PROJECT :

Life Cycle Thinking

TITLE :

The Role of Inventory Analysis in New Zealand

CLIENT : MoRST

PROJECT CODE : 5301-02

DATE : 29/08/08

AUTHOR : Timothy Allan

KEYWORDS : Life Cycle Inventory, Life Cycle Assessment, Life Cycle Thinking

DOCUMENT RELEASE : ◉ Confidential ○ Public

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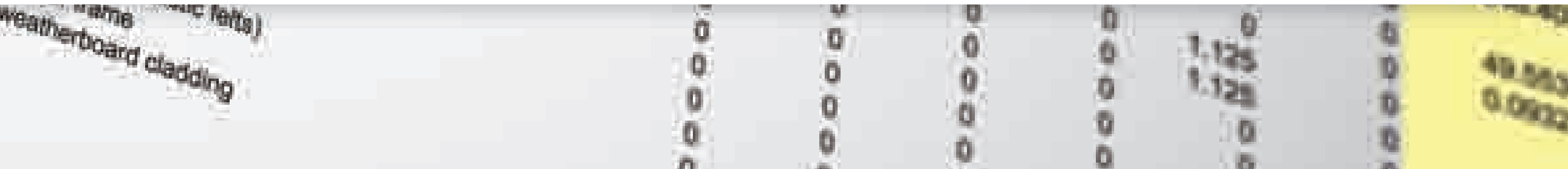

Document Title:

LCI Research Project

Project: LCI Initiative	Document #: 5301-02
Subject: Life Cycle Inventory	Client: 5300
Source: Timothy Allan	Client Manager: Andrew Huddart
Reviewed By: Timothy Allan, Andrew Huddart, Barbara Nebel	Date: 30/08/2008 4:27:00 p.m.
Revision date: 05/09/2008 3:33:00 p.m.	Revision: 3

Keywords: Life Cycle Inventory, Inventory Analysis, Life Cycle Assessment,

Introduction

The MoRST LCI initiative project sought to investigate LCI practice in a New Zealand context in order to gain a better understanding of the current status of life-cycle inventory and its relationship to the broader application of life cycle thinking in New Zealand. As such, it is deliberately broad and investigative in nature. It seeks to paint a picture of which approaches, methods, tools and data are in use by practitioners currently. It also seeks to identify challenges and opportunities, with a focus on a nationwide, cross-industry context.

This study is not aimed at producing an exhaustive, detailed list of existing life cycle databases. This is likely to be the subject of a subsequent practitioner-led effort to maintain a dynamic overview of past, current, and future datasets held in NZ.

The research includes the development of a list of practitioners who are currently using Life Cycle Assessment within their work. This is a qualified list which captures all key practitioners, although it could be investigated further.

It captures information about a wide range of research and commercial applications of the method, which includes infrastructure modelling and maintenance, for example, by large asset management firms. Even though the sample cannot be considered complete, the authors believe it nevertheless provides a very useful overview of activity, and highlights the main practitioners, identifying their respective areas of focus.

This report package is structure into three components, the short form executive summary report (separate document) a long form (this bound report) and a Data disk (with all resources and research work contributing to this report).

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Research Approach

The research was undertaken qualitatively through structured one on one interviews with the participants. All interviews were transcribed with some participants providing additional in-depth answers to particular questions. All transcripts and additional details have been recorded separately from the full report.

The original intent was to produce a multi-choice questionnaire. However, through the course of the investigation it became clear that the required information was available within the context of the structured interview transcripts. In addition, there were a range of parameters that were not able to be placed in the context of a simple questionnaire due to the complexity of potential responses; therefore, the multi-choice questionnaire was not undertaken.

Data used for the diagrams has been drawn from the practitioner responses in the transcripts and through discussion. Where any ambiguity existed this was clarified with participants.

Some additional detailed information from respondents was also documented and is appended to the transcripts used in the creation of the research findings.

Respondents have not been named on the diagrams, due to the unknown circulation of the report, to protect their responses on some issues.

The research established a range of factors which were deemed to be a part of, or have an impact on, the Life Cycle Inventory (LCI) stage of Life Cycle Assessment. These factors were explored through a structured series of interviews with participant practitioners.

For clarity, each factor investigated is narrated and explained to enable a clear understanding to be gained from participant responses in each section. The study parameters are listed in Table 1 Key Interview Topics , which were defined through the course of this investigation.

The key interview topics from the structure of the report cover both 'methodological' issues (such as Allocation) and practical application issues (such as dataset factors).

Table 1 Key Interview Topics

The 'Type' of LCA: defined in the goal – for instance 'Change Oriented' or 'Accounting' based goals

System Boundaries: both technical and natural systems, also encompasses time and geography

Inventory class: Cradle to gate or cradle to cradle etc (was discussed in the context of system boundary)

Functional Unit: the Life Cycle metric

Allocation: a complex area and one which would only be canvassed at a macro level

Choice of impact categories: as this influences data choices

Method of calculation (and use of tools for calculation)

Data quality: the rating and applicability of data being used

Interpretation: NA - ruled out through discussion

Classification: NA - ruled out through discussion

Dataset Factors: the creation, maintenance and use of datasets

Other Parameters: any other factors a practitioner felt were important

Participants

The participants were deliberately drawn from a range of organisations, both research and commercial based. This list was established by investigating the connections between key practitioners, and by conducting a qualitative research exercise which contacted organisations capable of applying LCA (consultancy, commercial, research), or potentially having capacity to apply environmental sciences.

The list provides an insight into the breadth of focus of New Zealand's practitioner community. This list is not exhaustive but could be considered an accurate snapshot of the connected industry in New Zealand at this time (May 2008). It captures all leading recognised participants operating in the New Zealand environment at this time and a range of participants that are involved at a more occasional level.

There is a very limited number of true experts in this area nationally that are actively practicing.

Table 2 Participant list.

Name	Organisation	Area of Focus
Sarah McLaren	Landcare Research	Broad
Andrew Barber	Agrilink	Pastoral, Horticultural
Andrew Alcorn	Victoria	Building
Daniel Kellenberger	Scion	Broad
Barbara Nebel	Scion	Broad
John McArthur	Laminex	Building Sector
Roman Jacques	BRANZ	Building Sector
Nigel Howard	BRANZ - AUS	Building Sector
Stuart Ledgard	AgResearch	Pastoral, Agricultural
Jake McLaren	Formway	Furniture/Manufacturing
Gael Ogilvie	URS	Building Sector
Stephen John	Canterbury Uni	Timber
Robbie Andrew	Landcare Research	Bio fuels, Storm water retention
Vicky Forgie	Massey University	Bio fuels
Per Nielsen	Nielsen Marketing Ltd	Energy
Caroline Saunders	Lincoln University	Pastoral
Ann Smith	Carbon Zero	Carbon Emissions
Amelie Goldberg	Victoria	Agricultural
Carol Boyle	ICSER	Faculty head
Geoff Vickers	Actronic	Electronics
A. Idil Gaziulusoy	F&P Appliances	White ware
Gayathri Gamage	Formway	Furniture/Manufacturing
John Crawford	Opus	Infrastructure
Brent Clothier	HortResearch	Horticulture
Suzie Greenhalgh	Landcare Research	Viticulture(Wine)
Peter Garrett	ERM	Broad

Acronyms

There is a fairly high level of technical jargon in Life Cycle Assessment. Some key terms and their related acronyms in this context are listed here.

