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TE201/3

The Role of LCA in Decision Making in the Context of Sustainable Development

Final

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About This Report

Title

The Role of LCA in Decision Making in the Context of Sustainable Development

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Abstract

Life cycle assessment (LCA) is a standardised methodology for the quantification of the potential environmental impacts of processes and systems. The data provided can be used effectively to assist in decision making situations. This paper gives examples on how the results from LCA studies and the process of conducting the study can assist in decision making processes. Emphasis is on explaining and guidance on interpretation of the information delivered by an LCA as an essential part of achieving broader goals such as sustainability rather than the simple comparison of products.

The role of environmental labels and rating tools in decision making processes from the perspective of LCA is discussed and examples from companies who have already successfully implemented LCA in their organisations are provided.

The paper concludes with recommendations about using LCA more effectively in decision making processes in the built environment in New Zealand.

Note

This report was written as part of the research Beacon Pathway Limited (Beacon) commissioned under the banner of “LCA education”. The project had two main components. The first was to conduct workshops that would introduce the concept of LCA, demonstrate its application in the built environment and highlight specific issues related to LCA and the building industry. The second component involved the production of two reports, the first to describe LCA methodology to help stakeholders interpret LCA studies and the second to document the role of LCA in decision making.

To reach our goal of a high standard of sustainability with respect to materials, Beacon (and ultimately the building industry and the regulators) needs to understand the impact of materials used in homes from cradle to grave.

This report should be considered within the series of reports written for Beacon on materials, in particular the following resources:

- White paper – LCA and the Building/Construction Industry
- Analysis of current profiles of building products.
- The workshop presentations given as part of this LCA education stream of work.

Reference

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Contents

1. Executive Summary

Life cycle assessment (LCA) is a standardised methodology for the quantification of the potential environmental impacts of processes and systems. The data provided can be used effectively to assist in decision making situations. The following attributes of LCA contribute to its overall usefulness in the decision making process:

- LCA takes a holistic approach to identifying and quantifying environmental impacts;
- LCA is data driven;
- LCA is replicable where it is based on standard methodologies (i.e. ISO 14040 and 14044);
- A range of tools already exist to effectively collate, manage and report data;
- LCA provides a robust methodological framework for quantifying environmental and economic factors, and over time is also likely to include social and cultural issues.

Decision making situations can be categories in both operational and strategic decisions. The choice between two building products would be an operational decision and the choice to implement sustainability in a manufacturing process would be a strategic decision. The use of LCA in these situations is demonstrated in the examples of a wall system for an operational decision, and the production of brick for a strategic decision.

The paper also discusses tools such as environmental labels and rating tools which are frequently used for decision making processes. LCA is increasingly implemented in these tools, but often they are not based on data. Environmental product declarations are one way of communicating LCA data for the use of decision makers.

Companies such as Formway Furniture and BlueScope Steel have already successfully implemented LCA in their organisations. How these companies use LCA, and how they benefit from using this holistic approach in their pathway towards sustainability, is briefly described.

The paper concludes with recommendations about using LCA more effectively in the built environment in New Zealand:

- Life cycle assessment approaches should be implemented in the development of new building materials as well as building components.
- The use of LCA should be demonstrated in operational as well as strategic decision making by looking back at the construction process of the two NOW Homes®.
- There should be increased use of LCA data in the development of product specifications for eco-labels and to promote the uptake of environmental product declarations as a tool for the communication of environmental information.
- LCA approaches should be fostered in the building industry in New Zealand, as they have been used successfully in previous New Zealand-based examples.

2 Introduction

The development of more sustainable products and processes requires comprehensive and reliable decision support systems which are based on data. Life cycle assessment (LCA) is an established methodology for quantifying potential environmental impacts and can feed into decision support systems for improved environmental choices by manufacturers, policy makers and consumers.

Previous reports (White Paper (Nebel 2006), Methodology Paper (TE201A, Nebel 2006a)) have focused on the process of LCA, explained the methodology, and highlighted the use of LCA as a framework to support the implementation of a "sustainable development" strategy for the building industry in New Zealand. LCA is a particularly useful tool for this latter point as it can contribute to:

- a greater understanding of product life cycles and interrelationships between users and stakeholders.
- the building industry in New Zealand becoming a leader in the systems approach to sustainable development and gaining recognition for its contribution to the development of robust procurement systems, rating tools and environmental labels.
- the development of processes that encourage a high level of transparency and which ensure that both internal and external stakeholders receive regular and appropriate information on improvements through benchmarking and 'hot spot analysis', as well as effectively explaining decisions and implications.
- the application of a 'sustainable design' process, on a company level, that allows effective lock-in of 'environmental gain' and for individual companies' members to position themselves ahead of other companies and their products in terms of product stewardship and extended producer responsibility.

This report focuses on using LCA results and outcomes to improve overall sustainability for the built environment, i.e. for making decisions that impact on sustainability. The focus is on use in improving supply chains as well as on the comparison of building products. Other applications for LCA include decision aiding systems such as environmental labels, databases and rating tools. These are also briefly discussed in this report. The respective applications and limitations in the decision making process are described for each system.

Quantifying the potential environmental impacts helps to improve the production processes of certain products by analysing each production step with LCA and comparing the results one below the other. The result of this so called product- and company-specific life cycle analysis is to find out where improvement measures could be started and where the biggest improvements can be obtained

This report intends to assist organisations to use Life Cycle Assessment both to improve their products internally and to place their products in the right context for comparing them with other products or product systems.

3 Definitions

This study focuses on the use of LCA in decision making in the context of the built environment. In order to ensure a common understanding of the terms building material, building product, building component, LCA and the decision making process, these terms are briefly defined in this chapter.

Building material:
A material that does not fulfil a specific function, but will be used in different applications. For example, steel can be used as a connector for timber frames or for steel framing.

Building product:
Products are based on one or more materials and have a specific function. For example, timber can be a stud or a weatherboard. The term building product does not necessarily refer to a specific brand of a product, e.g. the building product would be plasterboard and not Gib® board.

Building component:
Building components consist of different building products. A wall would include framing, insulation, external cladding and internal lining.

