Life Cycle Approaches

The road from analysis to practice

UNEP/ SETAC Life Cycle Initiative

First edition 2005

This UNEP publication was supported financially by the sponsoring partners of the Life Cycle Initiative: Alliance for Beverage Cartons and the Environment (ACE), American Plastics Council (APC), Association of Plastics Manufacturers in Europe (APME), International Council on Mining and Metals (ICMM), General Motors, Governments of Canada, Germany, the Netherlands, Quebec and Switzerland as well as the National Institute of Advanced Industrial Science and Technology (AIST), Japan.

UNITED NATIONS PUBLICATION
ISBN:

PRINT:

Life Cycle Approaches

The road from analysis to practice

United Nations Environment Programme

Division of Technology, Industry and Economics (DTIE)
Production and Consumption Unit
39-43, Quai André Citroën
75739 Paris Cedex 15
France

Tel: +33 1 44 37 14 50

Fax: +33 1 44 37 14 74

E-mail: unep.tie@unep.fr

URL: http://www.uneptie.org

A publication of:

UNEP/ SETAC Life Cycle Initiative

“We must develop production and consumption policies to improve the products and services provided, while reducing environmental and health impacts, using, where appropriate, science-based approaches, such as life cycle analysis“.

Plan of Implementation, World Summit on Sustainable Development

“Consumers are increasingly interested in the world behind the product they buy. Life cycle thinking implies that everyone in the whole chain of a product’s life cycle, from cradle to grave, has a responsibility and a role to play, taking into account all the relevant external effects. The impacts of all life cycle stages need to be considered comprehensively when taking informed decisions on production and consumption patterns, policies and management strategies.”

Klaus Toepfer, Executive Director, UNEP

“The results from the working groups [of SETAC on life cycle assessment] constitute a key contribution to the start of the UNEP-SETAC Initiative. A first activity in this Life Cycle Initiative will be to perform definition studies…; the results presented here will be an important input to the latter study. It is an explicit aim of the Life Cycle Initiative to incorporate working groups into the programme, in order to stimulate bottom-up scientific input.”

SETAC book, Life Cycle Impact Assessment: Striving towards Best Practice

Authors

This publication was prepared by **Helias A. Udo de Haes** and **Martijn van Rooijen** from the Institute of Environmental Science (CML) at the Leiden University in the Netherlands. The report is based on the Definition Studies whose elaboration was led by **Konrad Saur** (Five Winds International), **Greg Norris** (Harvard University) and **Olviier Jolliet** (Ecole Polytechnique de Lausanne). **Guido Sonnemann** from UNEP DTIE reviewed the first drafts of the document, had the operational responsibility, and provided input on sustainable consumption and production policies and for the overview on life cycle approaches. Furthermore, this report includes written contributions from the authors of the Definition Studies of the three programmes, as listed in Annex 5.

Acknowledgements

The Editorial board of the production comprised Fritz Balkau and Bas de Leeuw of UNEP DTIE. Thanks are also to the following members of the International Life Cycle Panel who provided comments to an earlier draft of the publication:

Financial support for the project was provided by the sponsoring partners of the Life Cycle Initiative: Alliance for Beverage Cartons and the Environment (ACE), American Plastics Council (APC), Association of Plastics Manufacturers in Europe (APME), International Council on Mining and Metals (ICMM), General Motors, Governments of Canada, Germany, the Netherlands, Quebec and Switzerland as well as the National Institute of Advanced Industrial Science and Technology (AIST), Japan.

The English text was revised by:
The design of the publication was done by:

The Definition Studies of the UNEP/ SETAC Life Cycle Initiative, on which the report is based can be downloaded from the web-site of the Life Cycle Initiative.

- Life Cycle Management Program - www.uneptie.org/pc/sustain/lcinitiative/lcm_program.htm
- Life Cycle Inventory Program - www.uneptie.org/pc/sustain/lcinitiative/lci_program.htm
- Life Cycle Impact Assessment Program - www.uneptie.org/pc/sustain/lcinitiative/lcia_program.htm

Table of Contents

Preface

In 2002, UNEP joined forces with the Society of Environmental Toxicology and Chemistry (SETAC) to launch the Life Cycle Initiative, an international partnership to put life cycle thinking into practice. The initiative is a response to the call from governments for a life cycle economy in the Malmö Declaration (2000). The mission of the Life Cycle Initiative is to develop and disseminate practical tools for the evaluation of opportunities, risks, and trade-offs associated with products and services over their entire life cycle to achieve sustainable development. By this, the Initiative contributes to the 10-year framework on sustainable consumption and production that is co-ordinated jointly by UNEP and UN DESA as a follow-up to the World Summit on Sustainable Development (2002).