Table 3 Terms & Acronyms

LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
LCI	Life Cycle Inventory (alternately known as Inventory Analysis)
EIOA	Economic Input Output Analysis
PAS 2050	Publicly Available Specification on embodied greenhouse gas emission quantification and labelling within consumer products
FMCG	Fast Moving Consumer Goods (e.g. food products)
GHG	Green House Gas
LCM	Life Cycle Management

**Please note ISO standards are left out of this list as they are explained in the body of the document.*

Life Cycle Inventory & Inventory Analysis

Life Cycle Inventory (LCI) or Inventory Analysis refers to the same phase within the Life Cycle Assessment process. The inventory analysis phase was developed within the Life Cycle Assessment (LCA) framework. It is therefore deemed useful to outline the current LCA framework (2006) and to illustrate and understand the position of LCI within this process.

The Life Cycle Assessment process is defined as the investigation and valuation of the environmental impacts of a product or service, caused or necessitated by its existence. The process has evolved through a lengthy gestation period with the current methodology being finalised in the 2006 ISO 14040 and 14044 international standards. There are ISO standards which prescribe the LCA process and methodology through the following two standards (International Organisation for Standardization, 2006):

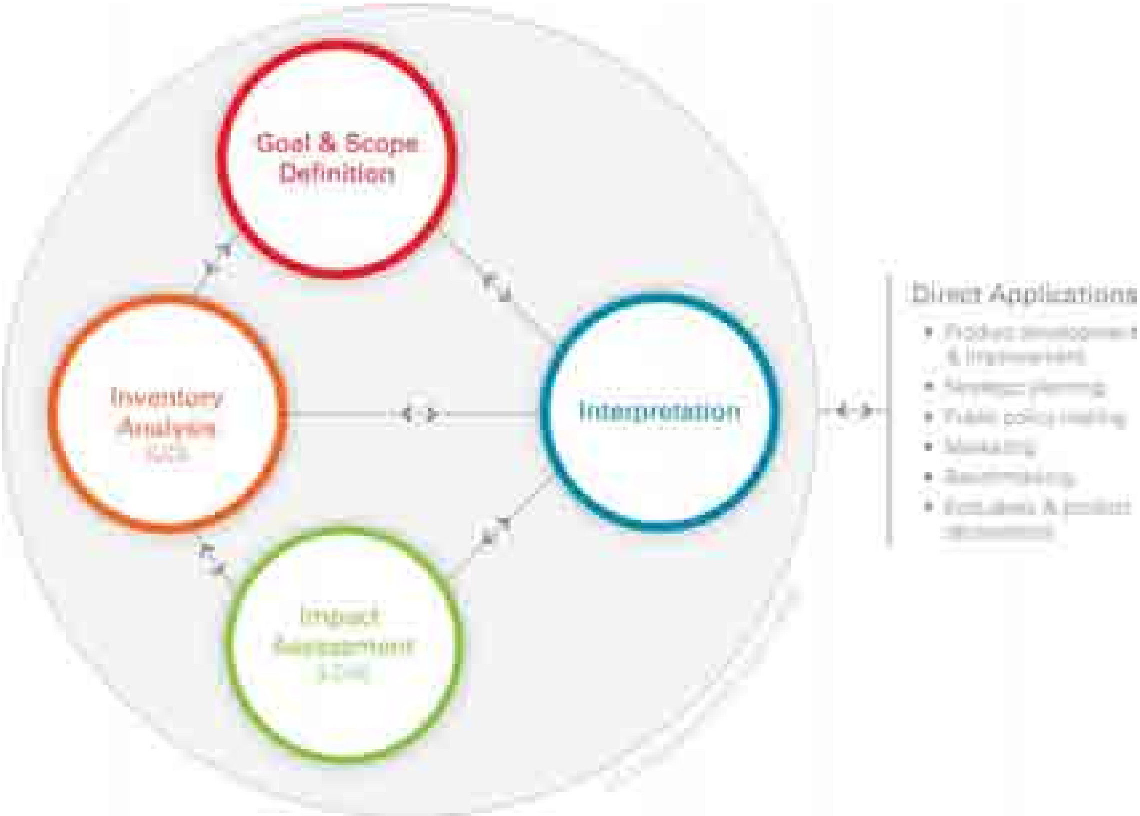
- **ISO/DIS 14040**: Principles and Framework
- **ISO/DIS 14044**: Requirements and Guidelines

In these standards there is still a wide range of choices practitioners can make which can influence the shape or efficacy of any targeted LCA study. A conventional life cycle assessment is defined as being formed through a four-step process:

- **Goal & Scope Definition**: Determining what the aims are and whether these can be delivered within the given scope.
- **Inventory Analysis (LCI):** Modelling the flow of the life cycle and collecting any underlying data that is required.
- **Life Cycle Impact Assessment (LCIA):** characterising the impacts and evaluating against the defined impact categories (such as Global Warming Potential).
- **Interpretation**: Analysing the information and determining whether the aims of the study can or have been met.

Figure 1 Principles of LCA

Figure 2 ISO LCA Framework 1998**(Baumann & Tillman, 2004)**



The focal point for this research is the Inventory Analysis (LCI) phase of the LCA process. Some other phase aspects may impact on the LCI part, so an attempt has been made to question practitioners to capture and qualify what these aspects are and how they might impact LCI.

The LCI phase is primarily concerned with the capturing, research, creation and modelling of Inventory data related to the inputs and outputs of processes and product systems. There is a separate ISO standard for LCI data documentation **ISO/TS 14048**(International Organisation for Standardization, 2002).

This format is a standard for LCA data; "*This Technical Specification provides the requirements and a structure for a data documentation format, to be used for transparent and unambiguous documentation and exchange of Life Cycle Assessment (LCA) and Life Cycle Inventory (LCI) data, thus permitting consistent documentation of data, reporting of data collection, data calculation and data quality, by specifying and structuring relevant information*".

Practitioner Interview Summary

The structured practitioner interviews are summarised in the following section with visual summaries illustrating the responses to key areas defined in Table 1 Key Interview Topics.

LCA Type

There are three 'types' of LCA study as broadly prescribed (Baumann & Tillman, 2004)

- **Stand-alone** – Single and exploratory
- **Change Oriented** - Comparative and prospective
- **Accounting** - Comparative and retrospective

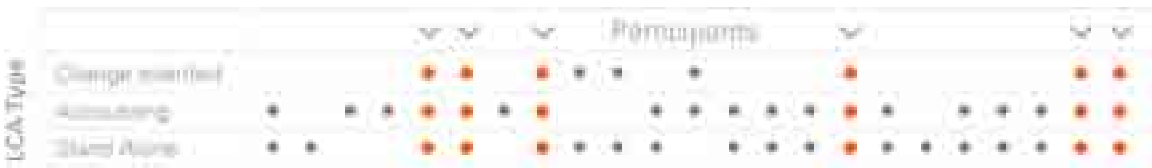
Stand-alone studies are the most common type of study internationally. They are often used to describe a single product and are used to identify 'hot spots'.