4 LCA Methodology

Life cycle assessment (LCA) is a standardised methodology for the examination of processes and systems from an environmental point of view that can assist the process of good decision making in many ways.

The key attributes of LCA that contribute to its overall usefulness in the decision making process are shown below.

- LCA takes an holistic approach to identifying and quantifying environmental impacts;
- LCA is data driven;
- LCA is replicable where it is based on standard methodologies (i.e. ISO 14040 and 14044);
- A range of tools already exist to effectively collate, manage and report data;
- LCA provides a robust methodological framework for quantifying environmental and economic factors, and over time is also likely to include social and cultural issues.

The LCA methodology has been described in detail in the White Paper (Nebel 2006) and the Methodology Paper TE201A (Nebel 2006a). Therefore only a short review of the main steps is provided here.

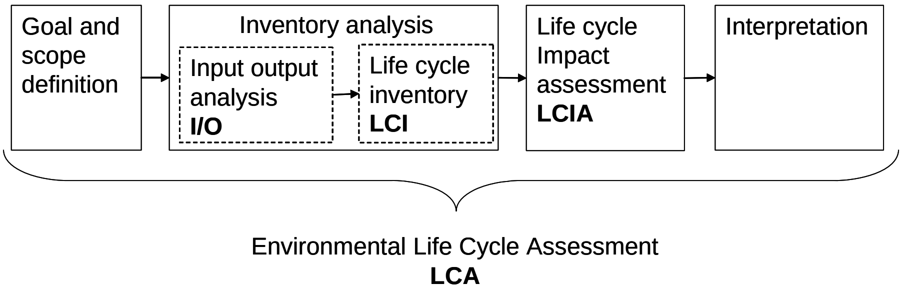

Figure 1: The key stages of environmental life cycle assessment

1. Goal and scope definition includes the following aspects:

- Intended application, reason for carrying out the study and the intended audience
- The functional unit
- The product system to be studied
- System boundaries
- Data requirements and data quality, assumptions, limitations
- Allocation procedures
- Categories, methods, and interpretation at impact assessment
- Type of critical review, if any, and
- Type and format of the report required for the study.

2. The inventory analysis includes the following steps:

- Input/output analysis:
  In this step all direct inputs and outputs related to production process are collated. This includes, for example, electricity, heat from natural gas, and in the case of producing bricks the raw clay product. The direct outputs would be the baked brick, emissions, waste to landfill and waste to recycling.

  Based on the input output analysis (I/O analysis) that is provided by the manufacturer, the LCA practitioner establishes the life cycle inventory (LCI).
- Life cycle inventory (LCI)
  In the LCI all upstream processes are included. This means that, for example, the extraction of coal, the transportation to the power station and all emissions from the electricity production are included. The same principle is applied to all intermediate products, for example the additives used in the production process. The result is a long

list of raw materials (all exchanges from nature) and all emissions from all included processes (all exchanges to nature).

All of the exchanges from and to nature compiled in the analysis are “translated” into environmental impacts during the impact assessment phase of LCA (LCIA).

3. Life cycle impact assessment (LCIA)

The aim of this phase is to evaluate the significance of potential environmental impacts (e.g. climate change, ozone depletion).

The results are displayed for each environmental impact and are then ready for interpretation.

4. Interpretation

In this phase conclusions and recommendations for decision-makers are drawn from the inventory analysis and the impact assessment.

4.1 Decision Making Process (DMP)

The decision-making process in general, as well as strategic and operational decision making situations, is described in this chapter.

The decision making process “generally involves determining the problem then trying to sift out relevant information on the subject…, and then, with the use of such information, trying to determine what will be the most likely outcomes should certain decisions be made; one of the possible decisions is then selected for implementation and execution.” (Encyclopaedia Britannica 1976).

The process can be summarised in the following steps:

- definition of possible alternatives,
- evaluation of alternatives,
- making the decision.

The definition of the alternatives includes a wide range of options as alternatives cannot be excluded until after their evaluation. This evaluation is usually based on criteria, such as aesthetics, cost, availability, environmental impact, etc. In order to assess these criteria, objective information has to be gathered and LCA can provide the information at this stage in the decision making process.

Only in a very few cases will one option be the favoured choice in all criteria, e.g. the preferred design, most economical and most environmentally benign. In all other cases subjective judgement is required in order to weigh the criteria against each other. Although LCA can produce the required information, decision makers will always have to apply their subjective weighting.

Decisions can be further grouped into two major categories, which include the immediate choice between a number of alternatives (operational decisions) and the longer term decision to make constant and/or significant improvements (strategic decisions).

4.1.1 Operational Decision

Operational decisions are concerned with small changes of small-scale systems with a short time horizon. In other words, a limited number of alternatives need to be assessed in order to achieve the best sustainability outcome in a particular situation.

Typically in these cases, only a limited number of alternatives are available, the problem is well defined and the potential stakeholders are identified. Quantitative information is often used in the operational decision making process (Cowell 1998, Mazri et al. 2004).

An example for an operational decision would be the choice of a specific building product in a house, e.g. fibre cement cladding versus timber weatherboards.

In the context of operational decisions, LCA is mainly used as a tool which provides quantitative information on the potential environmental impacts of a number of alternatives.

4.1.2 Strategic Decision

Strategic decisions are concerned with large and possibly qualitative changes of large-scale systems with long time frames. The level of uncertainty is generally high, the problem fuzzy and the stakeholder group might not be clearly identified. Qualitative information is often used in the strategic decision making process (Cowell 1998, Mazri et al. 2004).

Sustainability-related decisions from policy makers or industry often relate to constant and/or significant improvement and therefore have a more strategic nature. Strategic decisions can be made by management in companies and policy makers within government, and are also made by consumers. The decision to build a sustainable home, for example, is a strategic decision by a homeowner. The design choices made on the building materials, spatial relationships, environmental quality and site location all have long term implications – not only for the ongoing performance of both the building and its immediate surrounds, but also the health of its occupants.

A strategic decision for a company might be to move from a product-oriented to a service-oriented focus for its operations. The carpet manufacturer Interface is probably the most prominent example of this, by providing a carpet rather than selling the carpet to the customer. After a certain time period, the carpet is returned to the manufacturer; thus the responsibility of disposal has been shifted from the end user back to the manufacturer.

