

Literature Review of Enablers and Barriers to Adoption of Life Cycle Management

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Summary

Project and Client

This literature review collates existing research findings on enablers and barriers to implementing Life Cycle Management (LCM) in manufacturing firms. It supports the two-year LCM Project, which aims to identify key barriers and enablers to New Zealand manufacturing firms adopting LCM practice. The LCM Project has been undertaken by Landcare Research, Business NZ, the Ministry of Economic Development, NZ Trade and Enterprise and the Ministry for the Environment.

Objectives

- Define LCM and outline the key bodies of knowledge where findings were drawn (see subsections 3.1 and 3.2).
- Identify enablers and barriers to LCM adoption (see Section 4).
- Present recommendations for the LCM Project research: (1) for refinements to the research programme, (2) best practice factors for improving LCM programmes, and (3) factors that might amplify LCM across the manufacturing sector.

Key literature review findings of enablers and barriers to LCM adoption

Literature on the adoption factors of life cycle thinking in manufacturing firms is patchy at best. Scholars within the LCM field note a surprising lack of research on whether or how LCA studies have actually informed the development of new and revised products. Research has tended to focus on the constraints of undertaking LCA studies rather than the constraints of implementing LCM across an organisation. In addition research that has looked more broadly at LCA/M adoption has tended to compare firms with different structural conditions (size, sector, country) and has tended to see these structural conditions as key influencers in different adoption practices. As such, common recommendations to increase LCA adoption have primarily focussed on developing better LCA tools and sector standardisation.

However recent research has compared very similar firms and found they had very different experiences and adoption practices. This research found that factors associated with the firm's learning culture, its relationships with its suppliers and customers, and the skills and behaviour of employees all significantly influenced their adoption of LCM.

This review has therefore attempted to identify a broad spectrum of adoption factors both internal and external to a manufacturing firm including the influence of regulations and markets, the characteristics of the products, adequacy of LCM tools, organisational change

processes and inter-organisational management of value chains. The lack of existing research programmes which have holistically evaluated LCM adoption in this manner indicates that the approach taken in the LCM Project will provide comprehensive and valuable results.

The review has identified 10 adoption themes with 32 associated enablers and barriers. The 10 themes were developed within a theoretical model for organisational change for sustainability. This model, developed by Landcare Research, considers adoption factors in terms of a firm's organisation, the individuals within it, its organisational field (suppliers, competitors, customers and other stakeholders) and the broader economic and societal system within which the firm operates. The 10 themes against the organisational change model are illustrated in figure 1 and the 32 associated enablers and barriers are outlined in table 1.

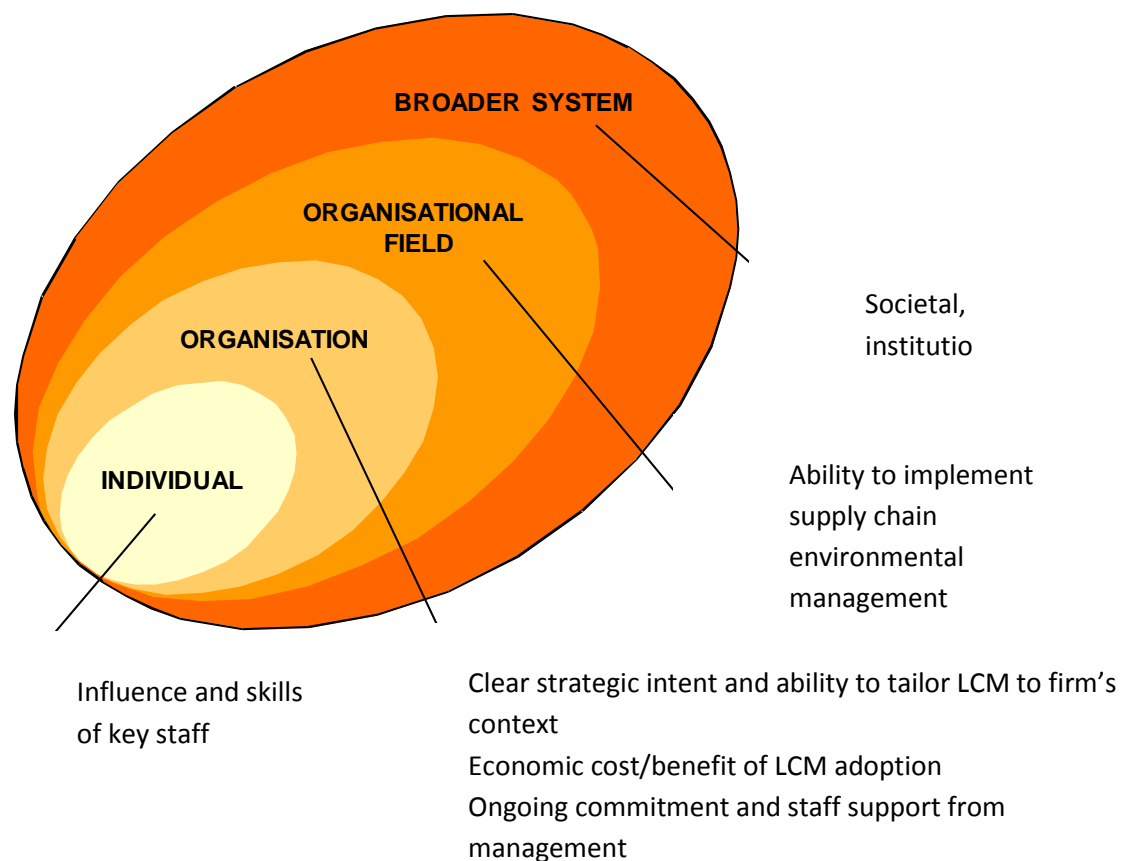


Fig. 1 Adoption themes aligned to the model for organisational change for sustainability.

Table 1 Adoption themes, barriers and enablers

	Adoption themes	Adoption Barriers	Adoption Enablers
Broader system	1. Societal, institutional, regulatory and market drivers	Constraints from wider patterns of production & consumption e.g. off shore outsourcing, throw away versus repair consumer culture The market imposing few if any direct requirements for companies to carry out LCM	Increased stakeholder demand for environmental performance which is shifting beyond an end of pipe focus
	2. Ability to implement supply chain environmental management	Suppliers often won't or can't provide data on their products Lack of sustainable material options Small and medium firms lack ability to influence the value chain The risks posed by increased dependency on suppliers/customers due to cooperative approaches	Emergence of strategic and cooperative approaches to implement LCM across value chain Existence of long term supplier and customer relationships
Organisational field	3. Customer demand & firm's marketing approach	Customers limited understanding of environmental issues & confusion over eco-labels Consumer resistance to paying more or switching brands for green products	Firm having existing or identified "green" customer segments Long term and close relationships with customers Heavy promotion and distribution through mainstream outlets
	4. Clear strategic intent and ability to tailor LCM to firm's context	Many Environmental Management programmes are "one size fits all" and inflexible	Time is taken at start of programme to clearly define firm's strategic focus and to tailor LCM to the context of the organisation
Organisation	5. Economic cost/benefit of LCM adoption	The direct and transactional costs of LCM may outweigh the immediate benefits	Factoring indirect and less tangible benefits into cost/benefit analysis Regulation and pollution taxes may improve the cost benefit Working on a sector standard approach
	6. Ongoing commitment and staff support from management	Reliance on cost benefit analysis to build management commitment and environmental policies to change staff practice	Clear LCM vision and goals developed with staff Long term tangible commitment to implementing LCM Providing staff with resources, training, recognition, Ensuring majority of staff committed and actively involved across all functions
	7. Existing sustainability culture and practice		Firm has an existing sustainability culture and practice

	8. Ability to pragmatically apply LCM throughout processes and functions	High level of product complexity Ambiguity around best environmental options Complexity of assessment tools and limitations of LCM as a design tool.	Simple products with few suppliers Integration of thinking and tools into existing management systems Whole organisational approach to LCM with integrated decision-making across functions
	9. The firm's ability to learn and change	Underestimating the scale and complexity of organisational change required to implement LCM	Implementing a practice of reflective learning and innovation within the firm
Individual	10. Influence and skills of key staff	Key LCM staff confined to operational departments Narrow skill set in LCM project teams	Project team have technical and organisational change skills and decision-making authority or direct access to authority LCM Community of practice to support staff and grow competencies

Recommendations for refinements to the LCM research project

The findings of the literature review indicate that enhanced value could be obtained if the following areas were further developed:

- Consideration of the firm's organisational field highlights a key adoption factor: the need for new forms of interorganisational collaboration required to manage the environmental impacts of a product through its lifecycle. LCM moves environmental management beyond the boundaries of the firm and it is within this sphere of suppliers, competitors, industry groups and customers that many of the improvements will need to be implemented, demanding new institutional norms around business responsibilities and business relations. The project needs to evaluate each firm's approach to Supply Chain Environmental Management (SCEM) and identify the enablers and barriers that emerge. The enablers and barriers should then be considered against the context of the firm's position and influence in the value chain, as well as against the external drivers for SCEM (e.g. whether there is a common threat to the firm and its competitors or whether the firm is seeking a competitive point of difference from its competitors).
- The degree of integration the firm has across its departments in terms of strategy, decision-making and operations and the degree to which this has enabled or created barriers to implementing LCM.
- Whether and how the company intends to implement LCM over the long term.
- Exploration of the firms' processes and capacity for organisational change and reflection. Specifically whether the firm's organisational learning goes beyond technical process improvements towards an examination of the underlying assumptions and values that underpin company decision-making and practice.
- Additional consideration of the firm's strategic marketing approach and customer relations. Specifically analysis of the appropriate marketing approach in response to strategic marketing aims. Environmental disclosures in promotional material will not

fully cover this; distribution of promotions and products also need to be considered as does the form and quality of company–customer relationships. Successful marketing will be context specific and relate to the specific customer characteristics identified by the firm’s strategic market analysis.

- The economic analysis undertaken for the LCM research project suggests that it will be difficult to measure intangible economic benefits. While this is true, it may be of value to attempt to capture those benefits in a qualitative way because the literature suggests that intangible benefits of LCA often tip the balance as to whether an environmental improvement should go ahead. Intangible economic benefits that could be examined include reduced need for pollution control equipment, reduced hazardous waste disposal, lower regulatory charges, or more efficient supplier systems. Intangible costs might include the transaction costs of organisational change, training, and costs for new information systems.
- The six case-study firms represent different manufacturing sectors, produce products of differing levels of complexity, are at different points of the value chain, and have different types of customers. When making comparisons between the different firms’ relative success in adoption, it will be important that these differences and their specific ability to affect adoption, are built into the analysis.

Best-practice factors for improving LCM programmes

Some key factors have been identified in the literature that may improve any subsequent LCM programme arising from this research programme:

- Most effort should be placed on the initial stage of the programme. The strategic needs of the firm, and how it would benefit from undertaking LCM need to be analysed and the firm’s ambition level / priority focus for LCM defined. The firm then needs to consider organisational or supply chain barriers that may hinder adoption and the implement actions to mitigate these. LCM should not be attempted without solid management commitment.
- A ‘one programme fits all’ approach does not appear to work effectively. Rather an overall framework approach that can be flexibly customised to each organisation’s needs and context is required, with customisation built into the initial stage of the programme. While sector approaches can be standardised, tailoring an LCM programme to each organisation will still be required to increase rates of success. Explicit guidance on how to tailor the programme to the organisational context (versus simply telling them that they should tailor it) will need to be provided to companies.
- A continuous process of improvement should be designed into the organisation’s LCM programme at the outset if the organisation’s goal is to achieve significant environmental performance. This is because significant environmental improvements are generally achieved through incremental steps over time versus one large and discrete step.

