environmental outcomes, in terms of their extraction of resources, generation of wastes, and emissions to air, water and land. Having developed such a model, potential environmental impacts can be calculated which can, in turn, be used to identify environmental hotspots, and inform decision making to reduce these.

Use of LCA is enshrined in the ISO 14000 environmental management standards, as ISO 14040 (2006a) and ISO 14044 (2006b). The application of LCA to construction has been developed as a series of separate standards summarised in Figure 1. This shows key international (ISO) standards and the equivalent European (CEN) standards.

	International standards (ISO)	European standards (CEN)
Methodology	ISO 15392 Sustainability in building construction - general principles	EN 15643 - 1 Sustainability of construction works - Sustainability assessment of buildings - Part 1: General framework
Buildings	ISO 21929 - 1 Sustainability indicators - Part 1: Framework for development of indicators for buildings	EN 15643 - 2 Sustainability of construction works - Sustainability assessment of buildings - Part 2: Framework for the assessment of environmental performance
	ISO 21931 - Framework for methods of assessment of environmental performance of construction works - Part 1: Buildings	EN 15978 - Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method
Building products	ISO 21930 Enviromental declaration of building products	EN 15804 - Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

Figure 1. Key ISO and CEN standards concerning application of LCA to buildings and building products

The Life Cycle Assessment points (credit 19A) in Green Star is based on the EN 15978 (CEN, 2011) standard from Figure 1, as set out by the New Zealand Green Building Council (NZGBC).

This report is structured according to EN 15978 (CEN, 2011) summarised in Figure 2. Where relevant, section references to the standard are provided throughout this report using square brackets "[ ]".

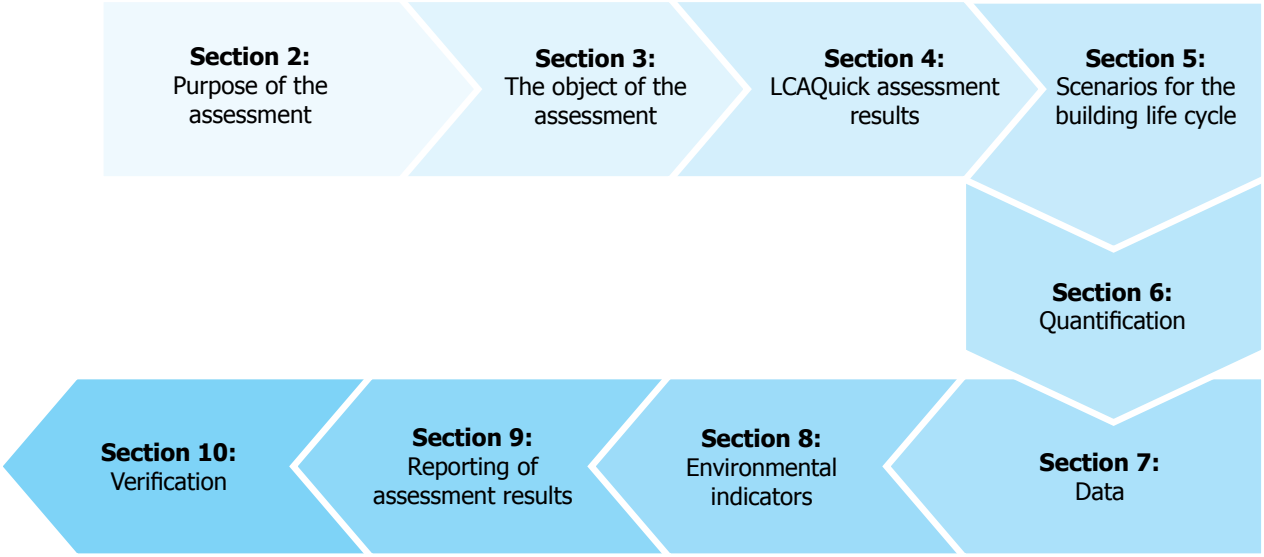

Figure 2. Summary of process for assessment of building environmental performance (based on EN15978: 2011)

2. Purpose of the assessment [6]

This assessment has been undertaken in support of an application for the Life Cycle Assessment points (credit 19A) in Green Star – Design & As Built NZ v1.0, as set out by NZGBC.

The goal of the assessment is to quantify and compare the quantified environmental impacts of a building design in comparison with a relevant reference building design in accordance with EN 15978 (CEN, 2011) and NZGBC's requirements.

Table 1 below summarises details of the client, assessor and method of assessment.

Table 1 Summary of stakeholders involved in this assessment

Client	
Client name	[insert client name]
Client address	[insert client address]
Client representative name and position	[insert client name and position]
Client representative contact	[insert client phone]
	[insert client email]
Assessor	
Assessor name	[insert assessor name]
Assessor address	[insert assessor address]
Assessor representative name and position	[insert assessor name and position]
Assessor representative contact	[insert assessor phone]
	[insert assessor email]
Assessment method	LCAQuick 3.3 (from Building Information Panel of LCAQuick)
Verifier	
Verifier name	[insert verifier name]
Verifier address	[insert verifier address]
Verifier representative name and position	[insert representative name and position]
Verifier representative contact	[insert verifier phone]
	[insert verifier email]

Section 3 provides information about the designed building under assessment and reference buildings that have been developed by BRANZ that are prepopulated in LCAQuick.

2.1 Completion of this template

Where an assessor in a design team is using a BRANZ reference building prepopulated in LCAQuick as the reference building, then the following sections require completion by the assessor:

- Front cover information.
- Table 1, Section 2 for client, assessor and verifier details.
- Section 3.1 for assessed building name and address.
- Section 3.1.1 for a brief description of the project and the design aim. Images of the building design can be optionally inserted here.
- Table 3, Section 3.1.1 for characteristics of the building.
- Table 4, Section 3.1.1 provides a description of the building elements included in the assessment. This should be completed for new build projects only.
- Table 5, Section 3.1.1 provides a description of the building elements included in the assessment. This should be completed for refurbishment projects only.
- Table 6, Section 3.1.1 for characteristics for the refurbished part of a building. This should be completed for refurbishment projects only.
- Table 7, Section 3.1.1 for a summary of energy performance criteria for the assessed building.
- Table 8, Section 3.2 for the identity of the reference building agreed with NZGBC.
- Figure 3, comprising summary information input to LCAQuick. This can be a screenshot of the LCAQuick Building Information Panel located in the "4a_SUMMARY ANALYSIS" worksheet.
- Figure 4, comprising the potential points available. LCAQuick undertakes the building LCA, and NZGBCs calculator tool (called "19A_life-cycle-assessment-calculator-NZv1.0 (available from the NZGBC website)) translates these results into potential points. This figure can be a screenshot of the POINTS ACHIEVED panel of NZGBC's calculator tool (cells C80 to F85). NZGBC's completed calculator tool should be submitted with this report.
- Figure 5, comprising a summary of module B6 energy demand (in Graph H) and how this is supplied (in Graph i). This can be screenshots from "4c_ENERGY ANALYSIS" from LCAQuick.
- Table 10, providing calculated environmental indicators for the assessed and reference buildings, which is used to populate NZGBC's LCA calculator tool called "19A_life-cycle-assessment-calculator-NZv1.0 (available from the NZGBC website). This can be a screenshot of Panel B in "4a_SUMMARY ANALYSIS" from LCAQuick. The drop-down menu in Panel B should be set to "per Area GFA" before taking the screenshot.
- Table 11 is in the same format as Table 10 except it provides results based on annual occupant hours. Before taking a screenshot, "per no. of annual occupied hours" should be selected from the drop down menu in Panel B.
- 10.Appendix A:, comprising more detailed environmental indicator results by life cycle stage. Here, screenshots of Panel C in "4a_SUMMARY ANALYSIS" can be pasted from LCAQuick. Care should be taken to ensure the results are presented "per Area GFA" (using the right dropdown box in Panel C provided). Each of the environmental indicators needed for this assessment can be selected in turn (using the left dropdown box in Panel C) and a screenshot taken for insertion into the report under the appropriate headings.

