



Background Report for a

UNEP Guide to

LIFE CYCLE MANAGEMENT

- A bridge to sustainable products

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Foreword

"Fundamental changes in consumption and production patterns are needed", this is what was highlighted at the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002. Ongoing discussions in international fora confirm that more systematic management of product and material life cycle, i.e. life-cycle management (LCM), can accelerate the shift towards more sustainable patterns of consumption and production.

Life cycle management has been defined as the application of life cycle thinking in modern business practice. Life cycle based product management approaches have been developed for companies, which have adopted a strategy to develop towards a sustainable business by incorporating product stewardship and "take back" systems and by producing or trading products, which should be as sustainable as feasible. In addition, life cycle impacts of these products need to be communicating in one way or the other. LCM has to address all three dimensions of sustainability: planet, people and profit. However, LCM is a new discipline where the meanings and definitions of terms are not yet standardized, and where procedures and methodologies are still open for discussion.

For LCM to be effective, we must be clear about the management models to be used. This raises some key questions. In the present day context where - with the exception of vertically integrated companies which have some potential for cradle to grave control of their products - most industry sectors tend to be fragmented, we must ask 'who manages the life-cycle of a product or material?', 'which parts of the life cycle should we manage?' and 'how are management links at various life-cycle stages established?'. It is clear, for instance, that bringing together a group of multiple, independent part-players in a coherent management exercise to optimize sustainability performance for a variety of products is a considerable challenge. In fact, a number of different management models may need to be adopted, depending on the products or materials in question.

To be useful to managers, scientific data from LCA will need to be accompanied by information on economic aspects and policy options, especially when alternatives have to be compared and when some of the LCM stages involve potential regulation. This presents practitioners with a considerable challenge in transforming their scientific results into management information. The need for more effective action on sustainable development policies suggests that we should move from the assessment of impacts of products along their life cycle to systematic management of reduction of those impacts. LCM is of course voluntary to implement, not standardized and can be seen as an internal management system offered to business. Introduction of LCM in a company will often be a dynamic process starting with a few issues and adding on issues during time and appearing needs.

We hope you will find in this publication useful information, which will enable you to develop your own life cycle management system. UNEP is pleased that its Life Cycle Initiative has catalyzed the preparation of this document, and is confident that other reports and training materials on life cycle management will follow.

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Reader's Guide

The aim of this document is to present background information for a more "popular" introductory guide to LCM which will be produced in the coming months and is – together with an accompanied slide show - intended to be used to promote life cycle thinking globally and be basis for various training activities.

Various individuals and groups of individuals involved in the LCM Task Forces of the Life Cycle Initiative did write the chapters of this document. The names of the authors are listed on the back of the front page, and their affiliations mentioned in the Appendix. Due to the diverse contributions, the various chapters are inhomogeneous in size, layout and readiness. We have tried to include as many illustrations and case studies as possible.

The general background for the need of a more sustainable business with an economic, social and environmental dimension based on product life cycle thinking is discussed in *Chapter 1*. In addition LCM is defined as the application of life cycle thinking to modern business practice, with the aim to manage the total life cycle of an organization's products and services towards more sustainable consumption and production. The main drivers and benefits of that and various possible entry gates of companies are listed.

This is followed in *Chapter 2* by practical advices, how to get started the development and management of a sustainability strategy along product chains, and how to introduce and implement LCM in businesses step by step. It is e.g. important for success to involve all internal departments and stakeholders.

The benefits of cooperation and communication in the value chain, and the relations of product-oriented environmental management systems to general environmental management systems and ISO are discussed in *Chapter 3*. *Chapter 4* identifies new product design and development as a key intervention point life cycle based sustainable development initiatives in corporations.

Chapter 5 discusses possible communication pathways and tools for life cycle product information to different stakeholders. It includes various labeling systems for communication to consumers, and product declarations and other business-to-business communication tools. A case study from ABB is included. *Chapter 6* discusses the importance of stakeholder relationships in greater details. Why and how to involve stakeholders.

The economic aspects are discussed in *Chapter 7*. Product profitability and cost management are central elements of LCM. Application of the concept of life cycle costing (LCC) is considered essential for connecting environmental concerns with core business strategies. A case study with a railway vehicle is presented as illustration. The social dimension in LCM, including Corporate Social Responsibility is discussed in *Chapter 8*.

Chapters 9 and 10, respectively, cover more special applications of life cycle management in connection with industrial processes and urban planning, and the final *Chapter 11* discusses the specific problems and challenges for the developing countries.

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Editors

1. Introduction to Sustainability and Life Cycle Thinking

1.1 Sustainability and the Triple Bottom Line

Sustainable development is now almost an everyday term, defined broadly as development meeting current needs of society while ensuring that future generations' needs are met. Sustainable Development should ideally improve the quality of life for every individual on earth without expending the earth's resources beyond its capacity. The journey towards sustainable development requires that businesses and individuals take action, i.e., changing consumption and production behaviors, setting policies and changing practices, and finding innovative ways to be profitable and at the same time improving the environmental performance and the quality of life.

Three dimensions characterize sustainability: an economic, a social, and an environmental. In the business community sustainability has been coined "the triple bottom line" that to industry have to expand the traditional business or economic aspect to include environmental and social dimensions, to create a more "sustainable" business (Elkington, 1997)¹. This is illustrated in Figure 1.1:

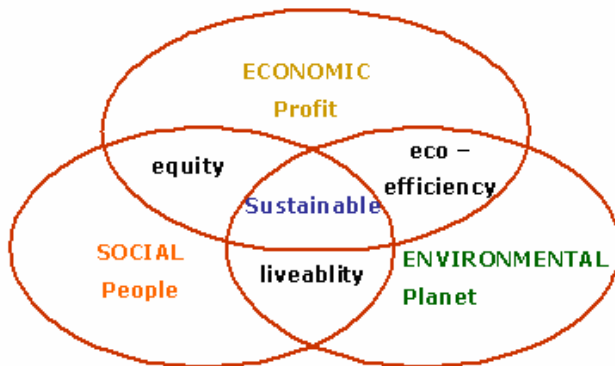


Figure 1.1: Sustainable dimensions.

Over the past few decades, organizations have taken more responsibility for the environment and have demonstrated that environmental initiatives or improvements bring economic benefits. In the 1980s, pollution prevention measures paid off: implementing cleaner production processes via good housekeeping and optimization of production technology reduced resource use, emissions and waste, and generated significant economic savings for the organizations. Organizations began to implement environmental management systems (EMS) like ISO 14001 and the EU EMAS scheme to secure continuous improvement of their environmental performance. Integrating quality and EMS created new opportunities for organizations, such as lower resource consumption, image recognition and/or improvement, and better relationships with external stakeholders like local communities, authorities, etc.

Businesses now embrace the life cycle concept, understanding that *products*, not just manufacturing processes, have environmental impacts associated over the product life, i.e., with their use, disposal, and distribution. Through improvement over the product's life, businesses find potential more economic benefits, both in the product (e.g., less material waste, substituted hazardous materials) but also in the organization (e.g., competitive advantage).

¹ Elkington J. Cannibals With Forks: The Triple Bottom Line of 21st Century Business. Capstone, 1997/ New Society, 1998.

Already in 1992 before the World Summit in Rio, the World Business Council for Sustainable Development (WBCSD) introduced the concept eco-efficiency to highlight the link between environmental improvements and economic benefits, in short, "creating more value with less impact".² As seen above, these links have been demonstrated³:

- Cleaner production processes → resource savings
- Environmental management → improved image
- Cleaner products → competitive advantage

So far, the social dimension of sustainability has not been given the same attention within the business community since the benefits are harder to quantify. However, there are examples of positive links between environmental improvements and health and safety improvements in the workplace. A general trend in companies and in governmental policies is now towards Integrated Management Systems, which include worker safety issues.

Another major trend in the business community has been companies taking accountability for their role in society. As large consumers and producers, businesses have obligations to society and should be accountable for their activities. Corporate Social Responsibility (CSR) can be seen as a parallel to life-cycle thinking, where companies make a commitment to sustainable development, expanding their social responsibility beyond health and safety inside the firm to influence the activities in the product life cycle to avoid child labor, discrimination, abuse of union rights, etc. as well as to make positive contributions to the families of employees and the local community.

1.2 Introduction to Life Cycle Thinking

Product life cycle thinking is essential in the path to sustainability by expanding the focus from the production site to the whole product life cycle. This facilitates the links between the economic and environmental dimensions within a company. Life cycle thinking is about widening views and expands the traditional focus on manufacturing processes to incorporate various aspects associated with a product over its entire life cycle. The producer become responsible for the products from cradle to grave and has for instance to develop products, which have improved performance in all phases of the product life cycle (see Figure 1.2).

The main goal of product life cycle thinking is to reduce resource use and emissions to the environment as well as improve the social performance in various stages of a product's life. In this way, companies achieve cleaner products and processes, a competitive advantage in the marketplace, and an improved platform to meet the needs of a changing business climate. Life cycle thinking examples and tools will be presented later in this guide.

² Schmidheiny S. Changing Course. A global Business Perspective on Development and the Environment. Cambridge, MA: MIT Press, 1992.

³ Remmen A. Greening of Danish Industry – Changes in Concepts and Policies. In: Technology Analysis and Strategic Management, Vol. 13, Number 1, 2001.

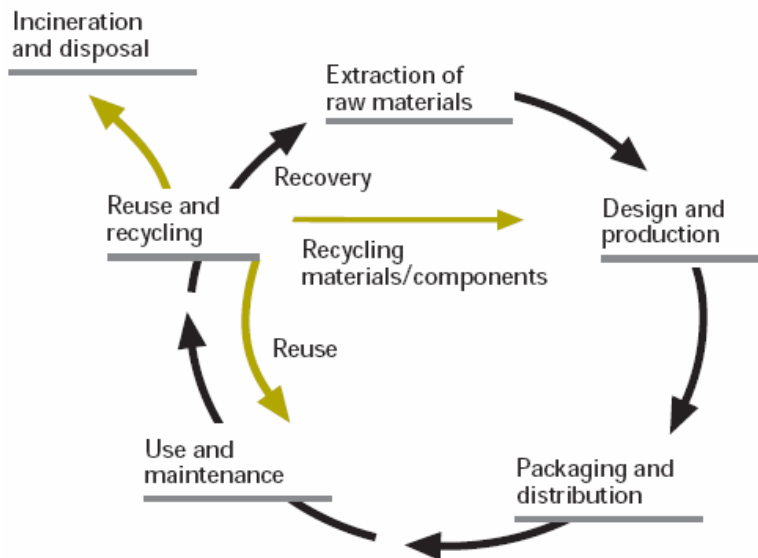


Figure 1.2: The life cycle of a product – and closing the loop.⁴

Life cycle thinking is based on the principles of pollution prevention where the environmental impacts are reduced at the source, and of closing the loop of materials and energy. These principles have so far been implemented internally in the organizations via cleaner production, environmental management and eco-design programs.

Life cycle thinking expands the concept of pollution prevention to include the whole product life cycle and sustainability. Source reduction in a product life cycle perspective is then equivalent to eco-design principles and what have been called the "6 RE philosophy":

- **Re-think** the product and its functions. For example, the product may be used more efficiently, thereby reducing energy use and other natural resources.
- **Re-duce** energy and material consumption throughout a product's life cycle.
- **Re-place** harmful substances with more environmentally friendly alternatives.
- **Re-cycle**. Select materials that can be recycled, and build the product such that it is disassembled easier for recycling.
- **Re-use**. Design the product so parts can be reused.
- **Re-pair**. Make the product easy to repair so that the product does not yet need to be replaced.

In each life cycle stage there is the potential to lower resource consumption and improve the performance of products.

1.3 What is Life Cycle Management?

LCM is the application of life cycle thinking to modern business practice, with the aim to manage the total life cycle of an organization's products and services towards more sustainable consumption and production. LCM is about systematic integration product sustainability e.g. in company strategy and planning, product design and development, purchasing decisions and communication programs.

⁴ Remmen A, Münster M. An introduction to Life-Cycle Thinking and Management. Environmental News, no. 68, Danish Environmental Protection Agency, Ministry of Environment 2003.

LCM is not a single tool or methodology but a flexible integrated management framework of concepts, techniques and procedures incorporating environmental, economic, and social aspects of products, processes and organizations. It is voluntary and can be gradually adapted to the specific needs and characteristics of individual organizations. The theoretical background for LCM has been developed by a SETAC Working Group and has recently been published (SETAC 2004).

An organization can benefit from adopting an LCM strategy in many ways. LCM can result in the following benefits:

Reputation and image improvement	<p>Improve of public image and general relations to stakeholders. Increase and maintain shareholder value Product branding ("green") Work towards being a sustainable business and be at the forefront of competitors</p>
"Sustainable" products	<p>Sustainable manufacturing processes in all parts of the business chain (measured by EMS, environmental performance indicators, green accounts). Extended product life time and technological efficiency (better quality products) Low environmental impacts in the product life cycle (measured by e.g. LCA) Lowest possible health impacts in the product life cycle (measured by LCIA or "Risk Assessment") Improvements of occupational safety and health conditions in the whole life cycle Lowest possible use of non-renewable resources in the whole life cycle (measured by LCI) Lowest possible economic costs to consumer and society in the whole life cycle (measured by LCC, "green taxes" or cost-benefit analysis) High "Eco-efficiency" (measure of relation between environmental impacts and economic costs) Designed for disassembling and reuse/recycling (screening LCA) Preferable usage of renewable and recycled materials Preparation for "Take back systems". Best social conditions for workforces (social responsibility) No child labor</p>
Being proactive: preparation for supplier, customer, and government mandates	<p>Be at the edge of and prepared for present or future legislative developments, e.g. introduction of Integrated Product Policy and "take back legislation".</p>
Ability to implement programs with a focus on sustainability and beyond the production fence	<p>Product stewardship programmes. Programmes for development and design of new products. Supply chain management, supplier evaluation. Communication in the value chain. Environmental product declarations. Corporate Social Responsibility Programme. Marketing activities</p>
Preparation for advanced international and national programs	<p>Prepared to join various eco-labeling schemes (increased visibility, image and sale). Be ready to get a "Dow Jones Sustainability Index" (increased shareholder value). Be ready to serve in "green" public procurement programmes (increased sales).</p>

LCM is a dynamic process; organizations may start with small goals and objectives with the resources they have and get more ambitious over time.

1.4 LCM drivers

Many external and internal factors can influence an organization to consider improvements towards sustainability, and to develop policies, implement tools and structure programs that integrate LCM into the core operations of businesses. Key drivers for implementing a LCM approach are corporate strategy, market requirements, increasing requirements from the finance sector, and global regulations.

Corporate strategy

Internally, a business striving for increased operational and resource efficiency may see a strategy for product sustainability as an opportunity to realize these goals and reduce costs. Leading companies will undertake initiatives to increase market share and enhance the potential for product innovation. More conservatively, internal drivers will include reduced fines and decreased liabilities.

Several organizations seek to gain competitive advantage through innovation, brand value enhancement and strategic positioning in the market. Taking a life cycle approach can help identifying important opportunities, but also risks. Often organizations implement LCM systems to improve public image and stakeholder relation, and to map their product chains and to develop criteria for product enhancement and value creation.

Institutional factors can play at least as important a role as technical factors in reducing the content of hazardous substances in products. In the case of product design and development processes, for example, design decisions take place within the broader corporate management structure. An integrated management system – covering quality, environment and health & safety – with a policy, goals, performance measures and strategic plan that support continuous improvements, will be a driver for integration of sustainable performance concerns. LCM offers a framework that allows management to organize and align the various tools in such a way to exploit the synergies and interrelations between them.

Market

The market is also an important driver of the implementation of a Life Cycle Management and mostly, of course, in areas with strong competition. In terms of opportunity, the market offers significant advantages to firms that are the first to move on these issues.

Leading companies are linking Life Cycle Management initiatives to increased market share and innovation. The market will also help drive the implementation of a Life Cycle Management framework.

Nowadays, when companies purchase raw materials, goods and services, more and more companies use a supplier evaluation system, for which they ask suppliers to provide specific information about e.g. life cycle data and social responsibility in addition to documentation of product safety and environmental performance. Those requirements are further imposed on the sub-suppliers in the product chain. To avoid playing 'catch-up' with a response-driven approach, firms have the opportunity to use an integrated, comprehensive, Life Cycle approach to manage their environmental impacts together with more traditional cost-driven supply chain management efforts.

Surveys in the US and Japan have indicated that, for 57% of firms included, market and cost are the primary economic drivers for LCM. Furthermore, over 40% of firms were engaged in

life cycle costing, often for the customers benefit to demonstrate that their product lowered total costs. The majority of firms combined quantitative and qualitative metrics. It was clearly acknowledged, however, that decision-making goes beyond indicators. Firms sought to have a decision support tool, which was matrix and life cycle based, flexible, transparent, iterative, and contained an external value system.

Financial sector

Investors, insurance companies, banks and ranking institutions have also an impact on driving firms toward sustainability and Life Cycle Management. Traditionally, investors look for funds with calculated risks and some level of predictability. As the characteristics of the business climate change, firms that do not have a comprehensive approach to understanding and managing their environmental and social impacts will be viewed as a bad-risk investment. This trend can be seen in the emergence of sustainability indexes such as the Dow Jones Group Sustainability Indexes and the FTSE4Good, which use social, economic and environmental criteria to assess and rank the sustainability of listed companies. While such ratings do not yet include a full product life cycle perspective, there is a clear indication that this is a development to come.

Using the same logic, insurance companies are beginning to charge higher rates to companies who, for one reason or another, appear to be a greater risk in terms of their environmental or social performance, both of their operations, and their whole value chain and products.

Legislation

Today, there are existing regulations that target substances of concern, pending regulations targeting specific products and increasingly policy emphasis on the sustainability of services and product service systems. Perhaps most well known are the EU directives on end-of-life vehicles (ELV) and on waste electronics (WEEE) along with similar policy initiatives at the national level. While the ELV and WEEE directive stem from a waste prevention background, they use a product perspective, though only focus on the end-of-life phase rather than on the complete life cycle. Public procurement efforts, such as the Environmental Preferable Purchasing Program in the US or other Green Procurement initiatives clearly are using a life cycle perspective; some specifically mention LCA and LCC.

The Integrated Product Policy (IPP) suggested by the European Commission and some member countries includes eco-design, green public procurement, eco-labeling and other product life cycle based concepts. Companies with a life cycle management system in place will have increased possibilities to comply with such product-related legislation. The focus is on producers because they have the knowledge and ability to adapt product design to proactively improve product performance and meet legislative requirements.

The existing regulatory framework also acts as a strong driver for firms to consider especially the environmental impacts of their operations, products and services. Liability for exceeding local air quality emissions limits, for example, can result in fines and, even licensing restrictions and costs. The threat of retrospective liability makes a clear case for a proactive life cycle management approach to understand all aspects of the organization and ensure life cycle information is available for decision making at all levels.

1.5 Entry gates in companies

Companies can integrate sustainability and life cycle thinking into the everyday management and decision-making processes using various environmental and economical approaches, concepts and tools operating at a management system level, a program level, or a technical

level. Companies can further deploy each of these systems, programs, and tools in different ways.

The introduction of LCM in a company has to be a top management decision and be according to the company policies and strategy. The continued support from top management during implementation of LCM is also needed.

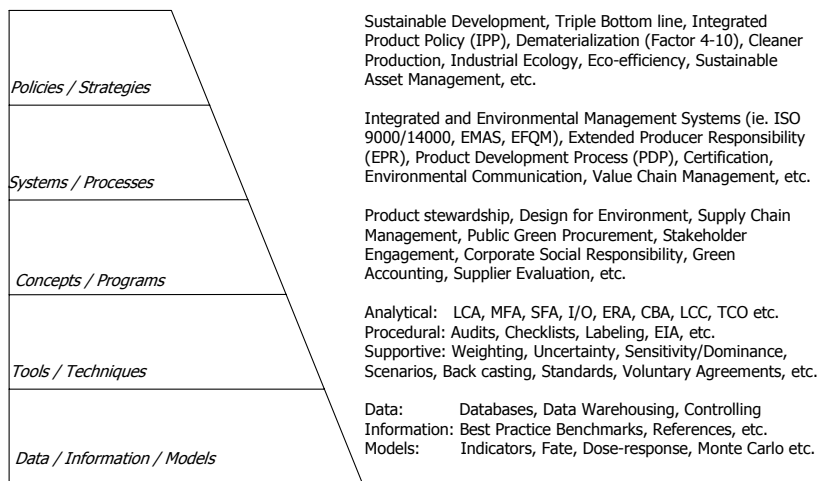
The entry gates of LCM in a company typically correspond to a function within an organization, such as manufacturing, procurement, marketing, research and development (R&D), or environmental health and safety (EHS). It is often a company's department of environment or sustainability who initially suggests implementation of an LCM system. However, the previously mentioned drivers of LCM will decide the entry gates in a particular firm. Interactions with internal and external stakeholders form an important basis for the priority setting in enterprises, and provide inspiration for the integration of environmental, social and economic thinking within firms.

Regardless of the entry gate selected and the LCM drivers, which are in place in a given organization, it is possible to set up a LCM implementation strategy and to validate economic, social and environmental results of this.

1.6 LCM issues

LCM offers a flexible approach for integration of various policies, systems, concepts, tools and data in a product-orientated sustainable management system. Companies have to decide what ambition level they have resources to implement and to choose the concepts, tools, or programs that make most sense according to the ambitions and objectives of the firm.

Figure 1.3 below presents a comprehensive overview illustrating the various decision levels and policies, systems, concepts, tools and data, which may be background for and be included in practical LCM-systems for Business:



Explanations:

EMAS = Environmental Management and Audit System; EFQM = European Foundation for Quality Management; LCA = Life Cycle Assessment; MFA = Mass Flow Analysis; SFA = Substance Flow Analysis; I/O = Input-Output Analysis; ERA = Environmental Risk Assessment; CBA = Cost-benefit analysis; LCC = Life Cycle Costing; TCO = Total Cost of Ownership; EIA = Environmental Impact Assessment.

Figure 1.3: Overview of LCM issues

2. Getting Started

There are three things to bear in mind for a successful LCM program:

1. Any organization, large, small, and medium, can implement a LCM program; and different ambition levels can lead to good LCM practices.
2. The LCM program should involve many levels of an organization, and the program need high priority by management.
3. The organization must be willing to “go beyond its facility boundaries” to adopt life cycle thinking.

2.1 Any organization can implement a LCM program

Often, life cycle or product initiatives have focused on the method, for example a detailed life-cycle assessment (LCA), followed by determination of the most significant environmental impacts in a product’s life cycle. Not only are these efforts resource-intensive and daunting for a small organization, but they often end up focusing on data collection and minutia, rather than concrete strategies concerning how an organization can improve the environmental profile of a product.

An organization need not “jump into” advanced tools like LCA, but instead take a step-by-step approach and begin with focusing on a life-cycle perspective and on concrete possibilities to improve the environmental characteristics of a product.

2.2 The LCM Program must involve many levels of the organization

The program must be a high priority on part of management

The benefits an enterprise achieves from a life-cycle-based initiative depend on the full support of management. In practice this support may be expressed in the following ways:

- The necessary resources have been set aside for the LCM initiative including time and educational resources.
- Management of the organization actively participates in setting up the strategic goals.
- There is explicit internal communication throughout the organization regarding the ambition level and goals.
- The ideas and suggestions of the employees involved in the initiative are taken seriously.

All the relevant departments/functions must participate

An LCM initiative is interconnected in all functions and departments of an enterprise. For example, a decision to change the material composition of a product not only affects the environmental aspects of a product, but also procurement of supplies, marketing the product, and distribution logistics, to name a few. Therefore, communication and sharing ideas within and across the relevant departments in an organization is the key to success. Not only does communication and interaction ensure a range of ideas, but it also helps to push ideas into fruition. The interaction of different departments is portrayed in the figure below.

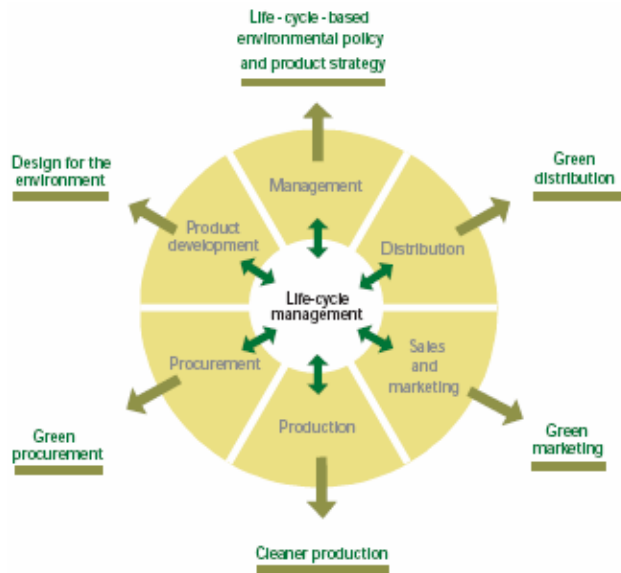


Figure 2.1: Involvement of all departments in the firm (from Brdr. Hartmann A/S)

Ideally, responsibility should lie in a coordination group with a team leader, who is responsible for ensuring that the group functions, meetings are arranged, minutes are taken, etc. The members of the coordination group should be selected so that all departments/ functions are represented, including management, product development, production, procurement, logistics and sales.

Participation of a range of employees ensures that the LCM initiatives will be deeply rooted in the organization and that the focus will be on concrete improvements to a product's environmental profile, rather than mere talk and data collection. Furthermore, broad participation ensures that the LCM program doesn't 'die' if a key employee involved leaves the organization.

2.3 The organization must "go beyond its facility boundaries"

The organization should expand its facility-focused EMS to an integrated management system - one that incorporates product life cycle thinking as well as interaction with internal and external stakeholders of the organization. The organization must also be willing and able to expand its collaboration and communication in the product chain.

Shifting the focus from within the organization's fence to the entire product chain includes:

- The product life cycle: flow of materials from acquisition of raw materials to production, transport, use and disposal.
- The market: a value and currency flow from the consumer to the producer.
- Communication and cooperation in form of exchange of knowledge and experience.

This is illustrated in the following way in Figure 2.2:

(inspired by Christoffer, 1998)

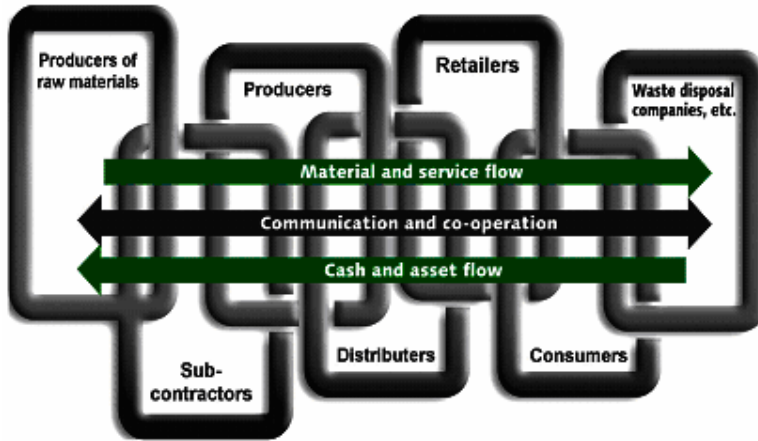


Figure 2.2: Collaboration in the Product Chain.⁵

In an environmental context, focus up to now has been directed towards the flow of materials as in the case of life cycle assessment. However, in a life cycle perspective the flow of values is as important in order that cleaner products meet the demands of the market. What expectations does the consumer have concerning the product's characteristics? How do consumers rate environmental and social considerations relative to other product aspects such as price, quality, functionality, design, etc.?

For enterprises, the challenge is to make linkages in the product chain in such a way that there is focus on both environmental optimisation of the material flow in the supply chain; and on the customer's expectations regarding environmental and social issues in the value chain. Communication and cooperation between the partners involved will build connections between the supply chain and the value chain. This is illustrated in the figure above, or in other words: product chain = supply chain + value chain + collaboration.

2.4 A step by step approach

The step-by-step approach may involve the following phases, which parallel the Plan-Do-Check-Adjust phases of a quality and environmental management system:

Phase	Approach to LCM implementation
Plan	<ol style="list-style-type: none"> 1. Set policies – set goals and determine the ambition level 2. Organize – get engagement and participation 3. Survey – make an overview of where the organization is and where it wants to be 4. Set goals – select an area/s where the efforts will be directed, determine goal(s) and make an action plan
Do	<ol style="list-style-type: none"> 5. Make environmental improvements – put the plan into action 6. Report – document the efforts and their results
Check	<ol style="list-style-type: none"> 7. Evaluate and revise – evaluate the experience and revise policies and organizational structures as needed
Act/Adjust	<ol style="list-style-type: none"> 8. Survey again, define more goals, etc. etc.

⁵ From Remmen A, Münster M. An introduction to Life-Cycle Thinking and Management. Environmental News, no. 68, Danish Environmental Protection Agency, Ministry of Environment, 2003.