The Fisher and Paykel whiteware take-back scheme in the North Island is another example. It offers return to dealerships and service centres as an alternative to landfilling used products. Fisher and Paykel can reuse or recycle 75% of returned appliances by weight. With sales of recyclable materials and internal savings from the re-use of packaging materials, this take-back venture is proving to be financially self-sustaining (Product Ecology 2006).

5 The Application of LCA in Decision Making

5.1 Introduction

The differences between strategic (vertical ranking) and operational (horizontal ranking) decisions are demonstrated below in two examples. The use of LCA in a **strategic** decision making process is explained for the production of 1 kg of bricks, from the point of view of the manufacturer. The **operational** decision making process is illustrated using two different wall systems – a solid, insulated masonry wall, and an insulated light timber framed wall with weatherboard cladding – from the point of view of a product consumer (e.g. designer, home owner, etc.). The same system boundaries and functional units are applied to both components.

5.2 Strategic Decision Making

An example from a manufacturer’s point of view is provided in order to demonstrate the application of LCA in a strategic decision making process.

5.2.1 Goal and Scope

Goal:

The key goal in a decision making context is the environmental improvement of the production process of the bricks from cradle to gate.

Further goals of the LCA could include:

- Preparation of a dataset of requirements of rating tools (labelling)
- Identification of hotspots in the life cycle to start dialogue with suppliers
- Preparation of information for marketing

Functional unit: 1 kg of bricks

Product system including system boundary:

The production process is separated into the different production steps. For each of these steps, an Input and Output analysis is required (see Figure 2).

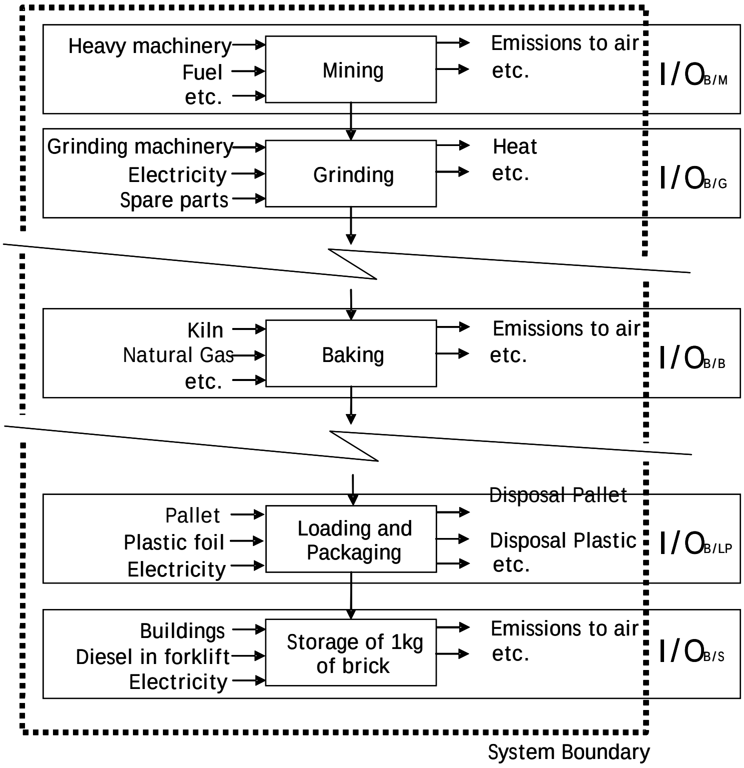

Figure 2: Steps of the production process of 1 kg brick from cradle to gate including a detailed input/output analysis for each production step

5.2.2 Inventory analysis (I/O and LCI)

Based on the Input and Output analysis in Figure 2, the next step links all the Inputs to the upstream products and processes. For example, the analysis of heat from natural gas would include the firing process with its emissions, the oven and the other entire infrastructure (e.g. pipeline for the transport of gas to the manufacturer) all the way back to the extraction of the natural gas. In the case of electricity this would include the production of electricity (e.g. by a diesel and coal based generator, nuclear or hydro power, etc.), the needed infrastructure for the generator and its distribution - everything back to the coal mining from nature.

The following example shows the overall LCI of the baking process of 1kg of bricks:

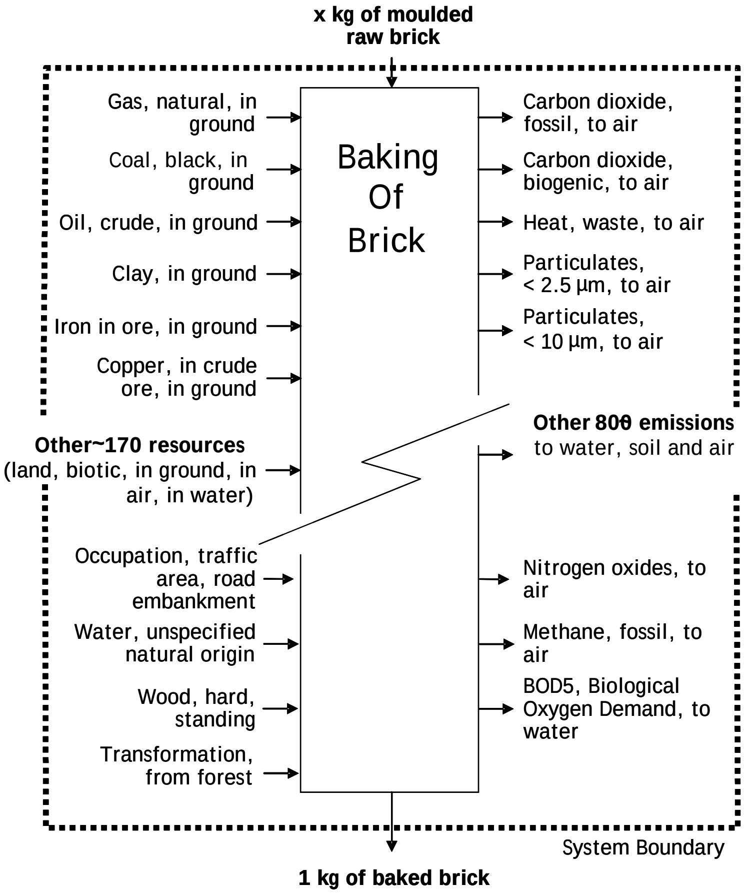

Figure 3: LCI of the baking process for 1 kg of baked brick

The list on the left in Figure 3 shows all the exchanges from nature into the production system and the list on the right shows all exchanges going back to nature (mainly air emissions in this case). A similar analysis would be carried out for the previous and the following production steps of bricks.