- 10.Appendix B:, comprising results of the energy simulation. Here, a screenshot of the table in the "2a INPUT PASTE- Energy Use" worksheet can be pasted from LCAQuick. This table provides quantified energy use, including plug loads separated from building-related energy demand arising from heating, cooling, fans, pumps, hot water etc.

When making any new selections using drop down menus in LCAQuick, it is worthwhile to get into the habit of clicking on the "CLICK TO CALCULATE WORKBOOK" button afterwards, to ensure values in tables and graphs are updated to reflect your new selection.

Where a design team has developed its own reference building in LCAQuick, then information in this report about the BRANZ reference building will additionally require modification to reflect information about the reference building that has been defined for the project.

3. The object of assessment [7.1]

3.1 Building being assessed

The designed building which is the object of this assessment is provided in Table 2.

Table 2 Identity of assessed building and stage of assessment

Name of assessed building	[insert building name]
Address of assessed building	[insert building address
Stage of assessment	[insert stage of submission]

For the purposes of a Green Star assessment, LCAQuick can be used to assess office buildings that are entirely offices or contain some additional uses, such as retail, café, gym etc. In these cases, the predominant building use should be as an office.

The scope of assessment within LCAQuick includes the building structure (including foundations) and enclosure i.e. the base build, over the building life cycle.

3.1.1 Description of the assessed building [7.2, 7.5.2]

[Insert here a short description of the building e.g. from the design brief, whether it is a new build or refurbishment 9if so, which aspects of the original building will be retained)]

Details about the designed building are summarised below as follows:

- **Table 3** lists the overall designed building characteristics (whether a new build or a refurbishment).
- **Table 4** is for new builds only. It contains a description of the building elements.
- **Table 5** is for building refurbishments only and provides a description of the retained building elements and the new building elements.
- **Table 6** is for refurbishments only and provides a summary of the changes to the building characteristics as a result of a refurbishment.
- **Table 7** provides a summary of designed energy performance criteria for the assessed building (whether a new build or a refurbishment).

Table 3 Summary of characteristics of the assessed building

Characteristic	Units	Value / Information	Notes
Type of project		[insert]	New build or refurbishment. If a new build, complete Table 4. If a refurbishment, complete Table 5 and Table 6.
Stage of design	-	[insert]	
Building location and NZBC H1 climate zone	-	[insert]	Auckland (1), Wellington (2) or Christchurch (3)
No. of storeys	No.	[insert]	
Storey height	m	[insert]	
Building height	m	[insert]	To highest point of roof
Gross floor area	m^2	[insert]	
Net lettable area	m^2	[insert]	
Office floor area	m^2	[insert]	
Office floor area	% of GFA	[insert]	
Other use floor area (conditioned)	m^2	[insert]	Other conditioned uses may be retail, gym, café (for example)
Other use floor area (conditioned)	% of GFA	[insert]	
Other use floor area (unconditioned)	m^2	[insert]	
Other use floor area (unconditioned)	% of GFA	[insert]	
Internal car parking	m^2	[insert]	
Internal car parking	% of GFA	[insert]	
Required service life	Years	60	This is the default used in LCAQuick.
Source of material quantities	-	[insert]	BIM model or QS. If material quantities are derived from a BIM model, see Section 6.1.

Table 4 New build only - description of assessed building elements

	Description
Frame	[insert a description here, including main materials used]
Foundations	[insert a description here]
External walls	[insert a description here]

	Description
Roof	[insert a description here, including whether photovoltaic panels are used]
HVAC	[insert a description here]
Hot water system	[insert a description here]

Table 5 Refurbishment only – description of original and additional elements

Building element	Description of retained elements	Description of new elements
Structure	[insert a description here]	[insert a description here, including main materials used]
Foundations	[insert a description here]	[insert a description here, including main materials used]
External walls	[insert a description here]	[insert a description here, including main materials used]

Building element	Description of retained elements	Description of new elements
Roof	[insert a description here]	[insert a description here, including main materials used]
HVAC	[insert a description here]	[insert a description here, including main materials used]
Hot water system	[insert a description here]	[insert a description here, including main materials used]

Table 6 Refurbishment only – summary of building additions

Characteristic	Units	Value / Information	Notes
Change to no. of storeys	No.	[insert]	Record any change in the no. of storeys due to the refurbishment in comparison with original building.
Change to building height	m	[insert]	Record any change to the building height due to the refurbishment in comparison with original building. To highest point of roof.
Change to gross floor area	m^2	[insert]	Record any change to GFA due to the refurbishment, in comparison with original building.
Change to net lettable area	m^2	[insert]	Record any change to NLA due to the refurbishment in comparison with original building.
Change to office floor area	m^2	[insert]	Record any change to office floor area due to the refurbishment in comparison with original building.
Change to other use floor area (conditioned)	m^2	[insert]	Record any change to GFA due to the refurbishment in comparison with original building. Other conditioned uses may be retail, gym, café (for example)
Change to other use floor area (unconditioned)	m^2	[insert]	Record any change to GFA due to the refurbishment in comparison with original building.
Change to internal car parking	m^2	[insert]	Record any change to GFA due to the refurbishment in comparison with original building.

Table 7 Summary of energy performance criteria for the assessed building

Energy performance criterion	Units	Designed value
Building occupancy	No./m^2 NLA	[insert value here]
Energy use intensity	kWh/m^2 GFA / year	[insert value here]
Internal heat loads – occupancy separated into latent and sensible heat gains	W/m^2	[insert value here]
Internal heat loads – lighting	W/m^2	[insert value here]
Internal heat loads – equipment/ plug loads	W/m^2	[insert value here]
Infiltration	ACH/hr	[insert value here]
Internal comfort temperature range e.g. 18-23°C	°C	[insert value here]

The following are not included in the assessment which focusses on preliminary design of the base build:

- Internal walls (non-structural)
- Doors
- Staircases (non-structural)
- Floors (non-structural)
- Ceilings
- Technical systems
- Sanitary systems
- Fixed fire-fighting systems
- Fixed lighting systems
- Communication and security systems
- Transportation inside the building
- Drainage systems
- Landscaping
- External lighting
- External parking
- On-site drainage
- Water treatment systems.

[3] Reference building codes are provided in Table 9. In these codes, the "x" in the term "Zx" should be replaced with a "1", "2" or "3" depending on the location of the assessed building, where 1 = Auckland, 2 = Wellington and 3 = Christchurch. Therefore, if the assessed building is in Auckland and the building agreed with NZGBC that will provide the reference is "Zx, Co, S4b", the code that should be inserted in Table 8 would be "Z1, Co, S4b" (as Z1 is Auckland).

[4] If you are defining your own reference building, you will need to provide sufficient information about the reference building to enable NZGBC to determine its suitability.

3.2 Reference building

A summary of the technical characteristics of the reference office buildings is provided in Table 9. The identity of the BRANZ reference office buildings is not provided. Therefore, a coding system has been devised that provides information about the buildings without revealing their identities. The coding structure consists of four parts as follows:

- The building's H1 zone definition – zones 1, 2, or 3 (Z1, Z2, or Z3) corresponding to Auckland, Wellington or Christchurch respectively. This is not the building's original location. Instead, it is the location the building has been modelled in for the energy simulation. All 10 buildings have been modelled in the three locations. When no specific zone is applied, the designation "Zx" is used.
- The building's primary activity – commercial office (Co) or commercial mixed (Cx).
- Building size – size class 3 or S3 (1,500–3,499 m^2 GFA), size class 4 or S4 (5,300–8,999 m^2 GFA) and size class 5 or S5 (9,000 m^2 GFA and more).
- A lower case letter (a, b etc) that differentiates when there is more than one building in the same location, with the same activity and size class.

Based on information presented in Figure 3, and communication with NZGBC concerning acceptance, the reference building from Table 9 that is used for this assessment is summarised in Table 8.

Table 8 Source of reference building

Assigned LCAQuick pre-loaded reference building for this assessment (see footnote 3 below)	[insert code here]
Developed own reference building (see footnote 4 below)	Yes

Documentation concerning acceptance of the selected reference building should accompany this report.