1. Set policies

LCM should become part of an organization's policies so that its importance rings through all levels of the organization. LCM policies should be visionary and long-range while also being realistic and concrete, parallel to its ambition level. Setting goals according to the level of ambition ensures conformity between policy and actions. There are at least three different level of ambition:

- Internal readiness and commitment to continuous improvements. This level signifies awareness that environmental and social improvements can be made using management frameworks such as ISO 9001 and/or ISO 14001, and that a commitment to improvements is the first step to a more integrated system.
- The desire for life cycle improvement of products. An organization understands the value of addressing its products beyond the manufacturing level, for instances in materials acquisition, use of the product, distribution and end-of-life
- The desire to take the environmental profiles of its products a step further by reporting and marketing activities and thereby create general organizational successes.

These ambition levels help an organization to better understand where they ought to begin in the LCM process. A less experienced organization can easily "graduate" to higher ambition levels as knowledge and familiarity associated with setting plans into action are achieved. When the policy has been set the enterprise must organize the effort and collect information regarding its plans.

2. Organize – get involvement in the organization

As noted above, management must be a part of the initiative, and different parts of the organization have to participate in the process (see figure 2.1). With higher ambitions then also the different actors in the product chain have to be involved (see figure 2.2).

3. Survey – have an overview of where the organization is and where it wants to go for its products

Many enterprises already have knowledge available on the environmental and social impacts of their products and processes, for example, in their corporate and environmental reports. In general, this information is presented in terms of the production process, rather than the single products.

A survey should thus be made to focus on an organization's product or product lines to help the organization sort out where and how it will begin the LCM program. The survey should cover information pertaining to a particular product as well as the knowledge surrounding the market and collaborative partners in terms of that product. Extending the survey to suppliers, sector organizations, authorities, retail shops, scientific institutions, etc. ensures that information is obtained from all aspects pertaining to the product.

Environmental impacts	<ul style="list-style-type: none"> • Life cycle phases – where are the most important environmental and social impacts? • Technology – is new technology available or being developed that can reduce the impacts?
Market/commercial conditions	<ul style="list-style-type: none"> • Supply – what is characteristic of the product's profile? • Demand – how important is the social and environmental awareness of the consumer? • Value – what advantages are achieved by adding positive environmental and social characteristics as an extra product quality?
Partners	<ul style="list-style-type: none"> • Product chain – are suppliers, retail stores, or others interested in collaboration on environmental and social initiatives? • Authorities – what are the demands of authorities? • Within sector – what are competitors doing? Codes of conduct within the trade?

Table 2.1: Aspects of a survey.

4. Set goals – select an area or areas where the efforts will be directed, determine goal(s) and make an action plan

Constructive responses to the questions listed above provide a basis for selecting an area or areas where product improvement would be worth pursuing. In some cases the social and environmental problems identified by an enterprise may be solved by another's efforts, for example, a new technology is nearly functional or a supplier is phasing out harmful substances.

Based on the current situation and knowledge, an enterprise must decide which area will be prioritized with regard to the LCM initiative. This decision may be made based on the following three questions:

- Where are the most significant environmental or social problems in the product's life cycle? (*Relevance*)
- Where is it possible to achieve environmental and social improvements? (*Potential*)
- Where can the enterprise make a difference? (*Influence*)

An enterprise may have several opportunities for improvements, so it should choose several initiative areas to involve as many of an organization's departments as possible – for example, procurement and logistics as well as product development.

Concrete goals and an action plan must be defined for each initiative area: Who is responsible for doing what and until when. An action plan is a means of explicitly stating the goals, delegating responsibility and setting the time frames, so that the circumstances surrounding the initiatives are clear for both management and employees.

5. Put the plan into action

Planning is important, but the practical results create credibility, enthusiasm, and active support for a product initiative. Focusing on the entire life cycle of a product will identify numerous possibilities for obvious improvements – the "low-hanging fruit" or "easy rewards"

which will improve a product's profile. Putting focus on a concrete problem will generate ideas for improvements.

Aside from the easy improvements, an organization can choose new challenges to tackle, which might include addressing new or potential issues. For example, what if an EU directive that required a company to take back all its scrap enters into force in one year? Such a demand would, of course, be added to an enterprise's list of initiative goals and an action plan. The company could implement life cycle thinking to engage a re-design of the product to meet the requirements of the EU directive, including easier recycling, easier disassembly, new materials selection, etc.

6. Report – document the efforts and their results

With regard to the commitment of management and employees, it is crucial that the results of the efforts are documented, and that the results are made public. Such documentation gives credibility when answering inquiries from customers, suppliers, etc. The form of documentation is completely dependent upon the ambition level in the enterprise. It is advantageous for enterprises to have some insight into the environmental and social impacts the enterprise's stakeholders prioritize, so that communication can be aimed at this group.

Corporate accounts and environmental reports, which already contain details of an enterprise's social and environmental initiatives, may be redirected to be more product-oriented, thus providing a good forum to document results and make them visible to the public. Product-oriented environmental reporting may address some of the following:

- To what degree has the energy consumption of the product in the use phase been reduced?
- How much of the product can be recycled?
- To what degree and how has transport been optimized?

Results may also be made visible by calculating some key figures, for example energy consumption during production of the product. The key figures and the results of the initiatives can be made public via a company folder, eco-labeling, or an environmental product declaration.

7. Evaluate and revise – evaluate the experience and revise policies and organizational structures as needed

After completing the first round of improvements to the life cycle profile of a product, it is a good idea to "take a deep breath" and evaluate the experience:

- What worked and what did not?
- How can the effort be improved?
- Should more of the employees be involved in the initiative?
- Should the efforts be focused in a different direction?
- Were the appropriate means and methods used?
- Should more partners be involved?
- Should the level of ambition be raised?
- Etc.

Such an evaluation, conducted once a year, makes an excellent forum for adjusting an enterprise's product policy so that it is consistent with the actual efforts. After such an evaluation an enterprise may decide to continue at the same ambition level until the internal commitment and readiness to undertake initiatives are well established, or until partners or

others voice demands regarding more extensive environmental and social commitment, and thus a higher ambition level.

Remember – the idea behind a step-by-step approach is ensuring a reciprocal interaction between developing knowledge concerning a product’s environmental and social impact, market demands, etc. and implementation of concrete product-oriented improvements.

In many ways, the systems and tools related to the environment are more developed and applied especially compared to the social dimension of sustainability. During the past couple of years this situation is changing. Corporate Social Responsibility (CSR) is setting focus on ensuring safe work places, avoiding child and forced labour, ensuring workers rights and reasonable minimum wages. Community and stakeholder involvement is examples of other aspects that are frequently mentioned in relation to CSR together with aspects such as openness, transparency, anti-corruption measures and communication with consumers. Specific tools include labelling for fair trade such as the Max Havellar for food products, social reporting, code of conducts etc.

8. Survey again, define more goals, etc. etc.

Through the experience from the first round of product improvements from a life cycle perspective, an enterprise has likely identified areas where further investigation may be advantageous.

If demands are made requiring an enterprise to supply further documentation regarding the environmental impact of a product, then a simple environmental assessment is appropriate. If it becomes evident that there are significant environmental impacts in the use phase of a product, then investigation of consumer desires and demands would be an obvious method to obtain ideas for design changes or to develop better instructions for product use. If an enterprise uses chemicals or materials, which are on the list of undesirable substances, it would be sensible to begin phasing out.

9. Define new initiative areas and goal(s)

On the basis of experience, the initiative area and goal(s) are redefined and a new round of efforts begins with plans, improvements, etc. Focus remains on achieving concrete environmental and social improvements to the product profile, while realizing results during the improvement process.

During this and subsequent stages, the organization can begin (or continue) to broaden its relationship in the product chain – it is much easier to develop a base of knowledge if there is good cooperation and an atmosphere of trust among producers, suppliers, retail store owners, disposal facilities and other stakeholders in the product chain.

3. Integrated Management Systems and Tools

At the level of the single actor in the product chain, an integrated management system can help the organization to address strategic planning, overall management, product and process development, procurement, production, distribution, marketing, communication and other functions in a more systematic and comprehensive approach. The organization will typically in the beginning focus on what is going on at the site and those inputs and outputs connected to its own activities. But after “picking the low hanging fruits” and achieving the easy improvements of quality and/or health and safety and/or environment, etc.), the organization will have to expand its focus. In the following paragraphs, an introduction to framework and guidelines as well as examples is given using environmental management systems as the basis; most of the information will though be relevant also for other aspects of management and sustainability.

In part 2 the systematic management approach based on Plan-Do-Check-Act is discussed for product-oriented environmental management systems as well as some key issues for life cycle oriented environmental management.

Part 3 discuss similar key issues for cooperation in the product chain i.e. how the different actors can approach the cooperation from a life cycle environmental management perspective.

3.1 ISO framework

There are many tools, methods, concepts, approaches in Life Cycle Management and the issue is not to develop or find the tool but the intelligent combination(s) for the specific problem or application. This statement is valid also for looking from a management perspective along the life cycle.

In the Table 3.1 below the compilation of environmental management systems and tools standard in the ISO 14000 family are briefly summarized. Typically, a differentiation is made between the standards oriented towards managing the site of the organization and those oriented towards the product chain (or the products) of the organization. It is though recommended to address the use of the standards as a whole and to combine the relevant standards in the management of the organization.

System standards	Product standards
ISO 14001:1996/2004 and 14004:1997/2004 Environmental Management Systems	ISO 14020:1998, 14021:1999, 14024:1999, and TR 14025:2000/2005 Environmental labelling
ISO 14010:1998, 14011:1998, 14012:1998 and 14015:2001 Environmental auditing ⁶	ISO 14040:1997/2005, 14041:1999, 14042:2000, 14043:2000, 14044:2005, TR 14049:2000, TR 14048, TR 14047 Life cycle assessment
ISO/TR 14061:1998 Informative Reference Material to assist forestry organizations in the use of ISO 14001 and ISO 14004	ISO Guide 64:1997 Guide for inclusion of environmental aspects in product standards
ISO 14031:1999, TR 14032:1999 Environmental performance evaluation	ISO TR 14062:2002 Integrating environmental aspects into product design and development
ISO/TR 14061:1998, Information to assist forestry organizations in the use of the Environmental Management System standards	ISO DIS 14063 Environmental communication
ISO 14001 and ISO 14004	ISO DIS 14064 Greenhouse gases
ISO 9000:2000 Quality management systems	
ISO 19011:2002 Guidelines for quality and/or environmental management systems auditing	

Table 3.1 Systems oriented and product oriented standards within the ISO 14000 family

ISO 14001 was not developed with a life cycle perspective, but as an organization-oriented instrument. Although conceptually it encompasses life cycle thinking, since at the core of an environmental management system (EMS) in line with the standard are the environmental aspects of "activities, products and services", practice shows that the ISO 14001 certified systems are in general applied to those activities under the organization's direct influence, mostly the manufacturing processes in industry (Rocha 2003). The new version of ISO 14001, as well as the current Eco-management and Audit Scheme (EMAS II) place more emphasis on indirect environmental aspects - those the organization can influence - and therefore opening room for aspects upstream and downstream the product chain. To what extent this will promote a more systematic approach of environmental performance improvement along the life cycle is still to be demonstrated.

In the very first paragraph of ISO 14001, products and services are cornerstones of the environmental management systems that have been developed since early and mid 1990'ies based on the experiences from quality management, but with different focus especially compared to the 1994 version of ISO 9001. ISO 14001 among other concepts introduced continuous improvement of environmental performance, a concept that is now also part of the ISO 9001 standard. Sector specific adaptations have been developed nationally together with numerous guidance documents. Also ISO developed a sector specific guidance for the forest industry, but there are no plans to update this technical report standard.

EMAS II is the European Union version of ISO 14001 adding further requirements on legal compliance, employee involvement and communication of the activities and results of the organizations environmental management. ISO 14001:1996 is included in the 2001 revision of EMAS i.e. requirements on procurement and purchasing from the organizational perspective are similar to the ones discussed above.

At the level of the individual organization, recent initiatives have been taken both nationally (e.g. Australia and New Zealand, France, the Netherlands, Denmark, and UK) and internationally (ISO working group) to develop standards (in the version of guidelines, not

⁶14010, 14011 and 14012 were replaced by ISO 19001 in 2002.

for certification) on integrated management systems (IMS). According to the French standard, applying IMS will:

- Address all market information likely to have an impact on the organization;
- Facilitate the identification and assessment of opportunities for improving performance in all management areas based on a prioritization of risks and opportunities – and a clear acceptance of the identified risks;
- Enable optimizing and rendering reliable of operations by applying common provisions, thereby reducing the risks of contradiction and/or inconsistencies;
- Ensure a better knowledge of the requirements, needs and expectations of all interested parties;
- Continually integrate new requirements, needs or expectations;
- Improve the external image of the organization, which is fully open to the market;
- Facilitate communication, explanation and justification of the top management's objectives and decisions throughout the entire organization;
- Render compatible, simplify and reduce the number and the management costs of the operational instructions, tools, manuals etc.;
- Aid in the harmonization of the internal organizational structure (network of key processes; optimum management methods; fair allocation and optimization of resources and responsibilities; regrouping of activities having similar purposes e.g. audits, management reviews, document management, and certification);
- Allow a better knowledge and a better control of the legal, regulatory requirements and of the other applicable requirements.

At the level of product and service systems, ISO has recently decided to revise the ISO Guide 64 on inclusion of environmental aspects in product standardization under Danish and German leadership. As the ISO member bodies of Denmark and Germany are also very active in the European standardization, CEN and the use of standards in EU legislation, a more comprehensive set of standards might be in sight within 5-10 years.

As an example of how the ISO family can contribute to management along the life cycle, purchasing has been chosen. Purchasing is part of the chapter on operational activities of an organization in ISO 14001, i.e. subchapter 4.4.6, and the organization is required to establish, implement and maintain procedures for the procurement or purchase activities although the text is not using the exact terms. The requirements are similar to those of ISO 9001:2000 i.e. the organization shall be able to show a supply management taking into consideration significant aspects of purchased products and services.

As stated in the annex, "the identification of environmental aspects does not require a detailed life-cycle assessment." i.e. the supply management does not require LCA's to be conducted or required by the suppliers. Operating an effective and efficient supply management will, although, benefit from a life cycle approach using e.g. life cycle assessment methodology to structure and specify information exchanges in the product chain.

Environmental communication is presently the subject of an ISO TC207 working group (ISO 14063, as the technical report will be numbered). Communication cannot be left out; actually before starting to use any tool or programme, internal and external communication issues should be considered e.g. for applying LCA. Communication plans for the results are part of the goal and scope definition (or should be!).

Surrounding the "ISO 14000 family" are other management systems, tools and programmes e.g. quality management using the ISO 9000-series, where large compatibility to ISO 14001 on environmental management systems can be found. Discussions inside and outside of ISO

on the options for a common management standard are still going on, and the next round of harmonization has just started – a common standard might be the result in a couple of years.

The combination of the overall strategic approaches – life cycle thinking and sustainable production and consumption to preserve and sustain human health and biodiversity are the core of a systematic approach to management along the life cycle. The ISO standards on environmental management systems and tools (<http://www.iso.org/iso/en/iso9000-14000/iso14000/iso14000index.html>) can assist in the process – but common sense is still needed e.g. do not to implement one or the other side alone, but use the synergy of combining e.g. by product-oriented environmental management **systems**.

3.2 Product-oriented environmental management systems

Product oriented environmental management overlaps with the concept of life cycle management or, to be more precise, corresponds to the environmental dimension of life cycle management.

Already in 2001 a workshop of the Integrated Product Policy Expert Group was dedicated to the role of EMS, and particularly product-oriented environmental management systems to the prosecution of this policy in Europe (EC, 2001). In various countries initiatives have been reported with the aim of promoting life-cycle thinking in EMS implementation or bridging the gap between product oriented environmental strategies, such as ecodesign, and environmental and quality management systems (Brezet et al. 2000; Schmidt, Christensen and Ollgard 2000). Many initiatives, either business-oriented programmes within national environmental policies, or companies' own activities illustrate a product-oriented environmental "movement" with various approaches and a common denominator, which is an EMS (or a quality management system) as a foundation. A compilation of cases is presented in Brezet et al. (2001).

For simplicity, the product chain is often represented as a single line but if one considers those suppliers of products and services that are indirectly related to the provision of a given product, complexity increases drastically, and a network or web would be a more accurate picture. Using the approach in life cycle assessment, choices on which e.g. suppliers and users to include in the "web" of the organization and in identifying direct and indirect environmental aspects to be addressed by the life cycle environmental management system.

The main results of a survey on product-oriented environmental management in the Netherlands, undertaken in the framework of a governmental subsidizing programme to stimulate this approach, can be summarized as follows (Brezet et al., 2000):

- Companies are more likely to integrate product-oriented environmental management, when the environment was in forefront of the companies' policy and strategy, partly because the organization was already working on certain aspects of product-oriented environmental management. Companies had more difficulty with product-oriented environmental management, when they are relatively small, compete on the basis of price and where there is less emphasis on innovation
- The previous implementation of management systems was also researched and it was observed that having a quality management system in place appeared to be a major advantage in taking a structured approach to product oriented environmental management.
- Most companies were positive about the outcome of the project in terms of the knowledge gained and the internal set up for product oriented environmental management and the environmental objectives formulated. However, maintaining contacts along the product chain turned out to be difficult for many companies during

the project. A frequently cited reason for this was that the organization considered itself a small link in the chain.

- Working with multidisciplinary project teams also appeared to have a positive effect on the success of environmental product design.
- Time and money were considered to be the major barriers to the successful introduction of product-oriented environmental management. It also appeared that while the project is in progress, it is difficult to find the right information and tools to identify, access and process information appeared to be lacking. Many companies also saw a role for government in the area of providing information on the subject of environmental product design.

In Denmark, the product orientation of environmental management was the subject of the "PROMILLE" project, funded by the Danish EPA, with the objective of finding the easiest way for companies to put it into practice; the main conclusions were (Schmidt, Christensen, Ollgaard, 2000):

- There are various ways to begin with a product orientation and there are no specific prerequisites for doing it.
- The level of ambition in terms of environmental improvements can be adjusted to the need of the organization but it is under all circumstances good to get a general idea of the products' environmental impacts through their lifecycle.
- Often, a good link between the environment and the market is what it takes to keep product oriented environmental management a continuous effort. Therefore, the environmental assessments should be complemented by analyses among the interested parties and market assessments.
- A good level of basic product related documentation saves time and makes it possible to meet the desires for documentation. This does not make improvements to the environment in itself. On-going co-operation with the customers and/or the suppliers is usually necessary. On the other hand, when an organization succeeds then completely new opportunities on the market show up.

Summarizing these and other examples, good practice in product-oriented environmental management means:

- Link between organization environmental initiatives and the market;
- Complement environmental studies with market studies and analysis of interested parties expectations;
- For companies which perform in-house product development, direct integration of environmental requirements into the product development routines allows for embedding eco-design in the organization, and concurrently the undertaking of a pilot project can be a valuable show case or eye-opener;
- The implementation of product oriented environmental management should adjust to the organization's reality, namely the existing product development process, routines and responsibilities, but at the same time question the *status quo* – why are things done the way they are?
- The environmental responsibility does not stop in the analysis phase (definition of the environmental profile of the existing product) and improvement objectives setting; networking and evaluation activities afterwards are necessary;
- Knowledge building is the key, as action only happens if the received information is interpreted and considered valuable. This requires knowledge resources on environmental impacts and demands, communication between the product development function and those knowledge resources (typically brought in by the environmental manager or coordinator) and the valuation of knowledge through interpretative structures.

When talking about product oriented management systems implementation in companies it is clear from the above reported initiatives that a lot depends upon the stage of the specific organization in the ecodesign and formalized environmental (and quality) management learning curves. Whereas in small or inexperienced companies need guidance to perform the first steps of implementation and general rules of the thumb like performance indicators.

3.3 Management approach

Based on the ISO management standards for environment and quality – and other international standards and guidelines – the following chapter introduces some key terms and recommendations on a systematic and holistic approach to management at the level of the individual organization in the product chain. When more organizations apply such an approach, also cooperation and overall results e.g. reduced environmental impacts, will arise.

The approach addresses the classical management areas, although not systematically:

- Policy, objectives and targets – and indicators;
- Action plans and programmes;
- Procedures and instructions;
- Monitoring and registration systems;
- Documentation and reporting – communication along the life cycle.

In stead, the chapter first addresses the PDCA-cycle used in the management standards, and then some issues found important in anchoring and further developing the organization from a life cycle management perspective.

3.4 Plan, do, check and act

Also called the Deming cycle after the creator, PDCA gives a systematic approach to management along the life cycle.

Plan

As commonly accepted and experienced in management, that the optimal results of a management system require the attuning of the business strategy with the relevant policy e.g. the environmental policy so that the environmental dimension is part of the organization's core values and resources for operationalization are provided. Products and services are at the core for most organizations and the most visible interface between the organization and the outside world, hereby making the need of such attuning even more obvious. A product oriented environmental policy should provide the framework for deriving objectives of eco-efficiency improvement in the relevant phases of the entire life cycle.

The definition of the product's profile should take into account legal requirements, an evaluation of the impacts along the life cycle and other interested party's' demands and opportunities (where do we stand in comparison to our competitors? Do we have the necessary information on supplied parts and materials? Are quality, environmental and social concerns of our customers being fulfilled?

Life cycle assessment (LCA) or other tools should be used for an evaluation of the products' environmental impacts and it is recommended to combine the results of the LCA with an assessment of the environmental costs on the life cycle (see Chapter 7). This allows the identification of those areas that are most eligible from environmental and economic points of view.

The results of the LCA or other assessment studies can be integrated into a comprehensive environmental performance indicators system for internal management and benchmarking, from which concrete objectives can be derived. ISO 14031 can assist companies in evaluating performance against their environmental policy, objectives, targets and other environmental performance criteria in the context of its EMS in general and in relation to product related aspects in particular. The approach and recommendations of ISO 14031 can also be applied to address other management aspects e.g. quality or health and safety; and even from a sustainability perspective also economic and social aspect.

Views of interested parties should be taken into account, not only those prescribed by law i.e. public authorities or by business relations e.g. suppliers, customers and share-holders, but also workers, consumers and environmentalists in broader terms. As an example, feasible operational objectives and targets will be translated in the product's characteristics and therefore have a direct impact in consumers' expectations and response and on the organizations positioning on the market.

Do

In the operational cycle, the Do phase is directly related to all production oriented processes and functions of the organization as well as the supporting processes and functions. Options generation and validation activities will help to identify improvement opportunities in line with the defined objectives and targets. Depending on the availability of accurate information and on the technological implications, some of them may be feasible in a shorter term and then be directly translated into the environmental programme of requirements; others will require the undertaking of R&D projects where innovation potentials are explored.

As for the managerial cycle, building capability for product-orientation e.g. in ecodesign as well as in social responsibility requires the allocation of appropriate resources, assignment of responsibilities in the context of an adequate structure, building expertise (including not only training but also the application of adequate tools) and internal and external communication. External communication regarding the improved product is of course within the context of the marketing strategy in the company and therefore is also an important element.

In order to guarantee sound management, operating methods in the form of written procedures should be established. Procedures clearly define methods of operation to be followed and guarantee continuity when people change jobs or new staff is hired. Existing practices have to be taken into account as a point of departure, in order to make the process work. The procedures should be established to support activities that are agreed as 'standard' at the organization, and also integration in existing procedures, as much as possible, is recommended.

Check

Checking involves measurements, monitoring and evaluation of the environmental performance of the organization's activities, products and services as well as of the management system. The most important elements from the products' perspective are:

- Monitoring the performance of the improved products in view of the defined objectives and targets, with the support of indicators. Feedback and criticism from customers and other interested parties are an important information source for the organization to improve its current or future products, as well as the product development process;
- Evaluation of compliance with legal and other requirements applicable to the organization's products;

- Handling non conformities of the products and of the product oriented environmental management system and establishment of preventive and corrective actions for the potential and actual non-conformities
- Conducting internal audits to determine and provide information to management on whether the product oriented environmental management system conforms to planned arrangements and has been properly implemented and maintained, as well as for identifying improvement options. They should also be performed to assess the environmental performance of the products.

Act

The cycle "ends" or "re-starts" with a 'review and set directions phase', described in ISO 14001 and ISO 9001 as the management review, which addresses the possible need for changes to policy, objectives and other elements of the system in the light of e.g. audit's results, products' evaluations, changing circumstances and the commitment to continuously improve the organizations and their products' performance. Furthermore, organizations periodically review their product design and development process and its results in order to assess performance and identify opportunities for improvement. The (environmental) management review of the of product development process and its results can cover (ISO TR 14062):

- Functionality of the product;
- Environmental benefits (prevention/reduction);
- Cost effectiveness and benefits;
- Appropriateness of selected tools
- Data sources, data collection methods and data quality.

3.5 Supply chain management

An organization's procurement policies, and procedures, are a common, and effective, gate by which life cycle management can develop in the firm. Working with suppliers and supply chain issues is rapidly increasing as an important strategic consideration. Traditionally, enterprises manage suppliers in order to optimize the supply chain, track flows of information, materials and funds, manage the logistics of supply and distribution, minimize cycle times and costs and to integrate processes and functions along the supply chain (Sanchez 2003). A life cycle management framework is for improvement that is continuous and is based on a full system or life cycle perspective; thus, supply chain management practices are an entry gate for life cycle management.

A similar discussion could be addressed related to the product chain as such e.g. cooperation and communication with customers, authorities, investors etc. The suppliers and the supply chain is used here as a typical example - and as a good example, as supply management is already on the agenda of most organizations.

Most importantly, existing supply chain management practices will be clearly enhanced by such an approach (Sanchez 2003). Firms are requiring suppliers to divulge information about the goods they supply, such as materials and substances used and systems for tracking and management of environmental impacts. As a supplier firm receives these requirements, they in turn pass requests along their supply chain. An organization that is unsure of how or where to begin can use an effective procurement policy to learn and benefit from the efforts of other firms in the chain. Alternatively, firms who are leading can improve the performance of up- and down-stream suppliers by collaborating on programs, tools and efforts. Thus, the understanding of environmental impacts through the supply chain can extend into other parts of the organization to begin a more comprehensive and integrated life cycle management approach.

This comprehensive approach might also serve to align the improvement progress of the chain (or web), and ensure the exchange of useful information. Producers often decrease the number of suppliers they deal with and establish closer and collaborative relationships and risks sharing with remaining suppliers. This is particularly true in established industries such as the automotive sector and in aerospace, where a contraction in the number of manufacturers has been observed over the past two decades. The complexity of the product chain is likely to decrease as this trend progresses. Despite decreasing complexity, firms are out-sourcing the assembly and sub-assembly of components, the supply of full systems and the design of components and whole systems, more as a rule than an exception.

Therefore, there are two key reasons for a firm to build solid, interactive relationships with suppliers (Hunkeler et al. 2004):

- To ensure that an externally designed component system meets all requirements, a firm must effectively interact with their suppliers.
- As firms search for the most effective and efficient point to make improvements along different stages of the product life cycle, they will inevitably have to act at points beyond their internal operations. Effective relationships are forecasted to be essential to finding the best points to act and to develop efficient actions.

3.6 Internal communication

Communication of LCM concepts and tools can be one of the major barriers to adaptation of LCM approaches in an organization. This can be illustrated by an example of attitudes from a "nameless" organization based on several examples from industry.

- "LCM is a concept, nothing you can use in practice."
- "LCM is a method to identify and implement cost savings and minimize resource consumption only."
- "LCM costs too many resources to understand and use"

Adding to these attitudes, a typical observation is, that LCM is not part of everyday decision making or management in general – a characteristic also known from many environmental management systems.

LCM is thereby not seen as part of the production oriented rules and practices. LCM is primarily applied in departments where external requirements play a decisive role, and less in departments, where it is only a requirement from site or corporate management.

In promoting LCM, similar recommendations can be made based on industrial experiences with LCM:

- "Concept" people at corporate level and "practical" people at the operational level should develop a common language and common experiences in use LCM e.g. by participating in each others projects
- "Corporate" projects e.g. LCA studies should be conducted as close to the sites as possible; site employees should participate not only as passive data suppliers, but as active participants in goal and scope definition and interpretation
- "Corporate" should continuously monitor and evaluate the use of LCM tools – and discuss improvements and changes in tools and methods as well as in processes and products with relevant internal (and external) actors.

In ISO/DIS 14063 on environmental communication, a common approach based on the other management system standards can be found. Communication is depicted as an integrated

part of management at all levels, stages, and phases and for all functions of management. Communication of life cycle concepts and tools both internally and externally can be planned and implemented using this approach, and hereby some of the barriers in the example above can be overcome. For other barriers, only hard work will help – in a life long learning perspective.

3.7 Learning organization

A common assumption not always pictured by the organizational model described by Porter (1985), is the rational and optimal behavior of the different actors within the organization or society at large. Setting up communication or training activities on life cycle management might not always lead to the perceived or expected results. Reality is not that rational and optimal.