Change-oriented studies are primarily used in a development process (prospectively) to provide decision-making support. This usually applies to the development of products and services.

Accounting types are undertaken after the fact (retrospectively) and are well-suited to comparative decision-making or scenario analysis that could support plans for future improvement.

The distinction between these general category types can be difficult to maintain if the intent of a study is both to identify and then to mitigate (as is often the case). The descriptions of LCA types are included in this document as they provide a useful insight into the 'Intent' of the studies being undertaken. Table 4 **NZ Practitioner Profile (By LCA Type)** provides a useful glimpse of practitioner depth, as well as illustrating how the more experienced practitioners operate across all three broad LCA type categories.

Table 4 NZ Practitioner Profile (By LCA Type)



System Boundary

A system boundary is defined during the goal and scope step. It affects the inventory analysis phase by determining what data should be considered, and what can be ruled out (scope).

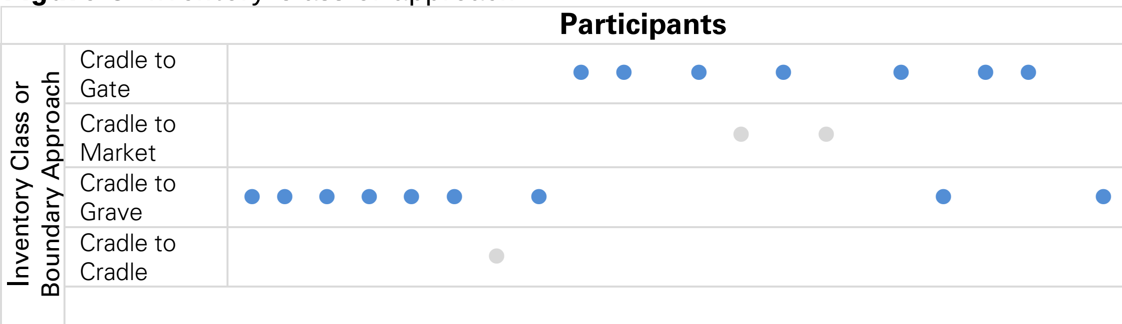
The establishment of a clear and defensible system boundary is crucial to the creation of a robust and effective LCA study. Boundaries are defined in relation to:

- Natural systems (Biosphere)
- Technical Systems (Techno-sphere)
- Geographic Boundaries
- Time Boundaries

System boundaries appear largely driven by the individual circumstance of any project, especially the goal and scope. The boundary can be widely affected by the client organisation's application and use of the study. Practitioners stated this would be a difficult area to harmonise nationally but that a normative 'approach' to determining system boundaries might be a useful mechanism to harmonise LCA practice within New Zealand.

Inventory Class was defined early as a term from the literature search which defined if an LCI was cradle to gate, gate to gate, or cradle to grave. This term did not have currency amongst New Zealand practitioners and became part of the system boundary discussion.

Figure 3 Inventory Class or approach



Even with strong support of a 'Cradle to Grave' approach within the practitioners work, they stated that end of life was a problematic area which led to some concern around results that were generated from a 'cradle to grave' scenario. The 'cradle to gate' and market studies represent predominantly food and primary sector exports, with evidence suggesting these studies were moving into cradle to market type studies (particularly in the fast moving consumer goods sector).

Functional Unit

A functional unit is the principal measure which 'frames' the environmental assessment. An example would be the comparison of a plastic milk bottle versus a glass milk bottle or a tetra pack. The functional unit for the LCA could be '*the delivery of 1,000 litres of milk'* to enable an effective consideration of the total life cycle, including bottle washing, transport, and disposal or recycling of any parts.

All respondents cited the identification and handling of functional units as a core part of their work with the exception of one, whose interest remained only in the LCI area and not in a total LCA. A range of functional units were described, providing some insight into the different sectors practitioners are operating in.

The definition of the functional unit appears to be controlled by the audience or client, and in some cases several functional units are needed within a single study to cater for the different stakeholders of a project (for example wool growers and producer boards) (Barber, 2008). Table 5 **Example Functional Units** provides a selection of functional units utilised by New Zealand practitioners.

Table 5 Example Functional Units

Functional Unit	Application
Metres (Length) of Finished Fabric	Wool
Weight (Tonne) of greasy wool	Wool
Kg meat (Weight or Mass) to market	Meat
Production of a kg of material	Building Materials
Per tonne of grapes crushed	Wine
Bottle or case of wine to the destinations via shipping	Wine
A square metre of gypsum board	Building Materials
A Tonne of gypsum board	Building Materials
'Amount of mega joules delivered' (Calorific Value).	Bio fuel
To provide stable ergonomic office seating over a period of 10 years	Furniture
Live weighing system over an 8.5 year period, used 8 hours a day, 365 days year	Industrial electronics
Per tonne of COD (Chemical Oxygen Demand) removed – milk and cream	Dairy
Raw board - (cubic metre)	Materials
Decorative surfaces – Formica (m2)	Materials
1 Megawatt hour of electricity	Energy
1 Gigajoule of electricity (Not the fuel)	Energy
Per hectare - Land use (fuels)	Energy
1 Gigajoule of energy	Bio fuel
Thermal performance (R) over a defined number of years	Building
Delivery of a certain quantity of juice	FMCG
Keeping baby in nappies for a (nominated) period of time	FMCG
Certain amount of kiwifruit consumed by the consumer	Horticultural
Per kilo of fat or protein corrected milk	Pastoral

Allocation

Allocation is defined as "*partitioning the input or output flows of a process to the product system under study*" (ISO14040 1997).

There are many processes that often have multiple outputs or uses. Allocating all the environmental burden to a single process would be inaccurate and also lead to duplication. A simple example would be a log which could be split into a percentage allocated to milled graded timber and a percentage is allocated to pulp and paper production. The allocation method selected determines how these different streams are dealt with; this can be achieved through partition, avoided burden or other mechanisms.

Allocation is one of the most difficult areas within the LCA methodology. It complicates the data collection process and can greatly increase the threshold of data required within any given system. The different types of allocation seen across the New Zealand practitioner community are summarised below.

Most practitioners adhere to the ISO standard prescription for the procedure of allocation which is as follows:

1. Don't allocate if at all possible
2. If required use system expansion
3. If not possible use physical allocation
4. As last resort use economic allocation

Figure 4 Allocation Methods

System Expansion: refers to the approach of widening the scope of a study to incorporate outlying systems that may be attributed or affected by impacts of the studied system. This approach is favoured by the more technical practitioners of LCA. It is not used by intermediate users because of its technical difficulty and the budget and work required to resolve more detailed systems that flow into other production systems.
Physical: was the most commonly preferred by most practitioners if allocation is required. This is where relative impacts are allocated on the basis of a physical measure such as mass or volume.
Biological: This approach is the most detailed, and is currently only used by one group in the dairy sector, for the division of milk and meat in production. This method is based on biological evidence of what inputs are required to produce a kilo of milk solid or meat.
Economic: allocates environmental burden on an economic or monetary basis. An example of appropriate use is a consumer's travel to the supermarket, the economic value of their shopping basket is the basis used for allocating the impact of the emissions of their travel to the supermarket.