5.2.3 Life Cycle Impact Assessment (LCIA)

The steps from the Input/Output analysis to an LCIA are shown in

Figure 4 with the example of global warming potential (GWP or climate change). The first column lists all the emissions stemming from the baking process (heat from natural gas). The second column lists the contribution of the relevant emissions to the GWP. The third column then calculates the overall contribution of the baking process to climate change.

Emission from baking process	weight [kg]	Global warming potential of substance [kg CO2 equiv.]	Global warming potential of production ste [kg CO2 equiv.]
Acetic acid	1.40E-7	0	-
Benzene	3.73E-7	0	-
Butane (n-butane)	1.07E-6	0	-
Carbon dioxide	8.22E-2	**1**	8.22E-2
Carbon monoxide	7.36E-5	0	-
Dust (unspecified)	1.63E-7	0	-
Ethane	1.14E-5	0	-
Exhaust	4.72E-1	0	-
Formaldehyde (methanal)	9.79E-7	0	-
Methane	1.75E-4	**21**	3.67E-3
Nitrogen oxides	3.12E-4	0	-
Nitrous oxide (laughing gas)	1.76E-6	**310**	5.47E-4
NMVOC (unspecified)	1.08E-5	0	-
Pentane (n-pentane)	1.59E-6	0	-
Propane	5.13E-7	0	-
Steam	6.14E-2	0	-
Sulphur dioxide	7.79E-7	0	-
etc., etc.			
Total			8.64E-2

Figure 4: Emissions from the baking process and their contribution to GWP

Linking all the exchanges from and to nature with different impact assessment leads to the LCIA results. Figure 5 on the next page shows the results for a selection of indicators.

Impact category	Sub-Category	Unit	Baking of 1 kg brick
Cumulative Energy Demand	non-renewable: fossil	MJ-Eq	1.49E+0
	non-renewable: nuclear	MJ-Eq	3.01E-2
	renewable: biomass	MJ-Eq	6.76E-4
	renewable: wind, solar, geothermal	MJ-Eq	7.85E-4
	renewable: water	MJ-Eq	6.68E-3
CML 2001	acidification potential	kg SO_2 Eq	8.53E-5
	climate change (global warming potential)	kg CO_2 Eq	8.64E-2
	eutrophication potential	kg PO_2 Eq	8.58E-6
	freshwater aquatic ecotoxicity	kg 1,4-DCB-Eq	4.26E-4
	freshwater sediment ecotoxicity	kg 1,4-DCB-Eq	9.84E-4
	human toxicity	kg 1,4-DCB-Eq	9.14E-3
	land use	m^2 a	9.71E-5
	malodours air	m^3 air	2.20E+3
	marine aquatic ecotoxicity	kg 1,4-DCB-Eq	6.30E-3
	photochemical oxidation (summer smog)	kg formed ozone	7.40E-6
	resources	kg antimony-Eq	7.34E-4
	stratospheric ozone depletion	kg CFC-11-Eq	2.18E-8
	terrestrial ecotoxicity	kg 1,4-DCB-Eq	2.53E-6
eco-indicator 99, (E,E)	total	points	4.63E-3
eco-indicator 99, (H,A)	total	points	5.49E-3
eco-indicator 99, (I,I)	total	points	1.64E-3

Figure 5: A selection of LCIA results for the baking process of 1 kg brick (assumption based on brick production process from[1])

When applying this process of doing an LCI for each production step, followed by an LCIA, the results could be compared within a certain indicator as shown in the next chapter.

5.2.4 Summary and Interpretation

The stages of an LCA from Input/Output analysis to inventory analysis (LCI) and life cycle impact assessment (LCIA) are shown in Figure 6. The full analysis would include the same amount of detail for all stages.

The LCIA shows the environmental assessment of all the production steps in relation to each other.

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[1] *www.ecoinvent.com. Version 1.3*

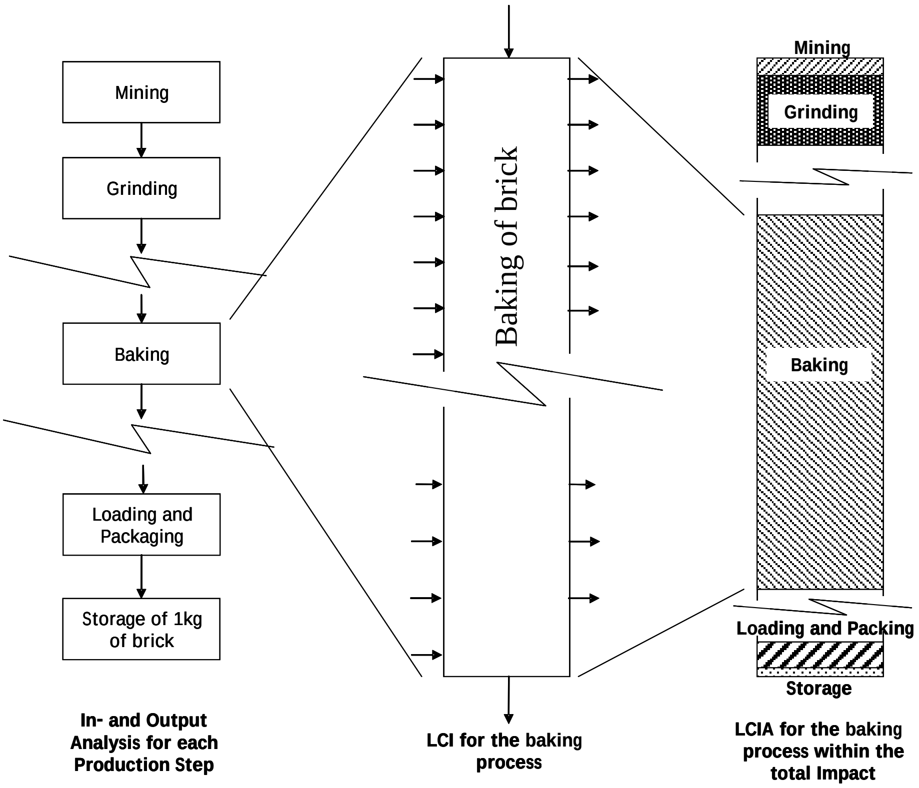


Figure 6: Correlation between I/O analysis, LCI and LCIA on the example of brick baking

The results of the LCIA are shown for one environmental impact category, in this case the example of global warming. The contribution of each production step is expressed in kg CO_2 equivalents. The results show that the baking process is the dominant step in terms of global warming potential.