One key tool for organizations to apply to do the right things in the right manner is organizational learning. Senge (1990) introduces the following dimensions for building organizations that can truly learn:

- Systems Thinking
- Personal Mastery
- Mental Models
- Building Shared Vision
- Team Learning

Many companies have successfully used this approach, but a comprehensive integration of this approach and LCM is still to be made. "Systems Thinking" and "Personal Mastery" are somewhat build in the managements system per se together with some aspects of "Building Shared Vision" (policy, objectives and targets of the management system) whereas "Mental Models" and "Team Learning" typically goes beyond the results of implementing a management system as such.

Using the business organization model of Porter (1985), a differentiation between operational activities (or processes as they are named in management terminology) – those who earn the money – and supportive activities – those who spend the money (according to the first category) are often very deep in the business culture. Operational means a daily, maybe weekly, perspective – supportive means year or 5 year; although sometime economy is in quarters of the year. But the consequence of the different time perspective is important to acknowledge both in setting up LCM activities within and among organizations – who do you work with? The language depends not only on your cultural and educational background – your master degree or your learning-by-doing experience, but also upon where you are in the organization. Going across departmental barriers can give a lot of insight on how to go across barriers between different actors in the product chain – and visa versa.

Within each function or department of the organization, activities, products and services can be described by using the dimensions of sustainable development: A focus on economic, social and/or environmental issues. As an example, in the environmental department, most of the human and economic resources are used on environmental issues. This is illustrated in Figure 3.1. Both in life cycle management and sustainability learning within the department and in communication with other department, both champions and examples might be found in other dimensions than expected from the "title" of the department. Establishing training offers or process and product development projects based on LCM aiming a increasing the life cycle awareness in the department or organization involved, might have higher chances of success using "champions" and "ambassadors" instead of the formally appointed managers ore communication officers.

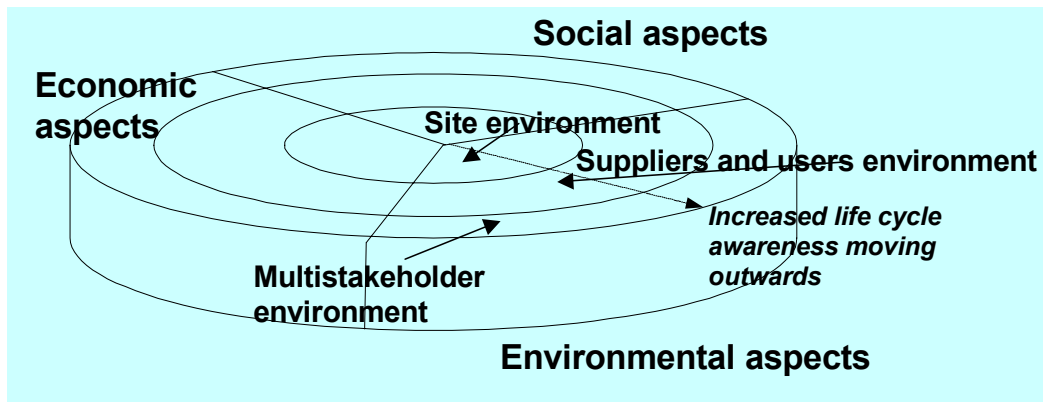


Figure 3.1 Life cycle and sustainability awareness in a department of an organization

Going back to the environmental management department, major competences and skills of the department will also be on environmental management systems and tools. When top management decides to introduce e.g. an EMS according to ISO 14001, they will typically appoint the environmental manager as the project manager and head of an internal working group. However, the environmental manager might not be the best skilled person to approach, e.g. the financial department. Maybe the organization instead should look for a communication champion within the environmental department or an environmental agent (person with interest for environment e.g. involved in Local Agenda 21 work in his private life) within the economic department. All actors can use the principles and dimensions of organizational learning as a common terminology and learning platform. Similar thoughts go for the other dimensions of sustainable development e.g. introducing personal development routines might better be communicated by other persons than the human resource manager.

This approach to a "crossover implementation" of (environmental) management systems in organizations is also applicable for governmental organizations and society at large. Hereby we go back to communication, where the term "Multistakeholder dialogue" can be used to comprise the issue: Sustainable Development will not be achieved if we don't involve all relevant interested parties and all relevant individual and organizational competences and skills in the process.

3.8 Cooperation in the product chain

Actors in the product chain

There are many actors in the life cycle even when considering a typical – and simplified – life cycle of a product (or service). The biggest influence of the real life of a product lays in the design phase, and the number of manuals and guidelines a numerous, see chapter 3. Considerations in design are similar to those in e.g. purchase and typically, its tempting to focus on selected issues e.g. renewable or not, more or less toxic, scarce or abundant, etc., how much energy is required for the use phase (in the case of an active product) and how easy is it to dismantle the product for refurbishment or recycling. Using LCA and other similar tools can help avoiding sub-optimization of these choices, but will not necessarily help in the communication or cooperation among the actors in the chain – LCA is not a communication tool per se. Other tools are necessary if the organization – and all other actors in the product chain (comprising supply chain and value chain) – is to move from traditional market-based (supplier-producer-user) relationships to cooperation for sustainability encompassing environmental, economic and social aspects.

Once the product specifications are completely decided, there are still possibilities for reducing the environmental burden and saving costs. These options are within the scope of life cycle management: for example, the environmental impact of distribution may be influenced by its design (size and shape of the product and its packaging), but there is a role for transporters in optimized logistics.

Present trends in management approaches indicate more focus on a problem-oriented and project-organized cooperation; the latter often named the matrix organization. Expanding the matrix to encompass also suppliers and customers, as well as other actors in the product chain, will contribute to the harvesting of potential benefits of life cycle cooperation.

3.9 Benefits of life cycle cooperation

For companies the benefit of management along the life cycle i.e. applying a life cycle perspective can be:

- Improvement of the transparency in the organization and between the companies in the supply chain
- Better options to set-up of a material and energy flow based cost accounting
- Improvement of the efficiency of material and energy flows
- Lower costs through product development and avoidance of material loss
- Lower costs through integrated development of information systems, organization and material and energy flows
- Less stress on the environment through waste avoidance and lower materials consumption
- Innovation through development of new procedures and relations in the supply chain
- Reduction of interfaces through flow and process orientation
- Better communication and coordination at the interfaces
- Access to up-front expertise on life cycle management that will be actively transferred to the companies during the project.

Key-factors of success are similar in many cases, e.g. (Goedkoop et al., 1999):

- Creating value for clients, by adding quality and comfort,
- Customizing offers or the delivery of the offer to clients,
- Creating new functions or making smart or unique combinations of functions,
- Decreasing the threshold of a large initial or total investment sum by sharing, leasing, and hiring,
- Decreasing environmental load. Often this will bring additional and perceived Eco-benefits,
- Increase the quality of the contacts with clients.

3.10 Overall objectives and targets

Is management along the life cycle just better accounting and budgeting of individual activities and sites, or is it using life cycle approaches and understanding in existing and upcoming management systems from a comprehensive and flexible perspective? And how can integrated management systems, product-oriented management systems, and other systems and approaches contribute to sustainable development, more sustainable production and consumption or the Millennium Goals of UN?

The concept of Sustainable Development comprises the environmental, social and economic aspects i.e. the traditional environmental focus of LCA will have to be supplemented with aspects of social and economic importance.

An operational approach to a breakdown of the three dimensions can be achieved by applying the UN Global Compact Principles (see <http://www.unglobalcompact.org/Portal/>) and the indicators of the Global Reporting Initiative (see <http://www.globalreporting.org/>). A checklist has been developed recently on how to combine the principles and the indicators; from a life cycle perspective the following *table 2* illustrates how these core issues can be addressed combining the overall principles and selected indicators.

In the table, only examples addressing the product chain as such are included; for labor rights, the indicators solely address the site of the organization and the interested parties i.e. labor organizations relevant to the specific site; as an example, principles and indicators for child labor are included. In the product chain, for each of the organizations involved, these indicators are also relevant for consideration. Similar considerations could be stated for other of the principles i.e. the table should only be interpreted as an illustration and not as a comprehensive checklist.

The GRI indicators are based on the three dimensions of sustainable development (environmental, social and economic) whereas the Global Compact Principles addresses human rights, labor rights and environmental "rights"; when combining, some indicators of GRI are relevant for more than one of the principles i.e. can be used as a measure for activities oriented towards sustainable development in more than one area.

Global Compact Principles		Global Reporting Initiative: Core indicators		
		Category	#	Indicator
Human rights	1. Businesses are asked to support and respect the protection of international human rights within their sphere of influence	Social Indicators: Human Rights Strategy and Management	HR2	Evidence of consideration of human rights impacts as part of investment and procurement decisions, including selection of suppliers/contractors.
	2. Make sure their own corporations are not complicit in human rights abuses	Social Indicators: Human Rights Strategy and Management	HR3	Description of policies and procedures to evaluate and address human rights performance within the supply chain and contractors, including monitoring systems and results of monitoring.
Labor	5. The effective abolition of child labor;	Social Indicators: Human Rights Child Labor	HR6	Description of policy excluding child labor as defined by the ILO Convention 138 and extent to which this policy is visibly stated and applied, as well as description of procedures/programmes to address this issue, including monitoring systems and results of monitoring.
Environment	7. Businesses are asked to support a precautionary approach to environmental challenges	Governance Structure and Management Systems Overarching Policies and Management Systems	3.13	Explanation of whether and how the precautionary approach or principle is addressed by the organization.
	8. Undertake initiatives to promote greater environmental responsibility	Environmental Indicators: Biodiversity	EN7	Description of the major impacts on biodiversity associated with activities and/or products and services in terrestrial, fresh water and marine environments
		Environmental Indicators: Products and Services	EN14	Significant environmental impacts of principal products and services.
			EN15	Percentage of the weight of products sold that is reclaimable at the end of the products' useful life and percentage that is actually reclaimed.
Environmental Indicators: Compliance	EN16	Incidents of and fines for non-compliance with all applicable international declarations/conventions/treaties, and national, sub-national, regional, and local regulations associated with environmental issues.		

Table 3.2 Indicators from Global Reporting Initiative relevant to the fulfillments of the Global Compact Principles from a life cycle perspective

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4. Life Cycle Based Design and Product Development

4.1 Introduction and scope

New product design and development has been identified as a key intervention point for corporate sustainable development initiatives. Early integration of environmental and social concerns into the design and development cycle is expected to reduce costs, promote innovation, facilitate supply chain integration, and assure greening initiatives are effectively aligned with overall business strategy. It is commonly asserted that design determines 70 to 80% of the total project life cycle costs, and consequently most of the total life cycle environmental impacts. Early assessment of the cradle- to- grave environmental footprint of the product system can lead to effective integration of environmental considerations into the design process and eliminate the unnecessary expense of retrofitting a designed- in problem. A holistic systems view of product development that includes all hardware and supporting services needed to deliver the function desired by the end user can side- step barriers imposed by business as usual, opening entirely new and innovative approaches that redefine the market.

The purpose of this handbook is to disseminate recommended practices for robust product design and development procedures to build internal capabilities and continuously improve the environmental performance and economic competitiveness of new product offerings. The intent is to provide guidance for the selection of appropriate tools and ecodesign approaches to fit with the existing business strategy. The intended audience is small to medium sized enterprises that comprise the supply chain of multinational corporations. However, these same processes can be used to manage breakthrough innovations that redefine the market and require an entirely new business model.

4.2 Generic new product development process

The literature describing new product development is complicated by a tendency for companies to develop highly customized processes described by their own unique terminology. However, most of these can be categorized as a stage- gate product development process (Cooper, 2001). A stage has a defined set of tasks that generate information, typically in the form of deliverables such as drawings, reports, etc. needed to support key business decisions. A gate is a point for review where ~~is~~ an executive level decision to continue investment in the project or terminate and divert limited resources to more promising projects is made. It is also the responsibility of management to assure that required activities have been adequately completed to support a quality decision. Company goals and policies define the criteria used to make the gate go- no go decisions.

This handbook uses the generic product design process described in ISO TR 14062 and shown in Figure 4.1 (International Organization for Standardization, 2002). Although shown schematically as a linear chain of distinct stages, in practice there is often significant iteration between various tasks and some overlap of activities between the different stages.

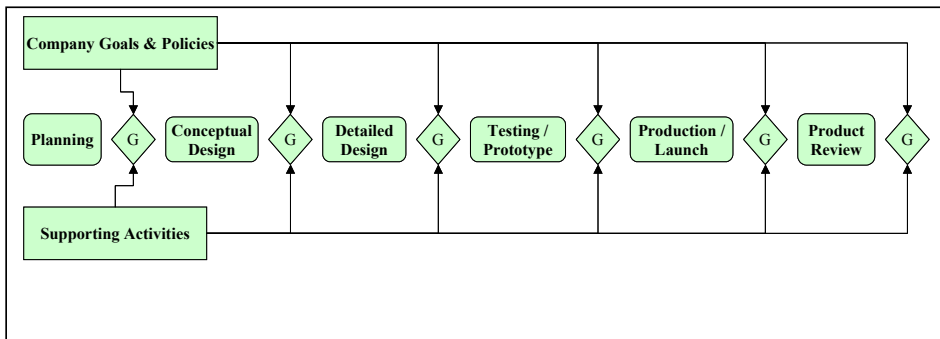


Figure 4.1 Generic Stage- Gate New Product Development Process

The initial planning stage surveys external pressures, public expectations, customer needs, and industry trends to define the requirements for a successful product offering. What will it take to excite the customer? What is the potential market and profitability? These questions determine the boundaries of the business opportunity and definition of the appropriate system boundaries for environmental evaluations.

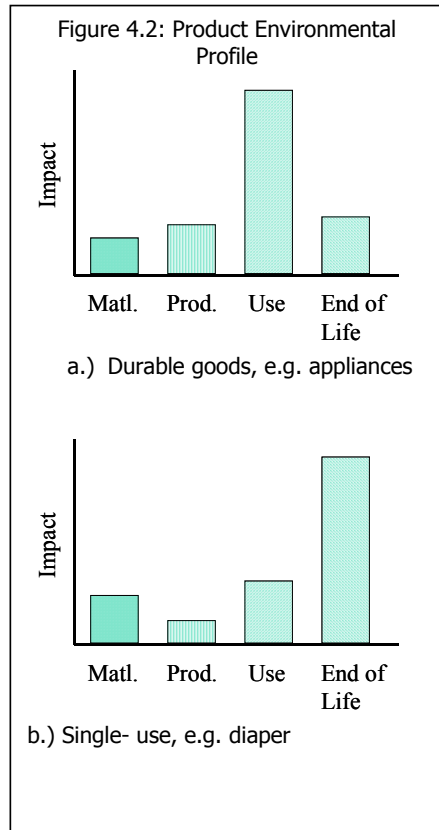
During conceptual design, the team assesses the strategic fit of the identified business opportunity with company capabilities and objectives to assure resources focused on most attractive projects. Is this an attractive opportunity for the company? Preliminary analyses are used to assure the feasibility of a fully developed conceptual plan that satisfies the customer need consistent with the strategy and capabilities of the company.

Detailed design activities develop complete bill-of-material, drawings, manufacturing plans, etc. that meets technical specifications and enables design of the manufacturing and support processes consistent with project cost and quality goals. Can we do it? The concept is translated to hardware and business systems needed to deliver the proposed customer benefits. Detailed plans demonstrate project goals will be met, at least 'on paper.'

Activities during the next stage demonstrate the feasibility of the product offering by testing prototypes or by analysis and simulation. Prescribed tasks confirm the product ability of the design and verify projected manufacturing costs. Can we deliver a winning solution? The go/ no go decisions are critical; because project costs escalate dramatically in subsequent stages.

Market launch introduces the product to selected markets to validate manufacturing processes at production levels. Plans are in place to ramp up volume to meet customer demand at required levels of quality. Support systems are in put place, and product performance in the customer environment is monitored to catch any surprises. If all systems perform as expected, the project is approved for full deployment as a proven product offering. The design team works with the product management function to provide technical and logistic support to maintain the offering at warranted levels of performance. Did we deliver what we promised? After a fixed period in service that will vary with product category and expected lifetime, a formal product review is held to assure lessons learned from the project are captured and used to improve subsequent projects.

The stage-gate process can be adapted to the complexity of the project. A clean sheet design of a new global platform is a high-risk project with potentially larger payoffs. These projects would be subject to rigorous analysis requiring completion of all activities and subject to gate review by top management. Derivative designs or regional products would face lower risks, but with lower potential gains. Project leaders would have the option to simplify the development process, skipping certain tasks, and the appropriate level of management would conduct gate reviews. Simple engineering changes to correct product design deficiencies or make minor enhancements are constrained projects with limited risk. The primary objective is to assure proper control to enforce design standards and avoid any new problems. These projects would skip many of the activities and lower level management would conduct the gate reviews.



4.2 Ecodesign concept

Ecodesign is most effective when integrated into the established design and development processes, and objectives are aligned with the overall business strategy. There will not be a one-size-fits-all concept. Ecodesign must be adapted based on the life cycle profile of the specific product, the business strategy, and the culture and capabilities of the organization. Examples of product life cycle profiles are shown in Figure 4.2. Typically, durable goods that last ten years or more and require energy to operate will be dominated by use stage impacts. Ecodesign targets will focus on energy conservation, and elimination of toxic and other minor constituents that complicate maintenance and upgrades. Communications would focus on customer cost of ownership and strengthen the product quality. Internal efforts to promote ecodesign would focus on design engineering and research and development and stress innovation. Single-use disposable products, such as diapers, are typically dominated by solid waste concerns and the source of wood fiber. Eco-design strategies could focus on biodegradability and elimination of any

problematic materials that could leach into groundwater supplies. Cost control imperatives suggest entry through manufacturing, while promotion of responsible disposal might appeal to marketing. Supply chain management would also play a critical role in certifying a sustainable source of fiber. Internal promotions would focus on supply management and marketing functions to capture business value.

It should be emphasized that the above examples are illustrative and not meant as a prescriptive solution. Each situation needs to be evaluated within the context of a specific product, business strategy, corporate culture, and established design and development procedures. Effective ecodesign will take a pragmatic approach and use whatever tools and resources are available to identify the environmental 'hot spots' that can deliver the most business value to the project and provide entry for gradual development of more comprehensive life cycle analysis and design.

4.3 Ecodesign approach

Ecodesign can be applied to existing or new offerings, whether they are products or services. The basic premise of the ecodesign approach presented here is that there is the function to be provided by the offering is identified and the opportunities for improving its environmental performance are identified in line with other traditional criteria. As shown in Figure 4.3, ecodesign is one of the steps in realizing a product with improved environmental performance.

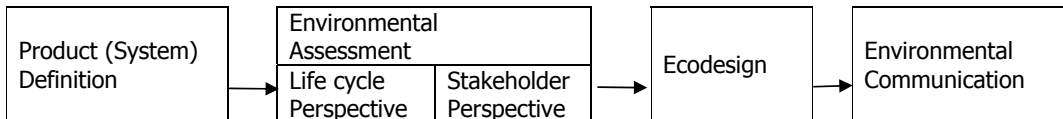


Figure 4.3: A systematic approach in implementing ecodesign.

For an existing offering, the first task in ecodesign is to define a product to be improved environmentally. This involves identifying product components, parts, and materials, plus life cycle stage information of the product. This task is the same as defining a product system. The output from this task is the product composition, product system, and life cycle stage data. In addition, technical parameters of the product relevant to the significant environmental aspects, environmental parameters, are also identified.

Based on the product defined, the environmental aspects of a product are assessed from two different perspectives: life cycle perspective and stakeholder perspective. The former is to assess the environmental aspects of a product system based on the environmental impact caused by the product system. The latter is to assess the environmental aspects of a product based on the stakeholders view such as legal requirements, market demands, and competitor's products. Commonly used tools for the former include life cycle thinking and/or life cycle assessment (LCA). For the latter, the environmental quality function deployment (EQFD) and the environmental benchmarking (EBM) are common tools in use.

Instead of full LCA, simplified or screening LCA is often considered practical tool for the environmental assessment of a product for ecodesign. Simplification can be made either by reducing the effort for data collection or focusing only on particular types of environmental impacts or parameters. Use of similar data, database, omitting certain life cycle stages, and exclusion of particular inventory parameters are examples of the former approach. Performing LCA on CO₂ is an example of the latter approach.

A LCA study of refrigerators conducted by the School of Industrial design at the University of Montreal showed the innovation potential of functional analysis and also illustrated the importance of aligning with the exiting business strategy. By reconceptualizing the product as preserving fresh food, the team designed a built in system that significantly reduced the environmental impact. However, the concept was not implemented because it did not fit with the existing business model. The company produced and distributed stand alone products. The new concept would have required much more integration with home building and kitchen design.

The output from the environmental assessment task is a set of significant environmental parameters of a product on the environment. Ecodesign task commences with these parameters. Below is a step-by-step procedure to implementing ecodesign task with relevant tools identified in bracket (Wimmer, Zust, and Lee, 2004).

- 1) Link the significant environmental parameters to relevant environmental strategies.
(Any set of environmental strategies and guides)

- 2) Identify relevant implementation measures for the improvement of the environmental parameters belonging to a certain environmental strategy. (Any checklist that allows evaluating implementation measures).
- 3) Develop redesign tasks for the chosen implementation measures.

The company SCA Hygiene Products has worked with the environmental improvement of its diaper and tissue products along their life cycle. By analyzing where the highest impact is, and use developed tools and procedures, a reduction of the products environmental impact is possible. In the development of new products there are procedures within the company that checks that necessary measures are taken to have environmental, product safety as occupational health assessments to reduce negative impact.

LCA has been used in more than ten years in the company as a regular "check" of products being developed and going for launch. It has been one of the tools in the company's environmental work as an established part of the product development processes. Other tools used are environmental management systems (EMS), product safety approvals, data collecting, assessment procedures, etc.

These assessments allow the company to focus efforts where maximum business value can be obtained. For example, in some business segments the most important concern could be demonstrating wood fibre is obtained from sustainable source. In other segments, meeting the requirements for eco- labels could be the key issue. The processes of mapping the life cycle aids supply chain management.

LCA has enabled the company to focus limited human resources on those environmental issues of most importance. Because there is a trend from society to demand more environmental information about the products, either for policy input or as information to make informed choices, to be able to provide good, environmental information can be of competitive value.

- 4) Develop product specification. It consists of fixed and wished specification.
- 5) Identify function of the reference product and then add new function and/or modify existing function based on the product specification (Function analysis).
- 6) Generate ideas to realize the function. (TRIZ, brain-writing, brainstorming, patent search, etc).
- 7) Generate variants. Assembling idea corresponding to each function of the newly improved product generates the variants.
- 8) Develop product concept by selecting variant. Variants are evaluated against criteria such as economic, technical, social and environmental ones
- 9) Continuing detailed embodiment design, layout, testing, prototype, production and market launch.

Upon completion of the ecodesign task, an environmentally improved product and/or service, is developed. Next task is then to communicate the environmental aspects of the eco-product to the market with the hope of increasing market share or at the least to enhance the image of the product and the company.

Conclusion

This introduction describes ecodesign, how the introduction of the environmental quality in business modifies the classical product development process by the introduction of new concepts and activities (product requirements readjustment, environmental product evaluation and ecodesign guidelines application). It should also be remembered that the introduction of environmental quality into product development processes is highly influenced by a company's environmental attitude, strategy or policy, in other words, the mixture of what a company can, want and must do in the environmental issue, influenced by environmental, competitive, financial and social considerations.

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5. Communication of Life Cycle Information

5.1 Drivers and target groups

Product related environmental issues are becoming increasingly of strategic concern for the business sector. Businesses and other organizations require more and better information about environmental aspects of products and their potential impacts in order to be able to make better-informed decisions. This also has relevant implications on the way these assessments are communicated to internal and external stakeholders. Industry is increasingly challenged with respect to information credibility.

The focus on products and on their life cycle and the crucial role of communication is also rapidly increasing among policy-makers. Consumer information tools and life cycle analysis are mentioned in the plan of implementation of the World Summit on Sustainable Development from 2002. They are also relevant elements of the recently issued Communication of the European Commission on Integrated Product Policy (IPP) that was reflected at the International UN DESA/ UNEP Expert Meeting on a 10-Year Framework of Programmes for Sustainable Consumption and Production, convened from 16–19 June 2003, in Marrakech, Morocco.

The main providers of Life Cycle Environmental Product Information (EPI) are industry and business. The latter are motivated by a series of driving forces, which depend on the target audience and which include the communication of EPI to (list not exhaustive):

- Final consumers, in order to get competitive advantage in emerging or new green markets
- Business clients, either because requested to (this is especially the case of SMEs in the supply chain), or to compete on the business-to-business market arena
- Societal stakeholders, to respond to the external pressure from environmental NGOs and consumer associations
- Financial stakeholders, which are increasingly attentive to the sustainable dimensions of organizations and products
- Public administrations, in order to apply to Green Public Procurement (GPP) programmes and/or to obtain tax incentives, whenever applicable
- Policy makers, providing credible life cycle information and reference data to support them in better-informed policy decisions and to prevent a misuse of life cycle approach and simplistic green claims, which might be highly misleading
- Several stakeholders (e.g. consumers, NGOs, public administrations), to convey a more holistic life cycle picture of products and services, in order to induce an appropriate use and disposal of products.

All these target audiences have different information needs, which can be satisfied by means of several communication tools, described in the next sections. The purpose of this chapter is to give an overview of:

- The existing toolbox for communication of life cycle information on products and services, and
- The ways these tools are applied in practice for life cycle management in companies.

This paper reflects the discussion and the main outcomes of the recent Workshop on Environmental Product Information held in Stockholm on September 29-30, 2003, and it is based on several studies on Environmental Product Schemes published in the last years 2002-2004.

5.2 Toolbox of life cycle product information

Definitions, existing standards and references


The actual landscape of existing voluntary EPI schemes is wide, ranging from voluntary seal-of-approval programmes, single-attribute programmes, hazard warning programmes, information disclosure programmes, environmental self-declaration by individual firms or test reporting. They can be classified in First-party and third party labeling programmes. Producers on their own behalf, to promote the positive attributes of their products on the market, perform first-party verification. On the contrary, third-party verification is carried out by an independent source that awards labels to products based on certain environmental criteria or assessment procedures.

The International Organization of Standardization (ISO), through the technical committee (ISO/TC 207), has done much effort to structure environmental labeling schemes. Three types of voluntary labels are distinguished:

ISO Type I label schemes are "Voluntary, multiple criteria-based third party programmes that awards a license authorizing the use of environmental labels on products. These indicate the overall environmental preferability of a product within a particular product category based on life cycle considerations. These labels provide qualitative environmental information" (ISO 14024: 1). They are covered by ISO 14024 published in April 1999. Life cycle thinking (but not necessarily LCA) is explicitly used to set the criteria, which involve multiple environmental indicators. Involvement of interested parties is required and detailed in the standard. An independent third-party body guarantees verification. The positive feature of Type I environmental labels is that they provide consumers with concise information, which enables them to take quick purchasing decisions.

**Illustrative classical ISO type I EPIS:
The European Community Eco-label**

The EU Ecolabeling Scheme – established in 1992 – is a voluntary environmental labelling scheme for consumer products. Criteria for a product group are identified considering the life cycle.



As of June 2004, environmental criteria have been developed for 21 product groups. The scheme does not cover food, drinks or pharmaceuticals.

ISO Type II labels are "self-declared environmental claims made by manufacturers, importers, distributors, retailers, or anyone else likely to benefit from such a claim without independent third-party certification" (ISO 14021: 3). They are covered by ISO 14021 published in 1999. The claims may take the form of statements, symbols or graphics on product or package labels, or in product literature, technical bulletins, advertising, publicity, telemarketing, as well as digital or electronic media, such as the Internet. The relationship with the product life cycle is implicit, and generally weak. Usually, just one life cycle phase is taken into account. Moreover, often just a single environmental criterion is considered. The positive aspect of ISO-type II for industry is quite obviously the high flexibility of the tool. However, the problem of credibility often remains. Many existing labels do not fully satisfy the ISO 14021 requirements and the possibility of misleading claims is a matter of fact. Environmental claims are subject to national legislation and to EC Directives aiming at protection of consumers.

ISO Type III declarations are "Quantified environmental data for a product, with pre-determined parameters, based on the ISO 14040 series of standards, which may be supplemented by other qualitative and quantitative information" (ISO/CD 14025). The Committee Draft ISO/CD 14025 covers them. The standardization process is expected to be completed by early 2006.

An ISO-type III environmental declaration is based on a Life Cycle Assessment (LCA) study, carried out in accordance with the ISO 14040 series. To be compared with each other, the results of LCA studies must have the same scope, system boundaries, and calculation rules and must be presented in the same format. This is ensured in an Environmental Declaration Programme, which provides both general and product category-specific prescriptions for data collection, handling and calculation rules. The latter are contained in the product category rules (PCR) i.e., a set of specific rules, requirements, and guidelines for developing Type III environmental declarations for one or more product categories. PCR are approved in a multi-stakeholder open consultation process. Information contained in the declaration gives no criteria for assessment, preference or minimum levels to be met, but the customer can compare products by comparing the quantified results presented in the corresponding type III declarations.