Figure 3 Extract from LCAQuick showing Building Information Panel

Table 9 Summary of reference office buildings[5]

Building identification code	Gross floor area (GFA)	Net lettable area (NLA)	Original location and zone	Building activity	Size class	Structural system (type)	Structural system (material)
Zx, Co, S3a	2,021	1,684	Auckland, Z1	Commercial office (83%)	3	Braced frame and shear-walled frame systems	Composite: concrete/steel
Zx, Cx, S3	1,933	1,642	Christchurch, Z3	Commercial mixed (office 57%, retail 28%)	3	Post-tensioned LVL frames and walls	Timber
Zx, Co, S3b	1,814	848	Auckland, Z1	Commercial office (47%) (car parking 39%)	3	Rigid frame system	Steel
Zx, Co, S4a	7,789	5,088	Auckland, Z1	Commercial office (65%) (car parking 24%)	4	Rigid frame system	Composite: concrete/steel
Zx, Co, S4b	5,911	4,430	Wellington, Z2	Commercial office (75%)	4	Rigid frame system	Composite: concrete/steel
Zx, Cx, S4a	6,373	5,446	Christchurch, Z3	Commercial mixed (office 86%)	4	Post-tensioned LVL frames and walls	Timber
Zx, Cx, S4b	6,625	4,256	Auckland, Z1	Commercial mixed (office 51%, retail 13%)	4	Braced frame and shear-walled frame systems	Reinforced concrete
Zx, Cx, S5	22,912	13,731	Auckland, Z1	Commercial mixed (office 59%, car parking 31%)	5	Rigid frame system	Reinforced concrete
Zx, Co, S5a	10,864	9,180	Wellington, Z2	Commercial office (office 74%, car parking 3%)	5	Rigid frame system	Reinforced concrete
Zx, Co, S5b	13,247	10,592	Auckland, Z1	Commercial office (80%)	5	Braced frame and shear-walled frame systems	Reinforced concrete

[5] This table shows the building's original location. The version of the reference building that is used as a comparator is matched to the climate zone where the assessed building will be located. For example, an assessed building is in Auckland. Based on the Building Information Panel, if the closest building in terms of characteristics is actually in Wellington e.g. "Zx, Co, S4b", then the version of the reference building that is used reflects operational energy if the same building was located in Auckland. The code assigned to the reference building reflects this as "Z1, Co, S4b".

3.3 Scenarios for the assessment [8]

The pattern of use and required building service life that form the basis of the assessment are provided in the following sections.

Further information about scenarios used for other parts of the building life cycle, including transport of materials to the construction site (module A4), construction site waste rates and end-of-life routes (module A5), maintenance (module B2) and replacement (module B4), energy use in the building (module B6), water use (module B7) and building decommissioning (module C1) are provided in Section 5.

Where materials quantities developed for the assessed building have been derived from BIM, the method in the BRANZ SR350 study report (Berg *et al.*, 2016) should be used for consistency. The report is available under "Reference Buildings" at www.branz.co.nz/buildingLCA. YouTube training videos are also available to help[6].

Reference buildings have been modelled using BEES template energy models (see Section 5.3.3). For consistency, the assessed building should be evaluated using the same defaults, unless project specific information is different.

A summary of energy simulation results is provided in Appendix B (taken as a screenshot of the "2a INPUT PASTE- Energy Use" worksheet in LCAQuick).

More detailed information about scenarios is provided in the BRANZ SR351 study report (Dowdell *et al.*, 2016), available under "Information" at www.branz.co.nz/buildingLCA.

Further information about underlying data, data quality, sources of data and assumptions used in the assessment for all stages of the life cycle is provided in Appendix D of the BRANZ SR350 study report (Berg *et al.*, 2016), available under "Reference Buildings" at www.branz.co.nz/buildingLCA.

In LCAQuick, these scenarios are applied to both the assessed and reference buildings for consistency.

3.3.1 Pattern of use

Use of energy during the Use stage of the building is based on BEES (Amitrano *et al.*, 2014a, 2014b) using data from BEES template energy models (Gates, 2013; Cory, Gates & Donn, 2011) produced as an output of simulation methodology research. These have been used to reduce the size of the performance gap between predicted and actual energy use in buildings, since the data are derived from measurements of actual energy use. The modelling includes plug loads. Further information on the approach to energy modelling is provided in Berg *et al.* (2016).

A summary of BEES default and other useful information for energy modelling is provided in the Module B6 datasheet available at www.branz.co.nz/buildingLCA under "Data". This includes building occupancy patterns and schedule of operation (for example).

The reference building has been modelled according to parameters in the Module B6 datasheet. The assessed building has also been modelled according to these parameters, unless project specific information (for example, provided in Table 7) is available.

[6] www.youtube.com/playlist?list=PLQeYTsvZ7o2yOIYdXCGYD27n6PCowu_te

3.3.2 Required service life [7.3]

In the absence of specific information, the office building required service life or reference study period is 60 years, as required by NZGBC and as set out in the Building service life (Use stage (modules B1 - B7)) datasheet available under "Data" at www.branz.co.nz/buildingLCA.

The underlying basis for 60 years is set out in the BRANZ SR351 study report (Dowdell *et al.*, 2016) available under "Information" at www.branz.co.nz/buildingLCA.

Both the assessed and reference buildings have been modelled for a required service life of 60 years.

4. LCAQuick assessment results

LCAQuick calculates the environmental indicators listed in Table 12 which are taken from EN 15978 (CEN, 2011). The results are used to populate the Green Star worksheet in LCAQuick. The results in light blue cells in this worksheet can be pasted directly into the corresponding tables in NZGBC's tool (called "19A_ life-cycle-assessment-calculator-NZv1.0") which calculates the potential points.

Note that LCAQuick aggregates the following:

- Module A4 transport and module A5 construction.
- Module B2 maintenance and module B4 replacement.
- Modules C1 deconstruction/demolition, C2 transport, c3 waste processing and C4 disposal.
- Therefore, in the NZGBC "19A_life-cycle-assessment-calculator-NZv1.0" tool:
- The figure under module A5 is a total for modules A4 and A5. The module A4 column is left blank.
- The figure under module B4 is a total for modules B2 and B4. The module B2 column is left blank.
- The figure under module C1 is a total for modules C1 to C4 inclusive. The module C2, C3 and C4 columns are left blank.

LCAQuick is unable to calculate additional environmental indicators such as human toxicity, land use etc, so these should be left blank.

The basis for assessment uses the New Zealand whole-building whole-of-life framework, details of which are available at www.branz.co.nz/buildingLCA.

The assessment is carried out according to information presented in this, and other referenced, reports.

Results are presented on a "per m^2 GFA" basis as required by NZGBC.

4.1 Comparative assessment across indicators

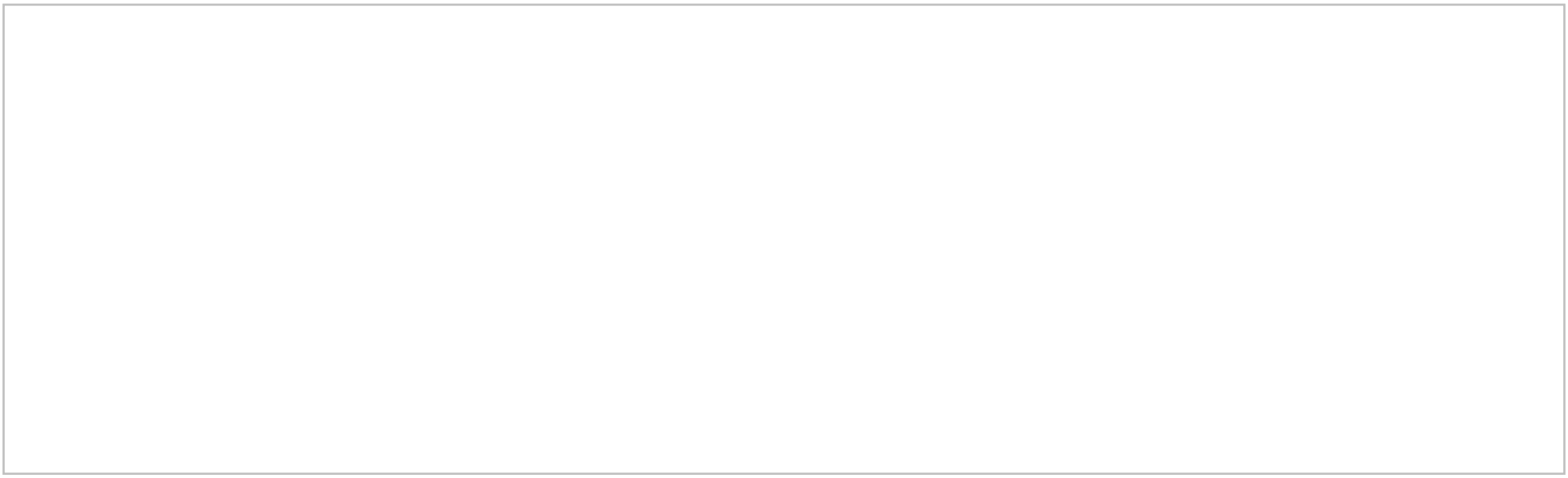

Figure 4 Summary of assessed building indicator results compared to reference building indicator results

Figure 4 is a screenshot of the POINTS ACHIEVED panel (cells C80 to F85) in NZGBC's calculator tool (19A_life-cycle-assessment-calculator-NZv1.0). This summarises the potential points available as a result of the building LCA carried out in LCAQuick.