- Both technical skills and organisational change skills are needed to facilitate LCM and these skills need to be present and actively engaged either from within the firm itself or via external programme support.

Factors that may enable LCM to be amplified across the manufacturing sector

While the original aim of the review was not to identify factors that enable LCM to be amplified across the manufacturing sector, insights are given below and in subsection 6.3 to contribute to discussion.

1. Identify and then prioritise effort on firms/sectors that are most likely to need to adopt life cycle thinking to adopt LCM. Literature indicates that these might be:

- Sectors/firms that have current and potential environmentally sensitive markets, especially ones that may soon require certification that includes a requirement to undertake LCA
- Firms in highly polluting industries that are likely to face increasing pressure from public stakeholders and subsequently their customers
- Firms that produce goods for the final market and therefore receive pressure from customers and stakeholders early on
- Firms that are likely to be part of the supply chain of large companies that are beginning to move towards supply chain environmental management. Many of these may be large international companies, and the New Zealand businesses that might be most affected may also be in the primary sectors.

2. Identify and then prioritise firms/sectors that are more able to adopt LCM. Literature indicates that these might be:

- Firms with a high level of vertical integration and few suppliers.
- Firms with simple products with relatively few components (e.g. paper in contrast to electronic products).
- Firms that are young, or that are developing new types of products, as the scope for product innovation may be greater.
- At the sector level, sectors that have strong industry associations¹ that are used to working collectively to improve industry practice and have the soft and hard infrastructure to support this.

3. Working with a selection of large consumer focussed firms to implement LCM across their supply and customer chains.

This approach, for example, has been developed in Tawain as the Corporate Synergy Model (CSS). In this model a large firm will initiate, coordinate and maintain the model and is supported by Government initiatives. This approach reflects literature findings that businesses closest to the end customer are most exposed to consumer demand and will

therefore often be the first ones to improve environmental performance. The requirement for environmental improvements typically starts to move up the value chain until even the smallest companies in the value chain are required to improve their performance. This indicates that working with large firms in the retail–wholesale sector might be one way of amplifying LCM in NZ.

4. Creating an enabling environment for LCM in New Zealand.

In the short term this could involve, for example, establishing community-of-practice networks for firms and staff implementing LCM, as this could help build the skill base within New Zealand and support LCM practitioners. This has been implemented in Sweden for LCA (see www.cpm.chalmers.se).

In New Zealand, the recent formation of the Life Cycle Association of New Zealand and the New Zealand Life Cycle Management Centre are positive initiatives. In the long term government policy can play a role in sustainable consumption education to increase customer demand, and in creating a level playing field so that firms investing in environmental initiatives are not at a financial disadvantage in the short term compared with others in their sector.

1. Introduction

This literature review collates existing research findings on enablers and barriers to implementing Life Cycle Management (LCM) in manufacturing firms. It was completed in August 2009 by Landcare Research and supports the two-year LCM Project undertaken by Landcare Research, Business NZ, the Ministry of Economic Development, NZ Trade and Enterprise and the Ministry for the Environment.

With the aim of identifying if any improvements could be made to the LCM Project approach and research plan, the review focuses on the individual firm's ability to adopt LCM (versus sector-wide adoption, for example), but recognises that firms are directly influenced by the wider context within which they operate, including their industry sector, markets, suppliers and other stakeholders as well as wider social and economic systems; therefore, all these influencers are considered within this report.

2. Objectives and Methods

- Define LCM and outline the key bodies of knowledge from which findings were drawn.
- Examine how different research approaches have resulted in different interpretations and subsequent recommendations on what is required to increase LCA/LCM adoption (In response to this, an organisational change model is presented within which the enablers and barriers to LCM adoption found in the review can be considered.
- Describe the identified enablers and barriers in detail within each sphere of the organisational change model.
- Present recommendations for the LCM Project research: (1) for refinements to the research programme, (2) best practice factors for improving LCM programmes, and (3) factors that might amplify LCM across the manufacturing sector.

3. Background

3.1 Defining Life Cycle Management

Life Cycle Management extends the concept of Life Cycle Assessment (LCA) from the **assessment** of products and services (Berkhout et al. 1996) to an integrated framework for **managing** the life cycle performance of those goods and services. LCM is still at an early stage of development; so definitions are still fluid but the UNEP/SETAC definition below has been commonly used. In this definition LCM has also been broadened to encompass social impacts and performance.

LCM is an integrated framework for managing the total Life Cycle performance of goods and services towards more sustainable forms of production and consumption. It comprises both existing analyses (analytical tools, checklists, methods and techniques) and practice (policy/corporate programs, policy/corporate instruments, and procedural tools), and provides an opportunity for proactively managing the economic, social and environmental performance of products and services in an integrated manner. (UNEP/SETAC Life Cycle Initiative – LCM programme)¹

A number of definitions have been presented in the literature, and these provide additional characteristics of LCM:

- *An integrated organisational approach.* LCM provides a framework to take a whole-organisation approach to life cycle thinking. This enables life cycle thinking to move beyond the purely technical application in design and production to be incorporated into organisational strategy, stakeholder relationships, regulatory tracking, and marketing (Hunkeler et al. 2003).
- *Integrated value chain management approach.* LCM can only be achieved through coordinated efforts of all parts of the organisation, its suppliers, and its customers (Sharfman et al. 1997).
- *A flexible approach.* The LCM framework provides a range of tools and approaches that can be used in a flexible manner and adapted to the specific needs and characteristics of an organisation (Hunkeler et al. 2003).
- *A pragmatic approach.* LCM may provide a more pragmatic users-perspective than LCA, as there is a need to focus on what an organisation can change rather than attempting to identify ‘a scientific truth’ (Tischner & Nickel 2003, p. 23).
- *An institutional shift in understanding the role and nature of business.* LCM is less of a tool and more of a structured approach for shifting institutional thinking and norms

¹ The United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) launched an international life cycle partnership, known as the Life Cycle Initiative, to support businesses and policymakers in the world to put life cycle thinking into practice (for more information visit <http://lcinitiative.unep.fr>).

around viewing and dealing with products and the environment (Welford 1995; Heiskanen 1999, 2000a; Baumann 1998).

- *An umbrella term* for a number of practices that encompass life cycle thinking, including: product stewardship, supply chain management and design for the environment, green purchasing (Sinding 2000, p. 84).
- Finally, Linnanen et al. (1995, p. 117) provides an applied definition or framework (Fig. 2)² that usefully relates LCM to a firm's core functions:

Life cycle management consists of three parts:

- Integrating environmental issues into the decision-making process of the company – the management view;
- Optimising the environmental impact caused by the product system during its life cycle – the engineering view; and
- Creating a new organisational culture to support the decision-making process – the leadership view.

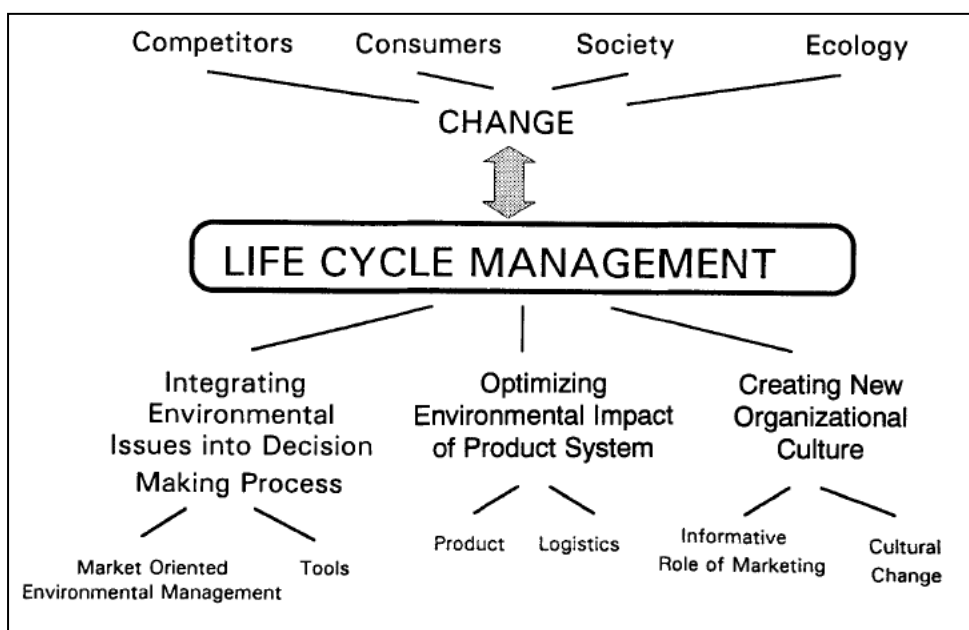


Fig. 2 Life Cycle Management framework (source: Linnanen et al. 1995).

² The framework was developed during compilation of an environmental management handbook for Finnish industry (Linnanen et al. 1994).

3.2 Theme areas from which relevant findings on LCM were drawn

This review drew on insights from the following bodies of knowledge:

- Life Cycle Assessment and Life Cycle Management research
- Programmes that incorporate life cycle thinking, e.g. green purchasing, industrial ecology, eco design, design for the environment, environmental supply chain management, integrated chain management and product stewardship
- Organisational change literature; specifically how organisational change theory has been used to evaluate environmental management programmes including the New Zealand Towards Zero Waste programme³

3.3 Different research approaches provide different solutions for increasing LCA adoption

Compared with LCM, LCA has a comparatively long history with a substantive amount of research. When LCA was first introduced into industry practice many technical problems needed to be resolved. This has led to the majority of research on LCA focusing on methodological issues (e.g. technical complexity and lack of standardisation) as these were seen as the key barriers to increasing industry uptake (Heiskanen 2000a; Rex & Baumann 2007, 2008).

So while many of the case studies on LCA application demonstrate that environmental improvements are possible, surprisingly few actually go into detail of whether and how these improvements were brought about (Heiskanen 2000b, p. 241). Therefore few studies have attempted to identify factors that contribute to effective LCA practice. Those that have indicate that LCA/LCM practice varies, but quite different explanations have been offered for that variation in adoption. For example, in a review of studies that focused on the effectiveness of LCA practice, Rex and Baumann (2008) found that studies that compared different firms across different sectors and sought causal regularities external to those firms tended to report that companies of similar structural characteristics will use LCA in a similar way. In contrast, studies that compared similar firms and focused on the culture of each firm and the individuals within them, found that an organisation's social norms and culture and the actions of individuals within the firm were as important factors as the structural factors in shaping LCA practice. These different approaches in studies have in turn led to different recommendations for improving adoption rates. For example the former approach tends to recommend standardised tools for specific sectors and the latter approach recommends tools that can be tailored for each firm (see Table 2).