Other relevant EPI schemes are not covered by the ISO standards. They include product certifications, like the Forest Stewardship Council (FSC), the Marine Stewardship Council (MSC), the Oeko-tex Standard 100, etc. They usually refer to one product group only. Because they are based on some major elements of the ISO type I standard (i.e. third-party verification, multi-criteria based, and partly open stakeholder participation), some authors classify them as "ISO-type I like" labels in literature, as opposed to "classical" ISO-type I labels like the EU-Flower, the Blue Angel in Germany and the White Swan in the Nordic countries (DEEP 2003).

Finally, social labels are relevant to promote sustainable production and consumption patterns. They include for instance the Social Accountability 8000 International Standard (SA 8000), the TransFair and the Fair Trade labels.

5.3 Existing programmes worldwide

ISO-type I labels

The German "Blue Angel" was the first official national eco-labeling scheme worldwide, launched in 1978, followed a decade later (1989) by the "White Swan" in the Nordic Countries and the "Eco-Mark" in Japan. The majority of national third-party labeling schemes have emerged during the late eighties and nineties. At supra-national level, the EU-Flower was introduced in 1992 and had a major regulation revision in 2000.

As of 2003, slightly more than the half of the European Union (EU-25) has developed own national ISO-type I

Illustrative ISO type III EPIS:

The Swedish EPD label

EPD's (environmental product declarations) are a very recent environmental



product information scheme. There are several experiences of EPD at the international level; both in Europe, the US, and Japan.

The Swedish EPD® system is the oldest and largest environmental declaration programme set up in Europe. It was created in 1997 and officially launched in 1999. The Swedish Environmental Council (SWEDAC) runs it. SWEDAC is currently collaborating in the EU-LIFE project INTEND, aiming at the establishment of an international EPD system. It is also collaborating within GEDNet on the harmonization issue of different existing EPD systems worldwide.

Illustrative ISO type I like EPIS:

The Forest Stewardship Council (FSC)

The Forest Stewardship Council is an international non-profit organisation founded in 1993 to support environmentally



appropriate, socially beneficial, and economically viable management of the world's forests. It is an association of Members consisting of a diverse group of representatives from environmental and social groups, the timber trade and the forestry profession, indigenous people's organisations, community forestry groups and forest product certification organisations.

Illustrative classical ISO type I EPIS:

The German Blue Angel

The German "Blue Angel" was the first official national eco-labelling scheme world wide It is by far the most important ISO type I label in Germany. It is



well known and broadly accepted. This is mainly due to the involvement of a wide range of different societal actors in the process of product selection and criteria development. The label apparently works well as a supplementary marketing tool, especially for SMEs.

labeling systems. This reflects a quite relevant focus of environmental product policy in EU-member countries.

Several other ISO-type I schemes have been developed in other countries at worldwide level (see Table 5.1).

EU Member States <i>with</i> national ISO type I	EU Member States <i>without</i> national ISO type I	Other states with national ISO type I
<ul style="list-style-type: none"> ▪ Austria ▪ (Catalonia/Spain) ▪ Czech Republic ▪ France ▪ Germany ▪ Hungary ▪ Lithuania ▪ Nordic countries (Denmark, Finland, Norway, Sweden) ▪ Poland ▪ Slovak Republic ▪ Spain ▪ The Netherlands 	<ul style="list-style-type: none"> ▪ Belgium ▪ Cyprus ▪ Estonia ▪ Greece ▪ Ireland ▪ Italy ▪ Latvia ▪ Luxembourg ▪ Malta ▪ Portugal ▪ Slovenia ▪ United Kingdom 	<ul style="list-style-type: none"> ▪ Australia ▪ Brazil ▪ Canada ▪ China ▪ Croatia ▪ Hong Kong ▪ India ▪ Israel ▪ Japan ▪ Korea ▪ New Zealand ▪ Taiwan ▪ Thailand ▪ USA

Table 5.1: National ISO-type I labeling systems in EU-25 and selected extra-European countries Source: Rubik & Frankl (2004) p.38.


Japan is historically one of the main leading countries worldwide in eco-labeling, together with the Germany, the US, Nordic Countries and Canada. Japan is also a founding member of GEN (Global Eco-labeling Network) and it is worth mentioning that the general affairs office of the latter is settled precisely in Japan, at the Japan Environmental Association (JEA), a non-governmental organization under the guidance and advice of the Environment Agency. The latter has the responsibility for the Administration of the Eco-Mark programme. Concerning the programme methodology, the latter was profoundly revised in March 1996 to conform to the draft (at that time) ISO 14024 standards. More specifically, two very important changes were introduced, i.e. a life cycle approach to develop label criteria and consultation with stakeholders and related parties (EPA 1998).

The Green Seal is the only US-wide eco-labeling programme fulfilling the ISO-type I standard. It is awarded by the Green Seal Inc. Currently, requirements for more than 30 product groups have been elaborated and accepted by a Stakeholder Committee representing manufacturers, trade associations, governmental agencies, product users, environmental and public interest groups.

In India, the Ministry of Environment (MoEF), Government of India (GoI) has initiated a scheme in 1991, which is basically a scheme of labeling the eco-friendly products. An earthen pot has been chosen as the logo for the Ecomark scheme and is awarded to consumer goods, which meet the specified environmental criteria and the

**Illustrative classical ISO type I EPIS:
The Japanese Eco-Mark**

The Eco-Mark is the official Japanese eco-label, established in 1989. Its administration lies within the responsibility of the Japan Environment Association (JEA), a non-governmental organisation under the guidance and advice of the Environment Agency. An LCA-approach has been incorporated in 1996 and has to be applied to all product categories added to the scheme since then.



quality requirements of Indian Standards. Sixteen categories of products such as soaps and detergents, paper, food items etc. are covered under the scheme so far (Sharma & Kurani 2003).

ISO-type III declaration programmes

In 2002, the results of a study commissioned by the EC/DG Environment and carried out by ERM reviewing existing EPD schemes were published (ERM 2002). The study reviewed over-sectoral initiatives in ten countries, three collaboration initiatives (GEDNet, NIMBUS and Asia), and sector-specific initiatives in the areas of automotive, chemicals, construction, energy & transport, electrical and electronic equipment, food, packaging, pulp & paper, textiles and tourism. In 2003, the study was further updated and expanded within the Task 1 of the EU-LIFE Project INTEND, whose main objective is to develop an EPD scheme at international level (INTEND 2003). Table 5.2 gives an overview of existing national over-sectoral EPD programmes and selected sector-specific initiatives, as of early 2003.

Countries	National Scheme (Scheme Owner)	Sectoral Scheme (Sector)
Europe		
Denmark	Pilot Project EPD (DEPA – Danish Environmental Protection Agency)	
France	Experimental standard on type III environmental declarations (AFNOR - Association Francaise de Normalisation)	AIMCC (construction)
Finland	-	RTS (construction), Paper profile
Germany	-	AUB (construction)
Italy	Pilot EPD Programme (ANPA 2000-2001) EU-LIFE INTEND Project – Pilot international EPD system (2003-05)	
Netherlands	-	MRPI (construction)
Norway	NHO Type III Project (NHO - Confederation of Norwegian Business and Industry)	-
Sweden	EPD programme (SWEDAC - Swedish Environmental Management Council)	Volvo Cars EPDs (Automotive) Volvo Trucks EPDs (Automotive) IT Eco Declaration (Information technology and telecom) Byggvarudeklaration (Construction) Teko Environmental Declarations (Textile)
United Kingdom	-	BRE environmental profiles (construction)
Extra-Europe		
Switzerland	-	SIA (construction)
Canada	EPDS – Environmental Profile Data Sheet (FPAC – Forest Product Association of Canada, in cooperation with Terrachoice)	-
Japan	ECO-LEAF (JEMAI - Japan Environmental Management Association for Industry)	-
South Korea	EDP program (MoE – Ministry for the Environment)	-
USA	CEP – Certified Eco-Profile Programme (SCS – Scientific Certification Systems)	-
No State Based		
	-	IVN “better-best” (textile)
	-	AISE Code of Conduct (household laundry detergents)

Table 5.2: Overview of existing national over-sectoral EPD programmes and selected sector-specific initiatives Source: INTEND (2003), updated and adapted from ERM (2002).

5.4 The use of communication tools in practice

Introductory remarks

Which tools are used by industry to communicate life cycle information to consumers and other stakeholders in practice? How effective is this information in fostering the production and consumption of more environmentally sound products and services? Is the use of specific communication tools just dependent on target-group or also on product groups? This section tries to give a first answer to these questions.

ISO-type I labels are still the EPI tools most widely used by industry and business for their communication to consumers in several countries. As far as these specific communication tool are concerned, an indirect measure of their effectiveness can be provided, in terms of:

- The number of product groups for which award criteria have been developed
- The number of awarded products and firms participating to the scheme, reflecting the adoption by industry and the behavior (change) of producers.
- The market shares of eco-labeled goods and services, which are meant to reflect the actual change in behavior of consumers.

However, ISO-type I labels have a set of important limitations. Therefore industry has been developing and using also other tools to increase the awareness of life cycle environmental impacts of products among consumers and to encourage the latter to be more closely involved in reducing impact via better use of the product. Communication materials include information on pack, in product catalogs and/or advertising campaigns via Internet, media and information brochures.

Another trend to be observed (e.g. in Japan) is the simplification of complex life cycle information into ISO-type II labels, through which the consumers can understand more easily how products are improved in a life cycle perspective. This kind of information is spread out via the web, product catalogues and environmental and sustainability reports.

As for business-to-business communication, the use of ISO-type III environmental declarations has been significantly increasing, especially in Sweden and Japan. Moreover, a number of initiatives have been taken in several industry sectors (e.g. in the electronics and car sectors) at international level to standardize the format of life cycle information data gathered from suppliers. Other initiatives aiming to standardize the format of EPI to other stakeholders in the supply chain, i.e. retailers, distributors and recyclers, are also being developed, for instance in the white good sector.

Product life cycle information is also increasingly being included in environmental and sustainability reports. The latter are meant as important communication tools for a variety of both private (e.g. financial) and public stakeholders.

Finally, it is worth highlighting that industry and business have been increasingly using a *combination* of tools for communication with stakeholders. For instance, in Japan, some companies carry out ISO-type III declarations on their products but at the same time use simplified communication to consumers. Moreover, a set of different tools is used for communication to public administrations for green public procurement (GPP).

5.5 Communication to consumers

ISO-type I labels

In

Table is summarized the indicators number of product groups, participating firms and awarded products for the main existing ISO-type I labeling schemes in different countries.

Country	Year of establishment	Product groups	Firms	Products
Japan ⁷	1989	64	2107	5152
Germany	1978	94	995	3114
Nordic Countries	1989	55	658	2872
Sweden (Falcon)	1992	14	617	1226
Spain/Catalunya (DGQA)	1994	16	79	864
Austria	1991	44	334	645
EU ⁸	1992	19	128	576
France	1992	15	47	443
The Netherlands	1992	69	257	360
Spain (AENOR)	1994	13	71	77

Table 5.3: Number of product groups, firms and products for the main ISO-type I labeling schemes, as of end of 2002. Source: adapted from Rubik (2004).

As shown in the table 5.2, the country with the largest number of eco-labeled products is by far Japan. This might let think to a very spread diffusion among all industry sectors. However, looking more specifically at the most diffused labels and at the different product groups, it can be observed that in Japan just six product groups (three of which are paper products) are responsible for 58% of all eco-labeled products. They are plastic products using recycled materials (17%), clothing made from recycled PET-resin (14%), paper stationary (9%), printing paper (6%), packaging paper (6%), and tile-blocks made of recycled materials (4%). The share of "zero-categories"⁹ for the EcoMark has been progressively decreasing down to 7%, thanks to the progressive focus of the label on a more restricted number of product groups.

Similarly, in Germany, six product groups dominate and are responsible for 65% of all eco-labeled products, namely paints/varnishes (26%), wall paints (14%), recycled paper (6%), recycled board (5%), copiers (5%), and woodchip wall coverings (4%). On the contrary to Japan, "zero categories" represent around 36% of all product groups of the Blue Angel.

Also in Nordic countries, seven product groups are responsible for 65% of all eco-labeled products. As far as the EU-Flower is concerned, absolute figures of awards are much lower, but rapidly increasing. The number of companies using the label was 37 in March 2000 (ERM 2002), 59 in January 2001 (Rubik & Scholl 2002), 128 at the end of 2002 and 185 as of June 2004,

⁷ Japanese data refer to mid 2003.

⁸ As of June 2004, the number of product groups for which EU-Flower criteria exist is 21 and the number of firms is 185.

⁹ i.e. product groups for which eco-labeling requirements have been elaborated, but label holders do not exist.

corresponding to an increase by a factor four in four years. Acceleration is particularly strong in specific countries (e.g. Italy, France and Denmark). Similarly to the other ISO-type I labels, for the EU-Flower four product groups alone correspond to 68% of companies using the label. Zero-categories represent 28.5% of all product groups.

The above mentioned figures reveal that the schemes in operation are in most cases "dependent" on only a small number of product categories. Most important product areas are paper products, paints, durable office equipment and some products addressing national/regional characteristics (e.g. products for water-saving, tourism, flower arrangements, bags, organizers, food, cat litter, and recycled plastic products). Very clearly, the diffusion and effectiveness of ISO-type I labels are not only dependent on countries but also on product groups and/or product group "families".

Finally it is worth remembering that, since not all criteria developed for ISO-type I labels are explicitly linked to the product life cycle for all product groups, the figures indicated above should be taken with care as an indicator for the diffusion of life cycle information. This holds specifically for the "older" product groups in the more ancient national ISO-type I labels (Blue Angel, EcoMark and White Swan). On the contrary, the criteria of more recent product groups are usually explicitly based on life cycle thinking approaches, taking into account the whole life cycle of the product or service.

The positive feature of Type I environmental labels is that they provide consumers with concise information, which enables them to take quick purchasing decisions.

Among the drawbacks of ISO-type I labels, the following ones are often mentioned, which limit the effective use for marketing purposes:

- The label covers not all product groups.
- The hurdle evaluation principle does not allow for competition within labeled products and does not award environmental excellence.
- Criteria renewal is too slow and not compatible with product innovation cycles at industry level.
- In many cases, criteria focus mostly on the production phase and do not actually cover the whole life cycle.
- Format is not appropriate for all product groups.
- Criteria are sometimes too strict.

These and other drawbacks are reflected in a large set of zero-product groups mentioned above.

ISO-type I like product certifications

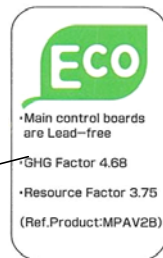
The international or European ISO-type I like schemes seem to meet quite a relevant success: The "Forest Stewardship Council" (FSC) label is awarded to 467 forest owners, the "Blue Flag" is awarded to 2,804 beaches/marinas, the "Eco Schools Flag" has membership of about 7,000 schools, the GUT-label (carpets tested for a better living environment) is awarded to 77 companies for 3,500 certificates and the "Eco Tex Standard" is applied by 4,500 textile companies (Rubik & Frankl 2004).

ISO-type II labels

There is another trend that can be observed in Japan, where life cycle information is usually considered to be complex. As a consequence, some electronics companies in Japan have tried to simplify such complex life cycle information so that consumers can easily understand how products are improved in a life cycle perspective. For instance, Matsushita, generally known as Panasonic, has invented Factor X, which represents the improvement ratio from the product life cycle viewpoint. They have applied the Factor X to most of their products. Purchasers and consumers

can access to the converted life cycle information easily, from the web and product catalogues. Matsushita and Hitachi have established an alliance about sharing those factor methods. Hitachi also implements the same concept. The main indicators to communicate environmental performance improvement are the greenhouse gas (GHG) factor and the Resource Factor, defined as follows:

- $GHG\ factor = (GHG\ efficiency\ of\ the\ new\ product) / (GHG\ efficiency\ of\ the\ old\ product)$, where
- $GHG\ efficiency = (Product\ life \times Product\ functions) / (GHG\ emissions\ over\ the\ entire\ life\ cycle)$
- $Resource\ factor = (Resource\ efficiency\ of\ the\ new\ product) / (Resource\ efficiency\ of\ the\ old\ product)$
- $Resource\ efficiency = (Product\ life \times Product\ functions) / (Resources\ that\ do\ not\ circulate\ over\ the\ entire\ life\ cycle)$



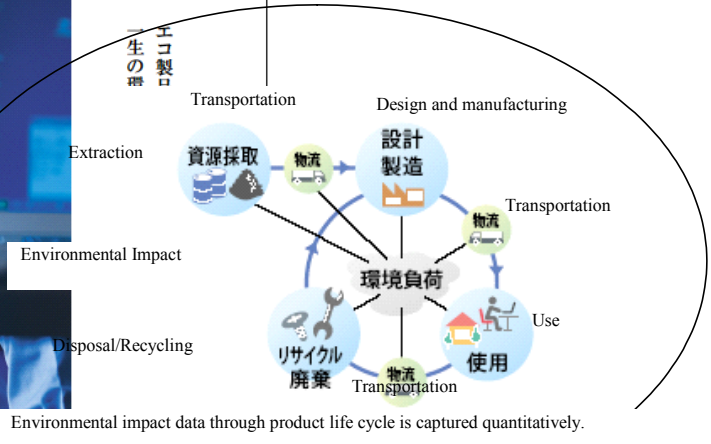
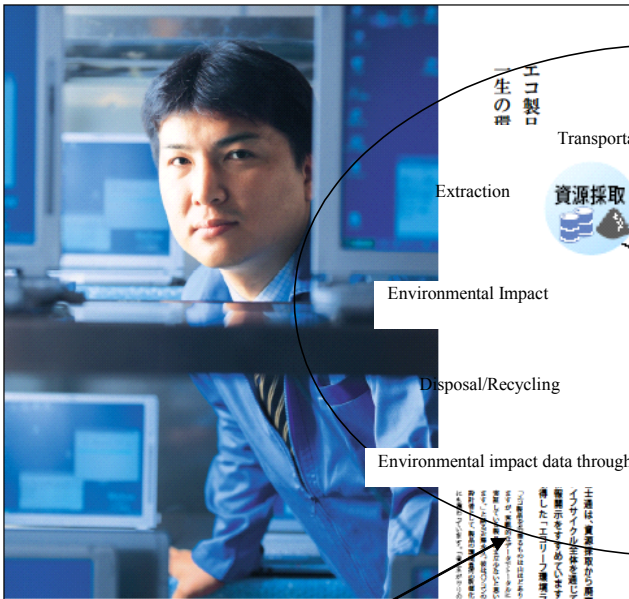
The Factor X by Panasonic

The Factor X developed by Matsushita / Panasonic in the electronic sector is an ISO-type II label, which provides final consumers with concise information about the improvement of new products with respect to old ones in a product life cycle perspective. Focus is on greenhouse gas emissions (GHG), resource consumption and product-specific environmental issues (e.g. lead-free)

Advertising and product catalogues

In Japan, several companies involved in the EcoLeaf ISO-type III declaration system also seek strategic ways to make the most out of their life cycle information made available to stakeholders. As a matter of fact, while life cycle information is being gradually more developed in industry, the concept of "life cycle thinking" itself has not yet been much acknowledged by purchasers and consumers. Previously, product-related life cycle information was usually to be provided through environmental reporting. However, environmental reports tend to be read only by environmental conscious stakeholders. Therefore, recently, Japanese companies carrying out Type III declarations have also begun to address various kinds of stakeholder target groups through a variety of communication tools. As a consequence, life cycle information has been emerging in advertisements, sales and marketing communication.

For instance, Fujitsu is one of the companies that are eager to promote life cycle information, which has issued more than 10 Eco-Leaf declarations for their notebook personal computers. Recently, the firm began to feel the necessity of communicating the idea of life cycle perspective as well as providing life cycle data. As a result, life cycle information was explained in newspapers advertising (see box) and included in marketing promotion kits (see section 4.3). Fujitsu believes information should be disclosed to promote environmental friendly products and eagerly pursues environmental information disclosure.



Advertising of Fujitsu Co. In newspapers

In June 2004, Fujitsu Co. took out a full-page advertising in major newspapers, including the Nikkei Shimbun, the most popular business newspaper in Japan. In the ad, an engineer points out that, "there are widely many environmentally conscious products in the market. But most of them are not proved with objective data comprehensively. Even if a product is called an energy-saving product during the use stage, it might consume numerous amount of energy during the production stage while consumers/purchasers are not informed. Such a product should not be claimed as environmental conscious product. In order to fulfill high ideals that real environmental friendly products are selected by consumers, environmental impact information through product life cycle stages, resource extraction, production, use, and recycling/disposal, including transportation should be reported".

エコ製品をグリーンにします
 eco.fujitsu.com/jp
 FUJITSU
 THE POSSIBILITIES ARE INFINITE

Another example is Toyota, which has included the life cycle information gathered through its in-house developed system ECO-VAS in the product catalogues of two models, i.e. the Premio and Allion. LCA information will be disclosed in all product catalogues in the future.

LCA information in the product brochures of Toyota Allion and Premio

Toyota has developed its own LCA system, called ECO-VAS, which allows to gather data from suppliers in a standardized format and to carry out a full LCA of a car model. Apart from its use as a environmental management tool for vehicle designers and developers, recently life cycle information obtained with ECO-VAS was also used for communication to customers in the product brochures of the two models Allion and Premio

Information campaigns

As mentioned, several companies in different industry sectors are concerned by the fact that ISO-type I labels do mostly focus on the production phase and not the whole product life cycle. This is particularly important for all those products for which the use phase is the source of the largest impacts over the life cycle. As response to this issue, some industry has carried out information campaigns with the aim to increase consumer awareness and provide guidance for best use of products.

This is for instance the case of campaign Washright carried out by the European Soaps and Detergents Industry Association (AISE) within its Code of Good Environmental Practice. The latter was the industry’s response to the European Commission’s Fifth Environmental Action Programme. It aimed to reduce further the environmental load created by the manufacture and use of household laundry detergents.

A Voluntary Agreement with measurable targets on detergent consumption, packaging consumption, use of poorly biodegradable organic substances and energy consumption in use was concluded with the European Commission in 1998 and resulted in an EU Recommendation 98/480/EC. It was implemented in the then 15 members of the EU plus Switzerland, Norway and Iceland. The commitments and targets in the Code were based on risk assessment and life cycle analysis which indicate that most of the environmental impact occurs in home during consumer use. A data collection system was organized with independent consultants and auditors to allow reporting on progress at both national and European level. All together more than 180 companies representing more than 90% of the total market participated.

The AISE Washright Campaign

The Washright Campaign carried out by AISE (The European Soaps and Detergents Industry Association) aims to encourage consumers to be more closely involved in reducing impact via better use of the product. Consumer communication material on best use of product was developed for use throughout Europe either on pack, or in advertising campaigns to encourage more sustainable consumption, and particularly energy consumption via the Washright campaign – see www.washright.com; where the commonly agreed washright panel for product is to be found.

Here are some useful hints if you want to help the environment when doing your laundry

If you want more information on this campaign, please contact the local industry association ([click here for contact details](#))

The companies committing to the code undertook to continue environmental progress when formulating products and packaging for household laundry detergents and to encourage consumers to be more closely involved in reducing impact via better use of the product.

5.6 Business-to-business communication

ISO-type III environmental declarations

Environmental product declarations are a very young EPI communication tool and quite obviously their diffusion/adoption by companies is fairly limited in absolute numbers.

As mentioned, the first scheme was developed in Sweden. The Swedish government introduced a national system for a Type III declarations programme based on certified environmental product declarations in 1999. Figure 5.1 shows the number of certified EPDs issued under the Swedish EPD® system from its creation in 1999 until July 2004. Pre-certified EPDs are ISO-type III declarations compliant with the requirements of the Swedish system, but for which Product Category Rules (PCR) do not exist or have not been approved yet. As of July 2004, in total 99 EPDs are reported in the official website of the Swedish EPD® system, 74 of which are certified. Not only Swedish companies participate in the system. As of July 2004, Italian, Japanese, Norwegian and other countries' EPDs have been also registered in the Swedish system.

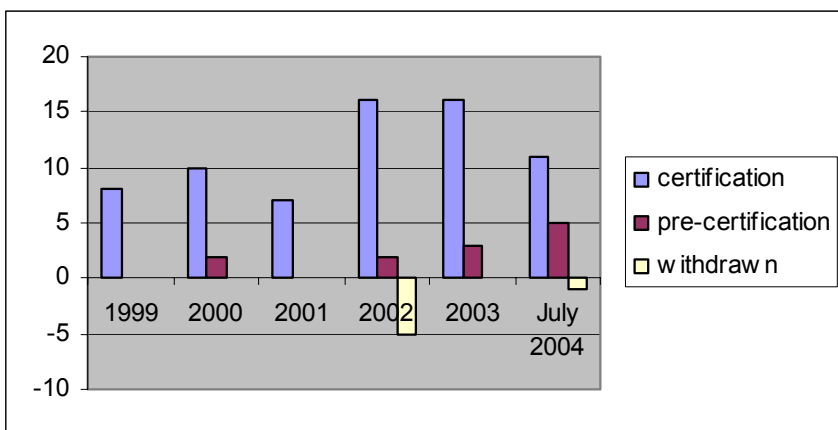


Figure 5.1: Number of certified EPDs under the Swedish EPD® system in the period 1999 – July 2004 (own elaboration on data from www.environdec.com as retrieved in August 2004)

Table 5. shows the number of companies issuing an EPD registered under the Swedish system per country of provenance. As shown, a quite significant number of Italian companies¹⁰ are currently participating in the system. This is the consequence of the Italian-Swedish LIFE project INTEND, currently being carried out. Also 5 Japanese companies have issued 13 EPDs certified under the Swedish system, further showing the increasing international dimension of the latter. EPDs in the Swedish system cover a wide set of products and services, ranging from consumable products like sawn timber to the electricity produced by a nuclear power plant. Just a few EPDs have been made by SMEs.

¹⁰ The number of companies belonging to the same corporate group are aggregated

	Certified EPDs	Reported EPDs	Companies
Sweden	23	23	14
Italy	18	18	13
Belgium	18	18	1
Japan	13	26	15
Norway	0	12	10
Finland	1	1	1
Poland	1	1	1
TOTAL	74	99	55

Table 5.4: Number of EPDs registered in the Swedish system per company's country (own elaboration on data from www.environdec.com as retrieved in August 2004)

In Japan, JEMAI launched the "EcoLeaf Type III environmental labeling program" in the 1st half of 2002. As of summer 2003, the Japanese system overcame the number of 50 EPDs, which shows a very good reaction of the market. As of July 2004, the number of EcoLeaf declarations has further grown up to 161, with 27 companies involved (see Table 5.).

Product Category	No. of declarations	No. Issuing companies	No. participating companies to PCR consultation meeting
EP (Electrophotographic Printer) and IJ (Ink Jet) Printer	33	6	10
Electro photographic Dry Process Photocopier	33	7	9
Single-use camera	21	2	2
Digital Camera	16	6	7
Notebook Personal Computer	14	2	1
Digital Printer Duplicator	11	5	3
Facsimile	7	5	8
Data Projector	7	1	7
Analog Camera (with silver film)	4	2	5
Water Meter Box	4	1	3
Insulation Material (polystyrene foam type)	3	2	3
Electricity	2	2	3
Card Printer	1	1	1
Construction Aggregates	1	1	1
Drainage Cover	1	1	1
Power Saving Device for Facsimile	1	1	1
Photo Print Scanner	1	1	1
Instant Photo Printer	1	1	1
Total	161	27	-

Table 5.5: EcoLeaf declarations in Japan as of July 2004 (Source: JEMAI 2004)

A key feature of the Japanese ISO-type III declaration system is that, unlike other countries' Type III programmes, several companies have issued declarations within the same product category. This allows for a real comparison of products of different companies by clients and customers. Though the absolute number of products is still limited, companies perceive that (ISO-type II) environmental claims without proof are just self-declaration with limited credibility and recognize on the contrary that certified ISO-type III declarations are a valuable tool to compete on the market with respect to environmental performance of products.

Looking at the different industry sectors involved so far in the Japanese system, the prominence of electronic products (e.g. photocopiers, printers, cameras, notebooks, etc.) is clear.

As far as other countries national ISO-type III programmes are concerned, the Norwegian system is still under discussion, and some uncertainty may have created a slow down of the EPD diffusion in the market.

In Canada the system exists from 1997 and is related to the Pulp and Paper sector. By the end of 2002 it had reached almost 40 certified products.

In the US, more than 200 products hold a Certified Environmental Profile (CEP). However this figure has to be considered with care for comparison with other ISO-type III systems, as the US programme is not fully compliant with ISO CD 14025.