Equal to living organisms, products have a life cycle as well: they are produced from raw materials, transported to the shops, bought and used by consumers, and eventually disposed of. At each phase in their life cycle, products interact with the environment (extraction or addition of substances), and with the economic (the costs to produce, or the profit to sell a product) and social systems (the personnel needed to transport from factory to shop). In a life cycle economy, decisions are made by industry based upon information on all stages of the life cycle. Incentives are given by governments to produce, reuse, and recycle products and services with the right energy and resource efficiency and with the lowest environmental impact possible. In this economy, consumers will choose between different brands of a product, after balancing these products' environmental impacts such as potential contribution to climate change, social consequences as for instance poor workers rights, and price.

The concept of life cycle thinking integrates existing consumption and production strategies, preventing a piece-meal approach. Life cycle approaches avoid problem shifting from one life cycle stage to another, from one geographic area to another and from one environmental medium to another. Human needs should be met by providing functions of products and services, such as food, shelter and mobility, through optimised consumption and production systems that are contained within the capacity of the ecosystem. Life Cycle Management (LCM) has been developed as an integrated concept for managing the total life cycle of products and services towards more sustainable consumption and production patterns. Life Cycle Assessment (LCA) is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle. It is standardised within the ISO 14040 series..

The three programmes of the Life Cycle Initiative aim at putting life cycle thinking into practice and at improving the supporting tools through better data and indicators. The Life Cycle Management programme creates awareness and improves skills of decision-makers by producing information materials, establishing forums for sharing best practice, and carrying out training programmes in all parts of the world. The Life Cycle Inventory (LCI) programme improves global access to transparent, high quality life cycle data by hosting and facilitating expert groups whose work results in web-based information systems. The Life Cycle Impact Assessment (LCIA) programme increases the quality and global reach of life cycle indicators by promoting the exchange of views among experts whose work results in a set of widely accepted recommendations.

The first action of the Life Initiative was to draft Definition Studies to determine a roadmap for the next years on how to put life cycle thinking into practice. The present report is based upon these Definition Studies of the three programmes of the Life Cycle Initiative: the Life Cycle Management Programme, the Life Cycle Inventory Programme, and the Life Cycle Impact Assessment Programme. The goals of the Definition Studies were to identify the deliverables of the three programmes, and to ensure that the deliverables identified are appropriate to the needs and concerns of all stakeholders. Special attention had to be given to life cycle approaches in SMEs and developing countries where special needs and challenges can be formulated. For these four topic areas the state of the art, user needs and envisaged work tasks were identified.

The objective of this report is to give an overview of the results of the three Definition Studies focusing on the product life cycle in the broader perspective of life cycle approaches and to add a special focus on SMEs and developing countries. It aims to describe the current gaps and limitations of these life cycle approaches that for instance also exists for materials life cycles, the needs of the users of these approaches, and formulate a roadmap to fulfil those needs. On the one hand, the report puts a particular emphasis on the improvement of current analytical tools to make them more relevant for applications in practice. On the other hand, the report calls for the inclusion of scientific analytical results into practice-orientated programmes. Therewith, a road from analysis to practice is drawn.

Reader's Guide

In the introduction, the need for sustainable consumption and production is outlined. Moreover, a general description of the potentials of life cycle approaches for society as a whole is given and the drivers for individual stakeholders to use life cycle approaches are presented. In addition, the current limitations of such approaches are discussed.

In chapter 2, an overview of the different life cycle approaches, related to concepts, scientific analysis as well as to management and policy practice is given. A number of case studies are presented in order to illustrate the experiences, which have been obtained during the last 10 years.

Chapters 3, 4 and 5 show more in depth the progress and first results of the UNEP/ SETAC Life Cycle Initiative and of related (regional) UNEP programs in the field of sustainable consumption and production. In chapter 3 an overview of the state-of-the-art of four core topics is presented: Life Cycle Management, Life Cycle Inventory Analysis, Life Cycle Impact Assessment and the use of life cycle approaches in SMEs and developing countries. In chapter 4, an overview of the user needs in these areas is given, based on a worldwide survey under different groups of stakeholders. Furthermore, one section describes the special needs and challenges concerning life cycle approaches by SMEs and stakeholders in developing countries. Finally, Chapter 5 presents the elaborated road map with an overview of the tasks in these four topic areas.