In the interpretation stage, which is the last stage of an LCA (not shown in Figure 6) the following conclusion could be drawn:

For environmental improvements within the brick production process, measures related to the baking process should be explored. A deeper analysis of the baking process will then show that the gas heater is the main CO_2 emitter. This again leads either to measures reducing the amount of heat needed by reducing the heat losses (better insulation of the kilns or more efficient heat production) or it could lead to a change in the heating system (e.g. wood waste instead of natural gas).

All stages of the process of carrying out the LCA, starting from the goal and scope definition through to the impact assessment, have contributed to the decision making process.

5.3 Operational Decision Making

The application of LCA for operational decision making is shown in the example of two different but comparable wall components from the point of view of a product consumer (e.g. designer, home owner, etc.). The following stages of an LCA are described: The goal and scope including the functional unit, a description of the product systems followed by the inventory analysis concentrating on the input and output flows and the system boundaries, and the environmental impact assessment for one impact category (global warming potential). The Life Cycle Inventories (LCIs) are not presented due to the long list of exchanges from and to nature. The interpretation concentrates on the main input and output flows dominating the results.

5.3.1 Goal and Scope

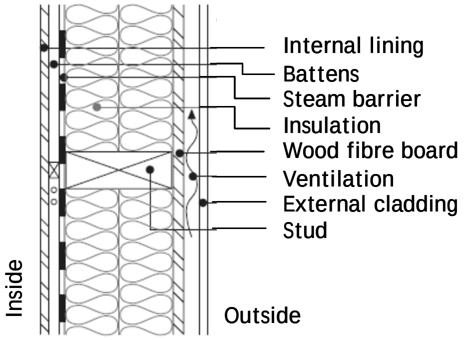
Goal: To compare two different wall systems (components) in order to provide information to decide which of these two systems should be chosen, with a specific emphasis on lower potential impact on global warming (kg CO_2-Eq.)

Functional unit: 1 m^2 exterior wall with a total R-value of 0.22 W/m^2K from cradle to grave over a lifespan of 100 years.

Product systems:

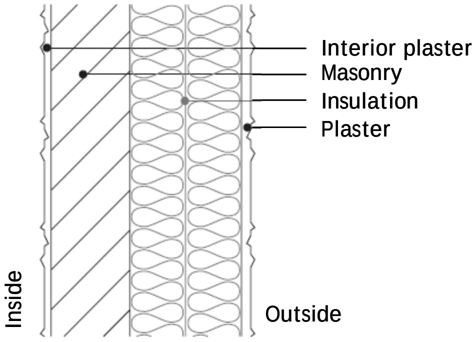
- Insulated light timber framed wall
- Insulated solid masonry wall

Wooden post-and-beam structure with intermediate insulation



Material	Thickness (m)
1 Softwood (battens and lining)	0.015
2 Steam barrier (PE)	0.0015
3 Rockwool (30/m^3)	0.19
4 Wooden studs 12/18cm	17.5 kg/m^2
5 Medium density fibreboard	0.015
6 Softwood (stud and cladding)	0.024

Brick wall with lined outer insulation



Material	Thickness (m)
1 Mineral interior plaster	0.015
2 Brick and cement	0.125
3 Adhesive Mortar (plastic based)	0.003
4 Extruded Polystyrene (18kg/m^3)	0.15
5 Mineral finishing coat plaster	0.015

Figure 7: Cross-section of two different types of wall construction

Both wall types are built up by theoretical layers. These layers describe the parts which, when replaced, are replaced at once. Looking at the wooden wall construction, the internal layer for example would include the lining, the battens and the steam barrier (lifespan e.g. 20 years). The different lifespans define the replacement rates to be taken into account.

5.3.2 Inventory analysis

The product system with all its direct input and output flows (input/output analysis), including the system boundary for the wooden wall construction is presented in Figure 8 and Figure 9 in for the brick wall respectively.