Supply chain information

Other instruments are also significant for B2B communication over the supply chain, in particular with specific respect to the gathering stages of life cycle information, i.e. addressing the question how and in which format data are requested. In terms of gathering information, used tools are for example questionnaires to potential suppliers of components, or requirements of suppliers to provide material declarations to Operational Equipment Manufacturers. With respect to this a number of interesting initiatives can be observed in the electronics sector, aiming to standardize the format for which manufacturers gather material content data from suppliers.

In fact, to obtain material composition data, many manufacturers have developed material declaration questionnaires (also known as green procurement surveys or supply chain questionnaires) that require suppliers to disclose certain information about the products and subparts they sell. These questionnaires usually take the form of a list of banned or restricted materials and substances that the supplier must certify are not present in the product or subpart. In addition, they often include a separate list of materials and substances that need to be identified when present.

Due to the diversity of information requests and formats, it is difficult for suppliers to manage material declaration requests. Recognizing the challenges that the entire global EEE industry faces from diverse material composition requests, a workgroup composed of representatives from the European Industry Association of Information Systems, Communication Technology and Consumer Electronics (EICTA), the US Electronic Industry Alliance (EIA) and the Japan Green Procurement Survey Standardization Initiative (JGPSSI) developed a material composition guide [EICTA-EIA-JGPSSI 2003]. It is worth highlighting that some of the reported material data are clearly related to the product life cycle, e.g. with respect to the end-of-life management phase (see box).

Also the car industry is addressing the issue of determining what materials and substances are in their cars with the set up of the International Material Declaration System, where suppliers can declare materials in their supplied parts. The already mentioned ECO-VAS system developed at Toyota is another example of B2B supply chain management and communication tool, which allow gathering data from suppliers in a standardized format to be used in the LCA of cars.

The EU-US-Japanese Electric & Electronic Industry Material Composition Declaration Guide

To overcome the diversity of information requests and formats from clients, EEE Industry associations in Europe, US and Japan have been making significant efforts in merging the three systems to internationally standardise the communication format of data. This effort resulted in the Industry Material Composition Declaration Guide for suppliers jointly developed by EICTA, EIA and JGPSSI.

This guide contains: i) the set of materials and substances for disclosure; ii) the composition amount that requires disclosure (i.e., Threshold Level.); iii) the regulatory requirements that establish threshold levels, where appropriate; iv) a recommended set of data fields for information exchange

More specifically the guide identifies

- The Level A. List, composed of materials and substances that are subject to currently enacted legislation that prohibits or restricts their use and/or marketing, and requires reporting or results in other regulatory effect.

- The Level B. List, composed of materials and substances that the industry has determined relevant for disclosure because they meet one or more of the following criteria:

a) Precious materials/substances that provide economic value for end-of-life management purposes

b) Materials/substances that are of significant environmental, health, or safety interest

c) Materials/substances that would trigger hazardous waste management requirements

d) Materials/substances that could have a negative impact on end-of-life management.

Communication to retailers

For specific product groups and categories, retailers can play a potential major role for the communication and promotion of life cycle information to final consumers. This is for instance the case of both energy-consuming (e.g. durables like white goods) and non energy-consuming products (e.g. detergents), for which the main environmental impacts arise during the use phase of the product. For these products, a correct information and guidance from retailers to consumers is crucial.

However, retailers must often confront themselves with the problem of lack of information or confusing data from producers. This was for instance the case for the household appliances sector in the past, where data sheets were significantly different depending on the brand. To overcome this difficulty, the European manufacturers of large household appliances, represented by CECED, have set up a common standard structure for product information to help retailers to take full advantage of electronic communication and data processing. This standard structure includes for instance information on energy and water (for washing machines and dishwashers) consumption information, which are responsible of the main life cycle impacts [source: www.picertified.com, as retrieved 5 Dec. 2004].

Marketing promotion kit

In Japanese companies, sales and marketing departments increasingly make use of life cycle information. For example, at Fujitsu Co. the environmental department and sales & marketing department work together successfully in order life cycle information to be understood and accepted by consumers. Fujitsu, which emphasizes "environmental friendly consciousness" as their product competitiveness, calls attention of its clients by using life-cycle environmental information both in its sustainability report and in its product promotion kits. During sales promotion, EcoLeaf is used as one of persuasive tools to prove the sincere attitude of the company. Type III declarations prove its activities of evaluating eco-design and recycling. Promotion staffs favor life cycle information because it can provide quantitative data steadily. Though clear outcomes of using Eco-Leaf have not been yet identified, client's response seems fairly good.

The " π - standard" in the Household Appliance sector

The European manufacturers of large household appliances, represented by CECED, have agreed to use one



standardized structure for supplying product information electronically to retailers.

Provided information includes important life-cycle data, e.g. energy and water consumption for washing machines. Data refer both to the EU energy label and to more detailed information (e.g. in terms of kWh/l under different washing conditions), which is crucial for a correct product use and consequent minor life cycle impacts.

The standard covers both large and small household appliances. So far, π -certified manufacturers are Bosch Siemens Hausgeräte, Elco-Brandt S.A., Candy Elettrodomestici, Electrolux, Fagor, Gorenje, Liebherr, Merloni, Miele, New Pol, Teka, Whirlpool.

Type III

Product's quantitative environmental burden indicated on the label

EcoLeaf environmental label

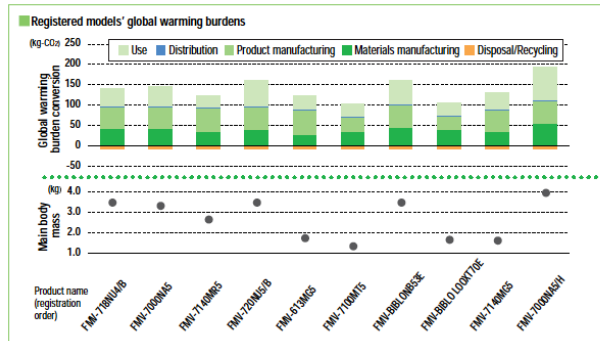
(Certified by Japan Environmental Management Association for Industry)
 In 2003, Fujitsu became Japan's first PC manufacturer to receive EcoLeaf environmental label certification. We are promoting expansion of certified products. (Label acquired for 10 notebook PC models as of March 2004.)



<http://www.jemai.or.jp/english/ecoleaf/index.cfm>

EcoLeaf environmental label receipt

The EcoLeaf environmental label is given to products that display their CO₂ emission volume and other effects on the environment quantified throughout their life cycle, from resources extraction and manufacture to distribution, use, disposal and recycling.



Source: FUJITSU GROUP 2004 Sustainability Report

Figure 5.2: Series of notebook computer CO₂ emissions, EcoLeaf in marketing promotion at Fujitsu.

5.7 Communication to other stakeholders

Environmental and sustainability reports

Life cycle information is increasingly being included in environmental and/or sustainability reports. These are communication documents meant for precise private and/or public stakeholders. Apart from the already mentioned Japanese examples of Fujitsu and Panasonic, there are several other global players doing so.

For instance, in the packaging and chemical sectors, world leader companies such as Henkel, Johnson & Johnson, Procter & Gamble and Unilever all report LCA activities or other life cycle information in their sustainability reports. For instance the P&G sustainability report 2004 mentions the development and use of state-of-the-art science and product LCA for the assessment of P&G environmental technology and monitoring progress towards environmental goals. The report also describes the company's forest resource policy, including the purchase only from suppliers who demonstrate (e.g. by third-party certification) forestry practices and sourcing commitments consistent with the principles of sustainable forestry.

Life cycle costs avoided at Johnson & Johnson

Johnson & Johnson tracks the life cycle costs avoided as a result of projects implemented by facilities to meet the Next Generation Goals. Total life cycle costs include the costs of purchasing, transporting, storing, treating and disposing of materials. By tracking both annual cost reductions and cumulative savings from prior years, Johnson & Johnson has built a strong business case for its environmental goals and programs.

CATEGORIES	ENVIRONMENTAL COST (MILLION \$)	COST AVOIDANCE (MILLION \$)
Water	26.3	0.05
Wastewater Management	12.6	0.2
Airborne NPO Management	21.9	11.8
Non-hazardous NPO Management	14.2	15.7
Toxic NPO Management	0.4	1.4
Air Emission Management	4.6	0.05
Management Systems	1.7	0.04
Regulatory Compliance	4.9	0
Governance	2.0	0
Construction	4.2	0
Landfill	6.3	0.04
Equipment	13.6	0.2
TOTAL	\$112.7	\$29.3

Category	Cost (Million \$)
Raw Materials	~ 64.9
Packaging	~ 25.4
Energy	~ 11.9
Water	~ 1.9
TOTAL	~ \$104.1

Capital for Environmental Equipment: \$41.4

*From implementation of NCG Projects

[Source: J&J sustainability report 2003]

Another example is given by Johnson & Johnson, which reports on the life cycle approach taken to evaluate environmental issues associated with their products [source: J&J sustainability report 2002]. In the 2003 report, the company shows a strong business case, by indicating the life cycle costs avoided taking into account the savings associated with avoided purchasing, transporting, storing, treating and disposing of materials (see box). For 2003, total cost savings from avoidance and cost reduction projects exceeded \$155 million. Moreover, in another report "Healthy People, Healthy Planet", the company describes in a detailed manner the used tool of Design for Environment (DfE) based on a life cycle approach and LCA [source: Healthy People, Healthy Planet Explorer, Issue two, August 2002]. Although the report is primarily meant to be published by J&J

Worldwide Environmental Affairs for the employees, it is fully available for other stakeholders on the corporate website.

Information brochures

Industry also uses targeted information brochures to adequately inform selected target groups. This is particularly the case when an adequate space is needed in order to both deliver life cycle data and adequately explain the concept, which is behind the data gathering. For instance, at Unilever there is a major concern about the fact that most of the potential impact from its products (detergents) is outside its direct control – i.e. when raw materials are produced and, above all, when consumers use and dispose of our products. There is also concern that ISO-type I labels mostly concentrate on the production phase, but do not adequately provides guidance to users on best use of products. Moreover, ISO-type I labels concentrate on products (i.e. respectively detergents and washing-machines) and not on functions (i.e. washing).

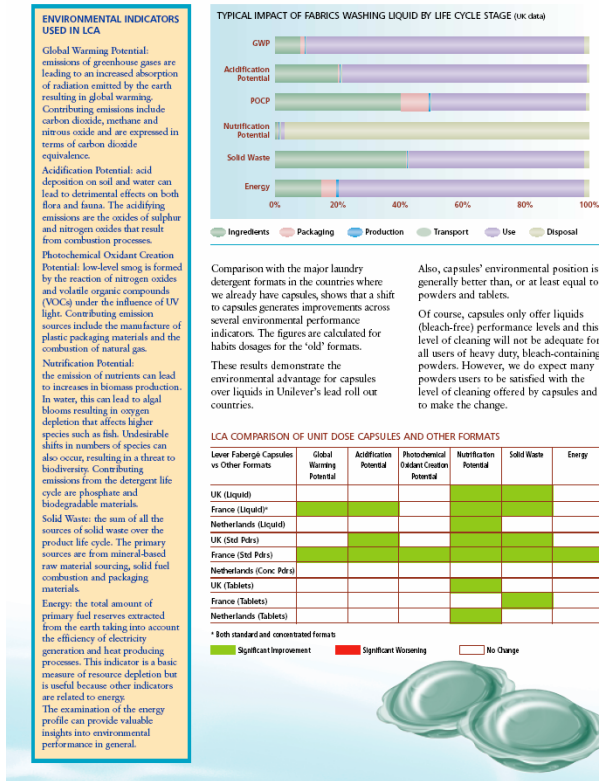


Figure 5.2: Product life cycle information in a brochure of Unilever

On the contrary it is recognized that "... the strongest sustainability advances happen when there is a good synergy between product benefits and evolving consumer habits. Finding that synergy - and maximizing it - is what we in the industry increasingly need to strive for." In order to contribute to this consumer behavior change, Unilever has produced a series of information brochures meant to explain life cycle impacts of detergents to stakeholders (consumers, collective clients, but also policy-makers). Even more importantly, the brochures show the environmental improvements over the life cycle, which can be obtained through the introduction of innovative products (e.g. tablets and/or unit dose liquids) instead of conventional powder or liquid products (see Figure 5.2). Results of LCA studies are explicitly shown. The meaning of the different environmental impact indicators is also included, for a better understanding of results and achievable improvements.

Green Public Procurement (GPP)

A variety of communication tools are used by industry and business to inform public administrators who are responsible for green public procurement.

Table 5. summarizes the different EPI tools used to communicate to different local administration authorities in Japan.

Local authorities	Total	Eco-Mark (ISO-I)	Energy star	FSC	Eco-Leaf (ISO-III)
Prefecture	56	55	52	7	4
	100%	98.2%	92.9%	12.5%	7.1%
Municipality -ward & city	449	441	247	11	20
	100%	98.2%	55.0%	2.4%	4.5%
Town & village in the prefecture	917	846	161	5	39
	100%	92.3%	17.6%	0.5%	4.3%
Total	1422	1342	460	23	63
	100%	94.4%	32.3%	1.6%	4.4%

Table 5.6: Different environmental product information schemes used for GPP by Japanese public authorities (Source: Resource: Japanese Ministry of Environment, 2003 Report of Green procurement).

GPP can function as an important driver, as shown by the Danish case. In fact, the public sector in a country has a significant buying power indeed, and by setting up product requirements it can drive environmental innovation of companies in another way than by imposing legislation. The Danish Environmental Protection Act from 1992 charges public authorities to fulfill the purpose of the law, also through their purchase and consumption of products. In 1994 an action plan for a sustainable public procurement policy was published looking at eight important product groups.


About one year later, in 1995, the plan was followed up by a circular stating that all governmental institution in the purchasing process of goods and services have to include environmental

aspects at the same level as for example price and quality. In 1998 the local authorities voluntarily joined an agreement where green procurement policies should be implemented also in the counties and municipalities by the end of 2001.

GPP and environmental purchasing guidelines in Denmark

Setting up environmental requirements in relation to purchasing products – either by invitation to tender or in a “normal” purchasing situation – requires knowledge. Hence, the Danish EPA during the last many years has provided the purchasers with environmental purchasing guidelines based on life cycle thinking. Today there are guidelines for about 50 product groups and they are currently being updated. A guideline is typically a 4-page document, but for those who do not want to go into more specific requirements a simple checklist is included. For each of these guidelines, however, there is also a background report describing the life cycle of the product going into more details.

All guidelines and background documents are available for free (in Danish) at the Internet, which means that both public and private purchasers can use them to set up life cycle requirements to their suppliers in an easy way.



Of course, in order to implement GPP, public authorities do need proper information on products. Therefore, the Danish EPA has provided the purchasers with environmental purchasing guidelines based on life cycle thinking during the last many years. Today guidelines for about 50 product groups are available and they are currently being updated (see box). All guidelines and background documents are available for free (in Danish) on the Internet for both public and private purchasers.

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Appendix: A case study of Life Cycle Management at ABB

ABB is a global leader in power and automation technologies that enable utility and industry to improve their performance while lowering environmental impact. ABB has approximately 105,000 employees in more than 100 countries. Sustainable development is integral to all aspects of ABB's business. It involves working in three dimensions: environmental, economic and social.

ABB's Life Cycle Management program formally started after signing the International Chamber of Commerce' Business Charter for Sustainable Development in 1991. The first phase of the ongoing program, completed in 1994, included establishing an environmental organization and a general environmental strategy, as well as completing an initial review of ABB's overall environmental performance through environmental audits of ABB manufacturing processes in about 500 facilities in 35 countries. ABB also started to develop LCA, (Life Cycle Assessment) into an operational tool in cooperation with leading scientific organizations and other industries.

The second phase, beginning in 1994, was the full-scale, group wide implementation of site-specific, formal environmental management systems (according to ISO 14001 standard) at ABB's manufacturing and service sites. After a few rounds of the PDCA (plan-do-check-act) system the company fully understood the need for a wider perspective in environmental management and LCA application was identified as a key tool for the product development. For this reason, a tailored LCA software tool and guidelines for environmentally conscious design were introduced in ABB's product development departments on a global basis along with education and training programs. During this period of time a massive number of LCA studies were carried out refining day by day the approach of the company towards the methodology and hundreds of persons participated in LCA related education programs. Thanks to this efforts life cycle thinking considerably grew within the company during that years. At the end of 1999, ABB came close to implementing Environmental Management System at 96% of all its sites, worldwide, corresponding to more than 500 units.

The work in phase two was mainly focused on internal processes and especially on manufacturing and product development. Environmental specialists and product managers, in order to understand and improve the potential environmental impacts of products, experienced the LCA tools. This work led to a significant environmental improvement of some new products series. In other cases, the extension of the environmental management system to the product life cycle with a simple integration of the LCA technique in the EMS system led to serious uncertainty about the efficacy of the results. The environment is a complex matter, where several parameters have to be evaluated. Multi-criteria analyses have to be carried out and in many cases these lead to serious interpretation troubles. The company faced the environmental priorities definition issues, discovering that in most of the cases there is no way to satisfy worldwide needs. The reason is that a global company sells the same products all over the world while each part of the planet has different environmental emergencies. This consideration caused the doubling of the goals of LCA studies now covering both the Design for Environment and the Environmental Labeling purpose. This doubling aims to drive the evolution of the products environmental performance by means of the market preferences. At this time the ABB's Life Cycle Management program, after the definition of the organizational framework, the system management procedures, the LCA technique and tools, is facing the challenges of communication. The overcoming of the actual gap on communication of product environmental information is a need in order to proceed towards a really sustainable production.

In order to cope with the new scope the marketing must be involved in the process. A key activity started, in 1999, for implementing a "marketing tool" (Environmental Product Declaration – EPD) aimed to communicate product related information to customers and other stakeholders.

This puts an even sharper focus on the environmental performance of the product over its life cycle. In order to support this development the environmental organization was broadened by the appointment of Business Area Sustainability Controllers with the responsibility for sustainability issues and the products' performance. This includes identifying market requirements, setting up product specifications, goals and programs and to develop environmental product declarations. The scope of EPDs for which development ABB is strongly committed (ABB participates to EU LIFE Project – INTEND aiming to establish an International EPD scheme) is:

- Provide customers with objective, credible and third party verified LCA based data of ABB products
- Enable ABB designers to assess and improve the environmental performance of a product
- Facilitate the comparison of the environmental performance of alternative products

Today, more than 60 environmental product declarations have been made for ABB's products, and more will come. Thirteen of these have been certified according to the system managed by the Swedish Environmental Management Council.

At the same time, on the product development front the implementation of environmental considerations in ABB's GATE model has been started. The GATE model, today implemented in all ABB's business areas, is an approach aimed at ensuring that product development projects are driven by business objectives and executed with full management commitment and in a professional way. During year 2001, ABB implemented environmental considerations in the GATE model. This was a very big step forward, since within the whole of ABB, there is now one common approach in place that fully integrates environmental considerations in product development projects (ABB participates to EU LIFE Project – DAN TES aiming to Demonstrate and Assess New Tools for Environmental Sustainability).

The environmental considerations in the GATE model includes the following concrete actions:

1. Identify environmental aspects and requirements for which market feedback will be expected thanks to introduction of EPD tool.
2. Set environmental goals and establish an environmental plan.
3. Communicate the environmental plan and execute actions in the project according to the environmental plan.
4. Follow up whether the environmental plan was met and document experiences for coming projects.

In 2000, the ABB's sustainability organization started also to manage the social area of sustainability aiming to integrate the social issues within the developed framework. A lot of work is ongoing investigating the social impact of ABB's operations in society; case studies were conducted in seven countries at sites where ABB is active. The first "triple bottom line" sustainability report, taking account of the Global Reporting Initiatives Guidelines, GRI, was produced in 2001 (GRI, 2000). Testing and breaking-in new management standard like SA8000 and identification of parameters more and more objectives and quantifiable are the main tasks actually under development at the global and local level.

How to involve stakeholders and at which level is another issue to be further explored. This is a transversal issue covering the whole sustainability matter faced in different ways. ABB uses the standard communication channels like the Annual Report according to GRI. ABB also participate to International Organization for Standardization works (TC 207 dealing with environment and since 2003 also with social issues) seen as one of the larger stakeholder roundtable of the world. In addition to these, ABB established the stakeholder Dialogues in order to define priorities related to

social issues and participates to the Open Consultation meetings aiming to establish relevant parameters and drivers for an environmentally sound product development within the EPD framework.

Even if many positive results can be identified from implementing the state of the art Life Cycle Management, there is a lot more to do. A major challenge is to accomplish the integration of sustainability considerations into ABB's strategic planning process and management control systems. An important part of this work is to improve the dialogue with the customers to explore different viewpoints and identify market requirements. Business area controllers and product managers will have a vital role in this process. The goal is to meet customer needs in new ways to deliver better performance.

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6. Stakeholder Relationship

Today, a comprehensive understanding of stakeholders' needs and demands are crucial for successful business operations – especially in the case of sustainable product chain management. The traditional orientation of corporate objectives is shifting from provision of sole financial value for shareholders to stipulation of benefits for a wider audience, i.e. stakeholders ranging from employees, customers to the local community.

As it is increasingly understood that stakeholder engagements affect intangible value creation with potential direct effects on the financial bottom line, then product chain responsibilities also gain more attention as in the case of corporate social responsibility. Development and management of a sustainability strategy along product chains in close cooperation with stakeholders can lead to product innovation, cost efficiency improvements, reputation gains (e.g. public acceptance), and so on. These value drivers will then positively affect financial factors (e.g. investor expectations, cost of capital, growth, product margins) improving shareholder value.

In support of these arguments, this section aims at answering three major questions:

- Who are relevant stakeholders along the life cycle of a product?
- Why is it important to involve stakeholders?
- How can stakeholder involvement be achieved?

6.1 Who are stakeholders?

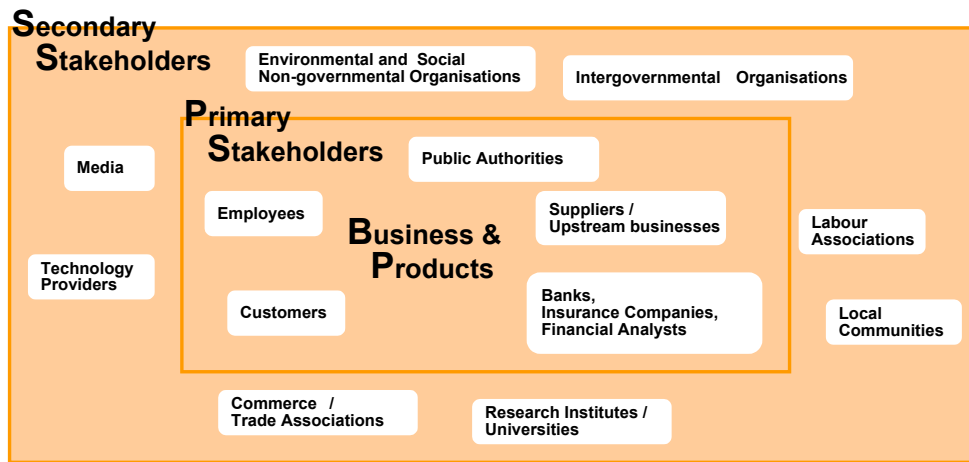
Organization needs increasingly to inquire; "Whom does my business affect? Who influences my business?" Stakeholders are any parties that have an interest ("stake") in a company or its products. Some examples of stakeholder groups are stockholders, employees, customers, suppliers, communities, competitors, financial institutions and NGOs. The stakeholder concept expands the responsibility for the effects of an organization's objectives and activities, including its marketed products.

Indeed, companies can basically be affected by, or can affect almost anyone. Hence, it can be expected that an organization will face a whole diversity of claims along its product chains. Yet, identification and engagement with each and every stakeholder might seem fairly demanding. Thus, it is necessary to anticipate the stakeholders' opinion on the business, the products and services and to assume what really matters to them.

Many researchers and consultants, who have put forward practical methodologies, recognize this challenge. Engaging with stakeholders, who address the latest sustainability challenges and extending the scope of the reach-out step-by-step is a welcomed approach. For example, the COMPASS methodology (for more information see <http://www.sustainability-compass.net>), which helps companies and sectors to manage their sustainability performance, suggests concentrating on the major stakeholders, whose demands are prominent. The tool suggests workshop like forums to elaborate on specific aspects and, if found necessary, extension of the stakeholder spectrum. At the end of the day, COMPASS enables small and large companies to better locate environmental performance improvement options along their product chains from sustainability and stakeholders' viewpoint. As an illustration, a multinational company to develop eco-efficiency indicators and to get an impression of their operating companies' global ecological footprint used COMPASS.

Another approach can be carrying out a categorization according to stakeholder attributes. Attributes or characteristics of stakeholders as variables that affect the product chain and stakeholder relationship would be an effective approach. Some hints for stakeholder characteristics can be listed as: identification as primary and secondary; as those existing in a voluntary or an involuntary relationship within the scope of the product chain; the ones affected from the resource use or impact created by the product and chain actors; those associated with the product chain regarding the environmental, social or economic aspects.

Figure 6.1 illustrates a map of stakeholders based on a differentiation of primary and secondary importance of stakeholders. Stakeholders interested in issues, which would directly influence the success of business and products, can be ranked as the primary ones. For example, public authorities have the obligation of following up the health and safety of your products and the capability to sanction, if they do not perform according to the legislation; or financial analysts question whether you manage economic, financial and social risks in the appropriate way prior to giving access to credits.



Source: Wuppertal Institute, 2004

Figure 6.1: Map of stakeholders that might be of primary and secondary importance to business and its products.

Complete identification of stakeholders is crucial for decision-making on the nature of engagement. An authority representing the stakeholder group should also be acknowledged. One challenge in this respect is that some stakeholders are not organized or do not have a "voice" or otherwise do not have the capability to engage (for instance "nature" or "future generations"). For some others, aggregation of interests might be required. For example, a "community" can potentially be made up of a number of other stakeholder groups including employees, customers, unions, pressure groups and environment.

In such instances, a systematic approach is considered to be valuable. Identification of authorities capable of presenting and discussing the concerns of interests groups should be located as an initial step. Afterwards, the roundtable of interest groups can be extended even addressing individuals.

Another important issue special to the case of stakeholders of global product chains is the physical distance between actors and the interested or affected parties. For example, stakeholders having interest in the activities of the upper part of the product chain located in the third world can actually be situated far from them, i.e. in the industrialized world. This is usually the case for the

high impact sectors such as mining. The global economies leading to these consequences also offer the remedy, as communication technologies allow connections between third and first world stakeholders such as environmental non-governmental information platforms, and international alliances between NGO's.

In the context of global product chains, several issues have to be discussed and delimitations have to be made regarding: Who of the identified stakeholders is important? What kind of legitimate and illegitimate interests do they have? Can all stakeholders be treated equally in terms of their importance to product chain activities? Should also the stakeholders related to the outsourced activities be taken into account? These questions are important in order to define the boundaries for product chain responsibilities, and for how the communication schemes are built up.

Indeed, it can be discussed whether there is a relationship between the degree of responsibility and the number of stakeholders. It can be assumed that there may not necessarily be a direct relationship. Extending the responsibility of a new product can be of interest for only a certain stakeholder, however it may be reckoned to be a considerable point for one and of less interest for others, who prioritize their values differently. An example is the assessment of new technologies, where societies may hold limited information and governments can be a rather forefront partner for discussion. Hence, discussion of intangible value creation for the society comes into the picture. This fact also points at the social, political and economic power of stakeholders as an important attribute.

The major issue in stakeholder identification is following a systematic plan in collecting interests and locating the authorities, which are capable of communicating and discussing major sustainability concerns. It should be assumed that this is not a one-time task, but rather an on-going learning process.

6.2 Why to involve with stakeholders?

For identifying risks and opportunities for "sustainable development"

Due to factors of globalization and the new economy, product chains have become long and international. Not only the product chains are getting global, but also the concern about sustainability. A diverse range of stakeholders from non-governmental organizations to financial institutions located around the world, in addition to local institutions, can be questioning the responsibilities of actors along the product life cycle (For example see www.EUintangibles.net). In addition, demands may have different weight of importance in different contexts. Priorities simply vary from one individual to another, from one community to another, from one country to another, from one culture to another, from one economic entity to another.

Hence, corporations should, and many do, consider stakeholder demands beyond their production gates. In order to gain competitive advantages, corporations are engaging in structured stakeholder dialogues. These processes allow them to attain critical strategic information, resources and problem-solving capabilities not currently available in the firm.

For the identification of areas of opportunity and risk for sustainable development along the life cycle of products, scientific methods are available or evolving. Besides methodologies based on the collection and evaluation of information such as life cycle assessments, approaches based on identification of major stakeholders and consultations concerning their priorities are effective action oriented methods. In this regard, companies would not only be enhancing their intellectual capital, but also mobilizing a discussion platform for disputable matters. All in all, acquirement of

stakeholder views can be an effective way of identifying major sustainability responsibilities of the actors along a product chain.