The annexes to this report comprise an extension of both the state of the art and the user needs, and provides an overview of Task Forces to be initiated by the Life Cycle Initiative. Furthermore, an extensive bibliography and the contact list of contributors to the Definition Studies are added.

Chapters 1, 2 and 5 are written in a way that they are understandable for a nonprofessional. Reading chapters 3 and 4 need some basic knowledge on life cycle approaches. The annexes contain additional information for those quite familiar with life cycle approaches.

Executive summary

Equal to living organisms, products have a life cycle as well: they are produced from raw materials, transported to the shops, bought and used by consumers, and eventually disposed of. At each phase in their life cycle, products interact with the environment (extraction or addition of substances), and with the economic (the costs to produce, or the profit to sell a product) and social systems (the personnel needed to transport from factory to shop).

In a life cycle economy, decisions are made based upon all stages of the life cycle. In this economy, consumers will choose between different brands of a product, after balancing these products' environmental impacts, social consequences (poor workers rights), and price. To reach such a life cycle economy, a change in attitude/ mentality is required, from one-phase thinking to life cycle thinking.

The need to achieve such a life cycle economy has recently been recognised on a high level (First Global Ministerial Environmental Forum in May 2000; WSSD in Johannesburg, 2002). Life cycle approaches can contribute to the realisation of such an economy; they are the tools, programs and procedures developed to help make decisions based on the life cycle. Life cycle approaches can be split in analytical and practical approaches. The analytical part, containing analytical tools, checklists, models and techniques, are used to assess the effects of planned decisions in a scientifically sound way. Life Cycle Assessment (LCA), for instance, is used to assess the environmental consequences of products or services over their whole life cycle ("from cradle to crave"). A producer, for instance aiming at developing a product that is easy to recycle, can use this tool to calculate the environmental impact of the re-designed product by comparing the environmental impact of the old and new design.

The practical life cycle approaches are meant to translate the results from the analytical approaches, and help to achieve a life cycle economy. Governmental and corporate programs, for instance, are programs that aim to reach (a part of) a life cycle economy. Both governments and organisations can enact a Green Procurement policy, which is used to encourage the purchase/ consumption of products or services with a reduced environmental impact. Policy instruments help governments and organisations to execute these programs. In the case of the Green Procurement policy, governments can use a financial instrument (taxes) to stimulate the purchase of sustainable products. Procedural tools, also practical life cycle approaches, consist of guidelines to develop and implement these programs.

The societal potentials of using life cycle approaches are extensive. Using life cycle approaches help to avoid problem shifting; where problems are not solved but (partly) shifted (from one stage of the life cycle to another, from one place in the world to another, from this generation to future ones). Using life cycle approaches can help to find places in the life cycle, where improvements can made cheaper and/or have greater effects. Redesign of products to increase its recycling efficiency often turns out to be cheaper then the improvement of recycling methods. And thirdly, in some cases, using life cycle approaches is purely required to achieve improvements. For individual companies, additional drivers exist to engage in life cycle approaches. Using life cycle approaches may improve market conditions, open new markets, or improve the image of the company.

Of course, life cycle approaches also have their limitations. Particularly the balance between the analysis and practice is criticised by users of life cycle approaches. Analytical and practical approaches are too far apart, more or less constituting two separate worlds. Analytical approaches should improve their accessibility and practical applicability, so that its results can be used in practice more easily. Practice, on the other hand, should improve its scientific bases, and include more results from analysis. These changes will improve the beneficial road from analysis to practice, where a proposal is analysed, and where the results of the analysis are used in the development of practice.

The aim of this report is to discuss possibilities for the improvement of current analysis, and practice, and the road from analysis to practice. These improvements will be discussed on three topic areas: Life Cycle Management (LCM), Life Cycle Inventory (LCI), and Life Cycle Impact Assessment (LCI). Furthermore, special attention will be given to life cycle approaches in SMEs and developing countries as special needs and challenges can be formulated here. For these four topic areas the state of the art, user needs and envisaged work tasks are discussed.