³ The Target Zero project was a 2-year 'cleaner production' (CP) demonstration project undertaken in New Zealand across 23 organisations (mainly business), initiated by the Electricity Corporation of New Zealand (ECNZ) and funded by the Ministry for the Environment (MfE). It was designed to show that the prevention or reduction of wastes and emissions at source can improve the environmental, as well as economic performance of participating organisations.

Rex and Baumann (2008) concluded that

‘...many attempts to facilitate use of LCA seem to have had limited impact on the adoption of LCA in industry as a whole. We argue that one reason for this lack of impact is the failure to grasp the individual and organisational context of LCA work, an aspect that tends to get lost in well-intentioned but technocratic attempts to help industry adopt a life cycle perspective’.

Table 2 Different research approaches provide different adoption solutions (Source: Rex & Baumann 2008)

	Functionalist approach	Interpretive approach
Selection of firms	Studies focused on different firms across sectors and firms operating in different countries	Studies focused on similar firms in same sector in same country
Analytical approach	Seeks causal regularities external to the individual firm to explain adoption and practice	Structural factors not dominant influence on adoption and practice, rather firm’s culture and individuals play important role
Findings	Companies with similar structural characteristics (such as belonging to the same industry sector, being the same size or operating in the same country) will use LCA in a similar way	Organisations’ social norms and culture and the actions of individuals within an organisation are important factors in shaping LCA practice
Implications for ways to increase adoption	Create standardised methodologies and tools for different sectors/countries (e.g. SPRU 1996) and standardisation bodies (e.g. Weidema 1996) Better tools required for uptake	Processes not readily generalised, rather LCM practice needs to be tailored for each firm Programmes need to understand and incorporate social processes of organisational change Best practice can cross sectors, and cross-sector networks can support firms

This review therefore considers both the external and structural factors of LCM adoption and the organisational and social factors. It structures findings around an organisational change model⁴ (see Fig. 1). The model recognises that an organisation is influenced both by its own institutions, norms and ability to learn and adapt, by the individuals within it, and by the wider context within which the organisation operate

⁴ The model was developed by Landcare Research to support its work on business adoption of environmental practices. The model is outlined in the Landcare Research working paper ‘*Organizations, institutions and transitions to sustainability*’ by Nick Potter, Bob Frame and Sarah McLaren, 2009, and can be requested from kingj@landcareresearch.co.nz.

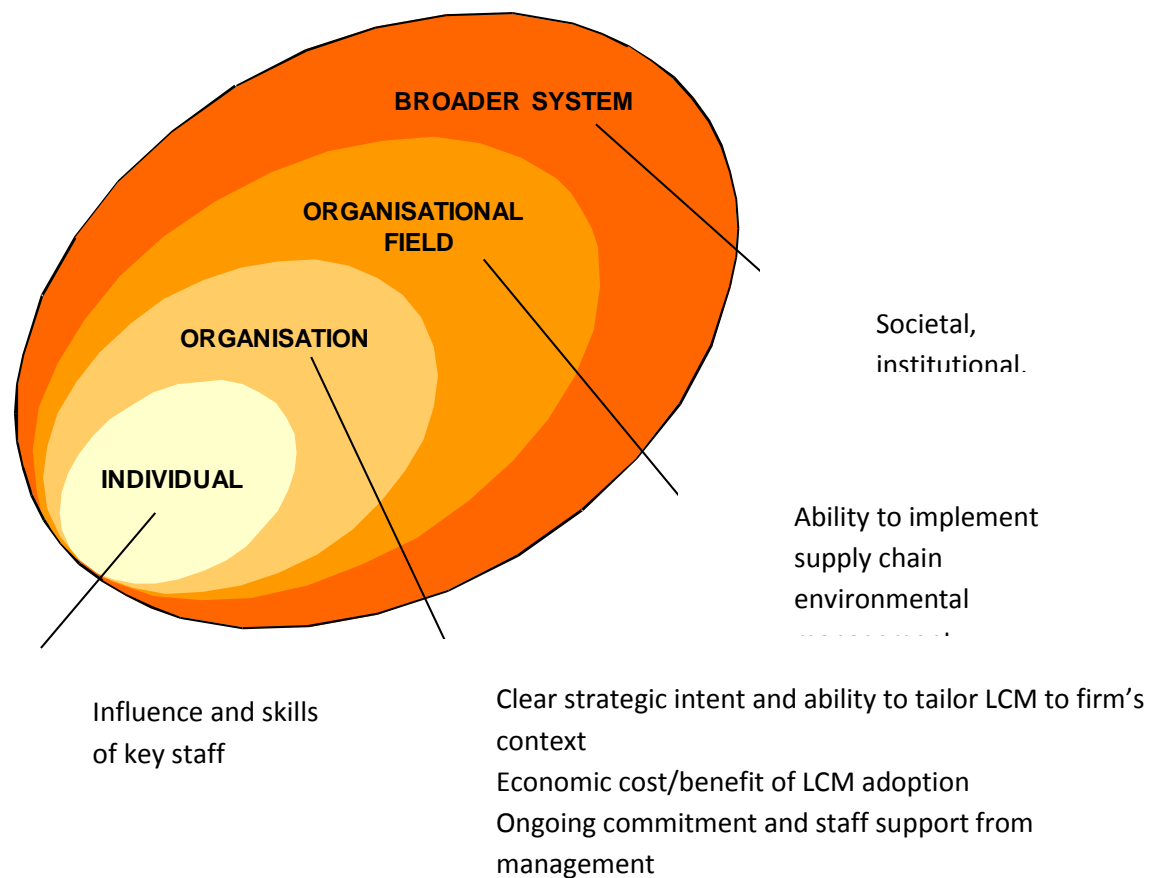


Fig. 1 Key adoption themes against an organisational change model.

The Organizational Change Model consists of four spheres of influence:

- 1. The broader system** – the wider ecological, social and economic systems within which the organisation operates, for example, national regulation, societal world views, and changing consumer demand.
- 2. The organisational field** – defined as an association of organisations that frequently and influentially interact with one another (Scott 1995). An organisation field might include businesses, citizens/consumers, regulatory agencies, and non-governmental organisations (Hoffman 1999). A field can be roughly defined around industry sectors and/or geographical areas. In terms of this review of manufacturing companies that are implementing LCM, the organisational field is likely to also include key organisations within a company's value chain (suppliers and customers), as a company will need to influence suppliers and customers in order to manage the full lifecycle of its product.
- 3. The organisation** – in this review this focuses on businesses and more specifically manufacturing firms.
- 4. Individuals** within the organisation – for example, this would include the LCM project team members and senior management in a manufacturing firm.

Considering adoption factors against the organisational change mode recognises that LCM adoption requires a change process within the organisation and the organisation field. It also provides insights into how the different spheres influence each other as part of the change process, which provides a more holistic understanding of what might be required to significantly increase LCM adoption in the manufacturing sector.

4. Enablers and Barriers against the Organisational Change Model

The factors contributing to enablers and barriers to adoption identified within this review have been summarised into 10 categories against the four spheres of the organisational model (see Table 1). Each category and their subthemes are considered in detail in the following subsections.

Table1 Adoption categories against the Organisational Change Model

	Adoption factor categories	Adoption barriers	Adoption enablers
Broader system	1. Societal, institutional, regulatory and market drivers	<p>Constraints from wider patterns of production & consumption, e.g. offshore outsourcing, throw-away versus repair consumer culture</p> <p>The market imposing few if any direct requirements for companies to carry out LCM</p>	Increased stakeholder demand for environmental performance, which is shifting beyond an end-of-pipe focus
Organisational field	2. Ability to implement supply- chain environmental management	<p>Suppliers often won't or can't provide data on their products</p> <p>Lack of sustainable-material options</p> <p>Small and medium firms lack ability to influence the value chain</p> <p>The risks posed by increased dependency on suppliers/customers due to cooperative approaches</p>	<p>Emergence of strategic and cooperative approaches to implement LCM across value chain</p> <p>Existence of long-term supplier and customer relationships</p>
	3. Customer demand & firm's marketing approach	<p>Customers limited understanding of environmental issues & confusion over eco-labels</p> <p>Consumers resistance to paying</p>	<p>Firm having existing or identified 'green' customer segments</p> <p>Long-term and close relationships with customers</p> <p>Heavy promotion and distribution through</p>

		more or switching brands for green products	mainstream outlets
Organisation	4. Clear strategic intent and ability to tailor LCM to firm's context	Many environmental management programmes are 'one size fits all' and inflexible	Time is taken at start of programme to clearly define firm's strategic focus and to tailor LCM to the context of the organisation
	5. Cost/benefit of LCM adoption	The direct and transactional costs of LCM may outweigh the immediate benefits	Factoring indirect and less tangible benefits into cost-benefit analysis Regulation and pollution taxes may improve the cost benefit Working on a sector standard approach
	6. Ongoing commitment and staff support from management	Reliance on cost-benefit analysis alone to build management commitment and environmental policies to change staff practice	Clear LCM vision and goals developed with staff Long-term tangible commitment to implementing LCM Providing staff with resources, training, recognition, Ensuring majority of staff committed and actively involved across all functions
	7. Existing sustainability culture and practice		Firm has an existing sustainability culture and practice
	8. Ability to pragmatically apply LCM throughout processes and functions	High level of product complexity Ambiguity around best environmental options Complexity of assessment tools and limitations of LCM as a design tool.	Simple products with few suppliers Integration of thinking and tools into existing management systems Whole-organisational approach to LCM with integrated decision-making across functions
	9. The firm's ability to learn and change	Underestimating the scale and complexity of organisational change required to implement LCM	Implementing a practice of reflective learning and innovation within the firm
Individual	10. Influence and skills of key staff	Key LCM staff confined to operational departments Narrow skill-set in LCM project teams	Project team have technical and organisational-change skills and decision-making authority or direct access to authority LCM community of practice to support staff and grow competencies

4.1 Societal, institutional, regulatory settings and market drivers

Societal, institutional, regulatory settings and market drivers strongly influence the firm's organisational field, and collectively provide the broader environment within which a firm attempts to implement life cycle management. This category includes the barriers and enablers to LCM adoption shown in Table 3.

Table 3 Societal, institutional, regulatory settings and market drivers

Barrier	Enabler
Constraints from wider patterns of production & consumption	
The market imposing few if any direct requirements for companies to carry out LCM	Increased stakeholder demand for environmental performance, which is shifting beyond an end-of-pipe focus

Constraints from wider patterns of production & consumption

Production and consumption patterns include geographic separation between producers and their suppliers and geographic separation between producers and their customers. This makes it more difficult, for example, to instigate product stewardship with customers or to actively involve suppliers in product redesign when customers and suppliers are in multiple countries across the globe.

Production trends have also diffused the responsibility for environmental impacts of products

The trend has been toward outsourcing, globalisation, competition and anonymity. These are problematic trends from the viewpoint of environmental ethics, because responsibility is so diffused among economic actors that it dissolves completely (Heiskanen 2000b, p. 240 after Beck 1992; Jamieson 1992)

The constraints posed by these patterns are less likely to be technical ones than cultural/social ones (Dillon 1994; Sinding 2000, p. 84). For example, in considering how industrial ecology might be organised, Dillon highlights that changing the behaviour of consumers will present one of the greater obstacles. Consumers, for instance, have become accustomed to single-use or short-lived throwaway products, and their concepts of value are often connected to price and fashion versus longevity of product (Vale & Vale 2009).