Stakeholder engagement – how does it help to identify priorities for sustainable development? A case example from the – European Aluminium Industry (EIA):

Stakeholder engagement can often be seen as an eye-opener and a learning experience. A gap might often exist between a company's internal perceptions and external stakeholder perceptions of sustainability aspects. European Aluminium Industry (EAI) recognized this gap, while conducting a project with the aim of identifying priority sustainability issues in the aluminum sector within the context of the European and the international debate. The aim of this project, "Towards a Sustainable Aluminium Industry", which has been carried out by the Sustainable Production and Consumption Team of the Wuppertal Institute on behalf of the GDA (Gesamtverband der Aluminiumindustrie) and the European Aluminum Association (EAA), is to develop sustainability indicators for the sector. For this purpose, a desk-based agenda review and stakeholder survey was done. Both internal stakeholders such as aluminum producing companies with global product chains and external stakeholder such as policy-makers, multi-stakeholder initiatives, financial institutions, business and NGOs, were contacted were involved in the survey. Participants were asked to evaluate sustainability categories and aspects pre-identified by the agenda review and to pinpoint additional categories and aspects. The survey showed that external stakeholders ranked responsibilities for social aspects, especially child labor and forced labor, along the life cycle higher than the industry itself (See Figure 6.2). Stakeholder discussion processes (roundtables and workshops) are still going on for the finalization of indicator sets.

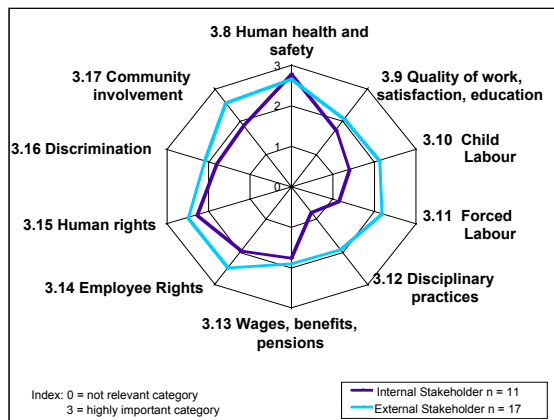


Figure 6.2: Spider diagram illustration of the gap in terms of internal and external stakeholder expectations for social aspects in the European Aluminium Industry product chains (For more information visit <http://www.eco-efficiency.de/download/SustainAlu.pdf>).

For identifying product innovation options and assessing their feasibility

Identification of priority areas for sustainability improvements (in other words risks and opportunities) along product chains is followed up by development of options for improvement and selection of the most feasible ones. Collaborating with stakeholders can be considered as an effective business strategy for harnessing external knowledge and resources, when both developing options and assessing their feasibility.

Options generation in the identified opportunity areas along the life cycle can range from on-site process related improvements to product-chain or system wide design improvements. While on-site process improvements addressing a single life-cycle phase concern good housekeeping measures, optimization of production techniques and on-site reuse and recycling, then product design related options include optimization of end-of-life system, use of low impact materials and reduction of materials usage. On the other hand, system-wide innovations are about new concept

developments, which will lead to radical social innovations or environmental improvements in the scale of Factor 10.

The more ambitious the product innovations are, the more stakeholder engagements are required. This is due to the fact that innovations require capabilities for having access to new ideas and information and ability to work collaboratively with others. Innovations are developed in complex processes with participation of different actors and often distributed in time and space. Due to this complexity, firms do never innovate in isolation.

Hence, collaborations and partnerships with stakeholders for sustainability improvement in the product chain are actually becoming more and more common. For example, Supplier Partnerships for the Environment (SP) among automobile original equipment manufacturers brings value to their members by providing a forum for small, mid-sized and large automotive and vehicle suppliers to work together, learn from each other, and share environmental best practices through task forces and work groups to study specific issues such as energy use optimization.

All in all, for long-term value creation

In general, stakeholder responsiveness and engagement along a products life cycle contributes to shareholder value creation through various pathways (see Figure 6.3).

Firstly, stakeholder interests directly affect the tangible and intangible value drivers for business processes. Stakeholders can increase or decrease the cost and speed of access to resources. Corporations, which are responsive to stakeholder demands and put management systems in place to answer these demands, are capable of using financial, environmental and human resources more effectively. Hence, this proactive approach leads to intangible value creation, which adds at the end of the day to the financial performance. For example, encouragement of sustainable supply chain practices enhances consumer trust and motivation for quality products. In this sense, stakeholders are acting as gatekeepers.

In this respect, responding to stakeholder demands by identification of sustainability risks and opportunities, development and implementation of improvement options with stakeholders' engagement, and finally, communication of performance to interest groups triggers intangible value drivers. Then, these intangible value drivers help creation of tangible value contributing to the financial bottom line (see Figure 6.3). For example, improving a good reputation can be counted among value drivers. Companies recognize that their reputation depends on developing credible relationships with their employees, customers, nearby residents and suppliers. This is especially true in a networked world where everything about a company can be known globally and almost instantly. Credibility and a good reputation is a major factor for success. Increased brand reputation contributes directly to an increase in product sales, which is regarded as a positive contribution to the financial performance of a company by the shareholders.

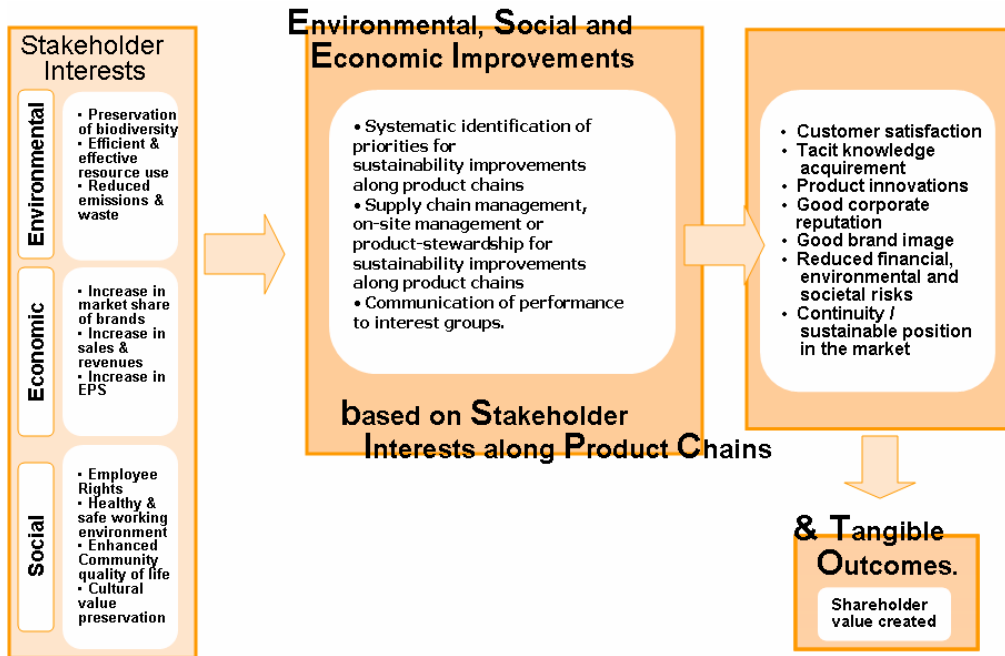


Figure 6.3: Illustration of the relationship between addressing of stakeholder interests through environmental, social and economic improvements along product chains and tangible value creation for businesses.

Consequently, companies do have high degree of interest to track demands from and concerns of their stakeholders and actively to involve them in improvements in the product life cycle, as derivation of tangible value is apparent.

6.3 How to be involved with stakeholders?

Common routes for stakeholder involvement

Stakeholder involvement can take many forms based on the nature of the dialogue and communication. These forms can be listed in the order of increasing degree of involvement as follows:

- *Deficient provision of information* – attaining compliance information usually limited to legal restrictions;
- *Unilateral communication* – delivering information in one direction without any feedback;
- *Bilateral communication* – exchanging information and experiences bilaterally;
- *Ongoing consultation* – developing an interactive dialogue with stakeholder groups to realize a common goal;
- *Collaboration* – creation of an ongoing dialogue with direct involvement of stakeholders in participatory decision-making. (adapted from Kuhndt et al. 2004, p. 24)

Deficient communication is carried out to minimize potential liabilities affecting short-term business gains. In this case, avoiding harm and reducing risks in three dimensions of sustainable development lies in the core of the strategy. Hence, regulatory changes are tracked, while public agencies and financial institutions seem to be the most important stakeholders. Deficient communication surely does not allow grabbing hold of possible sustainability improvement

opportunities, hence innovation. An example is to have a regulatory compliance management scheme for suppliers in place.

Unilateral communication can be utilized for disclosing product sustainability performance. This case can especially be observed in the multinational corporations' sustainability reports, in which product specific information is expanding. For example, Sony and BASF report on eco-efficiency analysis methods that they use for product improvement. Reporting targeted at a broad spectrum of audiences is usually seen as a means of enhancing social and environmental reputation. On the other hand, Type I, II and III product labels can be mentioned under this category of communication. For example, labels of organic agriculture certification schemes or energy efficiency labels aim at delivering information on supply chain performance indicating at competitive advantage of products. Labels provide the ability to develop customer satisfaction, quality recognition, in many instances, loyalty; thus brand value.

Bilateral communication can take diverse forms ranging from receipt of responses to corporate reporting, involvement in stakeholder discussion platforms, conferences or workgroups, and so on. However, there are no commonly accepted standard forms. Global Reporting Initiative's multi-stakeholder working groups on various sectors can be given as an example. These forums allow corporations to discuss their business processes, expand their networks and to receive occasionally new information on sustainability improvements for taking home.

Ongoing consultations are typically partnerships and many forms of involvement fall into this category. Partnerships (also including alliances and networks) are established to attain sustainability performance improvements of products greater than would be achieved working together in the absence of partnership. While the degree of commitments and stakeholder groups involved may differ, one common attribute is set up of clear goals.

The duration of NGO partnerships might differ based on their objectives. They can be established to coordinate selected supply chain activities, with short-term relationship and limited scope such as the case of micro-enterprise programme of Nike run by the China Poverty Alleviation and Mercy Cops or Verde Ventures micro-finance fund of Conservation International, which is capitalized by Starbucks. Another example can be McDonalds' collaboration with an environmental NGO to develop more efficient and more publicly acceptable packaging waste strategy. There can also be engagements, where a broader range of selected activities are integrated over a longer time frame. The engagement of RMC Group with the international conservation organization Birdlife International, which aims at creating a series of national and local partnerships between the members of each organization for environmental improvements, constitutes an example for this case. Another form can be commitments to a significant level of operational integration, with no anticipated end date. For example, the Clean Cargo Group, including HP, Home Depot, IKEA, Mattel and other shippers joined by ocean freight carriers aim at sustainable product transportation. This group working in collaboration with Business for Social Responsibility (BSR) developed voluntary specification and guidelines to evaluate environmental performance of their fleets and carriers. The Marine Stewardship Council (MSC) set up by Unilever in partnership together with WWF can be mentioned as yet another case.

Public-private partnerships are as well becoming common. Majority of the budgets of regulatory agencies are still devoted to enforcement, while there is continuous interest in more innovative, voluntary programmes that seek alternative approaches for achieving product environmental goals in a more flexible manner.

Despite the benefits of ongoing consultations are clear in terms of unleashed intangible values and tangible values, they can simultaneously be severely criticized for having a green-wash face.

Enhanced brand reputation, competitive advantage gained or savings can be simply wasted. This result might stem from the fact that it is in many cases still not clear how businesses identify their sustainability priorities prior to engaging with stakeholders. In order not to run into this danger businesses should locate their priorities also based on stakeholder interests.

The ultimate form of involvement, namely *collaboration*, indicates the highest level of stakeholder engagement in participatory decision-making. However, this form of engagement seems quite hard to establish as it requires high level of social capital i.e. trust, mutual understanding and shared values. In this way, the members of a network can be strongly bonded and cooperative action can be possible. For example, the KF food retailer chain in Sweden is governed by consumer cooperatives (for further information see www.anglamark.com). This type of governance structure gives consumers to be directly involved with product development decisions.

Corporate level involvement versus sector level involvement

In addition involvement with stakeholders at the discrete company level, sector level engagements are recognized as a common form. These are usually voluntary commitments to work with stakeholders in order to address most difficult issues in the industries.

The benefits of initiatives that are managed beyond a single company level by sector level associations or group of companies can be multiple. First of all, interacting with stakeholders to come to an understanding with society about how to address the challenges can be too big to handle individually, while a collective approach can be much more cost effective. On the other hand, each sector usually covers one or several stages of a product chain. Hence, sectoral overviews are useful for clarifying how sustainability aspects are linked and what responsibilities businesses have along the product chain. Furthermore, sector leaders are trendsetters for laggards. Forerunners can illustrate the gains of stakeholder involvement in sector-wide forums and can possibly drag the sector towards higher sustainability performance.

Various industries will derive different business benefits from stakeholder relationships. For example, companies involved in natural resource extraction (e.g. mining, forestry) have significant impacts on the environment and therefore must work especially hard at maintaining environmental and social license to operate. They must pay more attention to their relationships with environmental non-governmental organizations (ENGOs) and regulators. Companies, which belong to the information and communications sector, might have different preoccupations such as ensuring access to highly trained and motivated workers, whilst often facing more demands for improving social aspects such as decreasing the digital divide.

Stakeholder involvements at the sector level are usually in the form of occasional involvements often aiming at reaching an agreement between the industry and various stakeholders on the priority issues to be addressed. For example, the pulp and paper project of the World Business Council for Sustainable Development (WBCSD) assesses the role the paper industry worldwide, focusing on the entire cycle from fiber production to pulp and paper production, paper usage, recycling, energy recovery and final disposal (WBCSD 2003, p. 6). Similarly, the Cement Industry Initiative (CSI) under the auspices of the WBCSD has pulled together the industry to develop a common reporting framework. At present a total of 13 companies that account for one third of total global production, collectively operating nearly every country in the world, are reporting within a common framework. The initiative has identified a range of issues to be addressed including climate protection, fuels and raw materials, employee health and safety, emissions reduction, local impacts, internal business processes and engagement of other producers within the sector. The first five years progress reports are due 2007. The previously mentioned project of the European Aluminium Industry, entitled "Towards a Sustainable Aluminium Industry" (See Box 1), aiming at developing core sustainability indicators via a stakeholder discussion process and

acquiring feedback on the core indicator set. Following, the European Aluminium Industry aims at developing a sector-wide report. Besides the final list of sustainability indicators, such reporting will require collection of detailed data along the product chain and aggregation of data sourced from the production sites and company level.

Regional partnerships are also common at the sector level. For example the Mining, Minerals and Sustainable Development Project had the objective of gathering regional expertise in particular regions such as South America, Russia, China and Europe.

There are also large scales initiatives such as the Responsible Care scheme. This is a worldwide chemical industry initiative concerned with continuous performance-improvement at national and global level. While the industry seeks to interact with stakeholders through National Advisory Panel or the Community Advisory Panels in order to identify its priorities of action, the effectiveness of these instruments is in question. Either due to the difficulties of managing a large-scale initiative or due to the prevailing aim of maintaining a favorable image in the society, structured outcomes is rarely observed. Hence, concrete and verifiable methodologies, tools, metrics and targets are important for success of sector initiatives, while initiatives without documentation can be labeled as window dressing activities.

While sector approaches are considered to be favorable opportunities for locating priority areas along product chains, most product chain issues actually call for cross-sector efforts. Functional¹¹ approach is one creative option for covering cross-cutting issues. For example, Sustainable Mobility project has the vision of meeting the needs of society in moving freely and gaining access. It is introduced as a partnership between the auto, oil and supplier industries. Hence, addressing human needs rather than focusing on sector impacts automatically encourages product chain-wide sustainability improvement efforts, even system innovations.

Engagement of small companies versus that of larger ones

The business case for stakeholder engagement along product chains of small and medium sized enterprises (SMEs) can be quite different compared to the case of multinational corporations. SMEs function with limited resources, hence their working time, financial, technical and human resources are restricted. Small sized enterprises might often produce locally; however many of them have already become parts of global product chains such as suppliers of textile products in Asia working with large-scale retailers.

The benefits of stakeholder engagement for product sustainability improvements can be purely financial while others may deal with customer and employee satisfaction. A systematic approach to address current and potential risks will help them to save time and money in the short and long term. Costs savings and improvements in product quality can be achieved, if stakeholders along the chain such as suppliers, customers, and neighborhood community are involved starting from the product design stage or purchasing decisions. In this vein, intangible value can also be created, which will return as financial gains. For example, being a part of a global supply chain, a small business can gain the loyalty of its customers by communicating or reporting its efforts to improve environmental and social performance of its products.

¹¹ Functional thinking, also supported by the UNEP, takes the focus from provision of resource intensive product to satisfaction of needs and wants through service systems, where material products are treated as capital assets rather than consumables. An application of functional thinking is the Product Service System (PSS) concept. Providers of PSS applications aim to generate profit not from selling as many material products as possible, but from providing a function of the product or service. Applications of PSS can be seen in many sectors such as Information and Communication Technology (ICT), energy, transportation, food and in many forms such as remanufacturing, demand side management, chemical management services, car sharing schemes, functional designs, etc.

Small businesses are in need of practical tools and methodologies to realize these benefits. Methodologies with time consuming calculations and complicated language would not be helpful for SMEs to take action. Some practical methodologies in this regard can be counted as the Environmental Management Navigator toolbox including tools such as the Life Cycle Design, Life Cycle Assessment, Green Supply Chain Management, Environmental Performance Evaluation and Corporate Environmental Reporting (for more information see <http://www.em-navigator.net/>).

Bovince Limited, as small printing company located in the UK, is a good example of how SMEs can work closely with its internal and external stakeholders to improve sustainability performance of their products. Bovince Limited works externally with its suppliers, universities, NGO's and governments to progress "Bovince Tree of Sustainability", which has nine branches including six environmental branches for long-term strategic improvements. Internally, they use management meetings to develop their sustainability-related programmes and work with their staff to ensure understanding of their long-term strategies for their products and business. They benefit from these activities by developing an understanding of their impacts and how to adjust these to save costs.

Steinschalerhof Hotel is another illustration how stakeholder engagement can be utilized for product development. The owners invited a diverse range of stakeholders i.e. suppliers, farmers, local politicians, employees and representatives of tourist organisations to an evening dialogue on sustainability. At this round, they have heard about the concerns of their stakeholders. Building up on these, they have developed a report to communicate the measure they take towards achieving sustainability of their services and products. This has helped them to pass the message about their unique selling point. This communication also encouraged regional stakeholders to cooperate with them in reaching their vision of a sustainable hotel.

Source: GRI/triple innova/Wuppertal Institute (2004). High 5! Communicating your Business Success through Sustainability Reporting, A Guide for Small and Not-So-Small Businesses. p. 35 and p. 37. Online at: <http://www.globalreporting.org/workgroup/sme/intro.asp>

To sum up, businesses, regardless of their sizes, will continue to face a whole diversity of risks and opportunities along their product chains. Development and management of a sustainability strategy along product chains in close cooperation with stakeholders can lead to many financial (e.g. cost efficiency) and intangible benefits (e.g. product innovation, reputation gains) for businesses.

Further readings

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7. Economic Aspects in Life Cycle Management

7.1 From economic considerations to Life Cycle Costing

In the context of LCM, *cost management*¹² plays a crucial role. Therefore, profitability has to be taken into account as a central element of LCM [Hunkeler and Rebitzer 2003]. Environmental considerations, on the other hand, are often viewed as obstacles to business development, particularly in the very short term. This is where, within the sustainability framework, the concept of *life cycle costing (LCC)* emerges. *LCC* is an essential link for connecting environmental concerns with core business strategies [Hunkeler et al. 2004]. Synergies between the environmental and economic considerations have to be utilized in order to move towards sustainable development [Dyllick and Hockerts 2002; Hunkeler and Rebitzer 2003]. It is of utmost importance to assess the (potential) future consequences of decisions if more sustainable products and processes and thus more sustainable business practices are the goal. For instance, it is well known that *costs* and revenues [Ehrlenspiel 1985] as well as the environmental impacts of products [Keoleian 1996] are determined to a high percentage in the design phase of products and processes and that already during this phase a long term view incorporating the full life cycle should be taken.

When addressing the economic pillar in LCM, conventional cost accounting (*management accounting, financial accounting*) and *cost management* are not or only partly suited to assess *costs* and revenues over the life cycle of a product, since they do not have the specific systems and product perspective of LCM. Therefore, methods are necessary that can integrate and link existing financial data and specifically *cost* information with environmental metrics in life cycle approaches.

In short, *LCC*, with its systems approach, is a means to integrate the life cycle perspective into the costing view, e.g. by considering use and end-of-life costs in addition to the production costs/product price. Also, *LCC* can be used to move the environment from an indirect *cost* in the environment, health, and safety (EHS) units of the actors in the value chain to considerations as a direct, manufacturing, and liability issue, and, under appropriate conditions, an asset [Hunkeler and Rebitzer 2003].

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7.2 The scope and definition of LCC in LCM

It is important to note that the systems approach in *LCC* and the addressed life cycle resembles the physical life cycle as in LCA (see the definition of the life cycle in [ISO 14040]), which refers to the actual life cycle of a unit of product and thus to the functional unit [Rebitzer 2004]. This life cycle must not be confused with the marketing and sales life cycle of products (see Levitt (1965)), which looks at the establishment of a product on the market (introduction, growth phase, stabilization, phasing out) and focuses on the revenues and benefits of the number of units sold.

Based on recent developments [Rebitzer and Hunkeler 2003] one can define *LCC* in LCM as “an assessment of all costs associated with the life cycle of a product that are directly covered by any one or more of the actors in the product life cycle (supplier, producer, user/consumer, EOL-actor), with complimentary inclusion of externalities that are anticipated to be internalized in the decision-relevant future” (modified on the basis of the definition of [Blanchard and Fabrycky 1998]). In the context of LCM, *LCC* evaluates the economic feasibility of an option and relates it to environmental and social performance. In other words, if several options for managing the life cycle of a product are compared and one option is preferable due to environmental and social benefits, this option

¹² Terms written in italics are defined in the glossary

cannot be unsustainable in the economic sense, as long as someone in the economy produces and markets the product with success. This also implies that *life cycle costing*, without additional assessments, cannot serve as a sole indicator for good (sustainable) LCM practice, unless there is a validated correlation of low *life cycle costs* to low environmental and social impacts for specific products or product groups [Rebitzer and Hunkeler 2003] (for related arguments see also [Dyllick and Hockerts 2002]).

The preceding definition, therefore, defines *LCC* within LCM as a method that accounts for only those externalities, above a threshold (i.e., they are significant to the decision), that are anticipated to become internal costs. In simple words, *LCC* in LCM covers 'real-world' money flows that are associated with the life cycle of a product. These flows can occur in the past, present, or future, depending of the goal and scope of the *LCC* analysis.

The economic pillar of LCM often has a comparative nature, which means that only those *costs*, which differ between alternatives, are taken into account [Rebitzer 2004]. Therefore, comparisons and *cost* differences are frequently in the focus, rather than absolute and detailed costs figures. *LCC* does not resemble a *financial accounting* method, but a tool for *cost management* or *management accounting* along the life cycle. On the other hand, *LCC* can also be one component in *environmental management accounting*, when the product perspective is addressed [Bennett and James 1998].

There is also the concept of Total Cost of Ownership (TCO), which can be seen as a specific case of *Life Cycle Costing*, where the assessment takes the perspective of the product user/consumer (for a discussion of the perspective in *LCC* see [Rebitzer and Hunkeler 2003]).

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7.3 LCC applications

Overview of existing methodological approaches

In order to obtain an overview of *LCC* applications, goals and scopes, targeted audiences, and employed methods for *life cycle costing*, the SETAC Life Cycle Costing Working Group (WG) surveyed studies in 2004. All in all, more than 30 studies from the U.S., South Africa, Japan, and Europe were analyzed. The examined case studies dated from 1984 to 2003, though the vast majority was carried out in the period 2000 to 2003.

Results of the survey showed that there are in principal three different types of *LCC* applications and methods [Ciroth 2004]:

- Type A: Pure LCC studies, concentrating on assessing (conventional) costs of a product that are directly covered by life cycle stakeholders, without any connections to environmental assessments;
- Type B: LCC studies including monetarized environmental effects of the investigated product (leading to an environmental life cycle impact assessment result expressed in monetary units); and
- Type C: LCC studies performed in conjunction with a non-monetarized assessment of the environmental impacts of the product, typically via an LCA, where the results of the LCA and the LCC are kept separate.

The majority of studies in the survey (83%) belong to the types A or C; studies with monetarized environmental effects (type B) were not frequent in the survey. Table 7.1 provides a summary of selected key issues¹³.

¹³ All in all, the survey form asked for about 40 different issues.

Within the toolbox of LCM, type A and C studies, respectively the underlying methodologies, can be used, though type C is probably the most relevant. Type B is less relevant in the context of LCM, since environmental effects are covered by other life cycle approaches outside the scope of the economic assessment.

Issue	Type A	Type B small sample size	Type C
Initial product costs per unit [€] (mean / median)	4.69E+07 / 5.05E+06	2.60E+06 / 82.9	1.48E+06 / 2000
Product life time [yrs.] (mean / median)	30 / 25	19 / 35	13 / 1.5
Shares of studies using prognosis techniques	46%	33%	29%
Use of long time data measurement / validation	23%	0%	0%

Table 7.1: Identified key issues per type of LCC study (excerpt) [Ciroth 2004; Giroth and James 2004]

Moreover, the survey revealed a very interesting 'toolbox problem'. Some approaches and tools are selected, or not selected, for reasons of knowledge and tradition rather than for questions of methodological issues. *LCC* studies of type A are performed with the aim to assess the overall *costs* related to an investment as complete and detailed as possible. These investment decisions usually have a long time horizon and high initial *costs* per unit of product (e.g. the purchasing of a commuter train). Hence these *LCC* studies tend to use sophisticated methods for modeling and validation of *cost* figures and they tend to explicitly consider time, which is needed for discounting and for addressing uncertainties of future *costs* and revenues. Type C studies, on the other hand, currently seem to have an 'environmental assessment background' rather than a *cost management* background. Thus the functional unit is described following the concept of a functional unit as in ISO 14040, and typically, compared to type A, a smaller product unit is selected (1 m² floor instead of 'one building'). Detailed *cost* measurements and validation seem to have less priority, the focus is more on comparisons, and time is sometimes considered, sometimes not.

As a rule of thumb, *LCC* studies and methodologies of type C are most suitable for the integration of economic aspects in LCM. They stand the chance to consistently and efficiently address economic and environmental issues in LCM. Examples of such methodologies are presented by Bubeck (2002) and by Rebitzer et al. (2003), the latter basing the *LCC* on a life cycle inventory model of LCA. Type A approaches should be used if no information on environmental impacts is needed, while type C approaches target other applications than LCM such as cost-benefit analysis and are therefore not addressed in the scope of *LCC* within LCM (see Section 0).

7.4 LCC in resource-limited environmentally sensitive firms

EU defines small and medium sized enterprises (SMEs) as firms having less than 250 employees with a further restriction that less than one-quarter of the share capital is held by non-SMEs. This sector accounts for sixty percent of new jobs in Europe; a figure, which increases to seventy percent if one, examines High-Tech employment. The technology SME sub-sector typically includes firms with growth rates of 15% per annum based on new, quite evolutionary, products. Specifically, established High-Tech SMEs, who have survived the start-up phase, have a large risk in regards to environmental compliance since the *costs* associated with any inappropriate resource allocation decision may place the firm in jeopardy. The same is true of larger firms in emerging countries. The latter include the ten new members of the EU, as well as the Asian Tigers, South

Africa, Mexico, Chile, Argentina and Brazil. Therefore, technology based SMEs and larger firms in “emerging” regions can be categorized as resource-limited, due to their reduced access to credit, and environmentally sensitive, in that compliance with environmental norms may be a barrier to enter, or continue, in a given market. They, therefore, have a unique set of opportunities as well as disadvantages in regards to life cycle thinking relative to multinationals, which is concomitant with their higher risks. They can be characterized as follows:

- They have difficulty in complying with supply-chain related information, such as those demanded by multinationals who are certified to ISO 14001 or publish, generally bi-annual, corporate environmental balances or sustainability reports.
- Given the nature that they are often creating new infrastructure, they frequently have the opportunity to design environmental aspects into new sites.
- They are faster to respond to win-win economic and environmental opportunities than larger firms given reduced management infrastructure and more polyvalent employees with decision powers.
- Due to their lack of long-term contracts, they are more flexible at implementing supply chain transport savings.