LCM is the management of products and services along the life cycle, through product stewardship, green procurement, or responsible waste management. In order to achieve LCM, stakeholders in the chain must co-operate. This co-operation can be supported by policy instruments such product declaration, and certificates. Furthermore, LCM can be underpinned by analytical tools, such as LCA (see below). The major challenge is to further develop LCM in a way that includes his diversity, hereby building on the results of the SETAC working group on LCM. The main priorities in this field are to develop a better link between analytical tools and procedural approaches, to link corporate and governmental strategies in the use of communication tools such as different types of labelling, to develop stakeholder communication and participation in given product life cycles, and to develop training material and a description of LCM case studies.

In the field of Life Cycle Assessment (LCA), the focus is on the two analytical steps in this tool: LCI and LCIA. Also on these two topics, this report builds on the results of the SETAC working groups on these fields. The state of the art of LCI describes a large number of national and multinational LCI projects. These databases show large differences in their structure and content, and are not compatible. Consequently, there is a high need for a coherent global development of LCI databases. LCI users also like to see the use of LCIs stimulated on a global level, particularly in developing countries.

For LCIA, currently, methods are available for a variety of environmental impacts. An overall framework, together with standardised terminology is in development and will be completed soon. Users gave the highest priority to the development of a global, science based and transparent set of recommended methodologies and factors, both at midpoint level (the level of environmental processes and conditions) and at damage level (the level of human health and biodiversity). Furthermore, a high need was identified to include also environmental issues that are relevant for developing countries, and to broaden LCIA to the social and economic dimensions of sustainability.

Special attention in this report is given to the state of life cycle approaches in SMEs and developing countries. Special needs of SMEs and developing countries include the need for data availability and simple tools, the need for awareness-raising towards life cycle approaches, for technical capacity building and for the establishment of institutional frameworks for capacity building. More fundamentally, life cycle approaches are often seen as being not in line with the interest of developing countries. Life cycle approaches often are costly, and may well discriminate against developing countries, because of the higher environmental burdens due to less advanced technology.

This report will be concluded with the discussion of a number of priority tasks in the field of life cycle approaches. In the implementation of these tasks, the UNEP/SETAC Life Cycle Initiative will play a key role, in co-operation with other UNEP programmes and initiative. The primary tasks on the guidance of life cycle approaches are: the development of a handbook on Life Cycle Management, a global overview of existing LCI databases, guidance on methodological consistency and transparency on these databases, the development of a global LCIA information system, and concluding, the development of a global set of recommended methodologies and factors, where possible with regional differentiation.

In the relationship towards developing countries, the first focus shall be on the development of a library of life cycle case studies, and the development of training material and courses. In co-operation with other UNEP initiatives, a further aim is that life cycle approaches will be combined with technical development so that active participation can be achieved. These work items together offer many opportunities to connect analysis and practice in the field of life cycle approaches.

1. Introduction

1.1. Towards sustainable consumption and production

Changing unsustainable consumption and production has been one of the overriding issues in the work programme of the Commission on Sustainable Development (CSD) since Rio. The United Nations Conference on Environment and Development in Rio de Janeiro in 1992 represented a watershed in the international community's way of thinking about consumption and production. Agenda 21 states that the success of efforts to eradicate poverty and manage the natural resource base for economic and social development will depend upon fundamental changes in global consumption and production patterns. It has become also one of the priorities of UNEP after Johannesburg. The plan of implementation of the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002 calls in Chapter III for the development of "a 10-year framework of programmes in support of regional and national initiatives to accelerate the shift towards sustainable consumption and production."

Policies on sustainable consumption and production are based on the importance of the market – in which production and consumption comes together – for sustainability: the economic dimension, the environmental and the social dimension. The three very much go together in this increasingly globalised and transparent world. This renewed emphasis on consumption and production is aimed at addressing the fact that the gains made in production efficiency are being overtaken by the overall increase in the demand for products and services, also called the rebound effect, as stated in the latest version of UNEP's Global Environment Outlook (GEO-3). The rising demand for products and services generates economic growth and helps to reduce poverty and improve the quality of lives. However, it implicates also increasing consumption of resources, continuing high level of emission of hazardous substances and rapidly changing types of land use with the related negative impacts on the environment.