NZGBC's completed calculator tool should be submitted with this report, together with the LCAQuick file.

Table 10 summarises the environmental indicator values for both the assessed and reference buildings. Results are presented on a per m^2 GFA basis with a 60 year required service life.

Figure 5 summarises calculated energy demand and how this is supplied for module B6. This energy use includes separate reporting of plug loads, as a requirement of EN 15978 (CEN, 2011).

Table 11 provides results in the same format as for Table 10 except they are expressed per annual occupant hours.

Table 10 Environmental indicators for the assessed and reference buildings (GFA basis)

Appendix A provides a further breakdown of results by life cycle stage (including module D) for each of the reported environmental indicators.

Table 11 Environmental indicators for the assessed and reference buildings (occupant hour basis)

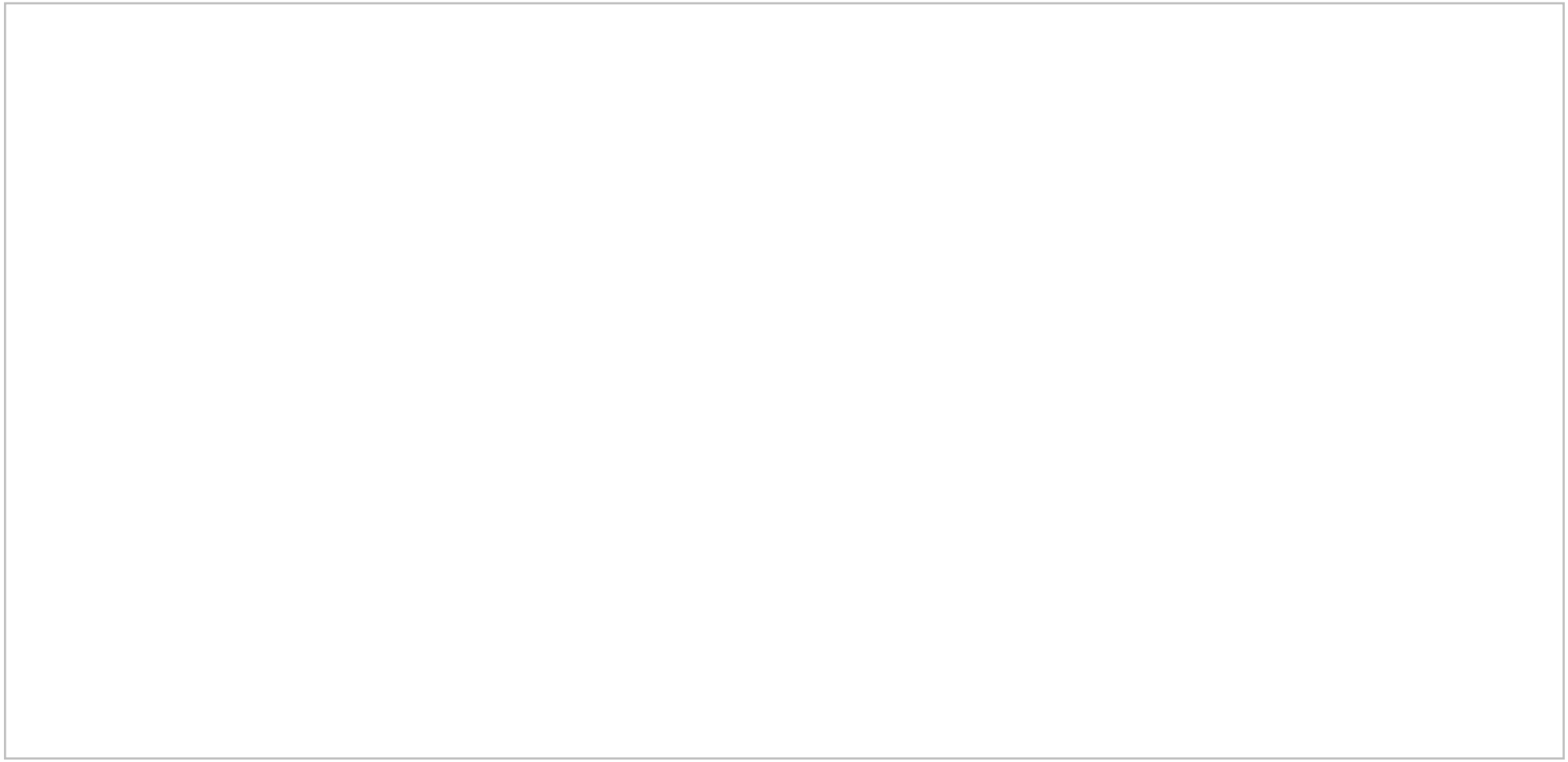

Figure 5 Summary of energy demand and supply in module B6

5. Scenarios for the building life cycle [7.4]

Based on Figure 6 in EN 15978 (2011) and information that can reasonably be expected to be available at concept/preliminary design, modules within stages of the life cycle included in the assessment are coloured in Figure 6. Modules that are not coloured have been excluded due to lack of data during early design.

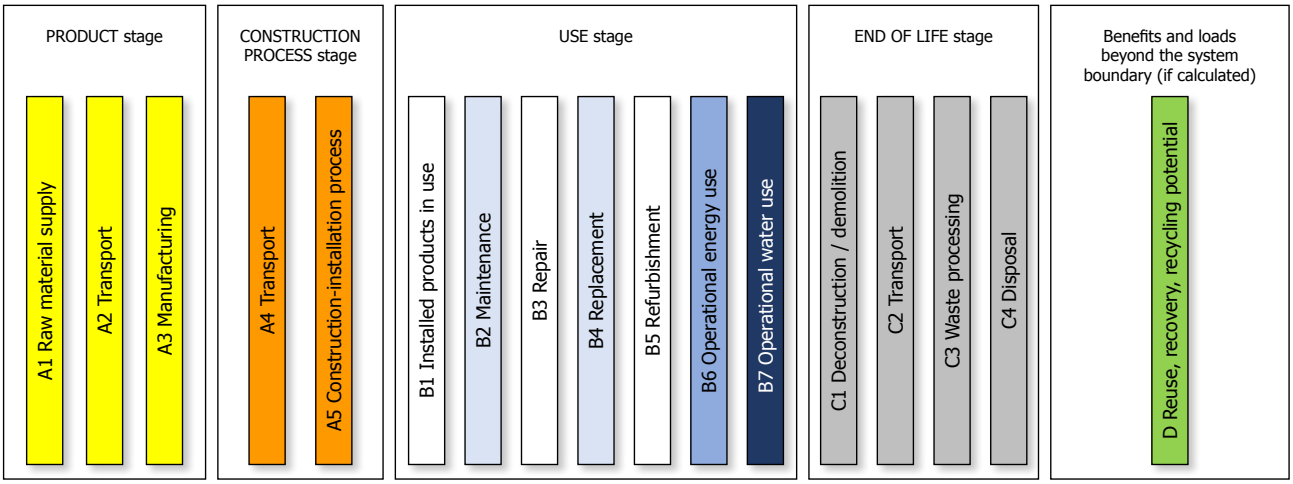

Figure 6 Stages of the building life cycle modelled in LCAQuick (coloured)

Further information about each of the included stages and modules is provided in the following sections.