To implement LCM at a broad scale will therefore require fundamental shifts in how we produce and consume goods. This represents an enormous challenge (Cramer 1996, p. 42) significant shift in consumer demand for sustainable products and services (discussed below) and the exponential growth in businesses implementing sustainability initiatives over the last decade indicates that a shift is underway.

The market imposes few direct requirements for companies to carry out LCM

Lack of market requirement occurs both at a broad-system and organisational-field level and both will be dealt with in this section. If the market imposes few direct requirements to carry out LCM then external drivers for change are reduced and voluntary adopters risk incurring additional costs in production that may reduce their competitive position.

There {is} little control over imports into Australia and...while Australian companies may be taking proactive, voluntary steps to improve certain products, less environmentally friendly alternatives that are manufactured offshore were still available to consumers (KPMG 2005).

Indeed strong disincentives to LCA may exist in countries such as the USA, where life cycle studies may result in future liability claims against manufacturers (Berkhout 1996).

Current regulatory approaches can also create barriers. Most firms already have environmental and health and safety regulations that they are required to meet, and voluntary measures such as LCM tend to be undertaken only when these requirements are addressed and resources remain to implement LCM (KPMG 2005). In addition regulators often focus and encourage internal and onsite environmental management of a firm because the regulator wants to assign responsibility to an easily identifiable entity (Sinding 2000, p. 81). This raises the question of how regulators will be able to assign relative responsibility for environmental improvements across an interorganisational supply chain?

Finally, if businesses are not required to internalise the environmental impacts of their activities, they will only go so far in improving resource efficiency before the cost-benefit analysis suggests insufficient return (KPMG 2005).

Increased stakeholder demand for environmental performance

Globally, the business sector is facing increasing demand from stakeholders to improve the environmental performance of their products. Stakeholders include consumers wanting green products, public authorities concerned about environmental impacts, employees and local residents concerned about local health impacts, and NGOs campaigning on specific issues of sustainability (Personen 2001). These demands often go beyond current compliance with environmental regulation (Sinding 2000).

The early adopters of LCA and LCM practice have been those industry sectors under the most market and regulatory pressure, for example, European chemical industries, automotive industries, and paper product manufacturers (Berkhout 1996, p. 148). Firms in highly polluting sectors producing simple final goods will have some of the strongest incentives to adopt LCM (Berkhout 1996). This is because they have strong regulatory pressure and produce final goods which can expose their environmental performance directly to customers.

While there are few direct requirements to adopt LCM, self-regulation initiatives such as the Australian National Packaging Covenant were cited by businesses as important triggers to shift business behaviour.

Firms that require access to environmentally sensitive markets such as the European Union are also likely to have to operate under more extensive legislation and regulation of environmental issues (KPMG 2005). Heiskanen (2002) argues that LCA is emerging as a business norm. She believes that it is becoming increasingly difficult for companies to make environmental claims on products without some form of life cycle assessment.

4.2 Ability to implement supply chain environmental management

The most distinctive aspect of LCM is the requirement for interorganisational collaboration to manage the environmental impacts of a product throughout its life cycle; from raw material to design, through to production, through to use and disposal. This interorganisational process is commonly termed Supply Chain Environmental Management (SCEM) or Integrated Chain Management (ICM)⁵ and it is this interorganisational requirement that distinguishes LCM from environmental management approaches that are internally focused on a firm's own operations. It also highlights the need to focus on the firm's organisational field and well as the organisation itself, for it is within this sphere of suppliers, competitors, industry groups, and customers that much of LCM will need to be implemented. Figure 3 illustrates the typical stakeholders (shaded in grey) that a firm will need to interact with for LCM.

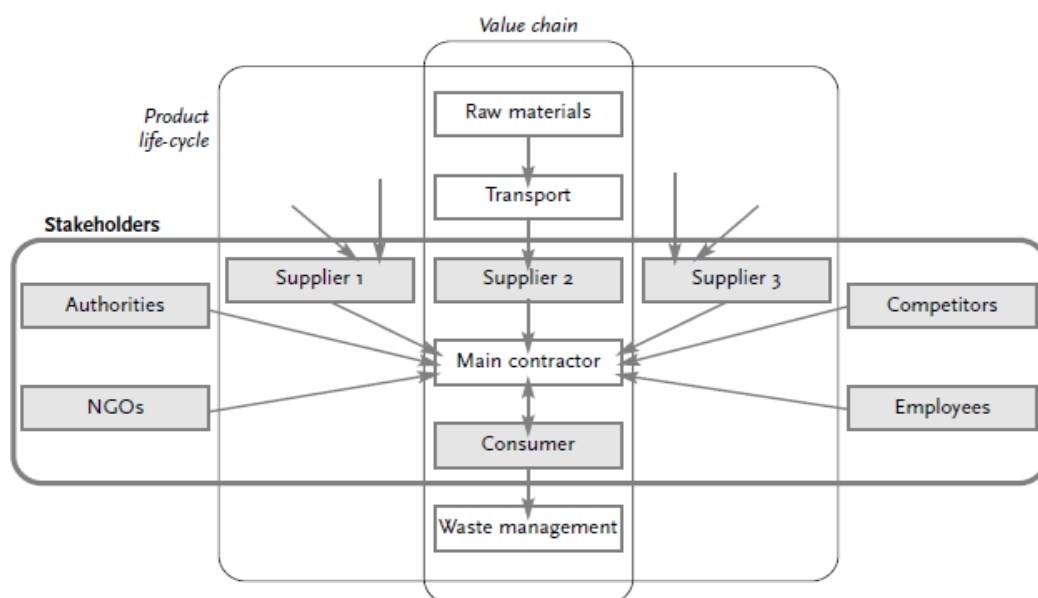


Fig. 3 Stakeholders in a product life cycle value chain (source: Personen 2001).

Personen (2001) describes managing the whole value chain of a product as an adaptation process of partners within a product life cycle chain. Adaptation includes hard factors (information systems, technological adjustments) and soft factors (development of communication, relationship development) (Personen 2001, p. 51). This category, *Ability to implement supply chain environmental management*, includes the barriers and enablers to LCM adoption shown in Table 4.

⁶ Similar concepts to SCEM are Integrated Chain Management (ICM) and value chain management; some of the literature uses these terms interchangeably, while Seuring (2004) distinguishes between them. Both are concerned with the social and technical processes and tools required to improve a product's environmental performance across a number of organisations (see Seuring (2004, p. 312) for detailed definitions and distinctions between LCM, ICM and SCEM).

Table 4 Ability to implement supply chain environmental management

Barrier	Enabler
Ability of small and medium-sized firms to influence the value chain	Simple goods and firms operating in vertically integrated sectors
The risks posed by increased dependency on suppliers/customers	Emergence of new interorganisational approaches and long-term supplier and customer relationships to implement LCM

Constraints on small and medium-sized firms to influence suppliers

Increased outsourcing and reduced vertical integration of firms have reduced the sphere of influence many firms have over suppliers, while increasing the number of suppliers they have to deal with. This makes it more difficult for them to implement SCEM.

Small and medium-sized firms often lack influence to impose standards or sanctions when they are a tiny customer of their suppliers (Heiskanen 2002; KPMG 2005). Also, requiring environmental performance information from suppliers in addition to performance in quality and delivery standards adds to the complexity of maintaining good relationships (KPMG 2005). Many firms interviewed in an Australian study believe they would only have influence over one level within the supply chain (KPMG 2005).

Even large firms experience difficulties. While they can use their buying power to enforce environmental performance of their suppliers, large firms often have hundreds of products and hundreds of tier-one suppliers, making the SCEM extremely complex and time-consuming (Heiskanen 2000a).

Some firms have difficulty getting information from their suppliers because suppliers see that information as being commercially sensitive (per conversation with Suzi Greenhalgh, Landcare Research, 2009) or they simply don't have the data or the resources to obtain it (Kogg 2003, p. 71).

SCEM is information intensive (Sharfman et al. 1997, p. 20) and firms often need increased data analysis and may need new or enhanced information systems that enable data to be shared and analysed across the supply chain. This interorganisational data sharing then raises issues about who has access to that data and who controls the information, which will need to be resolved between the companies involved (Sharfman et al. 1997, p. 21).

Finally, many firms do not have direct contact with their end customers and do not feel that they would be able to influence the way that customers use and dispose of their products (KPMG 2005).

Simple goods and firms operating in vertically integrated sectors

Firms that produce simple goods (e.g. paper versus electronic goods) may have greater ability to implement LCM as their products have fewer parts and a simpler supply chain. Working within a vertically integrated sector may allow firms greater coordination in supply chain management and sector-standardised approaches.

Emergence of strategic and cooperative approaches and long-term supplier and customer relationships to implement LCM

At both a broader system and organisational-field level LCM is essentially a shift in the way business regards its role in society and its sphere of responsibility. Firms have to address activities beyond their spheres of control and traditional responsibilities. This requires the adoption of new institutional norms within and between firms and the discarding of old ones.

Shifting institutional norms and paradigms at this level takes time. Organisations within an established field (e.g. a specific industry sector) tend to adopt common behaviour and thinking (Bansal & Roth 2000), which can limit an organisation's (and their field's) potential to learn (Greenwood & Hinings 1996) and make them highly resistant to change (Harris & Crane 2002, p. 230). Industry sectors that are relatively new may be more likely to voluntarily adopt new ideas and practices (Bansal & Roth 2000).

However, supply chain management is becoming increasingly important for business competitiveness, not just for LCM, but because of increased market globalisation and the speeding up of market cycles. Firms have to flexibly respond to customer requirements in an increasingly complex and rapidly changing environment; as no single firm can solve this alone, this requires close cooperation between firms within the value chain (Goldbach 2003).

This is evidenced by a trend where firms are beginning to rationalise suppliers and develop long-term supplier relationships (Goldbach 2003). This might reduce complexity and increase trust and commitment between companies for LCM adoption. For example OTTO, a large German mail order business, independent of environmental developments, reduced its number of suppliers, which then made it easier when it began to develop a green supply chain (Goldbach 2003, p. 56).

The existence of a long-term relationship with suppliers and customers appears to be one enabler of LCM adoption (Cramer 1996; Boons 2002; Tischner & Nickel 2003). Heiskanen's (2000a) study of a Nordic wholesale–retail firm indicated that the unit within the firm that achieved the most significant LCA uptake based its business approach on long-term and valued relationships with suppliers and customers. In a similar vein Rao (2002, p. 635) argues that green purchasing requires long-term strategic relationships with suppliers and the early involvement of suppliers in the design of new products and processes.

SCEM also requires *a system of control* so that the focal company can verify that their suppliers are complying with given standards (Kogg 2003, p. 78). This may require third-party control in order to satisfy external stakeholders such as government agencies and international markets.