The challenge of the rebound effect can only be tackled through an integrated life cycle approach that addresses both consumption and production. Therefore, the concept of a life cycle economy was proposed in s workable perspective to approach this issue in the 1st Global Ministerial Environmental Forum in 2000. More than 100 Ministers of Environment stated, "We have at our disposal the human and material resources to achieve sustainable development, not as an abstract concept but as a concrete reality". Furthermore, they state that our efforts "must be linked to the development of cleaner and more resource efficient technologies for a life cycle economy." By life cycle economy the ministers aim at a society that views the production, use and disposal of a product as a comprehensive cycle, covering all processes required: extraction and processing; manufacture; transport and distribution; use, reuse and maintenance; recycling; and final disposal. And in Johannesburg in 2002, the world leaders also recognised that: "We must develop consumption and production policies to improve the products and services provided, while reducing environmental and health impacts, using, where appropriate, science based approaches, such as life cycle analysis". According to the WSSD, life cycle approaches will have to play an essential role on the road towards Sustainable Consumption and Production (SCP).

However, these life cycle approaches must suit the requirements of all relevant stakeholders, particularly also including those from developing countries (see highlight). There is a need to strengthen the implementation of the related policies, and there is a need to reach out to those who are still unfamiliar to the issues. Capacity building, training and information are key for making our current consumption and production patterns more sustainable. Both capacity building and training have to provide important contributions in order to achieve this ambitious aim.

"All countries should promote sustainable consumption and production patterns, with the developed countries taking the lead and with all countries benefiting from the process (…). Develop awareness-raising programs on the importance of sustainable production and consumption patterns, particularly among youth and the relevant segments in all countries, especially in developed countries."
(WSSD – Johannesburg 2002).

The outcomes of the WSSD have been discussed at UNEP's 22nd Governing Council in 2003. The Governing Council "requests the Executive Director to strengthen existing eco-efficiency, cleaner production, and sustainable consumption programs, such as its partnership with the Society of Environmental Toxicology and Chemistry (SETAC), including facilitating the transfer of environmentally sound technologies, especially to developing countries and countries with economies in transition, and activities to stimulate the design of sustainable products and services." With these words, the Governing Council stimulates the co-operation between UNEP and SETAC. These two organisations have started to work together in the Life Cycle Initiative to contribute to a life cycle economy, to promote life cycle thinking, and to encourage the development of sustainable products and services by stimulating the use of scientifically sound methods and data for environmental analysis and putting life cycle thinking into practice.

Since then, the Initiative contributes to the 10-year framework on sustainable consumption and production that is co-ordinated jointly by UNEP and the United Nations Department of Economic and Social Affairs (UN DESA). The International Expert Meeting on this framework in Marrakech (2003) recommended the world-wide implementation and sharing of experiences on Integrated Product Policy approaches through international initiatives such as the Life Cycle Initiative. At several regional SCP meetings, the need for capacity building on life cycle approaches was included in the regional strategy on sustainable consumption and production by the respective governments.

1.2. An introduction to life cycle approaches

A life cycle approach

Just like living organisms, products have a life cycle as well. Where living organisms originate, reproduce, and eventually die, products are produced from raw materials, used by consumers, and eventually disposed of. A product's life cycle is generally broken down into stages. The number of stages can vary; six stages are often distinguished (figure 1):

1) Product design (not shown in figure);
2) Raw material extraction and processing;
3) Manufacturing of the product;
4) Packaging and distribution to the consumer;
5) Product use and maintenance;
6) End-of-life management: reuse, recycling and disposal.

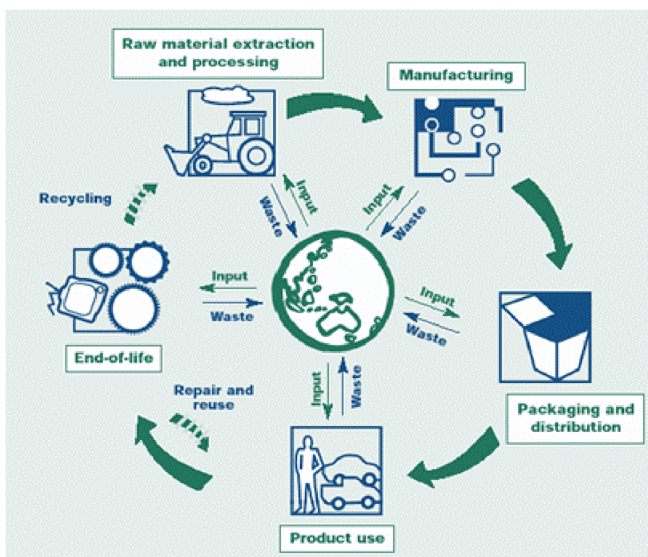


Figure 1: stages of a products life cycle – Australian Government: Department of the environment and heritage