Allocation is currently an area of significance to New Zealand. This is largely due to the recent development of embodied greenhouse gas emission labelling, or carbon reduction labelling(Carbon Trust UK, 2008). The driving force behind much of this emergent practice is based on the consumer-driven development of carbon labelling through the British-led BSI Publicly Available Specification (PAS) 2050 (British Standards International (BSI), 2008). The current methods of allocation within the PAS2050 are fluid and have been the subject of much discussion. The initial consultations of PAS2050 have specified the default allocation method as Economic.

Table 6 Allocation Methods

Impact Categories

This report does not pursue the aspect of 'Impact Assessment' methodology, but it was raised by respondents as an area to consider for future investigation and discussion.

Impact Categories are selected in the Life Cycle Impact Assessment (LCIA) phase of the LCA process, and define what environmental impacts will be assessed. The LCIA phase is conducted after the LCI phase, and is not considered a part of the formal LCI phase.

The separation of the LCI & LCIA phases is evidenced by leading Swiss practitioners, who divide the science of Inventory (data collection & aggregation), from the science of Impact Assessment (classification & characterisation). This indicates the natural delineation between the LCI phase and the LCIA phase.

Definition

The ISO classification of impact categories provides three broad categories or groupings. In these groupings there are a range of specific impact categories where assessments can be undertaken.

Table 7 ISO Impact Categories **(Baumann & Tillman, 2004)**

Human Health

- Toxilogical Impacts
- Non-Toxilogical Impacts
- Impacts in the work environment

Resources

- Energy & Material
- Water
- Land (Including wetlands)

Ecological Consequences

- Global Warming Potential
- Ozone Depletion
- Eutrophication
- Photo-Oxidant Formation
- Acidification
- Eco-Toxilogical Impacts

The choice of impact categories is an area of concern in the New Zealand context at the time of writing. There is an overriding focus on greenhouse gas (GHG) emissions and energy use, as evidenced in Table 8 **Impact Category Use in NZ**.

Table 8 Impact Category Use in NZ

		Participants																							
Human Health	Toxilogical Impacts								•															•	
	Non-Toxilogical Impacts																								
	Impacts in Work Environment																								
Resources	Water		•			•	•				•		•	•					•		•	•		•	
	Land	•	•			•	•						•						•					•	
	Energy & Material	•	•	•	•	•	•		•		•	•	•	•		•	•		•		•		•	•	•
Ecological Consequences	Global Warming Potential	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•	•	•	•
	Ozone Depletion					•	•			•	•													•	
	Eutrophication					•	•				•							•	•					•	
	Photo-Oxidant Formation					•	•				•							•						•	
	Ecotoxilogical Impacts	•						•				•		•										•	
	Acidification					•	•											•							
	Habitat Alterations													•											

Practitioners have noted that the restriction of impact categories through the focus on energy and green house gas (GHG) emissions have negatively impacted data collection. This was partly attributed to budget constraints and the current demand for climate change oriented studies and information.

Experienced practitioners (Nebel, 2008) expressed that the selection of limited Impact assessment categories should not affect the integrity of data collection, as all critical inputs and outputs should be collected for an assessment to be undertaken. This appears to warrant further investigation, as the demand for GHG accounting is likely to increase with the implementation of embodied greenhouse gas labelling.

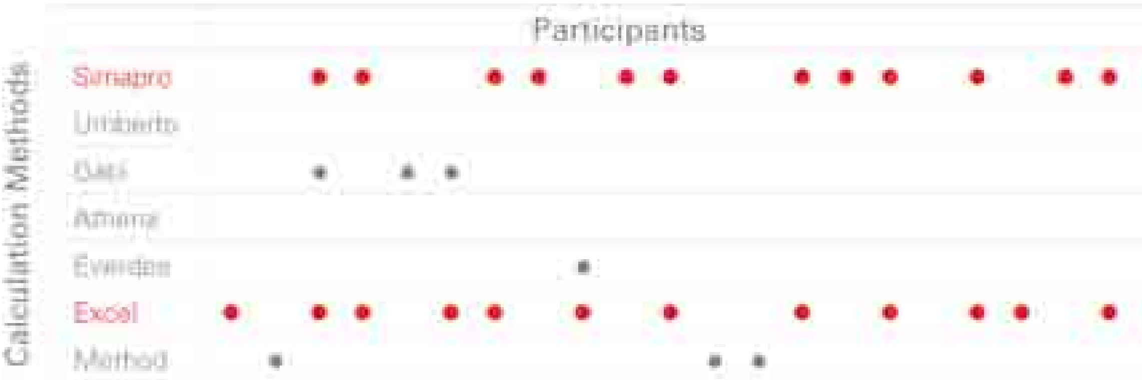
This issue would endorse the importance of a common data collection policy to prevent endemic data loss over time due to studies not collecting all useful data. Consideration would also need to be given to deciding what the most important impact categories are. This could be decided by a group of experts, and should assist practitioners generally to work with a greater focus and more confidence.

If as demonstrated, LCIA is impacting on LCI, then it would be prudent to further investigate the Life Cycle Impact Assessment (LCIA) phase of LCA to better understand whether there are unique aspects in the New Zealand environmental context that need further consideration. There are impact assessment methods which are specific to certain sectors such as the '*BRE methodology* (BRE Global, 2007) *for environmental profiles of construction materials, components and buildings'* (Jaques, 2008) or the pre-calculated Eco-Indicators (PRe Consultants, 1996-2008) method, which is useful in a product development environment where common materials and processes are used and ultimate data quality is not required.

Uptake of Tools

Development of LCA methodologies has resulted in the creation of software tools which enable dynamic modelling of system models. These allow the formation of calculations and visualisations, making the process easier and more streamlined. The adoption of these tools within New Zealand is patchy, with a range of practitioners still using self-generated Excel spreadsheets, mainly due to the intermittent nature of LCA projects and the capital cost of software purchase (rather than willingness to uptake).

Table 9 Tool Use



Both GABI and SimaPro are advanced Life Cycle Assessment software tools with a range of available databases for different industries. A greater number of participants used SimaPro, although GABI is a recent tool in the New Zealand context and is developing a following here.

Excel, though not an LCA tool, was commonly used. Advanced practitioners used Excel to devise their own formulas and dataset creation and organisation, and are using it to control their data and ensure they have maximum transparency during the LCA process. The novice users seemed to use Excel under the guidance of more experienced practitioners.

Everdee is another LCA tool that was used. Everdee was created through the EcoSMEs (Eco SME & Italian National Agency for new Technologies, Energy and the Environment) initiative that also gave rise to 'Tespi' for product innovation. The practitioner's rationale for selecting this tool was because of its industry-based electronics database, which was representative (Vickers, 2008).

The Landcare Research Carbon Zero programme has developed their own tool which integrates GHG protocols for assessments on climate change.