Since the designed building and reference building have been modelled in LCAQuick using the New Zealand whole-building whole-of-life framework, the basis for modelling the stages of the life cycle, assumptions, and the underlying data for calculating environmental indicators, are the same for both buildings.

Where the designed building is a refurbishment, parts of the original structure and enclosure that have been retained in the new design have been excluded from the assessment.

Further information about the framework can be found in the BRANZ SR349 study report (Dowdell & Berg, 2016) available under "Information" at www.branz.co.nz/buildingLCA.

5.1 Boundary of the Product stage [7.4.2]

This comprises modules A1 to A3 in Figure 6 and covers processes up to the factory gate of the manufacturing processes that produce the final products to be used in the building.

Data for materials typically used in the structure and enclosure of New Zealand commercial buildings have been developed, in addition to some alternative materials that may be considered.

A list of materials that have been modelled is provided in the BRANZ SR350 study report (Berg *et al.*, 2016) in Appendix D, available under "Reference Buildings" at www.branz.co.nz/buildingLCA.

For each material, data on environmental impacts[7] of manufacture was collected according to the following hierarchy of sources, where those higher in the list were considered more desirable from a data quality perspective than sources lower down the list:

- Independently verified EN 15804 (CEN, 2013) compliant environmental product declarations (EPDs) for New Zealand manufactured or imported products (for example, EPDs of construction products registered on the EPD Australasia website[8]).
- Independently verified EPDs developed to LCA standards other than EN 15804 (CEN, 2013) for New Zealand manufactured or imported products.
- Independently verified EN 15804 (CEN, 2013) compliant EPDs for the same or similar products manufactured in other geographical locations (for example, EPDs registered on the International EPD® System[9] or IBU[10]).
- Independently verified EPDs developed to standards other than EN 15804 (CEN, 2013) for the same or similar products manufactured in other geographical locations.
- Modelled processes based on generic data, adapted where possible for location of manufacture (for example, including use of New Zealand Grid electricity for processes in New Zealand).
- Modelled processes based on generic data in an unadapted form.

5.2 Boundaries of the Construction Process stage

This comprises modules A4 and A5 in Figure 6 and represents processes from the factory gates of the last manufacturing stages to completion of construction of the building.

The following sections provide information about how the Construction Process stage is modelled in LCAQuick.

5.2.1 Transport of construction materials [7.4.3.2]

LCAQuick considers transport of materials to a construction site in Auckland, Wellington or Christchurch (depending on the location of the designed building). One-way default transport distances have been pre-calculated and are available in the Construction transport (module A4) datasheet located in "Data" at www.branz.co.nz/buildingLCA.

The methodology used for developing transport distances is detailed in the BRANZ SR351 study report (Dowdell *et al.*, 2016) available under "Information" at www.branz.co.nz/buildingLCA.

The following are not included in the default transport distances:

- Return journeys, empty or otherwise.
- Intermediate storage.
- Losses due to transportation. Losses are considered in module A5.
- Transport of persons to and from the construction site.

[7] Based on EN 15978 (CEN, 2011) and list 1 indicators in BRANZ Study Report SR293 (Dowdell, 2014) plus total primary energy.

[8] www.epd-australasia.com

[9] www.environdec.com

[10] http://ibu-epd.com/en/epd-program/published-epds/

5.2.2 Construction process

Modelling in LCAQuick includes the following:

- Losses due to waste at the construction site. Default waste rates are used, which are available in the Construction waste (module A5) datasheet available under "Data" at www.branz.co.nz/buildingLCA. The basis for development of these default waste rates is set out in the BRANZ SR351 study report (Dowdell *et al.*, 2016) available under "Information" at www.branz.co.nz/buildingLCA.
- Manufacture and transport of material wasted at the construction site. The basis for this modelling is set out in Section 5.1.
- End-of-life of the wasted material. Defaults for end-of-life routes followed by materials are provided in the Construction waste (module A5) datasheet available under "Data" at www.branz.co.nz/buildingLCA. The basis for development of these default data is set out in the BRANZ SR351 study report (Dowdell *et al.*, 2016).
- Use of diesel on the construction site, for lifting materials. Further information can be found in Appendix D2 of the BRANZ SR350 study report (Berg *et al.*, 2016) available under "Reference Buildings" at www.branz.co.nz/buildingLCA.
- Use of diesel to pump concrete. Further information is available in Appendix D2.2 of the BRANZ SR350 study report (Berg *et al.*, 2016) available at www.branz.co.nz/buildingLCA.

The following are not modelled in LCAQuick as they represent a level of detail that is not normally available at preliminary design:

- Ground works and landscaping. Materials data for the building may be derived from a BIM model. Therefore, data for groundworks and landscaping are not normally available.
- Provision of heating, cooling and humidity that may be necessary for storage of materials.
- Transport of materials, products, waste and equipment within the construction site.
- Temporary works, including temporary formwork for concrete.
- Ancillary materials, for example, fixings.
- On-site cleaning.

5.3 Boundaries of the Use stage [7.4.4]

This comprises modules B1 to B7 in Figure 6. In LCAQuick, only modules B2, B4, B6 and B7 are modelled for preliminary design. Other modules are not calculated for reasons set out below:

- Module B1: There is a lack of data about release of substances from surfaces such as the façade, roof and floor coverings, including standardised testing methods for assessment. These data are likely to become increasingly available as testing is standardised and reported in documents such as EPDs.
- Module B3: Repair is necessary due to a lack of maintenance or because of accidents or random events e.g. acts of terrorism or earthquakes. We assume that timely maintenance is carried out and have not included consideration of accidents or random events in the scope.
- Module B5: Refurbishment may occur at some future time during the life of the building. Reasons for refurbishment may be driven by changes in policy e.g. earthquake strengthening, or for economic reasons e.g. to attract tenants. The type and extent of any refurbishment is difficult to evaluate at early design. Therefore, the assumption is that no refurbishment occurs during the service life of the building.

Modules in the following sections are included in LCAQuick.

5.3.1 Maintenance [7.4.4.3]

In LCAQuick, maintenance is modelled based on default schedules available in the Building materials maintenance (module B2) datasheet under "Data" at www.branz.co.nz/buildingLCA. The method used for developing default maintenance data is set out in the BRANZ SR351 study report (Dowdell et al., 2016) available under "Information" at www.branz. co.nz/buildingLCA.

Maintenance largely consists of reapplication of protective coatings or decorative finishes, and washing. Default data in the Building materials maintenance (module B2) datasheet includes:

- A description of the maintenance.
- The types and quantities of materials required for maintenance.
- The frequency of the maintenance.
- Source(s) of information.
- Additional notes and any exceptions e.g. when a material is used in different applications that make maintenance difficult or unnecessary.

LCAQuick includes the following for maintenance:

- Manufacture of materials used for maintenance e.g. coatings.
- Supply and disposal of water via a reticulated network

Further information about the approach to modelling maintenance is available in Appendix D3 of the BRANZ SR350 study report (Berg *et al.*, 2016), available under "Reference Buildings" at www.branz.co.nz/buildingLCA.

5.3.2 Replacement [7.4.4.5]

In LCAQuick, replacement of materials during the life of a building is based on estimated service life values available in the Building materials replacement (module B4) datasheet under "Data" at www.branz.co.nz/buildingLCA. The method used for developing estimated service life data is set out in the BRANZ SR351 study report (Dowdell et al., 2016) available under "Information" at www.branz.co.nz/buildingLCA.

When a material reaches the end of its service life, an equivalent new material replaces it. Therefore, this module includes manufacture and transport of materials (based on modules A1 – A3 and A4 – A5) required to replace obsolete materials and waste management of replaced materials, based on default data set out in the Building end-of-life (module C1) datasheet (see Section 5.4).