To implement LCM '*more collective forms of cooperation are likely to be established in the future*', particularly for small and medium-sized firms (Cramer 1996, pp. 44–45). To achieve this firms and sectors that have pioneered LCM have developed a range of cooperative approaches. The approach chosen can often depend on the firm's driver for LCM adoption and on its relative power within the supply chain (Kogg 2003). The following case studies provide two quite different but common approaches to supply chain management, the hub and the industry standard approach. The Hub (or go it alone) approach is typically used when

a company sees competitive advantage in distinguishing itself from its competitors, while the industry standard approach is usually a response from a group of competitors to a sector-wide threat (e.g. new regulation or threat to a key market) (Kogg 2003, p. 79).

Vernar Frang, a small Swedish textile trading company, took the *hub* approach working alone with its suppliers to improve environmental performance across its product value chain. Vernar Frang provided its suppliers with finance to train and support farmers to transition to organic cotton, and pay suppliers a premium for that organic cotton (Kogg 2003, p. 71).

B&Q, a large DIY retailer in the UK, took an *industry standard* approach whereby they collaborated with their competitors to implement similar criteria for sourcing wood products. This enabled cost sharing, increased their negotiation power with suppliers, and reduced transitional costs for those suppliers as they had only one set of questionnaires to answer. B&Q also provide funding to small suppliers in developing countries to help adopt sustainable forest management (Kogg 2003, p. 75). The aim was to reduce the transitional costs of LCM by operating at a sector level. This is encapsulated by Alan Knight, B&Q's environmental manager:

What we need to do is to create an environment where we don't really have to do any work. {We need} people to realise that if you want to trade with the DIY sector in the UK, you have to be independently certified and you have to know where your timber comes from, and there is no point in even approaching us unless you have that information (Kogg 2003, p. 75).

Another example of an industry standard approach at an international level is the Global Responsible Care programme in the chemical industry (Linnanen et al. 1995, p. 122). Regardless of whether a firm is taking a hub or industry standard approach, Rao (2002) identifies four mechanisms that firms can take with their suppliers to achieve SCEM.

- A company will send questionnaires to its suppliers to gain a better understanding of the supplier's environmental performance (often asking if they have EMS certification, for example)
- A company will assess suppliers at their own sites, sometimes using a third party or consultant, supported by examination of company records etc.
- A company may mentor suppliers in improving their environmental management, e.g. by providing free guidance to set up environmental programmes and free technical advice. This was the approach taken by Vernar Frang with its small suppliers in developing countries.
- A company may enter a partnership with its suppliers aimed at collectively improving the operational efficiency of all the firms. For example a firm may include its suppliers in the design and development of a new product (Hines & Johns 2001).

There appears to be an increasing trend towards the mentoring and partnering approaches (Rao 2002) and four examples are provided below.

1. In Rao's (2002) study of 52 firms in South East Asia there was a marked preference for the mentoring and partnership approach. For example Taiwan has the corporate synergy model (CSS) in which suppliers are treated as 'extended family'. In this model a large firm will initiate, coordinate and maintain the model. The central firm rewards its

suppliers' involvement through special credits, free staff training, and relaxed audit requirements. Taiwan's Ministry of Economic Affairs supports the model by sponsoring several banks to provide low interest loans to implement industrial waste minimisation. Many large companies at that time were thinking of setting up funding cooperatives for small companies to use for environmental projects.

This mentoring and partnering preference partly reflects the culture of this region where all forms of business development have generally chosen a relationship approach (Rao 2002). As one of the fastest growing manufacturing areas in the world, coupled with New Zealand's trend of offshore outsourcing, the relationship approach favoured by South East Asian firms should be noted if New Zealand firms attempt SCEM with firms in this region.

2. The Ford Motor company used its buying power to require that all manufacturing suppliers (5,000 companies worldwide) obtain third-party certification of environmental management. Ford provided awareness seminars and training for its suppliers.
3. In the INGENIA project the two main producers in the Finnish metal industry provided training and consultation to their 12 SME suppliers⁶ (Personen 2001).
4. OTTO, a major German mail order company, greened its textile chain by taking responsibility in coordinating the entire value chain, including providing free consultancy to support suppliers in improving their environmental performance. OTTO has considerable power as a major customer and therefore can require that suppliers adopt not only environmental standards but also OTTO's environmental values. This value adoption is realised through communication, joint problem solving, and meetings with all partners in the chain. Failure to meet standards results in sanctioning and loss of OTTO as a customer (Goldbach 2003).

For sustained success partnerships will require continuous attention and participants need to be willing to invest in developing their relationships '*for a common future*' (Personen 2001, p. 56). In the INGENIA project Personen identified that this common relationship would involve

...more work with information management, regular supplier audits and cooperation in any future product or process design and manufacturing development issues (Personen 2001, p. 56).

The experience of companies that have pioneered SCEM/ICM indicate that it must be consolidated at the strategic level first and then translated into action and changes in operational systems (Cramer 1996). This would suggest that supplier relationships need to reside at a very strategic level in the firm as opposed to resting in the production and operations area. Finally, Rao (2002, p. 637) cautions that the mentoring approach requires companies to have staff who have mentoring skills.

⁷ The INGENIA project involved two main producers in the Finnish metal industry (Safematic and GWS Systems, both operating globally and employing over 200 people) and their 12 SME suppliers with the aim of developing documented quality and environmental management systems.

Research on SCEM-type approaches is still rare (Seuring 2004) and at an explorative stage (Rao 2002). As with the case of LCA, Goldbach argues (2003, p. 49) that literature on SCEM has focused primarily on external and structural factors, while not enough research has examined the social factors required for implementation. As a consequence there is a lack of tools offered to resolve management issues in value chain relations (Personen 2001, p. 47).

Risks posed by increased dependency on suppliers/customers

Increased collaboration runs the risk of a firm having increased dependency on its suppliers and customers and therefore reduced negotiation power (Sharfman et al. 1997, p. 20; Boons 2002, p. 503). For example, if a company adapts its operations to meet the requirements of a main customer, its dependency on that customer increases and therefore the company becomes more vulnerable. However, if it is able to capitalise on its adaptations to increase its customer base (which requires new customers seeing a competitive advantage in the adaptations) then dependency decreases (Personen 2001).

4.3 Customer demand & company's marketing response

This category, *Customer demand & company's marketing response*, falls between the firm's organisational field, i.e. the customers, and the organisation sphere, i.e. the firm's marketing approach and response to customers. Barriers and enablers are outlined in Table 5.

Table 5 Customer demand & company's marketing response

Barrier	Enabler
Customers' limited or partial knowledge of environmental issues	Having existing 'green' customer segments
Consumers unlikely to pay more or switch brand for eco product	Heavy promotion and distribution through mainstream outlets

Customers' limited or partial knowledge of environmental issues

Consumers often don't connect the environmental performance of a supplier to the company producing the end product. They often place higher value on non-environmental characteristics of a product; for example, many customers value virgin material over recycled material and expect products containing recycled material to be cheaper (KPMG 2005). Because of the complexity and ambiguity of LCA findings, customers often misinterpret the results or are unable to compare products due to methodological issues (WRI & WBCSD 2008). Even eco-labelling can be confusing for consumers due to the proliferation of labels, while a lack of rigor in eco-labelling can reduce consumer trust (KPMG 2005).

In addition trends in consumer demands (in comparison with regulatory requirements) are often poorly defined and open to interpretation. This can make it problematic for firms to formulate environmental strategies that are meaningful for customers (Sinding 2000, p. 81).

Customers unlikely to pay more or switch brands for an eco product

Firms within the Australian study (KPMG 2005) believed that there was not enough real consumer demand for LCM. They believed that consumers want green products but at the same price and convenience as non-green products. Research in New Zealand (Colenso BBDO, 2005, for ARC and MfE, for the Reduce your Rubbish national waste campaign) provided similar findings. Firms within the Australian study believe that ongoing work is required to better understand household consumption and modify behaviours towards the use of more sustainable products, and that government can play a role in education for sustainable consumption (KPMG 2005, p. 29).

Having existing ‘green’ customer segments

Having existing or identified environmental markets appears to have helped the implementation of LCM (KPMG 2005) as does having long-term relationships with customers (Tischner & Nickel 2003).

Many authors of the reviewed literature believe there will be increasing environmental markets particularly in the European Union and Japan (KPMG 2005). Companies with environmentally sensitive markets may increasingly have to develop green supply chains and verifiable environmental products in order to maintain their legitimacy with stakeholders.

Heavy promotion and distribution through mainstream outlets

Firms that have had success with ‘green products’ have generally undertaken a very proactive sales approach and have distributed in mainstream outlets thereby making it easy for customers to buy their green products (KPMG 2005, p. 20).

They may continue to distribute their green products even when sales are relatively low because it provides them with a point of differentiation from other competitors in the market place (KPMG 2005).

4.4 Strategic intent and ability to tailor LCM programme to company’s context

Table 6 Strategic intent and ability to tailor LCM programme to company’s context

Barrier	Enabler
	Programmes tailored to organisational context and firms identifying their strategic aim for LCM

Programmes tailored to organisational context and firms identifying their strategic aim for LCM

Context is critical; an LCM programme needs to be customised according to the firm’s specific activities, needs and culture (see Argyris & Schon 1974; Senge 1990; Schein 1992)

and this might be done by distinguishing the firm's underlying motivation, which influences its ambition level, which in turn will help the firm set relevant and useful goals (Heiskanen 2000a; Kogg 2003, p. 78). The most successful LCM projects occurred when this form of situational analysis and tailoring of the LCM programme was undertaken (Kogg 2003; Tischner & Nickel 2003 on Heidelberger Druckmaschinen (HD) programme).

Understanding the specific context is also true of supply chain management. Supply chains differ even within one sector, due to different structures and characteristics of the company, institutional settings, and social factors such as the degree of dependence or power a firm has over its suppliers, and the level of trust between buyers and suppliers. Therefore one approach to ESCM cannot necessarily be effectively applied to all supply chains (Kogg 2003).

Being context-specific, strategic about the focus, and tailoring the programme to each firm's specific needs have also proven critical for effective adoption of cleaner production and zero waste programmes. Stone (2006a, b) evaluated 23 New Zealand organisations that had undertaken a two-year Target Zero waste programme. A high proportion of these firms were in the manufacturing sector. Stone found that the organisations that took a more flexible approach in the Target Zero programme achieved better results.

... the greatest successes occurred when culture, needs and/or existing projects were acknowledged and the programme was customised to improve compatibility (Stone 2006b, p. 19)

Identifying a company's strategic intent for LCM, and tailoring the LCM approach to fit the company's context, has strong ramifications for the approach taken to provide programmes for LCM adoption. It indicates that a 'one size fits all' programme is not suitable; rather a programme might be developed around a common framework and that the programme should focus a lot of its effort upfront in defining the strategic needs and intent of the company first.

4.5 Economic cost–benefit of LCM adoption

Table 7 Cost–benefit of LCM adoption

Barrier	Enabler
The costs of LCM may outweigh the immediate benefits	Factoring in the indirect and less tangible benefits in addition to the cost–benefit analysis
	Regulation and pollution taxes can reduce costs and risks

Costs of LCM may outweigh benefits

The benefits of LCM need to outweigh and justify the complexity and risk associated with dealing with suppliers and customers and with applying the tools. Small and medium-sized enterprises often lack resources to undertake environmental initiatives (Biondi et al. 1998). For example the most critical barrier to green purchasing appears to be related to cost (Min & Galle 1997; Cox et al. 1999).