The intermittent nature of LCA work until recently appears to have been an impediment to the uptake of more advanced life cycle engineering tools (Ogilvie, 2008) due to up front capital outlay and training. In addition, a range of practitioners stated they did not have a requirement to conduct a full LCA so were content with using spreadsheet tools and formula’s for completion of data collection and inventory analysis.

The Importance of Data

The inventory analysis process hinges on the availability of high quality, effective data to form an accurate picture of a system being assessed. The credibility of any LCA or GHG assessment is substantially dependant on data quality.

Most of the work in generating data within New Zealand has been biased toward the primary sector that has produced a growing body of information up to farm gate. As markets have become more interested in transport distances and the impact on climate change of entire product systems, these studies have extended to consider the whole supply chain, all the way through to market and in some cases end-user disposal. This is seen with the emergence of cradle to market studies seen in the food exporting sector outlined in Figure 3 Inventory Class or approach.

The evidence gathered in this study shows that manufacturing and value-added industries have little New Zealand-specific data of a general nature to draw on as yet and have tended to source data from international datasets. As a result, there is a nationwide need to create better country-specific and industry vertical data.

Data Quality

When discussing data quality the study looked at the following areas:

- **Relevance**
  - Relevance relates to the context and whether the data is used or approximated from other sources.
  - This factor is of particular interest to the study
  - Time-related coverage
  - Geographical coverage
  - Technology coverage
  - Completeness
- **Representativeness**
- **Reliability**
- **Precision or accuracy** of the data collected and being used.
- **Accessibility**

Data quality appears to be variable, with some intensive and highly detailed studies in certain areas (e.g. Pastoral) where real-time data was collected on-farm to give a high degree of data quality (Barber, 2008). Whilst in other studies data was used from existing literature research (which may be of uncertain age and provenance).

Generally most practitioners cite data quality as a serious issue, both in terms of availability and accuracy within the New Zealand context. In addition they had real concerns about the cost of data collection and maintenance, which were seen as a recurrent hurdle cost to SMEs especially (Smith, 2008), and even to larger enterprises. This hurdle is due in part to the requirement for continuous data collection that requires technically-sophisticated methods or devices and specialised staff.

There are a range of approaches taken by most participants which could be broadly categorised as:

- **Created Datasets**: researched and created for the environmental analysis.
- **Modified Datasets**: existing datasets modified for a particular application.
- **Existing Datasets**: using existing datasets for a particular application.

Most of the advanced practitioners have been, or are involved in the creation of homogenous datasets, as well as using modified international databases of materials and processes where required.

Created datasets

The datasets created range from highly detailed studies (direct measurement), to studies which are based on historic research papers. One such study went to a huge amount of detail to include the whole capital cost of building a plant and amortised the environmental impacts across the lifespan of the structure, and allocated this to the end product on a per unit basis (Crawford, 2008).

Modified datasets

Modified datasets are primarily international (originating from the EU or the USA), that are generally linked to, or embedded in, LCA software tools. These databases, such as Ecoinvent (Ecoinvent Centre, 1998-2006), contain a wide variety of materials and processes which enable modelling at a schematic level and in some cases offer detailed levels at which there is parity in application and context.

Existing datasets

The commonly referred and used international data sets are as follows:

- **Ecoinvent** (Swiss) – Uses literature so it can be open and transparent, but may not have the industry accuracy.
- **GABI** (German) – Uses industry data and (therefore) is aggregated and cannot be fully transparent, but is considered accurate.

There are other databases used which are more industry specific, a useful exercise may be defining all the major sector databases which would be considered applicable to the New Zealand context. This information could be made available to all stakeholders so they may find relative datasets with greater ease.

Compatibility

There are a number of data formats available which tend to be application specific. Exchange formats are used to port the data between applications; the most widely used exchange file format is 'XML' (extended mark-up language) (Nebel, 2008). This supports a fast and easy exchange of inventory data into different software packages, such as GABI or SimaPro, as well as handling in open source and Internet environments.

Availability

Many of the datasets are private (or not accessible), which prevents them from being openly exchanged or used for the benefit of other companies. Research organisations often retain the right to use aggregated data for other applications (within their own projects and for their own benefit). This type of practice would appear to work against wider transparency, discourage openness, and encourage competition.

Some data is published, and is therefore partly available in aggregated form (although not accessible at a detailed application level) and some data is made available on specific request to students and other practitioners.

Currently there is no central repository for inventory data and therefore no easy way to determine if a study has been conducted in the area or if there is other useful data in New Zealand that could be applied in other studies.

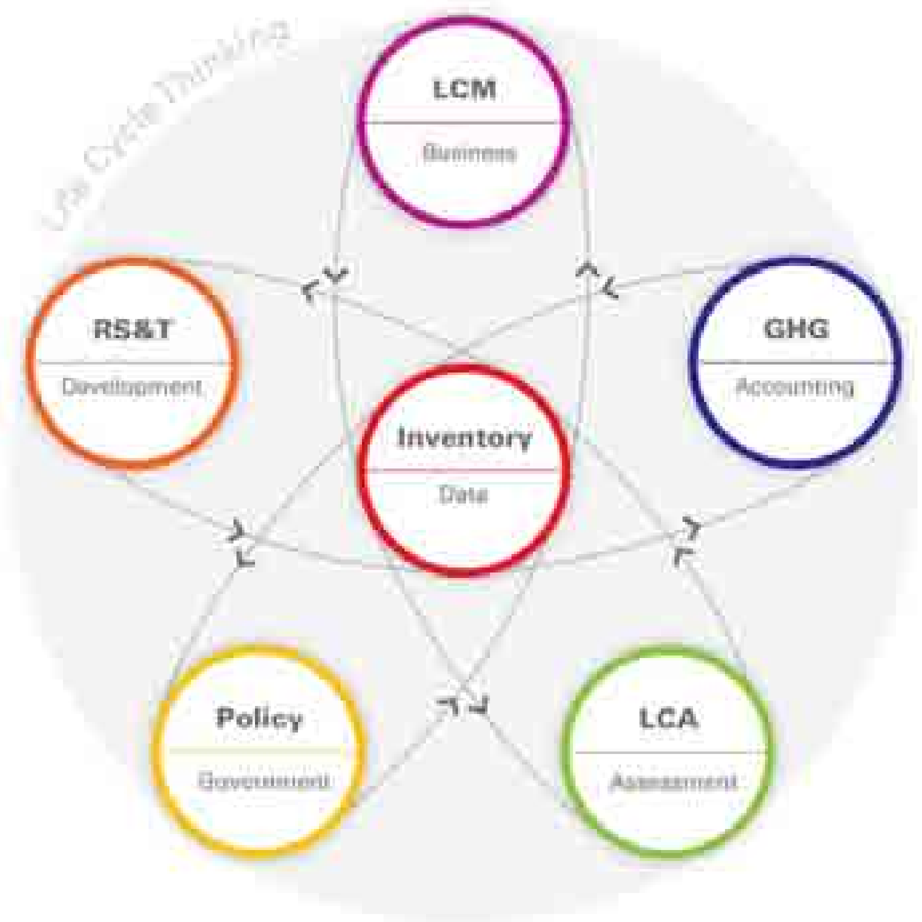
Research also plays a key role in the creation and support of assumptions and the development and formation of new datasets. It would also be useful to have a reference of critical industry or sector level research that can be applied to inventory analysis at a national level. This research could then be monitored for efficacy and relevance as industries evolve.