LCAQuick includes the following for replacement:

- Manufacture of materials required to replace materials that have become obsolete in the building. This manufacture will occur at a time or times during the service life of the building. For the purposes of modelling materials manufacture, the same data are used to represent materials manufacture as used in the Product stage.
- Transport of materials from the manufacturing site to the building. The distance travelled and mode(s) used is assumed to be the same as used in the Construction Process stage.
- Wastage during replacement by new materials. This includes manufacture of the material that is wasted during replacement and end-of-life of the wasted material.
- Diesel use to lift materials into position and pumping of concrete (if relevant).
- Transport and end-of-life of obsolete materials. This is based on end-of-life route(s) used currently and may therefore be considered as conservative.

Modelling in LCAQuick excludes:

- Manufacture and transport of fixings.
- Manufacture and end-of-life of any packaging associated with new materials used to replace obsolete materials.

Further information about the approach to modelling replacement is available in Appendix D3 of the BRANZ SR350 study report (Berg *et al.*, 2016), available under "Reference Buildings" at www.branz.co.nz/buildingLCA.

5.3.3 Operational energy [7.4.4.7]

Operational energy use is represented by Operational energy (module B6) in Figure 6.

This includes modelling energy use during the operation of the building based on defaults provided in the Operational energy (module B6) datasheet available under the "Data" section at www.branz.co.nz/buildingLCA.

Default information in the Operational energy (module B6) datasheet includes:

- Occupancy by building activity.
- Internal energy end uses.
- Internal heat gains.
- Zone airflow and ventilation.
- Thermostat setpoint and HVAC.
- Building materials.
- Air gaps.
- Glazing and frame materials.

Further information about the defaults in the Operational energy (module B6) datasheet and how to use these is provided in Section 8 of the BRANZ SR351 study report (Dowdell et al., 2016).

The Operational energy (module B6) datasheet includes defaults derived from BEES, a multi-year study that monitored how energy is used in commercial buildings in New Zealand. Therefore, defaults from BEES are derived from measured energy use data.

LCAQuick can take the outputs of an energy model which should include:

- Heating.
- Hot water supply.
- Air conditioning (cooling and humidification/dehumidification).
- Ventilation.
- Lighting.

EN 15978 (CEN, 2011) requires consideration of building-integrated technical systems such as lifts, escalators, safety and security systems. However, reference buildings in LCAQuick only include energy use due to lifts. This is because focus is on performance of the thermal envelope of the building at the preliminary design stage.

Energy modelling should be based on the location of the building and take into account aspects such as the building form, orientation, window-to-wall ratios and insulation levels, for example.

In LCAQuick, plug loads are additionally calculated based on BEES defaults set out in the Operational energy (module B6) datasheet. Graph C in the "4a SUMMARY ANALYSIS" worksheet of LCAQuick shows the environmental impacts of total energy use including plug loads. EN 15978 (CEN, 2011) requires that energy use by appliances that are not building-related i.e. plug loads, are documented separately. This is provided in Graph C as "tenant operational energy use". Further detail is provided in Graph H, i and J in the "4c_ENERGY ANALYSIS worksheet.

No current reference buildings include any on-site renewable energy supply, although this may change as more reference buildings become available in the future. LCAQuick allows consideration of one form of on-site renewable supply, being photovoltaic panels. Renewable energy supply, when present, is first allocated to meeting building-related energy demand and then non-building related energy demand (as required by EN 15978 (CEN, 2011)).

The calculation of environmental indicators for buildings with or without on-site photovoltaics in LCAQuick is in accordance with EN 15978 (CEN, 2011) in all cases except one. The exception is a situation when a proportion of electricity demand is met by Grid electricity imported at particular times of the day and/or year in order to supply demand peaks caused by building users' temporal consumption patterns. This imported electricity is required to meet demands not being fully satisfied by the on-site generation, for example, the photovoltaics not generating electricity at night for lighting. However, at other times of the day and/or year, the photovoltaics supply too much electricity for building needs, and at these times, the photovoltaics generated excess electricity is exported to the grid.

The approach required by EN 15978 (CEN, 2011) and implemented in LCAQuick is set out in detail in Section 8.2.2 and 8.2.3 of the BRANZ SR351 study report (Dowdell *et al.*, 2016) available under "Information" at www.branz.co.nz/buildingLCA.

In summary, EN 15978 (CEN, 2011) requires that a separation is maintained between annual energy exported and annual energy imported, so that the environmental impacts of imported energy are considered within module B6, and the environmental impacts of exported energy are considered within module D (Section 5.5). This means that a net import or export of electricity should not be calculated. The need to sometimes export energy and sometimes import energy is likely to arise due to imbalances in peak demand and supply and/or due to insufficient on-site renewable generation capacity.

At preliminary design, it is more likely that energy simulation results will be based on an annual balance rather than hour-by-hour electricity demand and supply simulation over a year. Such an approach also aligns with the International Energy Agency definition for net zero-energy buildings which states that these are "buildings over a year are neutral, meaning that they deliver as much energy to the supply grids as they use from the grids. Seen in these terms they do not need any fossil fuel for heating, cooling, lighting or other energy uses although they sometimes draw energy from the grid" (Marszal & Heiselberg, 2011).

For this reason, LCAQuick takes the total calculated demand for electricity from an energy simulation model and subtracts the electricity available from photovoltaic supply over a year, based on the photovoltaic capacity (regardless of whether this supply is used in the building or exported). The effect of this simplification, which is made to align with the form of energy simulation data likely to be available during concept and preliminary design, is to under-report environmental impacts in Module B6, since only environmental impacts of Grid electricity in excess of total photovoltaic supply (either used in the building or exported) are accounted. This is illustrated as Case 5a in Section 8.2.3 of the BRANZ SR351 study report (Dowdell *et al.*, 2016).

If results are considered as the total of modules A1 through to C4, plus module D, then this modelling approach has no overall effect.

5.3.4 Operational water use [7.4.4.8]

This is represented by module B7 in Figure 6.

In LCAQuick, water demand is calculated based on benchmarks for New Zealand offices in units of m3 water/ m^2 NLA/year reported by Bint (2012). Benchmarks for Auckland and Wellington are derived from measurements whilst data for Christchurch are an estimate calculated from the sample median of the Auckland and Wellington data combined. These benchmarks are provided in the Operational water (module B7) datasheet available under "Data" at www.branz.co.nz/buildingLCA.

Benchmarks developed by Bint (2012) reflect water used in sampled buildings during the sampling period and include:

- Drinking water.
- Water for sanitation.
- Domestic hot water.
- Water for heating, cooling, ventilation and humidification.

Specific building-integrated water uses, such as fountains, will contribute to the data if these were present in the sample of buildings. Similarly, maintenance activities such as washing, will be included if these activities occurred during the sampling period (Bint has confirmed that this was the case for at least one building).

EN 15978 (CEN, 2011) requires that water use by non-building related functions e.g. dishwashers, washing machines are separated out, if reported. The benchmarks used in LCAQuick comprise total measured water use in sampled buildings and therefore include all water use, including by non-building related appliances (such as dishwashers). Due to the nature of the data, water use by these non-building related appliances cannot currently be separated out.

Wastewater volume is taken as being the same as water demand.

Calculated water demand is presented in LCAQuick as an indicative figure, calculated as the product of the relevant benchmark value (depending on city in which the building is located) and the floor area. More detailed analysis is not provided as this is not an area of focus at preliminary design.

Treatment of water (pre- and post-use) is included.

5.4 Boundary of the end of life stage [7.4.5]

This stage is represented by modules C1 to C4 in Figure 6 and commences when the building is decommissioned with no intention for further use.

5.4.1 Deconstruction [7.4.5.2]

This module considers the end-of-life of the building and not necessarily the end-of-life of the materials of which it comprises.

Typical and best practice rates for diversion of materials from landfill by mass are provided in the Building end-of-life (module C1) datasheet available under "Data" at www.branz.co.nz/buildingLCA. For the purposes of modelling in LCAQuick, the more conservative "typical" rates listed in the datasheet are used.

Further information about the method for developing the Building end-of-life (module C1) datasheet can be found in the BRANZ SR351 study report (Dowdell *et al.*, 2016) available under "Information" at www.branz.co.nz/buildingLCA.