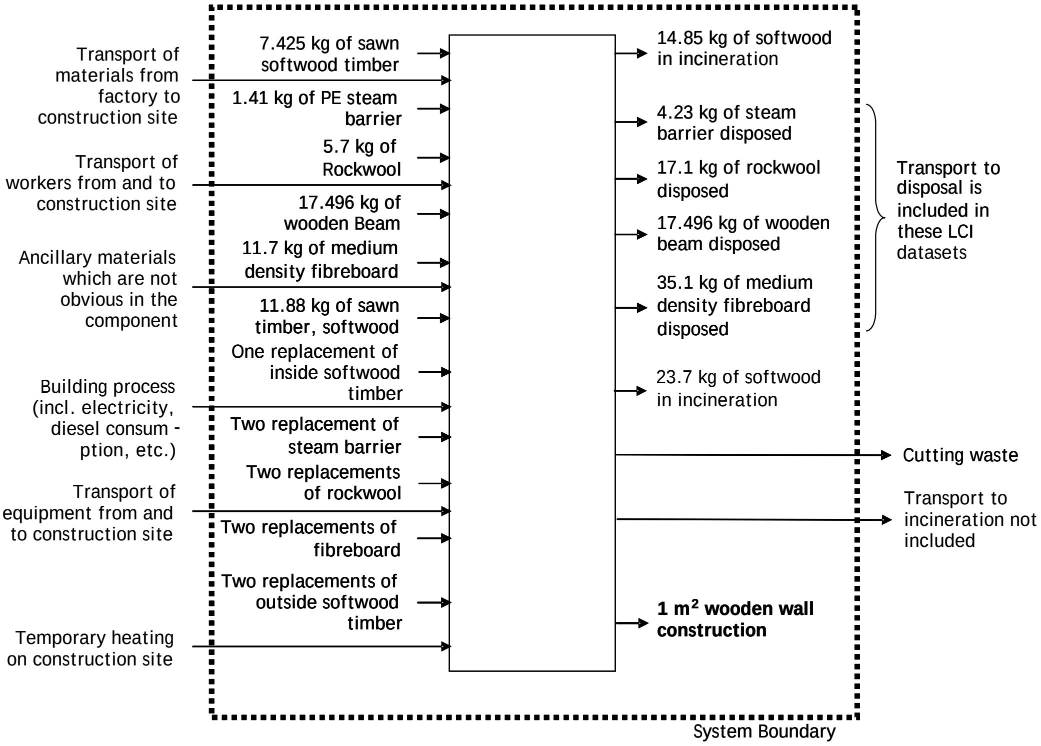


Figure 8: Input / Output analysis of the wooden wall construction including the system boundary

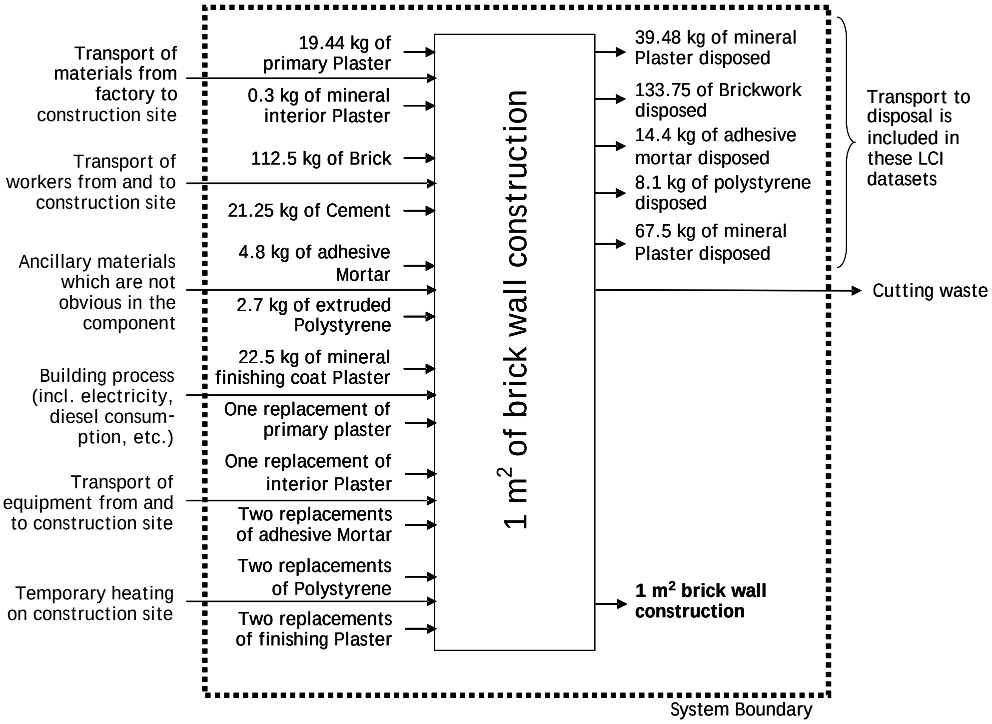


Figure 9: Input / Output analysis of the brick wall construction including the system boundary

The dotted line represents the system boundary. All inputs within this boundary are taken into account, and those starting from the outside are excluded from the analysis.

In the next step the assumed lifespan of each product, the number of replacements, the predefined disposal option and the replaced layers are all combined to calculate an overall LCI for the components. This would take the production process of each product into account, as explained in the example for brick production. As in the example of the use of LCA in the strategic decision making process, the next step here is also the LCIA.

5.3.3 Life Cycle Inventory Assessment (LCIA)

According to the goal of this LCA which stated an emphasis on the potential impact on climate change, only the results related to this impact category are presented here. Other results would include for example the total energy consumption (renewable and non-renewable), the potential impact on ozone depletion, etc.

The results for the GWP (Global Warming Potential) are expressed in kg CO_2-Eq. The results for 1 m^2 and in one year for the two wall constructions are:

Brick wall construction 1.10 kg CO_2-Eq./m^2a

Wooden wall construction 0.88 kg CO_2-Eq./m^2a

5.3.4 *Interpretation*

In terms of the global warming potential, the wooden construction performs better. Although there are great differences in some of the building products, the overall results do not vary greatly. Polystyrene insulation, for example, has significantly higher CO2-Eq. emissions than rock wool (5.98 versus 1.43 kg CO_2-Eq.) per kg of material. However, due to a thinner layer of polystyrene (15 instead of 19 cm) with a much lower density then rockwool (18 versus 30 kg/m^3), the overall results, related to the same function, are not very different. Both insulation materials have a replacement rate of two (which means replacement will occur twice in the designated time frame – in this study the time frame is 100 years, as mentioned in section 3.2.1).

The brick product within the brick wall construction leads to relatively high CO_2 emissions during the baking process (gas heater), but it is not replaced during the whole lifespan of the building component and therefore the overall difference from the range of timber parts with several replacements is reduced.

An analysis of each system could be used for the improvement of each option. This would lead to a strategic decision making process, which would require the collaboration of a number of stakeholders in the supply chain.

6 Existing Tools

Besides full LCA studies, which can be combined with life cycle costing for the economic analysis, there is a range of LCA-based tools which are available to aid stakeholders in the decision making process. These tools include:

- Environmental labels
- Rating tools

In this section the different tools are briefly described and discussed from a sustainability perspective.

6.1 Environmental labels

One potential application of LCA results (i.e. the outcome of the application of LCA as a tool) in a decision making process is the development of environmental labels such as New Zealand's Environmental Choice and Environmental Product Declarations. Environmental labels are an effective way to communicate complex environmental information in a simplified fashion for non-experts. Baumann and Tillman (2003) differentiate here between business-to-business communication and communication between business and consumers (Figure 10).