Conclusion

There are a range of issues confronting the application of life cycle thinking in New Zealand. The creation and maintenance of detailed, accurate and up to date inventory is central to the application of Life Cycle Management (within business), Life Cycle Assessment (in practice), Greenhouse Gas (accounting), government (policy) and Research Science and Technology (development).

Inventory information needs to be consistent, transparent and available to ensure the wide uptake and use of the various tools and techniques on hand.

Figure 5 Life Cycle Thinking



Challenges and opportunities

As an emergent discipline, capability is still in a development phase in this country and needs a concerted approach at a nationwide level to ensure the consistent spread of efficient practice, while building up and retaining the confidence of industry, business communities and consumers.

As an emerging concept there is a case for providing information around what Life Cycle Thinking is, and what it can deliver for New Zealand firms and industries including their stakeholders, customers, supply chain partners, regulators and social partners. This would ideally include specific information about Life Cycle Assessment and Life Cycle Management in the public domain for easy access such as the Environmental Protection Authority website on LCM (EPA Victoria, 2008).

Figure 5 **Life Cycle Thinking** provides an overview of the different stakeholders which utilise inventory in differing contexts. There are many relationships between these sectors, but this figure illustrates the central nature and importance of inventory data to enable broader application of Life Cycle Thinking.

Impact on SMEs

The creation and maintenance of data at an individual company level can be very difficult without specialised staff or guidance for existing staff in an enterprise.

This is a particular hurdle for SMEs, which can be faced with a disproportionate cost relative to their business scale. Several practitioners in the GHG accounting area have noted concerns about the ongoing costs to SMEs in different sectors (Smith, 2008), stating that keeping their information up to date is becoming a particular concern in areas such as the food and beverage sector, especially as their product ranges evolve quickly and involve ongoing changes in ingredient mixes.

PAS 2050

The economics of embodied carbon labelling and reduction for SMEs is a challenge which the PAS 2050 has sought to address by promoting a method which can be more inclusive and enabling for a wider range of stakeholders. The PAS 2050 is yet to be fully finalised but contains some contentious aspects such as the use of economic allocation, which is generally perceived to have negative value for New Zealand products and services.

Taking a proactive approach at a pan-industry level is likely to be imperative for New Zealand's business and science partners to establish a risk-avoidance system of assessments. Over time this will allow them to bolster a range of international market- leading positions for economically significant products and services, including energy, tourism and transport.

Top down vs. bottom up

The application and use of new and hybrid methods such as Environmental Input Output Analysis (EIOA) (also known as economic or extended input output modelling) is going to increase in importance as a viable way to achieve Life Cycle Thinking outcomes. EIOA uses economic data to model the inputs and outputs of a company or industry sector using averages from applied research.

Semantically, LCA is 'bottom up' using specific process data while EIOA is 'top down', using economic data and averages. As LCA can be cost-prohibitive to undertake, EIOA offers some potential to deliver similar results at lower cost in certain areas although it does have some limitations. There are also emerging tools in countries such as Australia that allow companies to use their economic data to model their environmental footprint using averages (Andrew, 2008).

Understanding and developing these other skill sets is a valid priority to pursue alongside other initiatives, and would ensure NZ develops strategic capacity and understanding in this emergent field.

Data

Data up to the farm gate (cradle to gate) has been researched effectively, with a focus on primary sector data collection. There is, however, little in the way of post-processing (i.e. manufacturing and distribution) or credible end of life (cradle to grave) data, and this gap can only become of increasing significance to key industries in New Zealand as global consumer and regulatory requirements tighten.

Some data used is becoming outdated and may need to be revised or replaced, including in key sectors where New Zealand industry needs to maintain its momentum in impact mitigation in order to retain its world market position. For example, some processing information that is being used in the dairy sector is based on reports from the 1990's (Barber, 2008). Ascertaining the need for any key gap-filling research through discussions with practitioners would be useful to maintain the currency of the information being used as a basis for commercial decisions.

There are a wide range of research projects and initiatives underway in the private and public sector. These are being communicated in a partisan or ad hoc manner, and this can result in affected practitioners and industry having difficulty accessing the findings or lessons learned.

It is probable that at least some, if not all, of these projects could offer some common data (for instance energy or emissions factors) that is of potential use to others. Currently, there is no unified approach to these and other important datasets, which leaves the way open for inefficient behaviours such as duplication, variation and inconsistency of interpretation of the same data.

If datasets are made more freely available this would directly reduce the cost to undertake LCI, LCA and GHG work, thereby reducing the barriers to entry.

The Australian Life Cycle Inventory Database Initiative offers some real potential for learning and involvement. It can be outlined as follows:

"*The Australian National Life Cycle Inventory Database Initiative (AUSLCI) will provide a national, publicly-accessible database with easy access to authoritative, comprehensive and transparent environmental information on a wide range of Australian products and services over their entire life cycle.*

It will be an invaluable tool for those involved in LCA, as it will also define and develop consistent guidelines, principles and methodologies for the collection of LCI data, along with protocols for LCA processes for different sectors." (Australian LCI Project, 2008)

One of the key reasons for the creation of this project was to have a unified approach that would give industry and consumers confidence in the consistent use and application of LCI data.

The Australian team has approached New Zealand to invite practitioners and coordinators to be involved with this project, which warrants serious consideration.

Consideration should also be given to the establishment of a unified register of all databases within New Zealand, working with interested parties from research and industry. Maintaining updated knowledge of new and existing databases and their status is likely to enable and encourage sharing of information while eliminating inefficiencies. There is a role for industry to contribute aggregated information (e.g. through industry organisations) and to fund such initiatives alongside research and industry development partners to reduce individual company costs.

A register should ideally incorporate reference to both private and public data as there may be commercial situations where private data can be used for mutual benefit for each party. This data would need to be stored in a common format (XML) and have common data collection annotations (ISO14048) and the status (Public or Private) to ensure effective management of all nationally useful LCI data. It is likely that the creation and maintenance of sector-level data would mitigate or spread the cost of essential data collection among wider groups of stakeholders

Data Collection

If Statistics NZ was to collect data on simple key metrics for environmental assessment (Alcorn, 2008) this could be a significant and enabling step. It would immediately reduce some costs of data collection and collation and open the way for increased uptake of LCA and other analytical methods, such as carbon foot printing. It would also embed the collection of environmental information in New Zealand, driving a leadership position in the area internationally.

Existing economic input/output tables could also be reviewed and improved to deliver more advanced information to those using EIOA and hybrid processes, as these are noted to have limited quality (Andrew, 2008).

Other approaches

There are a range of different methods that are being used in addition to, and in combination with, LCA. Currently the best example of this is Economic Input Output Analysis (EIOA). This is used in conjunction with LCA as a hybrid where appropriate process data is not available or cannot reasonably be obtained.

It is important that NZ encourages consideration of the adoption and evolution of new approaches to prevent over-commitment in one area.