These tendencies show that the approach of SMEs to LCM and *LCC* is typically rather ‘ad hoc’, and overseen by successful managers, often entrepreneurs, who have learned enough about the life cycle aspects to render the environment an issue of equal importance to technology or quality. Environmental awareness and activities are quite polarized in SMEs. Specifically, it is more often to be either ignored or prioritized as a key business element, rather than a general corporate function coupled with health and safety, as it often is in multinationals. Indeed, in all three areas (technology, quality, environment), SMEs may identify advantages, even USPs (Unique Selling Propositions), but decline to exploit them, given necessary investments or other initial *costs*. Often, SMEs have a very limited access to capital, which can pose barriers even to profitable investments. On the other hand, due to this budget restriction of SMEs, they focus much more often on absolute monetary figures, rather than percentages or ratios, and the latter permits a different planning horizon. It is certainly not that SMEs have a longer-term view than large companies, however, they have the ability to justify budgets more rapidly and seek profit as an absolute number, rather than profitability as a percentage, which is quite advantageous in *LCC*. Furthermore, SMEs inherently incorporate investment thresholds rather than indicators used by large firms, which, again, is more advantageous in regards to *LCC* calculations.

Overall, one can say that *LCC* within LCM, for SMEs and larger firms in emerging countries, which have somewhat similar characteristics, has tremendous potentials, both for sustainable development as for the economic success of the firms. Keys to this success are the involvement of experienced managers and education in life cycle approaches, two factors that are often lacking. Therefore, awareness rising and education measures are crucial issues for *LCC* being broadly applied in SMEs and also larger enterprises in emerging countries.

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7.5 Application of LCC in multinational corporations

Multinational corporations are organizations with suppliers, facilities, and customers literally throughout the world. Besides aspects being valid for all private corporations, there are specific characteristics valid for multinational corporations that make the application of life cycle management tools, including *LCC*, both easier and more difficult, as described in the following. Due to the size of multinational organizations, there are typically dedicated resources available to apply *LCC* (time, money, software tools, knowledge, databases, etc.) if this method is used at all in the organization. In some cases they have sufficient data inventories as well as clear internal tools and standards on how (by whom, and when) to apply life cycle related methods. In some cases

they also include their suppliers, industrial customers, and other life cycle stakeholders in these efforts [Schmidt 2001].

In most multinational corporations different parallel "LCC worlds" exist, all historically well established:

- Life cycle costs that are traditionally linked to manufacturing calculations covering in particular the life-time of one tool or – if linked to product costs – of the entire production time for a certain product (type A, see Table 7.1).
- Cost of ownership targets and calculations looking at the competitiveness as practices for example by product marketing departments (type A).
- Life cycle costs of environmental or sustainability departments that for example relate environmental LCA data to the economic dimension (efficiencies) or aim at calculating an environmental business case (type C) [Schmidt 2003].
- Cost calculations covering certain life cycle periods including warranty costs, end-of-life product costs, etc. as calculated by the responsible departments (type A).

Obviously, confusion starts if the same name (*LCC*) is used within different contexts within one firm. One challenge is to put these results together as they have often different approaches (without discounting or using different discounting rates, reflecting different perspectives, different currencies, different relations to the regional or time context, etc.). As for all organizations, it is necessary to reflect different discounting rates [Schmidt 2003]. More difficult is to consider taxation (including exemptions), regulations (e.g. responsibility for end-of-life *costs*), and prices for e.g. energy in different markets or production locations relevant for the corporation. However, if compared to LCA, often the subjectivity in *LCC* is perceived to be more limited. As a consequence, consensus on the aforementioned issues, differentiated by production locations and markets can usually be found, while this is not possible for environmental value choices [Schmidt and Sullivan 2002].

Comparing *LCC* approaches in multinationals to other applications the aforementioned parameters all add uncertainties, in particular if a prospective use of *LCC* is desired or demanded (as by [European Commission 2003]). Therefore, the interpretation of *LCC* results should reflect the uncertainties and decisions and need additional information beyond the *LCC* result figures. *LCC* studies in this context require other information supplied by LCM as well as other more traditional decision support (e.g., investment calculations, risk and liability assessments), depending on the specific applications.

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7.6 Recommendations for the implementation of LCC

Three types of *LCC* approaches exist: pure economic *LCC* (type A in Section 0), *LCC* in conjunction with environmental life cycle approaches (type C), and *LCC* including monetarized environmental effects (type B, in the sense of macro-economic cost-benefit analysis). For LCM, only the former two are relevant, since LCM addresses all three pillars of sustainable development and thus *LCC* must not lead to double counting of identical effects. In addition, within LCM, the three pillars of sustainability should be kept apart in order to enable a balanced and transparent decision-support. Business relevant costs, either on a very detailed level (generally type A) or as a rather simple comparative measure for assessing the life cycle of alternatives (generally type C), are in the focus in LCM, with type C having priority since it is carried out directly in conjunction with environmental assessments (for an example of a type C *LCC* study, see Appendix 1). *LCC* should always be seen as one pillar of sustainability, in addition to environmental and social life cycle approaches (however, it is also possible to assess the environmental and economic dimensions independent

from each other, though probably not very efficient, as long as all assessments consider the same product system in a consistent way).

Besides the desired level of detail, there are different requirements for *LCC*, both within SMEs and similar firms (see Section 0) or multinationals (see Section 0). As in LCA, the goal and scope should carefully consider questions such as internal use within a company versus external publication, different perspectives (e.g. manufacturer's point of view, focus on supply chain or user's view) [Rebitzer and Hunkeler 2003], time horizons to include, the handling of uncertainties, etc. All these issues govern the methodological and data requirements for a study as well as the involved effort [Schaltegger 1997; Seuring 2001], which should be as minimal as possible in order to follow the general goal of LCM ('to put sustainable development into (business) practice').

Based on the definition of goal and scope, a *cost* model has to be developed according to the system boundaries and *cost* issues selected. Appropriate data have to be collected or estimated (where necessary) considering the quality required. The quality and completeness of the relevant data is of highest importance for the results and should be supported by sensitivity analyses.

If quantitative data on the processes and the corresponding material and energy flows from an LCA are available, then it is very efficient to base the *LCC* model on the life cycle inventory analysis, since an existing product system model can be used (as described e.g. in [Fleischer et al. 1999], [Norris 2001], [Rebitzer et al. 2003]). In such cases the model only has to be supplemented by the related *cost* and price information and, where relevant, additional processes that are omitted in LCA due to their negligible environmental impact. An example for such a process may be the R&D phase of a product.

Glossary

Cost

Cost is the cash or cash equivalent value sacrificed for goods and services that are expected to bring a current or future benefit to the organization [Hansen and Mowen 1997, p. 782].

Life Cycle Costs (LCC):

All costs associated with the life cycle of a product that are directly covered by any one or more of the actors in the product life cycle (supplier, producer, user/ consumer, EoL-actor) with complementary inclusion of externalities that are anticipated to be internalized in the decision-relevant future ([Rebitzer and Hunkeler 2003], modified on the basis of the definition of [Blanchard and Fabrycky 1998]).

Environmental Management Accounting

Environmental management accounting (EMA) as defined by the International Federation of Accountants [IFAC 1998: paragraph 1] "is the management of environmental and economic performance through the development and implementation of appropriate environment-related accounting systems and practices." While this may include reporting and auditing in some companies, environmental management accounting typically involves strategic planning for environmental management and is usually limited to the boundaries of the organization or site.

Management Accounting

Management accounting is an information system that produces outputs using inputs and processes needed to satisfy specific (company-internal) management objectives [Hansen and Mowen 1997].

Financial Accounting

Financial accounting is primarily concerned with producing outputs *for external users and uses well-specified economic events as inputs and processes that meet certain rules and conventions* [Hansen and Mowen 1997].

Cost Management

Cost management encompasses all (control) measures, that aim to influence cost structures and cost behavior precociously. Among these tasks the cost within the value chain have to be assessed, planned, controlled, and evaluated [Hilton et al. 2000; Kaplan and Cooper 1997].

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Appendix: LCM case study concerning Life Cycle Costing

Title

BAHNKREIS project, case study of double deck carriage floor [Verbundprojekt BAHNKREIS 2000].

Summary

This project was concerned with the development of a method to operate railways in a sustainable way through the use of internal life cycle cost and environmental assessments. The project also involved the gathering of interested parties and stakeholders through the life cycle of railway vehicles such as railway consultants and scientists, railway operating, and railway producing companies. Specifically, the case study investigated life cycle costs plus environmental impacts, via a life cycle assessment, of a double deck carriage floor from a specific train system operating in Germany.

Definition of case study

Why?

The decision making context involved the railway carriage producing company and the operating company (i.e., decision on construction of floor; and on cleaning, maintenance, disposal, respectively).

What?

The floor in a double deck railway carriage (i.e., load-bearing frame, cover, finish, plywood, aluminium structure) was investigated. Figure 7.4 provides an illustration of the railway carriage).

The floor was constructed from plywood with an aluminium sandwich profile. The functional unit was 1 floor of a specific train operating in the Ruhrgebiet-Aachen area in Germany, with an annual operating distance of 377,238 km, and operating for 30 years. The floor measures about 42.5 m² and comprises a rubber coverage on a weight-bearing construction. A life cycle inventory and life cycle costing was performed in parallel with the total life cycle costs arriving at 262 000 €. The costs considered were production, operation, cleaning, maintenance, modernisation and disposal.

The purchase cost of materials was found to be 3% of the overall life cycle costs, while cleaning and maintenance costs over the life cycle were 75% and use costs (allocated energy consumption due to the weight of the floor) contributed 16%. Other information collected was the reliability of floor covers to determine maintenance frequency.

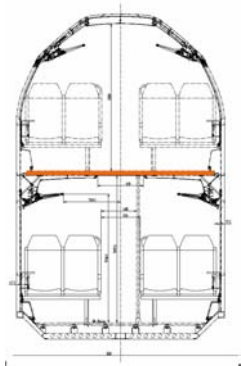


Figure 7.3: The object of study: A floor in a double deck carriage operating in Germany [Verbundprojekt BAHNKREIS 2000; reprinted with permission from Bombardier].

How?

The approach taken was to assess the life cycle costs on the basis of a life cycle inventory. The materials within the inventory were multiplied with estimated specific prices, including working and machine hours in the inventory. Specific prices per man-hour and machine hour (distinguished by type of machine, type of work) were also included. All other costs were allocated on the level of processes in the inventory. The time (year) for each process was determined. To do so, starting from a maintenance regime (maintenance processes at scheduled time or distance intervals), with stochastic additions by unplanned repairs due to component failures, and completed by durations defined for every process, the inventory was modelled over time. Inventory costs were aggregated per year, and then discounted (5% rate) per year. A software program was developed to enable the calculations. Figure 7.4 shows combined results for climate change indicator results and life cycle cost figures for the floor, with a life time of 30 years.

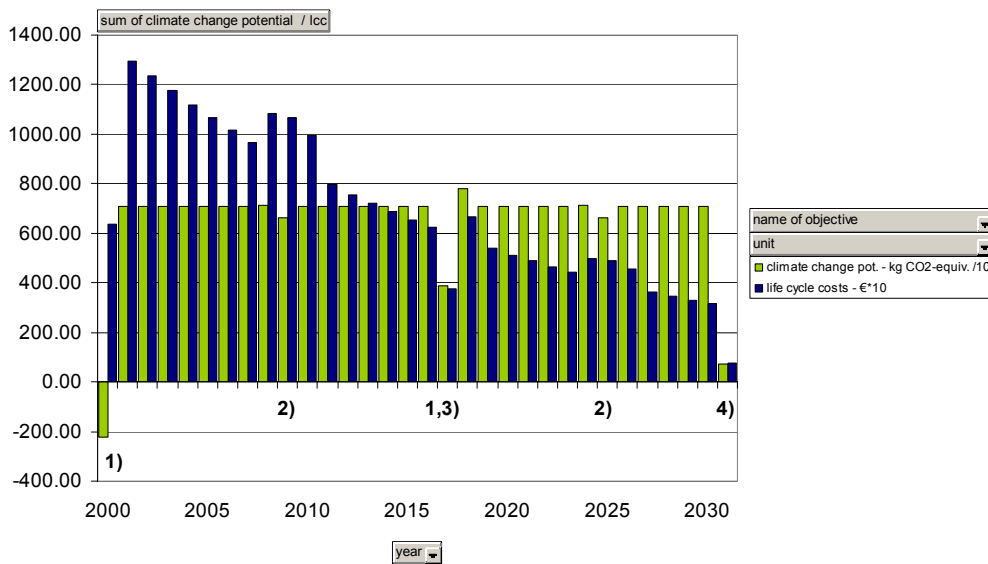


Figure 7.4: Results of life cycle costs [k€] and climate change potential per year, for the wooden floor variant. Costs are discounted by 5%. 1) Negative potential due to incorporated CO₂; 2) Revision of the train; 3) Modernization and re-production of the floor; 4) disposal (waste incineration plant).

Whom?

The study was conducted within a joint research project funded by the German Ministry of Education and Research in Germany during 1998-2000. Personnel involved in this project include scientists from two universities, an external consultant as project co-ordinator, railway operating company, and railway producing companies.

Entry gate and drivers

Entry gate in organization (description of business functions involved)

Entry gates comprise senior management and senior construction engineers. They were supported by external consultants and by a public project sponsor.

Drivers, reasons for change

In the railway sector, purchase costs only make up a small portion of the overall costs of ownership and of the life cycle costs. Hence when answering a call for tender, providing and guaranteeing life cycle costs in addition to purchase prices is becoming more and more common. A reason for launching the project was a fragmentation of individual solutions in industry, and a

need for networking between industry, consulting, and railway operators. The environmental assessment was added due to a general interest in industry and also motivated by the project sponsor. In the case study, a lightweight metal frame was clearly preferable to a traditional wood construction, both from economic and environmental aspects.

Implementation

Barriers

Cost data is sensitive data; data exchange along the supply chain thus is a problem. Different cost definitions, different allocations of costs possibly hamper consistent decision support. Even more intricate seems a consistent combination of environmental and economic assessments. These are methodological issues. Knowledge and (expert) language differences are barriers for implementation, as well as a lack of adequate tools for providing accepted and sound decision support figures, and finally, a lack of cost data.

Process to achieve change

Process to achieve change included in the project intensive, and open, communication between academia / method persons, consultants, construction engineers and middle management. It included the development of a tool for calculating the life cycle of a train, over time, consistently for LCC and LCA. Data collection was done in the project for the case study.

Successes, results, and benefits

The end of the project has achieved understanding between stakeholders. Continuity within the project team was an issue, which hampered communication progresses. A tool was developed and is used by the project partners. The tool incorporates methods for a consistent coupling of LCC and LCA. The applicability of the tool and the methods developed could be demonstrated with the case study, which showed a clear preference for a new construction variant.

General learning

A combination of different assessment methods allows coping with different backgrounds and interests in interdisciplinary projects, and answering purchase or product design questions that influence a multitude of different areas as costs and the environment. Understanding and trusting a tool's result comes prior to using it in decision support. Thus demonstrating benefits of an application is a prerequisite, and enabling understanding and trust takes time, for experts and laymen.

Overview of tools used

Life cycle assessment according to ISO 14040; Compass Method by Siemens; Life Cycle Costing; Relative costing according to VDI [VDI 1984].

In a more narrow sense, a tool for calculating Life Cycle Costs, Life Cycle Assessments, and other environmental performance indicators (recycling rate, mass flows), over time [Ciroth 2002; Citroth et al. 2003].

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8. Social Aspects in Life Cycle Management

The globalization of the economy, pressing ecological issues such as climate change, and recent market failures (ref) are shaping and changing how we view the role of corporations in society. Traditionally, the role of the corporation has been understood primarily in economic terms. Companies provide products and services and, in doing so, they create jobs and wealth. Increasingly, stakeholders (shareholders, investors, communities, regulators, employees, customers and non-governmental organizations) are taking a broader perspective of corporate responsibility that incorporates not only economic performance, but also social, governance and environmental performance factors. This new role of business was emphasized at the World Summit on Sustainable Development (WSSD) in Johannesburg, in August 2002, where the private sector was been recognized as a key player in promoting sustainable development.

There are four performance areas stakeholders are evaluating to determine whether a company is moving toward more sustainable business practices and whether a company is conducting its business in an ethical and socially responsible manner. Those are:

- Economic performance,
- Social performance and responsibility,
- Environmental performance and
- Conduct and governance.

Organizations, in particular brand based companies, consumer goods manufacturers and retailers increasingly face challenges to manage “their” products from a total value chain perspective. Social aspects such as safe work places, child and forced labor the right of workers organizations etc, increasingly become state-of the art requirements. While managing such aspects within an organization is long standing practice in some companies, it is increasingly difficult to manage those aspects for the whole value chain. Supply chain management, procurement and corporate strategy are therefore required to also manage social aspects from a product life cycle perspective. Alone – there are only few, if any, tools and management systems that allow a successful implementation. Life Cycle Management becomes an opportunity to integrate those aspects into a comprehensive product life cycle management approach.

Evidence of this broader perspective on corporate performance can be found in a variety of guidelines and standards (e.g., the Global Reporting Initiative’s sustainability reporting guidelines and SA8000, a social performance standard based on International Labor Organization (ILO) conventions, the Universal Declaration of Human Rights and the United Nations’ Convention on the Rights of the Child). Additionally, rating schemes are emerging in the financial sector, which attempt to identify best-in-class performers (e.g., the sustainability rating schemes developed by companies such as Innovest and the Dow Jones Sustainability Index).

Other key issues that are covered by Corporate Social Responsibility are i.e. human rights, employee rights, community involvement and supplier relations. It also advocates an open information policy, including issues on disclosure, transparency, consumer education and anticorruption measures. Depending on the emphasis placed on supplier and consumer relations, Corporate Social Responsibility comes close to the definition of ethical trade, which can also extend throughout the value chain. As such, Corporate Social Responsibility can become a key element in or with LCM.

8.1 How far does Corporate Social Responsibility extend in the value chain?

To answer this question, it is useful to look at the parallel question in Life Cycle Assessment (LCA): "What processes should be included in the product system?" Since it is, in principle, not possible to find any sharp boundaries between environmental and social responsibilities, it is reasonable to conclude that the system boundaries for LCA and LCM can also be applied to Corporate Social Responsibility issues. Thus, the methodology of ISO standard 14041 (on Life Cycle Inventory) can provide an objective means for delimitating system boundaries in Corporate Social Responsibility/ethical trade, as well.

8.2 Continuous improvement and site certification

Linking Corporate Social Responsibility to LCM will drive a commitment to continuous improvement, as expressed in the ISO 14001 and 14040 standards on environmental management. It also implies that any attempt to quantify Corporate Social Responsibility should focus on marginal improvements rather than on average performance. When seeking to quantify social influences in the value chain, a fundamental problem occurs: It is very difficult to find any consistent differences between different technologies or production routes involved in the production of any given product, simply because the social impacts are so site-specific that the variation between sites exceed the variation between technologies or production routes. In LCA, a parallel problem has been described for emissions of toxic substances. However, this has not led to the conclusion that toxic releases should not be included in LCA, but rather that it may be necessary to ensure site certification with respect to this issue. Similarly, we may conclude that the quantification of social influences may in general require site-specific certification of suppliers.

8.3 Which social elements can be covered under LCM?

Which aspects to include under the social pillar of sustainable development? A variety of definitions and suggestions are available. Some aspects are closer to the core of organizations operations, some others reach out to societal preferences. The possible breadths of aspects to be included, requires not only structuring, but also selection for the specific applications and market requirements. The following table presents a possible structuring of social aspects and examples of social impacts.

Group	Type of social aspect
Workforce health and safety	Hazard, risk exposure at work Accidents avoided
Labor rights	Fair wages, right of labor organizations Minorities and ingenuous people Forced and Child labor Education
Supply chain performance	Human rights
Community impacts	Employment Community development
Societal benefits	Employment Taxes paid
Consumer benefits	Safer products

The aspects to be chosen depend of the nature of an organization and the respective positioning in the supply chain.

Life Cycle Management is an adequate approach to integrate social, environmental and economic considerations into one overall umbrella. Taking a product life cycle perspective offers the opportunity to systematically assess the whole value chain, including product use and final disposal, and it:

- Allows for cross functional fertilization and achieving win-win solutions across business functions and supply chain actors,
- Demonstrate and document commitment and conduct, and
- Is the often-missing opportunity to arrive at balanced decision-making support in organizations?

9. Process Life Cycle Management

In order to foster the application of good practice and tools according to life cycle thinking in enterprises there arises a need to consider not only the product life cycle, but also a different perspective.

9.1 The requirement of industry for an LCM approach centers on processes.

The Life Cycle Assessment (LCA) methodology mainly focuses on assessing the environmental impacts associated with a product or service. The goal and scope step of a LCA study is subsequently clearly defined in accordance to a specific product or service life cycle. Whereas the results of an LCA study can be used directly for great variety of well-established applications on a long-term level (cf. chapters on communication and product design and development in this handbook) they are not tailored to business procedures. Conclusions and recommendations for firms additionally need to address a level of detail that is compatible with business practice. A scope that offers good access for business considerations and can also be examined as a part of the product life cycle is the process level. The following Figure 9.1 illustrates the basic approach, indicating the level of detail in modeling that is needed to provide reliable recommendations and decisions.

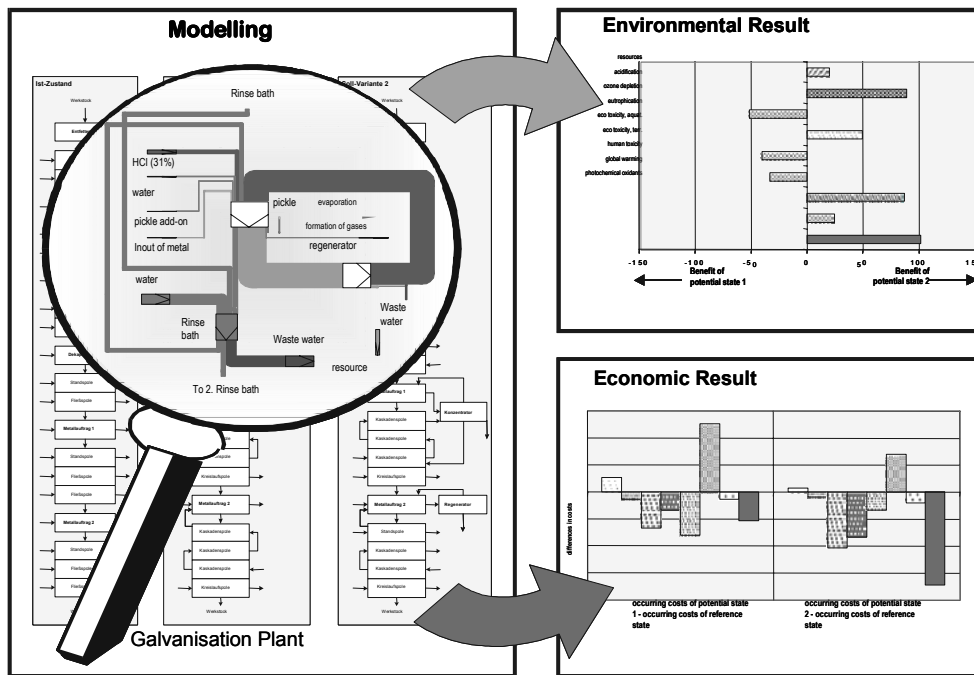


Figure 9.1: Basic approach in life cycle management with detailed modeling and different facets of interpretation [1, 2]

In order to clarify the different needs and drivers in a process-oriented LCM approach, the process object is defined briefly with the focus on characteristics that may affect the LCM concept.

Case: Ecological plant optimization of physical vapor deposition plant

Summary

With the Physical Vapor Deposition (PVD) technique at low temperatures (200 to 500 °C) thin film coatings with high hardness, high wear resistance and low friction coefficient can be produced. Those coatings improve the performance of tools and components and allow a longer lifetime.

There was not sufficient information about the environmental impact of the metal coating processes. Neither the contribution of the single coating process steps nor the contribution of the production of source materials to produce the coatings (metal targets and gases) was known.

Why?

For effective process research and development additional information was needed to improve the used PVD – technology.

What?

This case study was based on the data collection of the Unaxis Balzers AG and describes a comparative Life Cycle Assessment for the TiN, TiAlN, and WC metal coating processes. As functional unit the coating of 100.000 drills was used. In addition the comparative investigation has been carried out for two different types of coating equipment. For identifying the dominant impacts the CML impact assessment method was used.

9.2 Defining the process object

The process object is defined as a human activity that influences a material flow in a chemical and/or physical way and which can be found in industrial- and agricultural-related enterprises [3]. For example, in the chemical industry a process would cause a change of state of a material. A process usually comprises more than one change of state or unit operations. The limit between two different states is defined by a thermodynamic criterion of mass and, if necessary, energy balancing. Additionally a process may also cause a change of position (transport process) or degree of processing (value addition or optimized state). The sectors of economy that must be considered in order to define the process object more clearly are therefore agricultural engineering, mining and exploration engineering, chemical and metallurgical engineering, operations and production engineering, and transport and logistics engineering [4].

The Life Cycle Management (LCM) concept implies a holistic approach that encompasses the Business Procedure and Operational Levels within an organization [5]. In the manufacturing industry all management practices (or business procedures) of an organization are primarily centered on processes and assets (or operations) from which profits are derived in the form of manufactured products. From a manufacturing industry perspective, the objective of LCM is therefore to influence all of the life cycle phases of these processes, i.e. the detailed design, commissioning, operational, and decommissioning phases, through management practices in order to improve environmental performances [6]. The operational phase of the processes extends beyond the manufacturing facility and includes the life cycle of the manufactured product as stipulated in normal EMS's, i.e. the environmental performances of the supply chain and product consumption stages must also be considered [7]. Thus, industry requires LCM to apply a systems engineering approach [8] that covers any affected parts within the range of:

- Management practices, and especially project management life cycles, which drive changes across the life cycle phases of industrial processes.

- Processes, or assets, from the initial conception to the final closure and rehabilitation, including maintenance cycles, etc.
- Products, as stipulated through the formal LCA procedure, which are manufactured by processes. [9]

With several interacting life cycles, the level of detail and scope for an environmental assessment has to be balanced according to the possible impacts of a process or process-chain. The process-chain comprises core and casing systems (or foreground and background systems) [2, 10]. The distinction between the core and casing systems is that in the core system processes are specified to a large extent or parameters and operation modes are set.

The casing systems are subsequently influenced by these parameters and operation modes of the core system. In the casing system, the specification of processes needs to be less detailed. When operating and process parameters are provided by external entities (other than the core system), the influence is considerably lower. Moreover, supplies are purchased at the market from various providers using different processes. Generic data is consequently highly appropriate for these processes.

Figure 9.2 illustrates the general idea for the distinction between core and casing system [2].

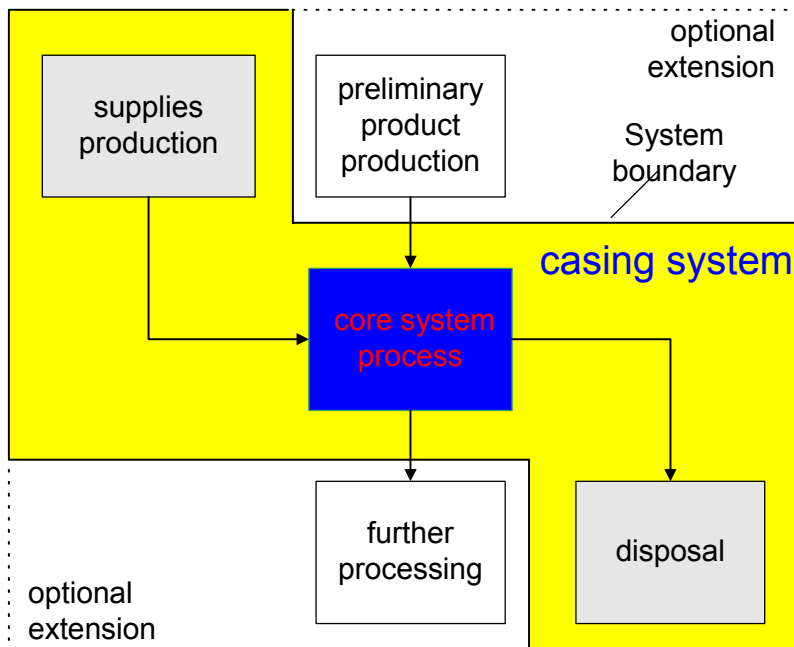


Figure 9.2: Distinction between core and casing system [2]

The primary purpose of implementing and operating a process object is to establish a service in order to fulfill an identified demand. From an LCA point of view (or ISO 14040ff-thinking) the main target of this need is to decrease the (global) environmental impact potential associated with a product value chain. LCA is therefore oriented towards the material and energy flow of the production and disposal system. A process is subsequently a system of activities to provide a service along the production and disposal system.

Case: Conversion of existing electroplating plants on a process technique with minimized substance loss and closing substance loops for abrasive treatments in wet processes

Summary

These projects were concerned with the development of a common method to operate electroplating and surface treatment plants with a minimized substance loss. Waste, wastewater and emissions are minimized according to business economics and environmental assessments. These projects also started with the problem definition and ended with the realization of the new plant solution. The changes of the processes were oriented towards substance loops and reduction of waste, wastewater and emissions. The projects not only developed concepts. The actual realization of the concepts was one of the main tasks. The solution is a joint result of operating company, consultant, producer of chemicals, plant engineering and construction and recycling company.