Costs include *direct costs* such as new technology and paying a higher premium to suppliers and *indirect and transaction costs* including organisational culture change, training, and new information systems (Cramer 1996; Sharfman et al. 1997).

Business is only likely to adopt LCM over other programmes and tools where it can demonstrate a risk–return ratio that is at least as attractive as that available from implementing another programme (KPMG 2005, p. 27).

Indeed if a listed firm drops its profit margins in order to implement LCM, it may be construed as a violation of its responsibility for increasing its value to shareholders (Sharfman et al. 1997). Whether the company needs or expects short-term returns on LCM adoption is also critical. Companies may incur immediate costs that will not reap benefits for two or more years and in such cases both the company and its shareholders must be prepared to cover the costs until those benefits can be realised.

Factoring in the indirect and less tangible benefits in the cost–benefit analysis

Factoring in the following benefits may outweigh the direct and transaction costs involved in LCM:

- Cost savings through efficient use of resources (Linnanen et al. 1995, p. 118; KPMG 2005)
- Cost savings through reduced need for pollution control equipment (Linnanen et al. 1995, p. 118)
- Cost savings through reduced hazardous waste disposal (Linnanen et al. 1995, p. 118)
- Lowered insurance costs from less potential environmental liability (USA in particular), lower regulatory charges, more efficient supplier systems (Sharfman et al. 1997; KPMG 2005)
- Estimating less tangible benefits such as worker morale or better corporate image is more difficult and often outside of traditional accounting systems. However, often it is these less tangible benefits that may make the difference to whether a greener product should be developed (Linnanen et al. 1995, p. 118)
- The firm’s environmental values may attract new employees and retain current ones thereby reducing staff turnover costs (Sharfman et al. 1997). Numerous studies indicate that a firm’s sustainability practice attracts skilled staff (KPMG’s 2002 International Survey of Corporate Sustainability Reporting; Albinger & Freeman 2000).

Regulation and pollution taxes can reduce costs and risks

Whether new technology pays for itself is often dependent on the extent that regulations and/or market forces mandate them. If regulation and pollution taxes are imposed on all competitors then equipment and other LCM costs are more likely to be cost-effective (Sharfman et al. 1997).

4.6 Ongoing commitment and support from management

Table 8 Ongoing commitment and support from management

Barrier	Enabler
Reliance on an economic cost–benefit analysis and environmental policies to build commitment and change staff practice	Ongoing commitment in implementing LCM in order to achieve environmental performance
	Providing staff support
	Ensuring widespread staff involvement

Ongoing commitment in implementing LCM

Most business environmental improvements are achieved incrementally rather than in one transformative step (Linnenam et al. 1995, p. 125; Stone 2006a, b, findings based on 23 NZ company case studies). Post and Altman (1994) describe three phases of change companies may typically go through in environmental management programmes: adjustment, adaptation, and innovation (see Fig. 4). Innovation generally requires a very serious commitment from a firm, and is achieved through examining and reflecting upon and usually changing its values, systems, structures and performance, and reaching this phase will generally take time and many firms fail to reach it.

Failure to achieve on-going improvement cuts to the core of sustainability. This is because businesses are unlikely to undertake the magnitude of changes required of them in one great leap. All of the best-practice guides on CP/PP strongly emphasize the need for on-going improvement (e.g., USEPA 1992, de Hoo 1991, USEPA 2001)... This is because they assume that organisations will be unlikely to eliminate environmentally unsustainable practices with the first attempt and that they will therefore need to use a series of incremental improvements.’ (Stone 2006a, p. 7)

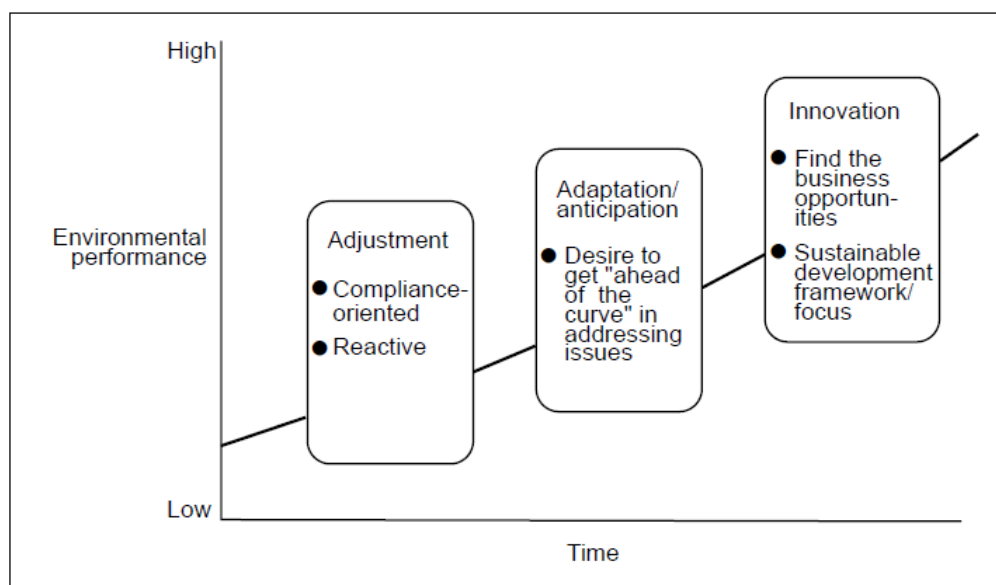


Fig. 4 Post-Altman Corporate Greening Model (1992), quoted in Post & Altman (1994, p. 70).

If we accept that ongoing improvement is required then Stone (2006a) argues this creates a chain of further requirements (see Fig. 5). The internalised value change and the reflective process of learning will be discussed in subsection 4.10.

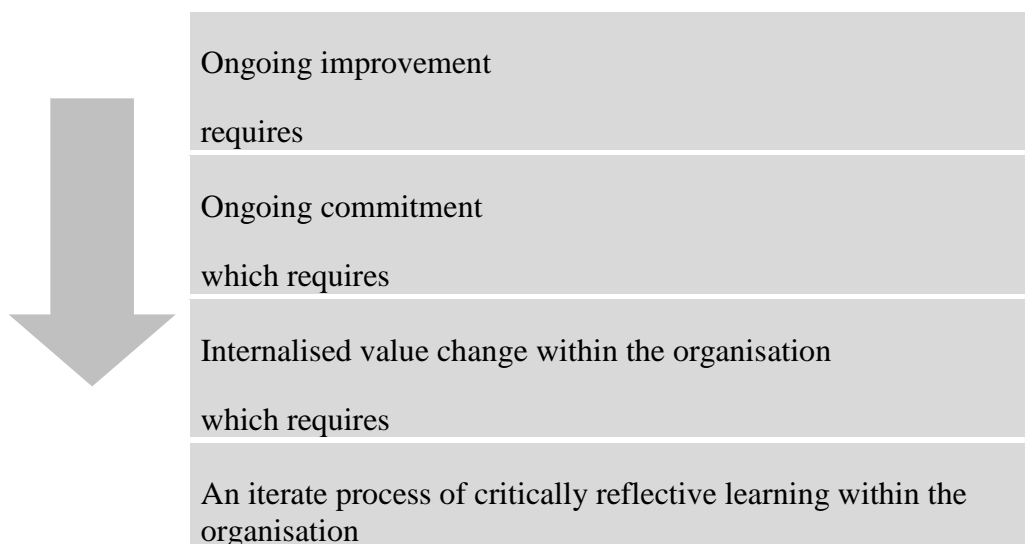


Fig. 5 Chain of requirements for ongoing environmental performance of organisations (adapted from Stone 2006a).

Reliance on cost–benefit analysis and environmental policies to build commitment and change staff practice

Many guides believe that creating a cost–benefit analysis will convince managers to commit to environmental programmes. This is based on a rational/normative decision-making model. Stone (2006a) argues this ignores the well-established fact that behavioural decision-making is seldom rational.

Equally Stone challenges the common reliance on creating top-down policies to demonstrate commitment and automatically lead to staff changing practices and values.

The existence of environmental policies and goals did not appear to alleviate difficulties encountered in overcoming barriers by organisations in the Target Zero project. Writing a policy does not mean it will get implemented and change will happen.

The Target Zero evaluation found that leadership and support were far more effective than policy as means for communicating top-level commitment (Stone 2006b, p. 18)

Stone argues that organisation theory tends to challenge this level of simplicity ‘people not policies and goals are what bring about change in organisations’ (Stone 2006b). Therefore while policies and strategies may be important to help a firm develop and articulate its strategic intent, much more is needed to facilitate organisational change.

Providing staff support

Stone's evaluation of 23 New Zealand organisations undertaking the 2-year 'cleaner production' (CP) demonstration project (The Target Zero project) identified that support for staff is an extremely important factor for successful adoption of sustainable practices and that it was generally inadequate, with a lack of clear expression of support from managers (Stone 2006b, p. 17). In addition Stone notes that staff need to be well supported to facilitate the type of changes within an organisation that an environmental programme usually requires.

If staff are inadequately equipped (particularly in terms of motivation, knowledge, skills and experience) and do not have the resources (particularly in terms of authority and support), they are unlikely to be prepared for the difficulties they will encounter during the course of what is likely to be a significant change programme (Stone 2006a, p. 6)

Stone identified that management need to demonstrate to staff tangible manifestations of commitment to the environmental change process. These included having (USEPA 2001; Stone 2006a):

- A clear vision
- Integration of [LCM} goals in broader business planning
- A guiding committee with participation by top-level managers who actively overcome problems
- Key staff well supported
- Provision of training for all employees
- Provision of an award/recognition system, and
- Organisational-wide communication

Ensuring widespread staff involvement

Gaining a critical mass of organisational members is seen as an important factor in any change process (Keogh & Polonsky 1998). Surveys (Huang & Hunkler 1995; Bultmann 1997; Smith et al. 1998) indicate that LCA programmes often lack integration across the firm's corporate functions and instead remain in the domain of the environmental staff (Heiskanen 2000b, p. 240). This was also the case in the Target Zero programme (Stone 2006b, p. 18).

4.7 Existing sustainability culture and practice within company

Table 9 Existing sustainability culture and practice within company

Barrier	Enabler
	Firm has an existing sustainability culture and practice

The presence of existing environmental values within a firm, particularly ones that recognise that sustainability in a firm needs to go beyond compliance, appears to increase the level of LCM adoption (Heiskanen 2000a; Hunkeler et al. 2003; KPMG 2005, p. 28.) For example Heiskanen's (2000a) study of a Nordic wholesale–retail firm revealed that the business unit that had the most significant LCA uptake appeared to be influenced by having existing and established sustainability practices and beliefs. This is not surprising as firms that already have staff commitment to sustainability values and that base their businesses practices on underlying assumptions concerning environmental protection will require less organisational change than firms that don't.