In every stage of its life cycle, products interact with other systems: life cycles are therefore called open cycles. In order to make a product, substances, energy, labour, technology and money are required, while other substances are emitted to the environment. Products can interact with the environmental (extraction or addition of substances, land use), economic (the cost to produce a product, implement technology, the profit to sell) and social domain (employment, workers rights). The relations between the environmental, economic and social domains are quite dynamic. The implementation of cleaner technology will decrease the pollution of the environment, but might increase the cost to make that product, at least in short tearm

In a life cycle economy, all decisions are made based upon an analysis of its consequences on the total life cycle, including the environmental, economic and social domains (see highlight). In a life cycle economy, a company that wants to design a new product will analyse the consequences of its proposal in a broad range of issues, including the environment, the company costs, the benefits for the local economy where the production will take place, the social workers rights, and so on. A proposal will be implemented if it has a good balance between its positive and negative effects. Life cycle approaches are used to assess this proposal; they are the tools, programs, and procedures to help making such life cycle based decisions. To achieve a life cycle economy, a change in attitude/ mentality is required, from one-phased thinking to system thinking.

> "In fact all decisions in government and business should be scrutinised with the 'sustainability lens' from a life cycle perspective."
> Mrs. Jaqueline Aloisi de Larderel, former director of UNEP DTIE in INSEAD Quarterly 4.

Life cycle approaches: potentials for society

Life cycle approaches are getting increased attention over the last ten years (box 1). This increase is not odd considering the advantages a life cycle approach has over the focus on a single process (like production or consumption of a product). For society as a whole, three potentials of life cycle approaches can be identified.

Using life cycle approaches will avoid the commonly encountered 'problem shifting'. Problem shifting means that, while trying to solve a problem, this problem is not fully solved but instead (partially) shifted: from one stage of the life cycle to another, from on location to another, from one environmental medium (e.g. air, water, or land) to another medium, or from the present to the future. A well-known example of problem shifting concerns the use of an aluminium car frame instead of regular steel one in order to decrease the energy consumption during use. However, the production of aluminium requires a higher energy input than steel production does. Studies that analyse the life cycle of steel and aluminium car frames from an environmental point of view show that the advantage of the lighter aluminium car frame is dependent on the amount of its future use: only after a certain number of kilometres, the change will pay off. By taking the whole life cycle into account, the danger of problem shifting can in principle be assessed and prevented.

Being able to oversee the entire life cycle of a product, the use of a life cycle approach gives the potential to optimise the effects of improvements. By making adjustments in that part of the life cycle where intervening is relatively cheap, the costs of environmental improvements can be minimised. For example, it can be cheaper to redesign a product to make it better fit for recycling, then to invest in the improvement of recycling methods. In this way, better design for recycling will reduce both the environmental and economical costs of recycling.

In some cases, the use of a 'consultative' life cycle approach is required to achieve improvements; some improvements can only be achieved by interactions between different stakeholders. For example, retailers can make agreements with producers on the production of sustainable products in exchange for larger markets or a higher profit. Naturally, the consumers' needs and opinions will greatly influence these agreements. Eco-labelled products can only be developed when co-operation (a "chain of custody") exists between a number of stakeholders on different levels of product's life cycle (e.g. farmers, manufacturers, retailers).

Company drivers for using life cycle approaches

The potentials discussed in the previous section, are potentials for the society as a whole. These potentials do not necessarily drive companies into starting life cycle approaches. For them, some additional drivers can be identified.

For some issues, the use of a life cycle approach can be formally required. This requirement can be regulated by law, like with waste management or packaging directives. Furthermore, joining a program can commit an organisation to use a life cycle approach. A yearly updated management plan, containing results of life cycle studies, can be compulsory for members of an environmental label.