Why?

The former decision making work is based on a concept, plant engineering or recycling strategy. But the results were sub-optimal single solutions with an unclear environmental impact. The joint activity of all partners in decision-making process in the system design and process chain is the condition for a successful realization of the improvement of the process, process chain or plant.

What?

The typical electroplating process comprises a stepwise stripping and covering of surfaces. This process chain consists mainly of three types of processes.

- Fresh water preparation (e.g. ion exchanger, reverse osmosis).
- Waste water treatment (separation of sludge, neutralization, Water separation).
- Production processes with rinsing (e.g. degreasing, electro polishing, chrome plating).

The different kinds of processes are mixed in a process chain with rinsing processes. The main task is to protect the surfaces with special substances. The main idea is a flexible solution for the minimized use of substances and energy. The assessment orientation is business economics with cost accounting and investment cost calculation of the change. The environmental assessment is based on LCA.

Who?

40 partners conducted these two projects. There are 18 special electroplating operating companies. The German research ministry promoted the projects during the years 1995-2002.

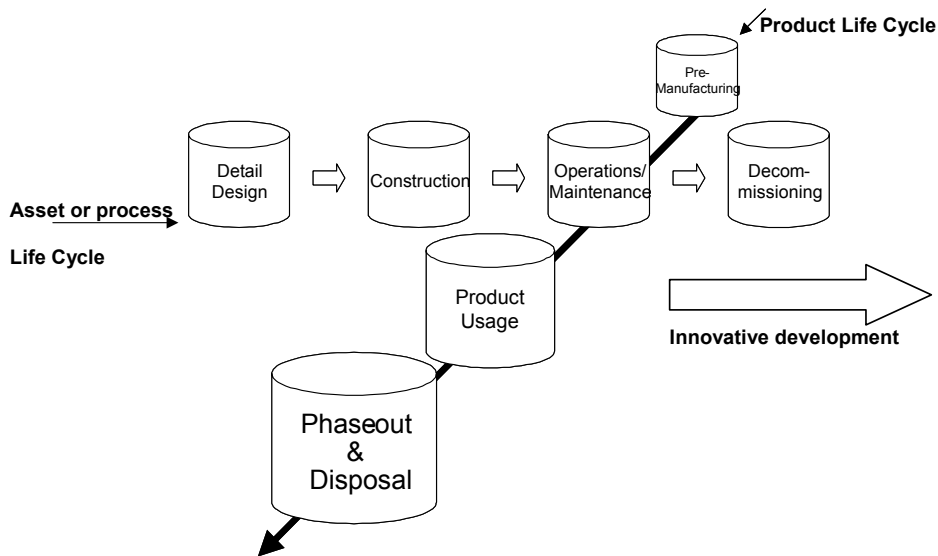


Figure 9.3: Interaction between the asset (or process) life cycle and development and product life cycle [7, 9]

The sum of all process objects along the product value chain generates a holistic life cycle, which is an interaction between the complete product life cycle and the life cycles of each process object (or asset) in the product value chain (including the development of these objects) (see Figure 9.3). The different life cycles describe a network of the material based complex system of anthropogenic activities.

Location

The process takes place in a production plant, using manufacturing equipment. This plant uses input materials (and energy) and produces output materials or manufactures value-added products. As described, the life cycle of the process differs from that of the product and consists of process development (including design and implementation), the use phase and final disposal.

The special tasks assigned to the process development are, among others:

- Optimization of the technical activity of the process
- Economic impacts
- Environmental impacts
- Local/regional requirements
- Social impacts, etc.

Case: Introduction of recycling strategies for the textile finishing industry

Summary

The textile finishing industry in Germany is characterized by small and medium-sized enterprises which use high amounts of (hot) water for finishing and rinsing processes. The factories use predominantly municipal sewage plants for the effluents – with only partly satisfying results due to refractory pollutants (e.g. colors). Membrane technology that can be used to close loops, recycle (hot) water and save energy comes with high investment costs and can only be applied when it can be thoroughly integrated in the production-process and some additional benefits can be revealed.

Why?

Within a research project, the production processes in several enterprises were examined thoroughly to find optimization strategies and access for membrane technology.

What?

For several applications it could be shown that by thoroughly integrating the membrane plant the main process (e.g. rinsing after textile dyeing) can be conducted more efficiently. The options for redesign could only be revealed by an examination on the process level.

As mentioned before processes can be identified in all phases of a product's life cycle. However, every process is assigned to a single product phase only. The basic phases of the product life-cycle are:

- The production phase (technical activities, business to business interactions);
- The consumption phase (customer activities);
- The End-of-Life phase (technical activities, i.e. recycling, waste management); and
- The environmental phases in conjunction with the first three phases (ecosystem activities, delivery of materials or buffer filling and alteration of substances for using immobilization in ecosystems).

A process usually does not include more than one of the product phases, though a technical or technological opportunity exists for all of the product life-cycle phases.

9.3 Process development

The development of new processes and the optimization of existing processes are constantly undertaken in industrial and agricultural production. Drivers for process development derive from the identification of deficits in product quality, economic value or environmental impacts (incentive). The complex interaction of industrial processes within several product life-cycle phases makes it necessary to use a systematic approach in order to identify the impacts of any proposed development. Figure 9.4 summarizes an overview for the approach.

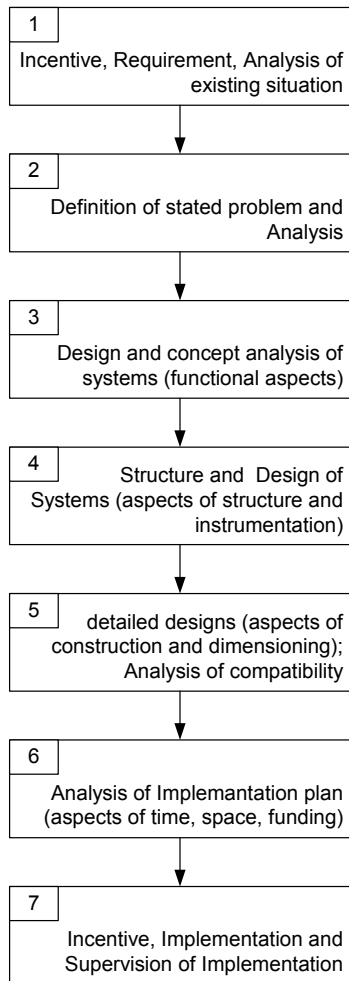


Figure 9.4: Procedure of process development according to VDI 4090 [11]

Three levels within an organization have been identified that can be subjected to change: Strategic Level, Business Procedure Level and the Operational Level [12]. At present, environmental sustainability mainly manifests at Strategic Level, e.g. through a company's vision and mission statements, or at the Operational Level where companies implement Environmental Management Systems (EMS) and report on the environmental performances of operations in annual sustainable development reports. Environmental sustainability is rarely considered seriously at the Business Procedure Level, i.e. as part of general management practices, although progress has been made to improve this situation [7].

Case: Incorporation of sustainability aspects at the business procedure level for a petrochemical company in South Africa

Summary

The decision to proceed with the financial support for the development of a new or improved process has traditionally been based on economic evaluations, e.g. cost accounting procedures, and technical evaluations. However, the need to consider other risks has been identified in certain industry sectors. For example, internal health and safety risks are determined early in the development of a process in the petrochemical industry and these risks are specifically considered during the decision-making gates of the development project. Additional sustainability aspects have now been incorporated at the business procedure level to evaluate the external environmental and social impact risks associated with the life cycle of the process and its related product life cycle, in order to ensure sound sustainable business decisions where new or improved processes are considered in the petrochemical industry.

Why?

A specific petrochemical company in South Africa has recognized that the current business procedures are not in line with the sustainable objectives that are set at the strategic level.

What?

The petrochemical company has subsequently developed and expanded its internal Business Development and Implementation (BD&I) model, which is used to guide the project management process when new or improved processes are developed. The model directs process designers to consider possible external environmental and social consequences, related to typical petrochemical processes, throughout the initial project life cycle phases. It further prompts decision-makers with possible questions that should be asked at decision-making gates between the project life cycle phase in order to ensure that all sustainability criteria, that are set at the strategic level, are met early on in the process development, before comprehensive and costly studies are undertaken, e.g. a full Environmental Impact Assessment (EIA).

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10 Life Cycle Management to Achieve Sustainability in Rapidly Urbanizing Regions - The Role of the Built Environment and Urban Climate Variability

This LCM case study illustrates how rapidly urbanizing regions, especially in the developing world, can craft practical solutions to meet the sustainable imperatives of environmental, economic and social well-being. The desert southwest region of the United States is facing unprecedented growth while also being an arid region in its 7th consecutive year of drought, similar to many parts of the developing world. By considering life cycle impacts, climate and costs in regards to the built-environment, a design-construction-redeployment LCM was developed which could be adopted by regional governmental entities as well as the private sector. This project was commissioned by the Mayor and Council for the City of Phoenix, Arizona with the final LCM product to be made available to governments around the globe.

10.1 Introduction

As recently as 1950, 30% of the world's population lived in urban areas. By the year 2030, 60% of the world's population will live in cities, according to the United Nations (2001) World Population Prospects Revision Report. Urbanization is quickly transitioning communities from the natural rural vegetation to man-made urban-engineered infrastructure. The anthropogenic induced change has manifested itself in microscale and mesoscale increases in temperatures in comparison to adjacent rural regions, which is known as the Urban Heat Island effect and results in potentially adverse consequences for local and global communities. One of the great challenges facing government and industry is how to support the growth of new urban centers in a sustainable manner. This is even more pronounced in arid regions, which will sustain the greatest rate of urbanization.

International attention paid to sustainable development has occurred at a time when urban areas are gaining an estimated 67 million people per year—about 1.3 million every week. Most of the world's future population growth will occur in arid regions of the world (Baker, L. et al. 2004). Furthermore, the urban population of developing countries is projected to grow at an average annual rate of 2.4%, twice the rate of 1.2% in the developed world.

The urban population of developed countries will grow faster than their total population and these countries will remain far more urbanized than the developing world. Research of rapid urbanization is important due to the far-reaching impacts urban centers create on the environment not only within the urban core but extending to regions that supply the consumed materials such as energy and water (McMichael, 2002). In many cases, the urban core to offset the urban heat impacts consumes these natural resources.

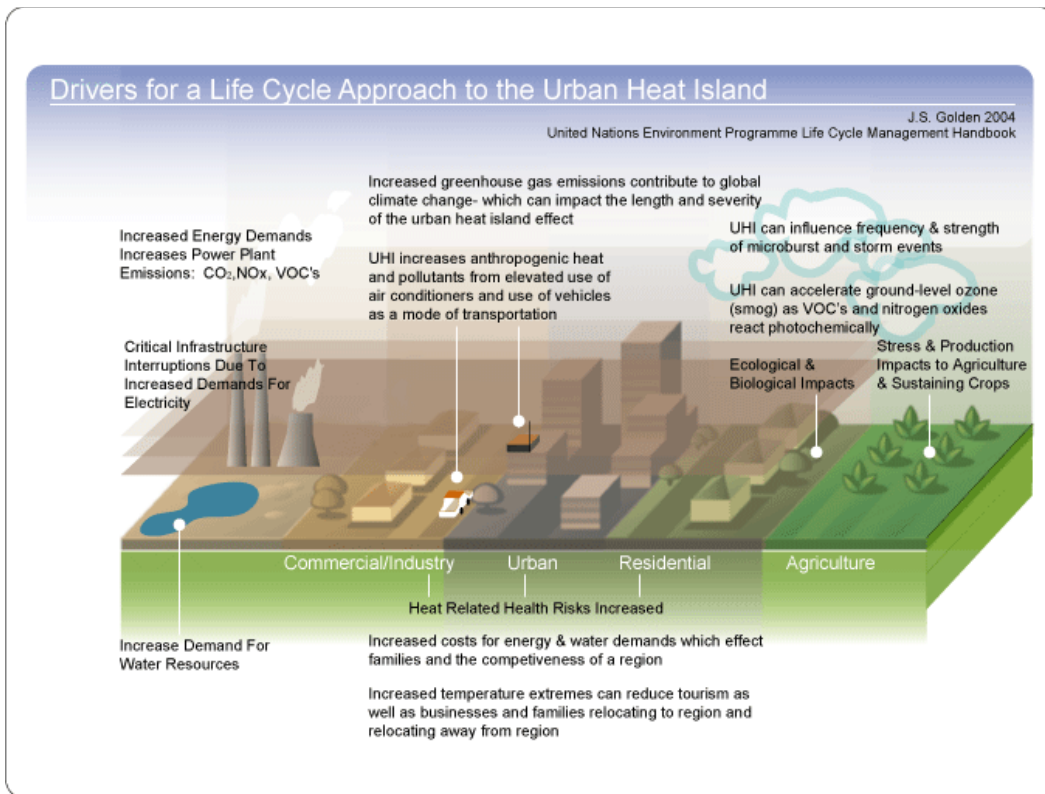
Urban areas take up just 2% of the earth's surface but account for an unbalanced amount of resource usage. For example, urban areas account for about 75% of industrial wood use, and 60% of the water withdrawn is for human use (O'Meara, 1999). The extent of urban impacts upon the environment increases not only as population grows but also as per capita demand for resources rises, both from industries and consumers. Additionally, the number of households has grown even faster than the population itself, reflecting a trend to smaller families and thus a decline in the average number of people per household.

The urban built environment—the nexus of architecture, engineering, and commerce— is one of the main attractors of population shifts from rural to urban areas. As the dynamics of this population shift occur, the 21st-century phenomenon of rapid urbanization is creating extreme

changes in land use that result in unintended environmental, economic, and social consequences. In urban areas, buildings and paved surfaces have gradually replaced preexisting natural landscapes. As a result, roads and rooftops absorb solar energy, causing the surface temperature of urban structures to become 50 to 70 °F higher than the ambient air temperatures (Taha et al. 1992). As surfaces throughout a community or city become hotter, overall ambient air temperatures increase in the urban region greater than that in the rural region ΔT_{U-R} . This phenomenon, known as an "urban heat island," can raise temperatures in a city from 2 to 8 °F (Oke 1987; Chandler 1965; Landsberg 1981; Bornstein 1987). This localized regional effect is in addition to IPCC estimates which put the potential of global warming to be +1.4°C to +5.0°C (+2.5°F to +10.4°F) over the next 100 years, in addition to the 0.6°C temperature increase already observed during the 20th century.

10.2 Why a LCM approach?

The impacts of the urban heat island effect government, industry and residents alike. Increased temperatures require increased usage of mechanical cooling systems, increased emittance of pollutants including greenhouse gases and increased operating costs. Additionally, the increased temperatures require large withdrawals of water supplies for the generation of power from fossil fuels and larger amounts of water usage to sustain crops stressed by the changing urban climate. Increased urban temperatures place the greater community at risk for heat related illnesses, especially the at-risk segments of the population including children and the elderly.



10.3 LCM project site

The State of Arizona, located in the southwest corner of the United States, is famous for one of the Seven Wonders of the World, the Grand Canyon. It is the sixth largest state in land area (113,635 square miles) in the United States. Arizona is an arid land with average annual rainfall varying from three inches in Yuma in the southwest corner to seven inches in Phoenix in the center of the state. At statehood in 1912, Arizona was populated by approximately 200,000 people and had a population density of two people per square mile. Over the last 100 years, the ratio between Arizona's rural and urban populations has essentially reversed. In 1900, less than 20% of the state's population lived in an urban setting; in 2000, more than 88% live in an urban setting.

Since 1990, the fastest-growing region in the United States has been the West, increasing by 19.7% or 10.4 million people, to total 63.2 million (US Census 2000). Of the top 10 US cities by percent of population growth from 1990 to 2000, six are Western cities, with Arizona at a 40% growth rate. Phoenix, now the nation's fifth-largest city in the United States has seen its regional population increase from 1,600,000 in 1980 to 3,379,000 as of July 2001, an annual gain of 101,400 people since 1990 (HUD 2002). The City of Phoenix is now larger than Los Angeles, California in geographic extent, surpassing 484 square miles. Phoenix now pumps in vast amount of water and electricity to fuel its consumption.

10.4 Entry gates and drivers

Traditionally, environment departments as well as legal departments to address risks manage environmental related issues in the governmental sector. Many times these issues are managed on a reactive basis rather than a proactive and voluntary basis primarily as a function of costs.

In this case study the regional University brought together executives from leading governmental, industrial and NGO organizations to identify the leading regional issues for community. The concerns of rapid population growth, land-use expansion and use of limited resources (namely water) was identified. This was coalesced into the heading of "Rapid Urbanization." The subsequent joint stakeholder meetings identified the need to understand the dynamics of the explosive growth of the built environment and the impacts based on sustainable imperatives.

Leading the effort was the executive management of the city, namely the Mayor and Council identified that the tremendous growth and corollary urban climate changes can have a variety of environmental, social and economic impacts. Similar to top management in the private sector, who ultimately have to ensure implementation of programs such as ISO 9000 and ISO 14000; the executive management for the City identified the need to implement a LCM approach to the built environment in such a rapidly urbanizing region. On 5 December 2001, the City of Phoenix adopted by City Council Resolution a revision of the General Plan that promulgated Goal 7 – The Urban Heat Island. This goal obligated the City to "explore options to minimize the impacts of the Urban Heat Island Effect" (Phoenix General Plan, page 271).

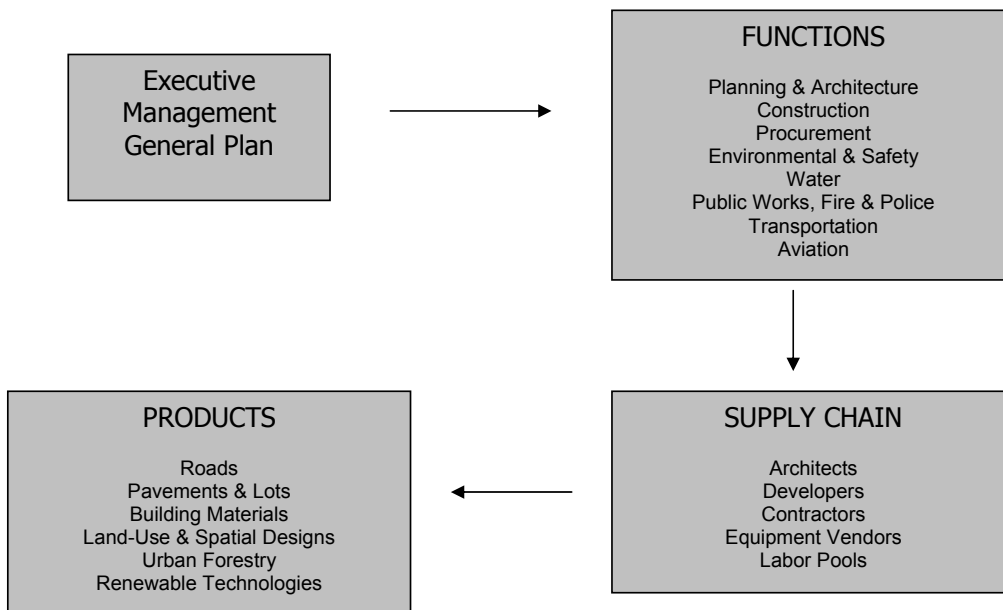


Figure 10.1: The management plan.

As presented by Saur (2003) the process of Life cycle management improves the decision making process by putting better information in front of decision makers. To be successful, a government driven initiative requires the acknowledgement of multiple sets of drivers including those of the corporation (Huang and Hunkeler 1996) as well as those of the government and its non-industrial

constituents. This included issues of cost minimization, avoidance of future liabilities as well as the role of regional image, which is critical to an area such as Phoenix where tourism accounts for a large segment of the regional economy. Perhaps one of the larger drivers for a regional initiative is something, which can be overlooked – quality of life.

10.5 Implementation

Barriers

A singular but significant hurdle to overcome is the lack of understanding of the business functions involved in understanding the coupled sustainable imperatives and how a life cycle management approach to costs can provide greater economic advantages versus traditional “low-bid” first costs. This is not a small hurdle as many governmental charters and regulations require that projects be awarded to the low bid. As a result, the development of a new set of ranking criteria is required. Finally, cooperation amongst various stakeholders and business functions is the most essential part in the development of the LCM program. Having the executive driver support and backing aids in the attempt to secure cooperation.

There are several steps to implementing the LCM including:

Step 1: Quantify both short term and long-term environmental, economic and social impacts associated with rapid urbanization and urban climate variations for the specific geographic region.

Step 2: Create a collective working group by stakeholders from multiple governmental agencies, industries and citizens. Facilitate the development of appropriate ranking criteria for the evaluation of contract specifications.

Step 3. Develop a hierarchical ranking of those purchased goods, services and design criteria which the regional entities have control and which can most significantly contribute to sustainable future of the rapidly urbanizing region.

Step 4. The stakeholder group actively engages vendors of materials as well as academic and governmental research laboratories to identify and model the performance, initial and operating costs, environmental impacts and the social/cultural acceptance of materials to be used to minimize temporal variability and increase regional sustainability.

10.6 General learning

A case study usually has the connotation that there are final results. That is not the situation in regards to this project. This LCM project for Rapidly Urbanizing Regions will be a multi-year and most likely a multi-generational LCM project. A new set of eco-performance criteria, and associated indicators, with thresholds, are necessary for easy adaptation by regions experiencing climate variation. These involve a set of readily available decision support tools in regards to materials and the urban heat island effect that also address the environmental and economic imperatives. By addressing the built environment through the lens of LCM initial successes presented in Figure 10.2 have been realized. One example is the use of rubberized asphalt for urban transportation infrastructure. This economically viable road-based material recycles abandoned tires yet provides for durability of product, significantly reduces automobile noise levels, reduces road slickness during rain events, reduces driver glare and most importantly, due to its porosity releases thermal energy at a quicker rate – thus improving the urban heat island effect. On-going LCM evaluations continue including the utilization of coupled material-renewable energy technologies to combat the Urban Heat Island while reducing dependence on fossil fuels and the infrastructure/costs requirements.

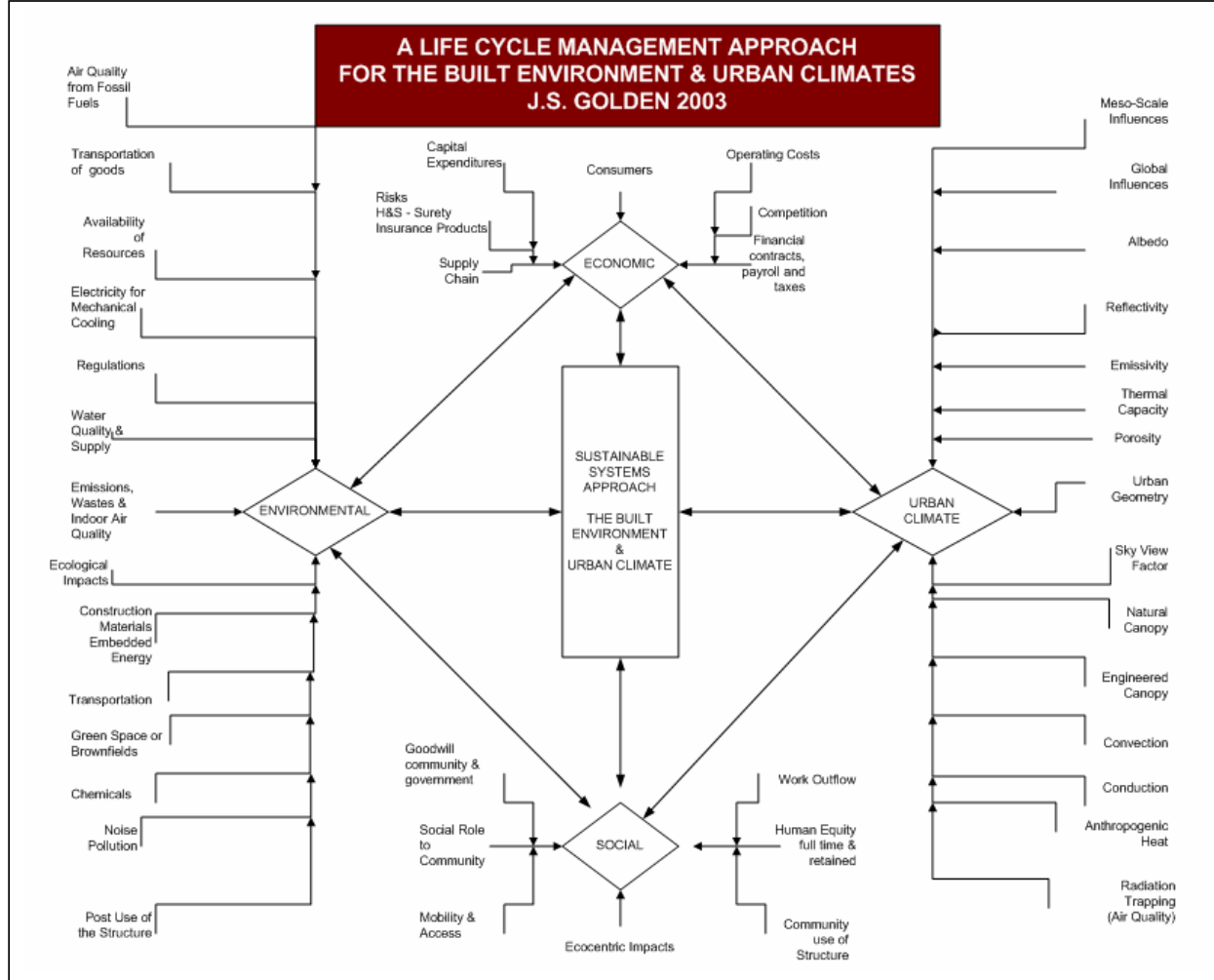


Figure 10.2: Life Cycle Management Approach for the Built Environment and Climate (Golden, 2003).

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11. LCM Challenges for Developing Countries

This chapter deals with the specific needs of developing countries, and how these countries could share the worldwide efforts to promote the life cycle thinking.

11.1 To promote streamlined LCA

Life cycle assessment very often involves the use of some, rather sophisticated, or so perceived methodologies that would require numerous sets of inventory data. In many of the developing countries data are not always available beside the limited experience needed to manipulate data and extract results and trends. In this respect it is rather important to promote the use of streamlined life cycle assessment methods as a reasonable compromise between the needs and capabilities of developing countries, such as in place in many through cleaner production centers.

11.2 The introduction of LCM related concepts

A variety of topics and ideas that ultimately contribute to the advancement and promotion of life cycle thinking are not quite well known in many of the developing countries.

Green Chemistry, with the diversity of topics it embraces such as atom economy, waste minimization, alternative solvents and solvent-less reactions, is very viable tools to promote LCA. Information about Green Chemistry at the different educational level should be given special priorities in designing new courses and curricula in developing countries.

11.3 Training Needs and Target Groups

Training is an essential component for the promotion of life cycle thinking. It is paramount to design needs, where various tiers of training programs should be considered. At one level, generic thematic application of LCA should be the core issues of training. At the other tier, themes such as sustainability, solid waste, land use, and biodiversity should occupy a core site for training program. In the first hand training should be targeted to those, who would undergo future training (training of trainers), along with another group of decision makers at industry or government level, though training material for each group would differ.

For the training program the fundamentals of life cycle thinking, LCA methodologies and other components of the state of the art should be included as training materials.

For decision makers the material should contain some special emphasis on the role of life cycle thinking in tackling some of typical chronic issues of the developing countries. Issues such as increasing export opportunities under the eco label slogan could be an attractive lead to decision makers of several industrial sectors. Well-planned case studies of how to manage solid waste in larger cities based on the life cycle approach could be one of the most appealing issues to decision makers at municipality levels and in environmental departments. Equally important is to promote the life cycle thinking as a viable tool that decision makers should adopt when handling all environmental issues. Addressing decision makers is the right start to promote life cycle thinking in developing countries, as they are the potential and factual launching pad.

11.4 The role of international bodies and industries and the establishment of national LCA societies

Both international bodies and multinational organizations should direct some more efforts to help develop and promote life cycle thinking, LCM and LCA in developing countries. Regional offices of international organizations and multinational organizations and cleaner production centers may support some regular meetings and/or training program. Further, the establishment of national societies dealing with aspects of life cycle thinking should be encouraged and given all possible logistic and otherwise support. Dissemination and knowledge transfer between such national societies could be an added value, with the possibility of forming nets of regional societies similar to that in place in the Asia Pacific region.

11.5 Gender issues

Gender equity in most of the developing countries is still lagging behind that in G8-countries. A great deal of the promotion campaign of life cycle thinking in developing countries should consider how to address the gender issue and how to empower the role of women, starting from simple housewives in rural and urban areas. Special program should be made to address women participation and how to introduce the concept of life cycle thinking to them.

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