Additionally, energy (from diesel) for demolition is assigned to structural materials only (concrete, steel, timber and engineered wood) using data from the Athena Sustainable Materials Institute (1997). Further information is available in Appendix D4 of the BRANZ SR350 study report (Berg *et al.*, 2016), available at www.branz.co.nz/buildingLCA under "Reference Buildings".

5.4.2 Transport [7.4.5.3]

Transport to landfill or recycling/recovery facilities is included.

5.4.3 Waste processing [7.4.5.4]

The boundary of modelling of waste processes is set where the end-of-waste state is reached. In practice, this is interpreted as meaning that processes are included within the system boundary until the point where an output of waste processing can be sold i.e. it has a dollar value.

Further information about data and assumptions concerning the approach used for modelling waste processing of specific materials are provided in Appendix D4 of the BRANZ SR350 study report (Berg *et al.*, 2016), available under "Reference Buildings" at www.branz.co.nz/buildingLCA.

5.4.4 Disposal [7.4.5.5]

Modelling of landfill processes following disposal is included. Information about the basis for modelling specific materials is provided in Appendix D4 of the BRANZ SR350 study report (Berg *et al.*, 2016).

5.5 Boundary for benefits and loads beyond the system boundary [7.4.6]

This is represented as module D in Figure 6. It quantifies the environmental benefits or loads that may accrue in another life cycle as a result of the net flows of materials and/or exported energy from the assessed building life cycle.

In LCAQuick, modelling for module D commences after a waste has reached its end-of-waste state[11] (Section 5.4.3). This may include additional transport and processing steps before a level of function can be delivered that can substitute for an equivalent level of function delivered by an alternative e.g. primary production of a material or electricity supplied by the grid.

The method used in LCAQuick to calculate module D is set out in Appendix D5 of the BRANZ SR350 study report (Berg *et al.*, 2016), available under "Reference Buildings" at www.branz.co.nz/buildingLCA.

[11] Further information about the "end-of-waste state" is available in Appendix D of the BRANZ SR349 study report (Dowdell & Berg, 2016), available under "Information" at www.branz.co.nz/buildingLCA.

6. Quantification [7.5]

LCAQuick has been developed to facilitate the development of a building LCA model. It has been designed to help design teams undertake an LCA of the building design and compare it to a reference building design.

EN 15978 (CEN, 2011) states that the quantification of the building is separated into:

- Its constituent parts.
- Related processes such as transport, construction, maintenance, repair, replacement, end-of-life processes.
- Operational use (energy, water)

The level of detail necessary for the assessment depends on the goal and scope of the assessment and availability of data. Research to date has focussed on developing supporting data and information to facilitate evaluation during early (concept and preliminary) design.

The application to date has been on offices.

6.1 Description of the physical characteristics of the building [7.5.2]

A description of the building being assessed is provided in Section 3.1. To calculate environmental impacts associated with materials, LCAQuick requires the input of material quantities which may be obtained by exporting a schedule of quantities from a BIM model, or manually entered based on Quantity Surveyor information.

A list of material quantities used for modelling can be seen in LCAQuick in the "1c INPUT – Material Quant." worksheet except for windows, doors and louvres. Additional quantities are required for specific activities and can be found in the following:

- 1c INPUT – Mat. Quant. WASHING – surface area information is added here to enable LCAQuick to calculate the amount of water required for washing (module B2).
- 1c INPUT – Window Mat. Quant. – quantity of materials used in windows, doors and louvres is added here to enable LCAQuick to calculate the environmental impacts associated with these products. The worksheet called 1c – WINDOW-DOOR BUILDER can be used to calculate the materials quantities for window and door profiles.

To aid consistency with respect to obtaining material quantities, the BRANZ SR350 study report (Berg *et al.*, 2016) sets out a methodology for modelling using BIM that ensures that the material quantities generated are accurate enough for the purposes of decision making at preliminary design.

If a BIM model is used to generate the material quantities for the assessment, it is important that it has been developed in line with the method in the SR350 study report.

Training videos are available on the BRANZ YouTube media channel[12] that can also help with this.

[12] www.youtube.com/playlist?list=PLQeYTsvZ7o2yOIYdXCGYD27n6PCowu_te

6.1.1 Reference buildings

The method of assessment in Green Star requires that a set of calculated environmental indicators for a designed building are compared to environmental indicators for a reference building.

The reference building may be:

- Standard practice – being a hypothetical building that represents standard contemporary construction practices.
- Actual case – a building that is similar in use, construction and operation to the project.

Design teams can choose to develop their own reference building for a project or use a reference building developed by BRANZ and pre-loaded into LCAQuick, where use of such a building is deemed as acceptable by NZGBC.

Information about reference buildings developed by BRANZ is available in the BRANZ SR350 study report (Berg *et al.*, 2016).

Based on information entered into the Building Information Panel of LCAQuick (Figure 3), the software suggests the closest reference building according to location, floor area and type of structure. Reference buildings are confidential so each has an identifier listed in Table 9. The reference building needs to be agreed with NZGBC prior to an assessment being carried out. This may differ from the building or buildings selected by LCAQuick. The reference building selected for this work is provided in Section 3.2.

Documentation setting out NZGBC's agreement to a reference building, and any conditions, should accompany this submission.

The reference buildings in LCAQuick have been modelled using the boundaries, data and assumptions set out in Sections 3.3.1, 3.3.2 and 5.

If a design team chooses to develop their own reference building in LCAQuick, then care should be taken to ensure that the material quantities and modelled energy use for the reference building have been developed based on the methodology set out in the BRANZ SR350 study report (Berg *et al.*, 2016). Information will need to be provided about the reference building in accordance with NZGBC's requirements.

7. Data

Currently in New Zealand, there is a lack of life cycle data for materials and processes in the life cycle of buildings.

The establishment of EPD Australasia (www.epd-australasia.com) provides a platform for construction product manufacturers to declare the environmental impacts of their products in a format suitable for use in building LCA.

Since LCAQuick is focussed on early design decisions, generic data for materials is reasonable. More product-specific data is becoming available as manufacturers register EPDs with EPD Australasia.

The process used for collecting data to calculate environmental impacts of products and processes across the building life cycle is set out in Section 5.3.3 of the BRANZ SR350 study report (Berg *et al.*, 2016), available under "Reference buildings" at www.branz.co.nz/buildingLCA. This process included independent, external review of the data for appropriateness at preliminary design.

Where data was not available from published sources, modelling of processes was carried out using the EcoInvent database (version 3.1)[13] developed by the EcoInvent Centre. The EcoInvent database was selected because it is comprehensive and is provided at the unit process level, enabling data to be adapted to more closely reflect New Zealand conditions where possible.

Information about the data used and developed for this research is provided in Appendix D and Appendix E of the BRANZ SR350 study report (Berg *et al.*, 2016), available under "Reference buildings" at www.branz.co.nz/buildingLCA. This includes the following:

- Description of the product and process represented.
- Platform or source of data e.g. EcoInvent 3.1, EPD.
- Data characteristics.
- Age of the data.
- Technological coverage.
- Geographical coverage.
- Assumptions.
- Completeness / exclusions.
- Plausibility checks.
- Consistency e.g. with EN 15804 (CEN, 2013).

7.1 A note about New Zealand grid electricity

Given the amount of Grid electricity that is used in office buildings, it is important that data is available that facilitates the calculation of associated environmental impacts. Furthermore, use of a common dataset for Grid electricity aids consistency across different building LCA studies.

Research carried out at the New Zealand Life Cycle Management Centre at Massey University, with input from BRANZ, led to the development of a New Zealand Grid electricity model on a 'per kWh low-voltage electricity at the plug' basis. The results of this work are published (Sacayon Madrigal, 2015).

[13] www.ecoinvent.org

Using the LCA model developed by Sacayon Madrigal (2016), Grid environmental impact factors by source of electricity were extracted (including transmission and distribution losses). These fuel-specific environmental impact factors were applied to Grid electricity scenarios published by MBIE (2016) to 2050. The results are provided in the Grid electricity 2018 - 2050_MBIE Scenarios 2016 (module 6) datasheet, available under "Data" at www.branz.co.nz/buildinglca. This provides calculated yearly average Grid environmental impact factors for each of the five scenarios in MBIE (2016). From these five scenarios, the "Mixed Renewables" scenario was selected as the basis for modelling future environmental impacts associated with use of Grid electricity. Thus, each year from now to 2050, the environmental impacts of the Grid change according to the changing mix of sources of energy supplying the Grid. The 2050 environmental impacts are then applied for each year following 2050.