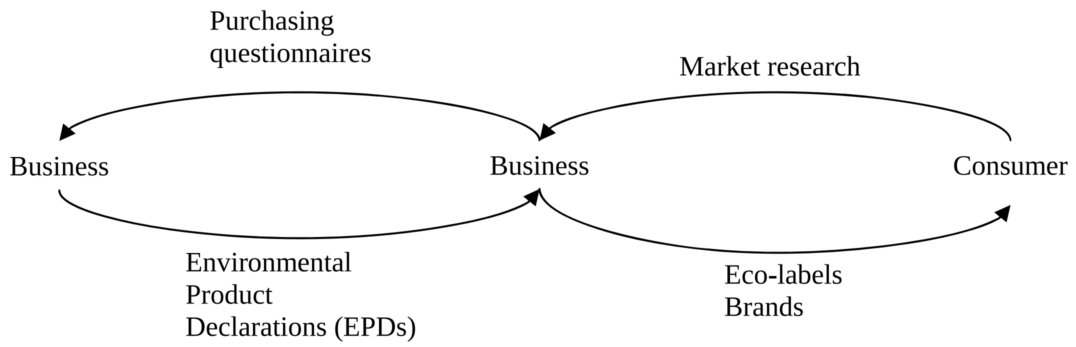


Figure 10: Environmental market communication and examples of the use of the environmental market tool (Baumann and Tillman 2003)

ISO standards for environmental market instruments are represented in the ISO 14020 series. The general principles are given in ISO 14040. ISO 14024 specifies ISO Type I labels, which are usually understood as eco-labelling. Type II labels are based on self-declared environmental claims and don't require third party review. A framework for Type III labels, or Environmental Product Declarations (EPDs) is given in ISO 14025. All these ISO standards state that:

"the overall goal of environmental labels and declarations is, through communication of verifiable and accurate information, that is not misleading, on environmental aspects of products and services, to encourage the demand for and the supply of those products and services that cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement".

This means that there clearly is an element of providing information for decision making, but the application of eco-labels and product declarations goes beyond this brief and has an emphasis on marketing.

6.1.1 Environmental Choice (ISO Type 1 Labels)

An example of ISO type I labels is "environmental choice". Environmental Choice New Zealand follows the ISO 14024 standard "environmental labels and declarations – guiding principles". According to this standard, the environmental criteria shall be based on indicators arising from life cycle considerations (ISO 14024) as well as on sound scientific and engineering principles (ISO 14024). It is also pointed out in the standard that "the product environmental criteria should … give consideration to relative environmental impacts" (ISO 14024).

Environmental Choice recognises the genuine moves made by manufacturers to reduce the environmental impact of their products and provides a credible and independent guide for consumers. The system is based on the life cycle considerations which manufacturers must adhere to if they are to gain product certification (the Enviro-Choice tick). The specifications are derived from careful background studies of the life cycle aspects of the products. As a minimum, the completion of life cycle templates (which examine the environmental inputs and outputs during raw material extraction, manufacture, distribution, use and disposal), are carried out to determine possible significant environmental issues. However, more formal examination of ISO 14040-based international studies may also be carried out, depending on the product.

The idea of Environmental Choice is to show best practice and base decisions on the life cycle of the product. The life cycle approach must be used to identify the environmental issues that are relevant to the product category, and in particular to:

- identify stages in a product's life cycle where there are environmental impacts
- identify impacts that are not significant
- ensure any environmental criteria selected will not result in impact being shifted from one stage of the lifecycle to another (without environmental benefits).

Likewise, the issues for which environmental criteria are set must be selected to:

- reflect the environmental issues identified as most significant
- differentiate environmentally preferable products, based on measurable and significant differences in environmental impact
- take into account local, regional and global environmental concerns.

The criteria by which the issues are set must be based on sound scientific and engineering principles, and be measurable and verifiable. Criteria may be made measurable using minimum thresholds, scale point systems, and quantitative and qualitative indices. Where standard tests or verification methods are set, these are usually based on international standards, regional or national standards, other repeatable methods or evidence provided by the manufacturer (the least preferred).

6.1.2 Environmental Product Declarations (ISO Type III Labels)

A transparent way of making LCA data on building materials available to stakeholders is through Environmental Product Declarations (EPD). Environmental Product Declarations are, amongst other things, the key future instruments to foster more environmentally sound production and consumption, and they are used by various decision makers in many applications. The main purpose of EPDs is to provide correct and verified information about the environmental aspects of products, based on internationally accepted and scientific methods of quantification.

However, EPDs can also provide further information such as technical information about the product, content of hazardous substances, disassembly information, recovery and recycling of used products and waste.

The ISO standard 14025 'Environmental labels and declarations - Type III environmental declarations - Principles and Procedures' was published on 1 July 2006. An Environmental

Product Declaration is based on a third-party-reviewed LCA of a specific product and is issued by an independent body.

An EPD would typically contain the following information:

- Product definition and physical data
- Information about raw materials and origin
- Specifications on manufacturing the product
- References for product processing
- Information on product in use, singular effects and end of life
- LCA results
- Evidence and verifications

See Annex 2 for an example for a product declaration for a building product (Rheinzink GmbH & CO KG 2005).

6.2 Rating tools

A number of green building rating tools have been developed in order to foster more sustainable buildings. Examples are BRANZ Ltd's Green Home Scheme for residential buildings or Green Star NZ, a rating tool for office buildings which is currently available as a pilot and will be launched in April 2007.

Internationally LEED (Leadership in Energy and Environmental Design), a rating tool for commercial buildings in the US, is widely known.

All tools have in common the fact that they deal with the efficient use of energy and water during building operations, indoor environmental quality and environmentally preferable building materials. A certain number of points are awarded for specific characteristics of the building, such the use of FSC certified timber, the use of paint systems which have an environmental label, or the access to public transport. A weighting system is then applied, (e.g. indoor air quality 20%, energy efficiency 20%, materials 10%, etc.) and a single score for the building is calculated. A building is then awarded with for example 4 or 5 stars.