4.8 Ability to pragmatically apply LCM throughout company

Table 10 Ability to pragmatically apply LCM throughout company

Barrier	Enabler
Level of product complexity and ambiguity of results	
Complexity of assessment tools and limitations of LCM as a design tool	Integration of tools into existing management systems
	Integrated decision-making across organisation

Level of product complexity and ambiguity of results

Some companies have products with too many individual components to practically assess (Tischner & Nickel 2003, based on Heidelberger Druckmaschinen project). Electronic products, for example [compared with paper products], require a lot of time, money and expert knowledge to assess. Therefore simpler products will lend themselves to LCM more easily.

In addition, establishing causality of the environmental problem and then allocating responsibility across the multiple actors in a life cycle value chain is extremely difficult and this is made more so because a product may have a multitude of different environmental issues associated with it (Heiskanen 1999, p. 62). Another issue is the ambiguity of results; when a firm develops and compares alternative options for a product there is rarely a clear-cut choice. Instead each option usually has different environmental/social impacts and more complex decision-making is required (Cramer 1996).

Complexity of assessment tools and limitations of LCM as a design tool

An enormous amount of research and development has gone into improving LCA assessment tools over the last decade in order to increase standardisation of methodologies and develop tools that are easier and simpler to use. Much of this work has been undertaken under the auspices of SETAC/UNEP.

Despite this, firms continue to find LCA problematic due to a range of issues including continued standardisation problems and the cost and time involved in accessing and analysing the data.

It is easy for firms to get so bogged down with data having considered too many aspects or potential situations that the project dies (Danish Environmental Protection Agency 2003, p. 20).

This requires a focus on the 'need to know' versus 'nice to know' data (Bhander et al. 2003). Respondents from case studies of LCM in Holland indicated the need for a clear description of key issues of environmental protection to prioritise effort (Cramer 1996, p. 42, based on Weterings et al. 1993).

LCA tools also have limitations as design support tools. The time-consuming nature of LCA doesn't lend itself to the dynamic nature of product design (Alting 1993; Allenby & Gradel 1995; Cramer 1996; McAloone & Evans 1997). In the early stages of design, when most resource commitments are established, comparatively little will be known about the final product, so environmental parameters and trade-offs between cost and environmental performance cannot be properly assessed. But as the product becomes more clearly defined, the scope for 'eco-balance studies' grows, but the 'design solution space' narrows (Berkhout 1996, based on Keoleian 1993). This 'paradox' is described in Fig. 6 (Bhander et al. 2003, p. 231).

LCA assessment has also been criticised for not being able to reuse or update its assessment parameters as circumstances change (Bhander et al. 2003) or support product evaluation throughout the design processes (Roche et al. 1998). Finally LCA has also been criticised for requiring high levels of environmental knowledge that design engineers usually don't have (Bhander et al. 2003).

In contrast, some companies have found that adopting LCM can facilitate greater innovation in both product design and process improvement within the business. For example the steel manufacturing company Bluescope identified that LCAs improved the steelmaking processes and products, and encouraged an innovative attitude in the company (KPMG 2005).

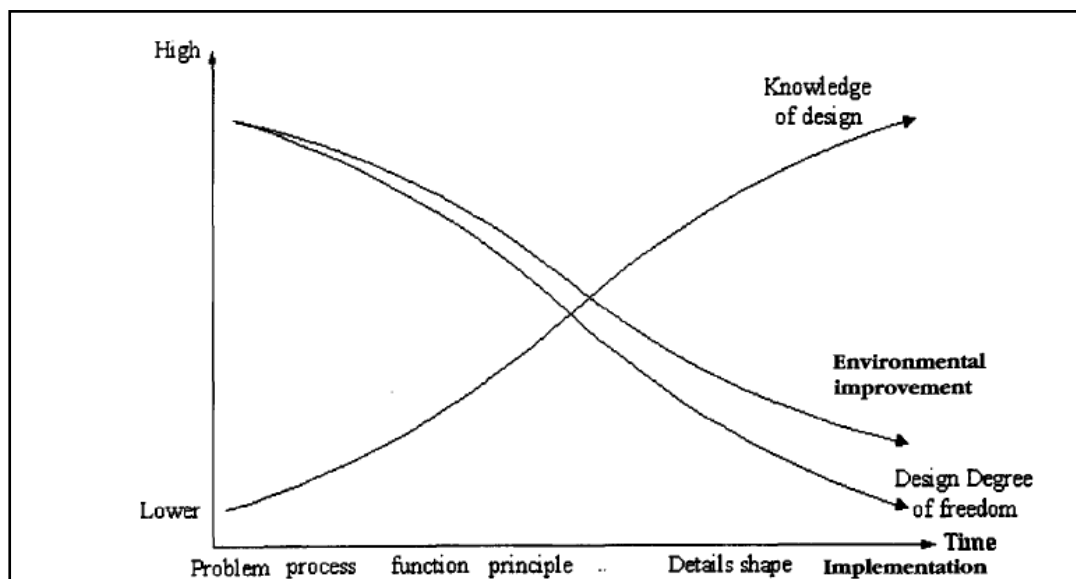


Fig. 6 Environmentally conscious design process paradox (source: Bhandar et al. 2003, p. 231).

Integration into existing management systems

LCM tools and processes will only be successful if they can be integrated into existing management systems and help fulfil daily tasks instead of leading to more work (Tischner & Nickel 2003). To enable environmental aspects to be better integrated into product design and development, McAlloone (2002, cited in Bhandar et al. 2003, p. 258) recommends that:

- Information must be accessible, useable, and in a form that can be understood by all members of the design team;
- Formal design methods, strategic frameworks, and guidelines must be adapted from existing practices, in order to maximize the chances of success in implementation;
- Product developers need help in identifying the environmental issues surrounding the products they are developing;
- Product developers should be aware of the use and benefits of the broad range of eco-design tools and techniques now available, and be confident of choosing the most relevant tools for the job.

There is evidence that companies are able to do this. Car and electronic goods manufacturers are commonly developing simplified LCA approaches ranging from lists and manuals to user-friendly eco-indicator software systems (Bhandar et al. 2003):

BMW conducts LCA studies on components (doors, body-in-white, air intake manifolds) and aims to establish 'eco-profile benchmarks' for key components in all its vehicles. LCA has become one of many inputs into key materials choice decisions, made early at the conceptual design stage. Dismantlability and recyclability assessments are also conducted concurrently (Bhandar et al. 2003, p. 254).

Companies that have been able to undertake LCA on commonly used components of their products have been able to overcome some of the design and cost constraints outlined in the previous section.

The firm Heidelberger Druckmaschinen integrated life cycle thinking tools into its management structures and procedures without causing much additional work. They achieved this through taking a very systemic approach. They first evaluated existing available eco tools and aligned these against the company's product development stages (see Fig. 7). They then selected the tools that were the best fit and further refined the tools so that they would better integrate into the company's current practice. As part of this process employees were interviewed in order to better understand staff working practices and needs (Tischner & Nickel 2003).

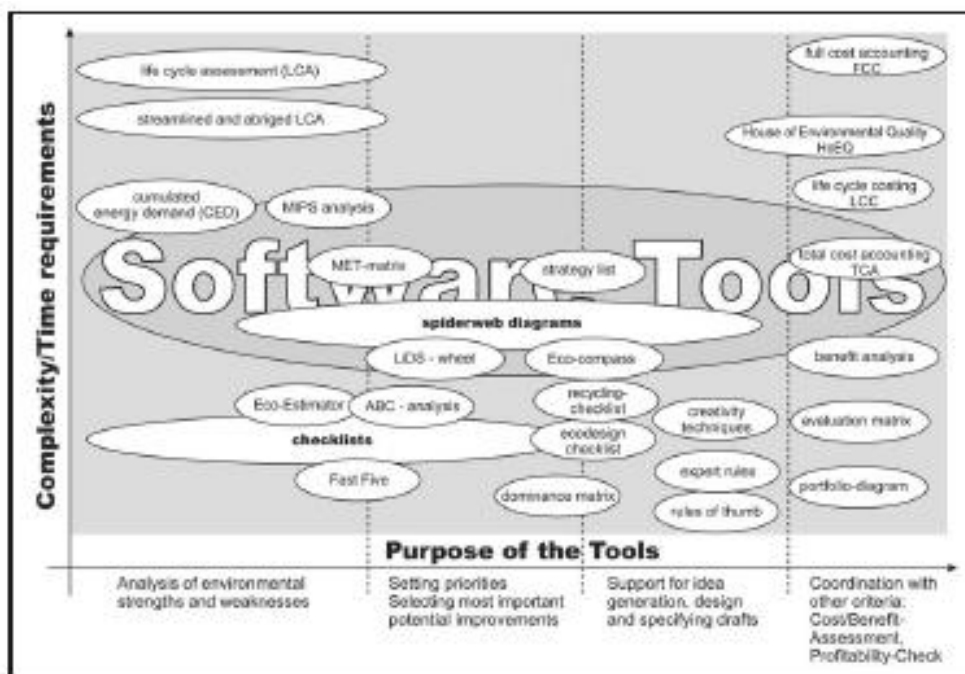


Fig. 7 Eco design tools aligned to product development stages (by Heidelberger Druckmaschinen. Source: Tischner & Nickel 2003).

Finally the concept of LCM reflects a more pragmatic approach to life cycle thinking than how LCA tools have been used in the past. Success in life cycle management may be achieved not just by developing better tools and integrating LCM into company practice, but by using LCM in a more conceptual way (Heiskanen 1999). In a similar vein Tischner and Nickel (2003, p. 23) suggest that:

Instead of detailed LCAs, companies need holistic life cycle thinking, which analyses the product's life cycle but in a more qualitative and pragmatic way. Such an approach would focus on the aspects that the company can influence instead of trying to find the 'Scientific' truth.

This is a critical point that in successfully implementing LCM within New Zealand organisations will need to take a pragmatic approach to finding a balance between the ideal environmental outcome and their ability to influence improvements at different the life cycle stages of their products

Integrated decision-making across organisation

The inter-functional boundaries of a company often have to be crossed when implementing LCM, indeed by doing so LCM may often redefine many of those boundaries within a company. Creating successful environmental solutions requires coordinated activities between all corporate functions (Linnanen et al. 1995, p. 122).

4.9 The organisation's ability to learn and change

Table 11 The organisation's ability to learn and change

Barrier	Enabler
Underestimating the scale and complexity of organisational change	Implementing a practice of reflective learning and innovation within the company

Underestimating the scale and complexity of organisational change

Often businesses underestimate the scale and complexity of social change that is required to implement environmental improvements. Substantive environmental improvements will usually require changes to core values of an organisation or what Schein (1992) calls 'basic underlying assumptions' and what Argyris and Schon (1974) call 'theories in use' (Stone 2006b). People (and organisations) seldom reflect on why they act in certain ways; generally they have adopted practices that they have found 'work' for them in certain circumstances. Their knowledge is usually practical in character and taken for granted (Giddens 1984, p. xxiii).

Implementing a practice of reflective learning and innovation within the company

Successful LCM adoption requires the ability of the company to learn and innovate and to do so in a way that reflects on their underlying assumptions and values. This is difficult if the formal structures and organisational culture of a firm inhibit change and innovation (Moxen & Strachan 1998). However, if a firm develops a conscious culture and the processes to enable the members of the firm to reflect on their practice this enables people to shift their basic assumptions/values. This assumption and value shift is often necessary for environmental programme adoption (Stone 2006a).