7.2 Limitations

LCAQuick has been developed for application during early design when the focus of decisions to meet the client's requirements is on issues such as:

- Extent of refurbishment of an existing building.
- Building orientation.
- Form.
- Number of storeys.
- NLA and GFA.
- Proportion of the enclosure comprising curtain walls and/or windows on different sides of the building.
- Enclosure materials and levels of insulation.
- Type of structure and main structural materials.

To maintain simplicity, LCAQuick contains data about materials with pre-modelled scenarios (set out in Section 5). This means that there is no facility in LCAQuick to adjust the following:

- Add additional structure and enclosure materials not already contained in LCAQuick. A check of material codes is performed in LCAQuick to ensure that materials used are included in the assessment. This check is shown in Appendix C. Ideally, all materials proposed for building elements within the scope of the tool are included in the assessment. Where materials are listed as "No, Recode Required" in Appendix C, they are not included in the building assessment. Where this occurs, and depending on the nature of the material and amount used in the building, this will need to be considered.
- Include fit out elements. LCAQuick currently only considers the base build.
- Consider additional environmental indicators other than those in Table 12.
- Alter underlying data in scenarios, for example, transport distances and construction site waste rates for materials. At preliminary design, it is unlikely that this level of detail will be considered.

8. Environmental indicators [11]

LCAQuick calculates the environmental indicators in Table 12, taken from EN 15978 (CEN, 2011).

Table 12 Indicators describing potential environmental impacts

Indicator	Unit
Global warming potential	kg CO_2 eq.
Depletion potential of the stratospheric ozone layer	kg CFC 11 eq.
Acidification potential of land and water	kg SO_2 eq.
Eutrophication potential	kg PO_4^{3-} eq.
Formation potential of tropospheric ozone photochemical oxidants	kg C_2H_2 eq.
Abiotic resource depletion potential for elements	kg Sb eq.
Abiotic resource depletion potential of fossil fuels	MJ, net calorific value

The underlying methodologies and characterisation factors for calculation of these environmental indicators are set out in the BRANZ SR293 study report (Dowdell, 2014), available under "Indicators" at www.branz.co.nz/buildingLCA. These are based on EN 15804 (CEN, 2013).

9. Reporting of assessment results [12]

EN 15978 (CEN, 2011) requires reporting to a sufficient level of detail to provide transparency and traceability of information.

Table 13 lists the information required by EN 15978 (CEN, 2011) and where this can be found in this report and supporting documentation developed as part of the NZ whole-building whole-of-life framework.

Table 13 Summary of reporting requirements (from EN 15978, 2011)

Information requirement	Location of information
Purpose of the assessment	Section 2
Identification of building	Section 3.1
Client for assessment	Section 2
Name and qualification of assessor	Section 2
Assessment method including version number and reference	Section 2
Point of assessment in the building's life cycle	[insert based on stage of assessment in design cycle]
Period for which the assessment is valid	[insert based on stage of submission]
Date of assessment	[insert date]
Statement regarding verification of the assessment	[insert whether a verification has been carried out and if so provide a reference to report]
Building type	Office
Relevant technical and functional requirements	Section 3.1.1
Pattern of use e.g. occupancy	Section 3.3.1 Operational energy (module B6) datasheet www.branz.co.nz/buildingLCA
Required service life	Section 3.3.2 Building service life (Use stage (modules B1 - B7)) datasheet www.branz.co.nz/buildingLCA
Reference study period	Section 3.3.2 Building service life (Use stage (modules B1 - B7)) datasheet www.branz.co.nz/buildingLCA
Technical type of building e.g. structural type	Section 3.1.1
Year of commissioning	[insert year]
Year of refurbishment	[insert year]

Design number of building occupants	Figure 3
Design occupancy schedule	Operational energy (module B6) datasheet
HVAC system and hot water system	Section 3.1.1
Lighting system	Lighting power density in Operational energy (module B6) datasheet www.branz.co.nz/buildingLCA
Power and communication system	Operational energy (module B6) datasheet
Statement of boundaries and scenarios used in the assessment	Section 3.3, Section 5, BRANZ SR349 study report (Dowdell & Berg, 2016), BRANZ SR350 study report (Berg *et al.*, 2016)
Data sources	Section 7, BRANZ SR350 study report (Berg *et al.*, 2016), BRANZ SR351 study report (Dowdell *et al.*, 2016), datasheets under "Data" at www.branz.co.nz/buildingLCA.
List of indicators used for assessment and expression of results	Section 8, BRANZ SR293 study report (Dowdell, 2014)
Communication of assessment results	Section 4
Verification of results	Section 10

10. Verification [13]

The NZGBC makes the decision about whether verification is required. The verification process should meet NZGBC's requirements.

Where verification is required, a purpose of this report is to provide transparency in order that information used, assumptions made and decisions taken can be reviewed.

According to EN 15878 (CEN, 2011), the verification shall include:

- Consistency between the purpose of assessment, boundaries and scenarios used. This means that the way the study has been conducted and the data used are suitable for achieving the goal of the study i.e. to inform early design decisions.
- Traceability of data used for products.
- Conformity with EN 15804 (CEN, 2013).
- Consistency between scenarios at building level and those at product level (if relevant).
- Completeness, in the context of the goal of the assessment.

When a verification is required, the verifier provides a verification report which should accompany this report when submitted.

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Appendix A: LCAQuick results by indicator by life cycle stage

Results presented in this section are screenshots taken from Panel C of LCAQuick, located in the "4a_SUMMARY ANALYSIS" worksheet.

Each of the sub-headings below has an "LCAQuick selection" in brackets. This refers to the name given to the indicator in LCAQuick, which should be selected prior to obtaining a screenshot for insertion in this Appendix. Care should be taken to ensure the results are expressed "per Area GFA" by selecting the appropriate category from the right drop down menu in Panel C.

When making any new selections using drop down menus in LCAQuick, it is worthwhile to get into the habit of clicking on the "CLICK TO CALCULATE WORKBOOK" button afterwards, to ensure values in tables and graphs are updated to reflect your new selection.

Results are shown over a 60 year reference service life. Bars show the stages of the life cycle and how they contribute to calculated environmental indicators.

Module D is also calculated. The net effect of including module D on results is shown as a circle for the assessed building and as a triangle for the reference building.

A.1 Global warming potential (LCAQuick selection: Global warming)

A.2 Depletion potential of the stratospheric ozone layer (LCAQuick selection: strat ozone depletion)

A.3 Acidification potential of land and water (LCAQuick selection: Acid of soil & water)

A.4 Eutrophication potential (LCAQuick selection: Eutrophication)

A.5 Formation potential of tropospheric ozone photochemical oxidants (LCAQuick selection: Photo oxidant form)

A.6 Abiotic resource depletion potential for elements (LCAQuick selection: Depletion abiotic resources (elements) Non-Fossil fuels)

A.7 Abiotic resource depletion potential for fossil fuels (LCAQuick selection: Depletion abiotic resources (fossil fuels))

Appendix B: Energy simulation results for the assessed building

Results below are a screenshot of the "Part 1: Building related / base building annual energy consumption" and "Part 2 Building related annual energy consumption" tables from the "2a INPUT PASTE - Energy Use" worksheet in LCAQuick, which summarise energy demand and supply, as well as results expressed per kWh/m^2 GFA/ year (with a 60 year Use stage).

Appendix C: LCAQuick materials check results

This Appendix provides a screenshot from LCAQuick of the "1c INPUT – Material Quant." worksheet, which is used to check that the materials listed are recognized by LCAQuick. You should paste columns AB (Parameter 4) to AN here from this worksheet. Where LCAQuick provides a "Recode required" message, this may be because the material has been miscoded or because a material is being used that is not preloaded into LCAQuick.

Appendix D: Additional information

Please enter below any additional information that does not fit into the provided text fields in the report.