Trusty and Horst (2006) have discussed in detail the integration of LCA in green building rating tools. They suggest that one of the key problems of rating tools is that the choice of the environmental criteria has typically evolved "from a consensus-based understanding of environmental issues, understandings that, in some cases, have taken on an aura of conventional environmental wisdom that does not always stand up to objective analysis." This can be demonstrated in the case of recycling. LEED, the Green Home Scheme and the current pilot of the Green Star NZ offer credits for the use of recycled materials. However, recycling in any given situation might be good or bad. On one hand recycling can save landfill space, but on the other hand the recycling process might use more energy than the extraction and transport of virgin materials. Anderson et al. (2000), for example, state a maximum distance for the use of recycled aggregate of 150 km. The focus on recycling automatically gives more weight to environmental issues of resource use and waste management than to global warming or other measures.

An evaluation of LEED from a life cycle perspective has been conducted by Scheuer and Keoleian (2002). They relate the results of an LCA to LEED points and discover a variety of discrepancies in outcome. Their general research conclusion is that “LEED does not provide a consistent, organised structure for achievement of environmental goals. … While LEED appears to be accomplishing the goals of an eco-labelling program, that is, as a marketing and policy tool, it is not as successful at being a comprehensive methodology for assessment of environmental impacts”.

7 Case studies of companies or organisations which have embedded LCA into their business systems

Two case studies are described which demonstrate how Formway Furniture and BlueScope Steel use LCA in their decision making processes in their organisations.

7.1 Formway

The New Zealand company, Formway Furniture Ltd., has applied LCA for a number of years. The company actively feeds back the findings of LCA studies to new product development, to inform strategic product direction and specific materials choices. In order to complete their LCA studies and to gather the required data, Formway has collaborated with suppliers.

Although they are not using LCA for decision making processes at this stage, their environmental manager, Jake McLaren, states that they “…use LCA in product design as one input to guide environmental design choices for materials and processes. But more importantly LCA has helped to improve the supply chain collaboration through a joint understanding and better working relationships” (Jake McLaren 2006).

Formway found that analysing products has sometimes resulted in surprising conclusions: life cycle assessment results do not always match a client or industry perception about how to design or specify a 'green product'. Also using LCA data to assess specific materials has not always matched the common public perception and NGO stance about a specific material’s environmental burden. This emphasises the importance of a systems approach and not focusing on specific details.

Formway also believes in providing detailed environmental product declarations (EPDs) to the market; to increase transparency and inform debate about the meaning of 'sustainable furniture'. This is a good example of how LCA studies help companies to collaborate and improve their products in a non-decision-making context.

7.2 BlueScope Steel

BlueScope Steel started working with LCA in 1993 for product and process assessment (BlueScope Steel 2007). They state on their website that they use LCA as a tool to support "cleaner production, new businesses, product and technology development, and environmental management."

Although 'decision making' is not specifically mentioned, the examples on the website state clearly that LCA approaches are used as an underpinning methodology in order to achieve cleaner production, new businesses, etc.

One of the specific examples is the Olympic stadium in Sydney, or rather the Sydney Olympic Games in 2000. The study looked at the buildings and infrastructure constructed for the Games, their utilisation during the Games itself, transportation, waste management, and carbon credits (BlueScope 2007). Incorporating the operational energy as well as the buildings is one of the key strengths of an LCA approach.

Three potential designs of the stadium were assessed using a mixture of LCA and cost/benefit analysis:

- a conventional stadium design
- a better environmental practice design
- a best practice design.

The better environmental design was chosen and lead to the following results:

- annual primary energy savings of 30 %
- 37 % in greenhouse gas emissions
- 13 % reduction in water use

The LCA also aided in the selection of materials, and the prioritisation and evaluation of initiatives. (RMIT http://buildlca.rmit.edu.au/casestud/stadium/Stadium.html)

8 Conclusions

Reliable information and data are essential for decision making processes on the pathway towards a sustainable built environment in New Zealand. LCA is a tool which can be used to quantify potential environmental impacts and is therefore suitable to aid decision making processes.

LCA can be applied directly in operational or strategic decision making situations or can be used indirectly to develop tools such as environmental labels and rating tools.

In an operational decision making situation, e.g. the choice of a building product in a house, LCA would be used for a comparative study 'horizontally' for different products, building components or systems with the same function and with a total life cycle perspective (from cradle to grave). This type of decision making helps to discover whether a certain component is more or less environmentally friendly than another.

The main advantage of using LCA within strategic decision making is to find out where 'vertically' in the production process the 'hot spots' are, i.e. in which product processes an improvement would be most beneficial. The overall result is usually an LCA of a certain product, building component. The recommendation is to implement life cycle assessment approaches in the development of new building materials as well as building components. An opportunity also exists for the application of LCA in the design of residential buildings. The recommendation is to demonstrate this by looking back at the construction process of the two NOW Homes®.

LCA data can be incorporated into environmental labels and rating tools. These are effective means of promoting environmentally preferable products and encouraging the demand for more sustainable building designs. Currently they are not necessarily designed to provide specific information on products/components or buildings. However, life cycle assessment approaches are increasingly implemented in the development of eco-labels and rating tools. The review of the Enviro-Choice specification for plasterboard based on LCA data and the incorporation of LCA approaches into the LEED rating tool are good examples. Environmental product declarations, which are also classified as eco-labels (type III according to ISO standard 14025) are based on LCA data and provide detailed information on the life cycle performance of building products. They have been introduced in Europe, and also in other countries including Japan and South Korea.

Based on these examples the recommendation for New Zealand is to increase the use of LCA data in the development of product specifications for eco-labels and to promote the uptake of environmental product declarations as a tool for the communication of environmental information. This detailed information can then be used by decision makers to make informed production and design choices.

In the example of the two companies in this report, it has been demonstrated how LCA has been applied. These examples show that life cycle assessment approaches can effectively be used in an organisational context in order to improve the environmental performance of specific products. The recommendation in this case is to foster the uptake of LCA approaches in the building industry in New Zealand, as they have been used successfully in previous New Zealand-based examples.

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10 Appendix One: Environmental Product Declaration