In terms of environmental sustainability, (members of organizations) will need to learn to identify and reflect on existing assumptions and values that prevent them from committing their organisations to sustainability, to develop and test new ones and use what they have learnt to continue the learning process. This approach was absent in the Target Zero project and the approaches that tend to be advocated by traditional CP/PP literature (Stone 2004a, p. 8).

Mechanisms for ensuring organisational learning and ongoing improvements in the organisation need to be incorporated into the design of the programme at the outset (Stone 2006a, p. 7). Programmes need to be designed to ensure that an iterative reflective learning process is in place that assesses existing company-held assumptions, identifies and tests new ones, and ultimately internalises a new sustainability ethic within the culture of the organisation (Stone 2006a, p. 13).

4.10 Leadership, role and skills of key staff

Table 12 Leadership, role and skills of key staff

Barrier	Enabler
Key staff often confined to operational departments	
Implementing LCM requires a wide range of skills often lacking in LCM project teams	Developing communities of practice to support staff and grow competencies

Key staff often confined to operational departments

[In the Netherlands] environmental coordinators in firms tend to be limited to operational activities as, traditionally, environmental management programmes could best be implemented from within this function. However, this is problematic as LCM requires a strategic approach and needs to be integrated into strategic decision-making and stakeholder management (Cramer 1996, p. 43). In addition traditional environmental management guides recommend that key participants need relatively high levels of authority in departments that are critical to the success of the project as well as an in-depth knowledge of the company. Evaluation of the Target Zero programme, however, found that in most organisations key participants did not have enough authority or often lacked in-depth company knowledge (Stone 2006b).

Implementing LCM requires a wide range of skills often lacking in LCM project teams

Key staff often have technical ability but lack excellent communication and change management skills that are critical for implementing LCM (Baumann 1998, 2000; Frankl & Rubik 2000; Stone 2006a, p. 12). Generally key staff had technical expertise and could usually deal with technical barriers, but they were less equipped to deal with barriers arising from the ‘political and cultural characteristics of the organisation’ (evaluation of the Target Zero project; Stone 2006a, p. 6).

Rex and Baumann (2008) also argue that the degree to which individuals believe they can change and recreate the structure of the organisation and the business sector within which they work affects the degree to which the key staff effectively implement LCM. Some people, they argue, tend to believe that they are constrained by the structures within which they operate, and that those structures are external to them, while others believe those structures are constantly under cultural construction and that they can play a part in reconstructing them.

Developing communities of practice to support staff and grow competencies

Practitioners benefit from learning and supporting each other. One example is the Swedish Centre for Environmental Assessment of Product and Material Systems, which provides a community of practice for staff working in companies implementing LCA (www.cpm.chalmers.se) (Rex & Baumann 2008) This community of practice is not sector based and the programme has found that people can gain valuable information and insights by sharing information between different types of organisations.

5. Conclusions

Literature on the adoption factors of life cycle thinking in manufacturing firms is patchy at best. Scholars in the LCM field note a surprising lack of research on whether or how LCA assessments have actually been implemented into new and revised products. Research has tended to focus on the constraints of undertaking LCA assessments versus constraints of implementing LCM across an organisation. In addition research that has looked more broadly at LCA/M adoption has tended to compare firms with different structural conditions (size, sector, country) and has tended to see these structural conditions as key influencers in different adoption practices. As such, common recommendations to increase LCA adoption have primarily focused on developing better LCA tools and sector standardisation.

However, recent research has compared very similar firms and found they had very different experiences and adoption practices. This research found that factors associated with the firm's learning culture, its relationships with its suppliers and customers, and the skills and behaviour of employees all significantly influenced their LCM adoption.

This review has therefore attempted to identify and bring together a broad spectrum of adoption factors both internal and external to a manufacturing firm including the influence of regulations and markets, the characteristics of the products, adequacy of LCM tools, organisational change processes and interorganisational management of value chains. The lack of existing research programmes that have holistically evaluated LCM adoption in this manner indicates that the approach that the LCM Project is taking, which looks at adoption factors from different perspectives will provide comprehensive and valuable results.

The review has identified 10 adoption themes (see Fig. 1) with 32 associated enablers and barriers (see Table 2). The 10 themes were developed within a theoretical model for organisational change for sustainability. This model, developed by Landcare Research, considers adoption factors in terms of a firm's organisation, the individuals within it, its organisational field (suppliers, competitors, customers and other stakeholders), and the broader economic and societal system within which the firm operates. This provides an understanding of how adoption might be influenced at different scales.

Importantly, consideration of the firm's organisational field highlights a key adoption factor – the need for new forms of interorganisational collaboration required to manage the environmental impacts of a product throughout its life cycle. LCM moves environmental management beyond the boundaries of the firm and it is within this sphere of suppliers, competitors, industry groups and customers that many of the improvements will need to be implemented, demanding new institutional norms around business responsibilities and business relations.

While the enablers/barriers provide a general guide, the adoption factors will play out differently from one firm to the next. One of the critical findings of the review is the importance of recognising and responding to each firm's strategic needs and of tailoring LCM implementation to the firm's internal and organisational field's context.

6. Recommendations

6.1 Recommendations for refinements to the LCM research programme

The findings of the literature review indicate that enhanced value could be obtained if the following areas were further developed:

- Consideration of the firm's organisational field highlights a key adoption factor – the need for new forms of interorganisational collaboration required to manage the environmental impacts of a product through its lifecycle. LCM moves environmental management beyond the boundaries of the firm and it is within this sphere of suppliers, competitors, industry groups and customers that many of the improvements will need to be implemented, demanding new institutional norms around business responsibilities and business relations. The project needs to evaluate each firm's approach to Supply Chain Environmental Management (SCEM) and identify the enablers and barriers that emerge. The enablers and barriers should then be considered against the context of the firm's position and influence in the value chain, as well as against the external drivers for SCEM (e.g. whether there is a common threat to the firm and its competitors or whether the firm is seeking a competitive point of difference from its competitors).
- The degree of integration the firm has across its departments in terms of strategy, decision-making and operations and the degree to which this has enabled or created barriers to implementing LCM
- Whether and how the company intends to implement LCM over the long term.
- Exploration of the firms' processes and capacity for organisational change and reflection. Specifically whether the firm's organisational learning goes beyond technical process improvements towards an examination of the underlying assumptions and values that underpin company decision-making and practice.
- Additional consideration of the firm's strategic marketing approach and customer relations. Specifically analysis of the appropriate marketing approach in response to strategic marketing aims. Environmental disclosures in promotional material will not fully cover this; distribution of promotions and products also need to be considered as does the form and quality of company–customer relationships. Successful marketing will be context specific and relate to the specific customer characteristics identified by the firm's strategic market analysis.
- The current economic analysis for the LCM project notes that it will be difficult to measure intangible economic benefits. While this is true, it may be of value to attempt to capture those benefits in a qualitative way because the literature suggests that intangible benefits of LCA often tip the balance to whether an environmental improvement should go ahead. Intangible economic benefits that could be examined include reduced need for pollution control equipment, reduced hazardous waste disposal, lower regulatory charges,

or more efficient supplier systems. Intangible costs might include the transaction costs of organisational change, training, and costs for new information systems.

- The six case-study firms represent different manufacturing sectors, produce products of differing levels of complexity, are at different points of the value chain, and have different types of customers. When making comparisons between the different firms' relative success in adoption, it will be important that these differences and their specific ability to affect adoption are built into the analysis.

6.2 Best-practice factors for improving LCM programmes

Some key factors have been identified in the literature that may improve any subsequent LCM programme arising from this research programme.

- Most effort should be placed on the initial stage of the project. The strategic needs of the firm and how it would benefit from undertaking LCM need to be analysed and the firm's ambition level / priority focus for LCM defined. The firm then needs to consider organisational or supply chain barriers that may hinder adoption and the implement actions to mitigate these. LCM should not be attempted without solid management commitment.
- A 'one programme fits all' approach does not appear to work effectively. Rather an overall framework approach that can be flexibly customised to each organisation's needs and context is required, with customisation built into the initial stage of the programme. While sector approaches can be standardised, tailoring an LCM programme to each organisation will still be required to increase rates of success. Explicit guidance on how to tailor the programme to the organisational context (versus simply telling them that they should tailor it) will need to be provided to companies.
- A continuous process of improvement should be designed into the organisation's LCM programme at the outset if the organisation's goal is to achieve significant environmental performance. This is because significant environmental improvements are generally achieved through incremental steps over time versus one large and discrete step.
- Both technical skills and organisational change skills are needed to facilitate LCM and these skills need to be present and actively engaged either from within the firm itself or via external programme support.

6.3 Factors that may enable LCM to be amplified across the manufacturing sector

While it was not aimed at identifying factors that enable LCM to be amplified across the manufacturing sector, the following insights from the review might contribute to an initial discussion on this objective.

1. Identify and then prioritise effort on firms/sectors that are most likely to need to adopt life cycle thinking to adopt LCM. Literature indicates that these might be:

- Sectors/firms that have current and potential environmentally sensitive markets, especially ones that may soon require certification that includes a requirement to undertake LCA
- Firms in highly polluting industries that are likely to face increasing pressure from public stakeholders and subsequently their customers
- Firms that produce goods for the final market and therefore receive pressure from customers and stakeholders early on
- Firms that are likely to be part of the supply chain of large companies that are beginning to move towards supply chain environmental management. Many of these may be large international companies, and the New Zealand businesses that might be most affected may also be in the primary sectors.

2. Identify and then prioritise firms/sectors that are more able to adopt LCM. Literature indicates that these might be:

- Firms with a high level of vertical integration and few suppliers
- Firms with simple products with relatively few components (e.g. paper in contrast to electronic products)
- Firms that are young, or that are developing new types of products, as the scope for product innovation may be greater
- At the sector level, sectors that have strong industry associations⁷ that are used to working collectively to improve industry practice and have the soft and hard infrastructure to support this

3. *Work with a selection of large firms to implement LCM across their supply and customer chains.* This approach, for example, has been developed in Taiwan as the Corporate Synergy Model (CSS). In this model a large firm will initiate, coordinate and maintain the model and is supported by government initiatives. This approach reflects literature findings that businesses closest to the end-customer are most exposed to consumer demand and will therefore often be the first ones to improve environmental performance. The requirement for environmental improvements typically starts to move up the value chain until even the smallest companies in the chain are required to improve their performance. This indicates that working with large firms in the retail–wholesale sector might be one way of amplifying LCM in New Zealand.

4. *Creating an enabling environment for LCM in New Zealand.* In the short term this could involve, for example, establishing community-of-practice networks for firms and staff

⁸ This was not specifically identified in the literature but case studies of sector approaches indicated that projects were often run through industry associations.

implementing LCM, as this could help build the skill base within New Zealand and support LCM practitioners. This has been implemented in Sweden for LCA (see www.cpm.chalmers.se).

In New Zealand, the recent formation of the Life Cycle Association of New Zealand and the New Zealand Life Cycle Management Centre are positive initiatives. In the long term government policy can play a role in education for sustainable consumption to increase customer demand, and in creating a level playing field so that firms investing in environmental initiatives are not at a financial disadvantage in the short term compared with others in their sector.

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