Life Cycle Thinking

It would be advisable to form and maintain a leadership group of top practitioners and business stakeholders to advise and inform all interested agencies and stakeholders on life cycle practices and quality standards, including the prevention of duplication of data.

Progress could also be achieved through existing bodies, such as the Eco-Verification Network, Sustainable Design Working Group and the Life Cycle Assessment Working Group by bringing Life Cycle Thinking into their scope and looking for ways to promote and support new approaches and their adoption where multiple NZ industrial actors can benefit. These groups however represent specific and not general interests; the real value would be generated by encompassing a wider range of Life Cycle Thinking perspectives at the same table.

Taking a ‘unifying’ approach would be seen as an essential tenet of forming a leadership group in the area of life cycle thinking due to the differing interest groups that are interrelated in this area.

There have been previous proposals tabled by the LCA working group (Nebel, 2008) which sought to create a portal for educating people in New Zealand about LCA and the wider issues of Life Cycle Management. This is attached to the appendices due to its relevance.

High growth and emerging sectors

To align effectively with government policy and RS&T spending, it is crucial that the environmental data needed for new high growth industries is identified. Without this step, there could be a risk that their entry into new markets is frustrated, and the RS&T and innovation spend would then have a restricted downstream impact.

Historically New Zealand firms and sectors have tended to 'react' to legislation and change rather than seeking out leadership positions. This probably stems from a well-understood pattern of this country's economic actors being largely 'standards-takers'. However, in a rapidly-moving and intensely competitive international economic climate it has become a serious risk exposure for many industries, especially those relying on manufacturing, energy inputs and significant raw materials use. The emerging sectors probably cannot afford to wait for industry or regulatory norms to be established in markets elsewhere before they move to the frontier of such trends as eco-verification and Life Cycle Thinking.

Capacity

There is a severely constrained pool of LCA capability within New Zealand. Only a few people (estimated to number fewer than 10) have comprehensive understanding of the whole LCA method and the wider related issues raised in this study.

This group tends to advise a wider peer group of practitioners about best practice and structure for various studies. This creates a bottleneck for any substantial studies that need to be undertaken concurrently.

This constraint represents a risk to New Zealand's ability to undertake and maintain complex datasets to ensure integrity of downstream assessments. Research providers often do not have good connections to each other or to Universities, and this can present another obstacle to efficient practice.

Capability

There is currently no tertiary education on LCA or analytical environmental assessment. This shifts the cost of education onto research providers, practitioners and ultimately their industrial clients, which further exacerbates the existing resource constraint and the squeeze on sectors and firms. In addition, it limits opportunities arising for graduates to pursue ongoing studies and careers in life cycle thinking.

The Landcare Research Life Cycle Management initiative (McLaren, 2008) represents a real and concrete step to address this. The project intends to develop six companies and educate six Masters students, as well as LCM champions in the companies. This should lead directly to a better base of understanding and skills in New Zealand. If successful, this programme could conceivably be extended under the stewardship of a wider group to incorporate more companies to accelerate uptake.

Practitioner Community

The practitioner community in New Zealand appears to be grouped into commercial and research concentrations. The linkages and collaborations around the research domain are relatively effective, but do not always take into consideration the commercial practitioners or the value they could provide. Creating the impetus for 'Life Cycle Thinking' from all sectors and practitioner groups to collaborate would generate more discussion and social ties, and assist in the formation of functional linkages between the private and public sector. There is a likelihood this would then lead directly to an increase in uptake.

This study has in part established that there are a wide variety of sectors engaged with LCA, which is a positive. But these sectors are operating in isolation with limited understanding of other parallel initiatives.

Facilitating a more nationwide approach would sharpen the focus on how the discipline and approach can benefit New Zealand and increase competitiveness both now and in the future.

Suggested Actions

There are a range of initiatives and actions that could be discussed and instituted. These include the consideration of:

- **National LCI register and common format:** assuming that a data collection policy was instituted, create a national register with consistent data descriptions and requiring data in an open XML format, for example. This would be an effective tool to build a clearer picture of where gaps are and would therefore help to target new research accurately.
- **Data collection policy:** defining the information that needs to be specified for data collection instituted with government endorsement. This might follow the ISO/TS 14048 outline which already exists.
- **Code of practice:** A government-endorsed code of practice to develop consistency in application. This would provide businesses with confidence that they are employing a practitioner who is using the most current, appropriate and efficient approaches for the New Zealand context.
- **LCI Co-Funding:** co-funding LCI development would provide practitioners with the ability to reduce the cost burden to companies. This could also be made conditional on the practitioners submitting their aggregated data to a national register and collection to contribute to a wider pool.
- **Tertiary & Continuing Professional Education:** a clear imperative which requires urgent action is the implementation of teaching at a tertiary undergraduate and post-graduate level to educate and train new practitioners, and build capability in this strategic area. (Such as the Landcare Research LCM programme).
- **Establishment of Advisory groups:** on Life Cycle Thinking (Incorporating LCA and LCM and other areas), Inventory Analysis and Impact Assessment to ensure specific advice on these three critical areas. These groups should be facilitated in such a manner as to involve key practitioners without creating unnecessary work for them.
- **Establishment of a structured community:** to support wider discussion, presentation and learning about life cycle thinking and its application within New Zealand.

Recommendation for further research

Within this document are some key observations which could result in further research. These are summarised as follows:

1. Research and establish a formal register of all New Zealand Datasets across all sectors that is specific to New Zealand or modified and applied within a national context (this may not include data collection).
2. Investigate and make recommendations on forming a New Zealand collection of databases in an open format (XML) with standardised data collection information.

3. Investigate the possible loss of data richness or quality through excessively narrow selection of impact categories such as Global Warming.
4. Investigate the barriers and impediments to uptake of LCA within New Zealand export sectors.

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Appendix 1 - Research Structure

LCI Research Project

Project: LCI Initiative	Document #: 5301-02-Research Structure
Subject: Life Cycle Inventory	Client: 5300
Source: Timothy Allan	Client Manager: Andrew Huddart
Reviewed By: person reading report	Date: 30/08/2008 4:27:00 p.m.
Revision date: 05/09/2008 3:33:00 p.m.	Revision: 3

Keywords:

Introduction

This body of research will drive toward building a better understanding of current practice and applications of LCI within New Zealand.

The current level and scope of practice may restrict some of the Quantitative information which can get gathered. This is due in part to a significant focus on GHG emissions. It is also acknowledged that some practitioners are using elements of the LCA process and not the whole methodology, where this is apparent attempts will be made to understand why this occurs.

Participants will be given a questionnaire which would also form the basis for the structured discussion. The structured discussion would seek to more clearly understand some of the information around their decision making, and assist to qualify the answers to various questions.

Format

1. **A multi-choice questionnaire** submitted by PDF that will allow respondents to answer the questions. This will enable results to be collated automatically downstream.
2. **A structured discussion** with a limit of 2 hours, some of these may be done in a group where this is appropriate. Based off the structure of the multi-choice questionnaire.

The success of the multi-choice questionnaire may be limited if respondents exceed their level of knowledge, experience and application in practice.

Research & Discussion Structure

Interview discussion

The information below will form the substantive part of the discussion, it is acknowledged some areas may be not significant factors within your current workload but it would be appreciated if you could comment on these during the discussion. If key areas are not currently utilised within the context of your work it would be useful to discuss why this is in brief to ensure these reasons are clearly understood.

Core Parameters

The core parameters of the LCI discussion are listed (in no particular order) as follows:

- **The 'Type' of LCA** defined in the goal – for instance 'Change Oriented' or 'Accounting' based goals
- **System Boundaries** – both technical and natural systems, also encompasses time and geography
- **Inventory class:** Cradle to gate or cradle to cradle etc
- **Choices of impact categories:** as this influences data choices
- **Method of calculation** (an use of tools for calculation)
- **Data quality:** the rating and applicability of data being used
- **Interpretation:** there are relative aspects of this that may need to be considered.
- **Allocation**: a complex area and would only be canvassed at a macro level

LCA Type

What Type of LCA do you typically undertake; change oriented or accounting based?

- **Stand Alone:** Descriptive singular
- **Change Oriented:** Comparative and prospective.
- **Accounting:** retrospective. Suitable for Eco Labelling Schemes etc.

Notes:

System Boundaries

With specific respect to system boundaries, can you elaborate on the system boundaries you have used or would use on typical LCA projects you are involved with?

- Boundaries in relation to **natural systems**:
- **Geographical Boundaries**:
- **Time Boundaries**:
- Boundaries within **Technical Systems**:

Notes

Functional Unit

Can you provide an example(s) of a functional unit from an LCA course of investigation, explaining the relevance of the FU choice? If none are used can you identify why and how this affects your use of the LCA method.

Notes:

Allocation

Do you currently use allocation? If so could you briefly outline the generalised approach you take to this.

Notes:

Choice of Impact Categories

What are the primary impact categories which you would consistently apply during the application of LCA please indicate all categories used in your work but indicate the categories which are dominant.

<u>Broadly these impacts should be categorised under:</u>

- Human Health
- Resources
- Ecological Consequences

Human Health
Toxilogical Impacts
Non-Toxilogical Impacts
Impacts in the work environment
Resources
Energy & Material
Water
Land (Including wetlands)
Ecological Consequences
Global Warming Potential
Ozone Depletion
Eutrophication
Photo-Oxidant Formation
Acidification
Eco-toxilogical Impacts
Habitat Alterations and impacts on biodiversity

Notes:

Tools & Method of Calculation

What is the primary method of calculation you use, indicate whether software tools are used to create these calculations, and if so what tools are used.
Specify rationale for tool choice.

Notes:

Data Quality

What parameters do you apply to your data quality?

Notes:

Relevance

Relevance relates to the context and whether the data is used or approximated from other sources.

<u>This factor is of particular interest to the study.</u>

- Time related coverage
- Geographical coverage
- Technology coverage
- Completeness
- Representativeness

Reliability

Precision or accuracy of the data collected and being used.

Accessibility

Is the data you use accessible or transparently available?

Interpretation

Do parameters relating to interpretation influence your decisions made during the creation of LCI.

Classification

Although part of Impact Assessment (LCIA) aspect could have some bearing on the LCI facet.

Notes:

Dataset Factors

The key leading question here is do you create your own datasets or utilise modified or existing datasets not specific to New Zealand's national production context.

Public or Private

Is the data available to be used by others (i.e. could a company request an assessment using this data, rather than is the data 'free'?)
Could the data be opened for general usage in the future?

Industry Sector

What industry sector/s is the data going to be used in?

Importance to NZ

Some datasets will be more or less important to NZ. What data do you believe you would need to more effectively do your work?

Usage

What was the data created for and where has it been used.

Other parameters

What other parameters do you believe are critical to the delivery of LCI in New Zealand context?

Notes:

Appendix 2 – Letter of Invitation

Saturday, 30 August 2008

«First_Name» «Last_Name»
«Organisation»
«Address_1»
«Address_2»
«Address_3»
«Address_4»

«GreetingLine»

Re: Participation in the LCI research initiative

Locus Research and the Ministry of Research, Science and Technology (MoRST) would like to formally request your organisation's involvement and engagement in a Life Cycle Inventory (LCI) research initiative.

You or your team's involvement would be in the form of a structured interview with an accompanying questionnaire on the same subject matter. It is unlikely to take longer than 2-4 hours in total over a period of several weeks.

This research is aimed at creating a national view of LCI activity, approaches and data to better understand and inform future policy and engagement with the sector. This is under a broader 'Eco-Verification' programme that exists within the government.

Working with the Ministry of Economic Development (MED) and other agencies and partners, MORST intends to use the data from this project, in combination with other input from Life Cycle research/application specialists and industry stakeholders, to set out some options for improving the effectiveness of tools, information exchange and linkages between end users (such as businesses and industry groups) and the research provider community.

This partnership with the sector is part of a strategic aim to improve capability in the research, tertiary education and environmental service sectors for environment footprint measurement and reduction.

Oversight of this wider Eco-Verification strategy is provided by a steering group drawn from multiple ministries and agencies, led from MED. It takes advice from a closely-engaged stakeholder group that involves science, education and industry experts, and you may have been connected to their activities in recent months.

Disclosure:
The level of disclosure required is limited to the following:

LCI methodology questions: how are you currently approaching your work in this area?
LCI dataset questions: what datasets do you currently have that you have either tuned or created to suit NZ context, and what industry sectors could this data benefit?
Please note – this means there is no imperative to view or see actual data

As such the disclosure level is requested to be public domain. If there are any concerns please revert either Timothy Allan or Andrew Huddart with your concerns. Our contact details are at the end of this note.

The primary use of the findings and report will be for policy development and to provide a structured understanding for those involved within the broader Eco-locusresearch

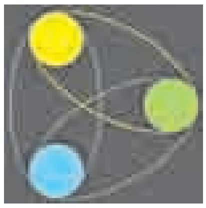
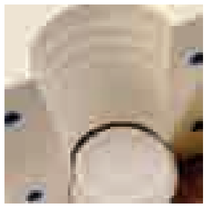
Sustainable Design & Development









locusresearch™ is a design company with fresh ideas on design and research. We operate in the four broad areas of Design, Applied Research, Sustainability, and Manufacturing.

In the six years since Locus was started we have built a reputation for deep research, original design and effective implementation. Our approach to sustainability has been pragmatic and practical, we simply aim to address these issues on a daily basis for both ourselves and our clients benefit.

This is achieved with simple design strategies, through to more advanced analysis using life cycle assessment and systemic analysis. As a team we have an overarching commitment to sustainable product design (SPD) from research into SPD through to commercial applications of the products that we design.

Our focus has been on research and development rather than just design; we drive to deliver a basic point of difference by using research to build a platform for product development and engineering. We believe in the strategic use of design on a short, medium and long term basis.

Locus has a client base that extends from New Zealand to the UK and has an informed international outlook.

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Verification initiative. As such, there may be elements of this research project's findings which in time are distributed in the public domain.

It is likely that the report produced from this work will enable ongoing engagement within the sector, and your involvement in this research will ensure your organisation contributes to the development of LCA/LCI and Eco-Verification in New Zealand.

Kind regards,

Timothy Allan

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