Box 1: Unilever's corporate sustainability programme

Extensive LCA studies have been carried out for a large number of Unilever products since the late 1980s. With the experience from these studies it was possible to carry out an "Overall Business Impact Analysis" in 1997, in which the total environmental burden of all products marketed by Unilever world-wide was estimated. Based on this analysis three key issues for Corporate Sustainability Policy were identified: sustainable agriculture, sustainable fisheries, and clean water management. These three issues are directly relevant for the business of Unilever; and the most difference can be made there. At present Unilever hardly carries out full LCAs anymore, but is looking for useful indicators within the above themes in order to be able to steer the process of improvement and monitor progress.

For the agriculture, Unilever is working with a wide group of stakeholders to develop a set of standards for sustainability. Together with Groupe Danone and Nestlé, Unilever founded the Sustainable Agriculture Initiative (SAI) Platform. This platform aims to develop knowledge about sustainable agriculture and communicate widely with a range of stakeholders. It's ultimate goal is the definition and implementation of commodity-specific guidelines for sustainable agriculture, which are harmonized along the food chain.

Towards sustainable fisheries, Unilever began working in 1996 with the international conservation organisation WWF, to help establish a certification programme for sustainable fisheries - known as the Marine Stewardship Council (MSC). This became an independent non-profit organisation in 1999. In 2000, Unilever launched it's first product certified to the MSC Standard - Alaskan salmon in Switzerland (subsequently discontinued for commercial reasons unconnected with the certification). At the end of 2002, on third of the fish was sourced from sources that are assessed to be sustainable, of which 5% are certified to the MSC Standard. Although, short of the 1996 target to source all the fish from sustainable fisheries by 2005, substantial progress has been demonstrated.

Efforts on the issue of water reduction were taken in two ways: by reducing Unilever's impact on water consumption, and by forming partnerships to help protect the water resources. To assess the impact of Unilever itself, they looked at the water use through the full life cycle of their products. This showed that in some product groups (agriculture) most water was used during production, while in other product groups (Home and Personal Care) consumers used the most water. Based on these results, a water reduction policy is performed. Examples of partnerships are the Sustainable Water Integrated Catchment Management Initiative (SWIM) and the Living Lake Partnership.

Source: http://www.unilever.com/environmentsociety/sustainability

Furthermore, using life cycle approaches may help to identify win-win situations, where with the same amount of money more results may be obtained (box 2). By using life cycle approaches, different stakeholders can identify and prioritise the greatest burdens or risks and then can collectively develop solutions to reduce those. In this context the burdens and risks can be in the environmental, social or economic domain. Of course, such a co-operation between stakeholders can only arise if equally distributed benefits are available for all stakeholders in the life cycle, and if there is one stakeholder who takes the lead of this process.

And last but not least, the use of a life cycle approach may well improve the image of a company. Consumers attitude towards companies are positively influenced by an active sustainability policy. Moreover, it helps to avoid criticism that a company is only interested in shareholder value and possible impacts in the direct sphere of influence, and that it does not bother about impacts abroad or in the future. Marketing and selling departments of companies are always looking for new or better ways to communicate to their customers, and the communication of the life cycle environmental strengths of its products and services, provides a company additional information to promote the selling of its products and services.

Although, in most cases, organisations can freely choose whether or not to use life cycle approaches, governments can enhance the use of these approaches with policy instruments. These policy instruments include legal (laws), financial (taxes or subsidies), and communication (training, information) instruments. Communication instruments can also be used to influence the consumers' attitude towards companies using life cycle approaches.

Box 2: J Sainsbury Plc's environmental management policy

J Sainsbury plc is a leading UK and US food retailer with interests in financial services. The Group comprises Sainsbury's Supermarkets and Sainsbury's Bank in the UK and Shaw's Supermarkets including Star Market in the US. The Group's turnover in 2003 was £18.5 billion.

Concerning the environmental policy, three key priorities and six goals were defined by the company in 1998. The three key priorities are to reduce the environmental impact of products, to reduce CO_2 emissions, and to reduce waste. The six goals concern:

- an Environmental Management System, to manage the significant environmental effects over which direct control exists;
- improve environmental quality of own-brand products by influencing suppliers and more sustainable sourcing;
- increase efficiency of product transport, and address employee and costumer travel;
- reduce CO_2 emissions from energy through responsible energy sourcing and increasing efficient consumption;
- reduce that waste produced from operations, increase recovery, and ensure responsible disposal;
- develop, design and operate stores and distribution centres to reduce their environmental impacts.

Next, targets have been set in order to achieve these goals. A selection of the targets for the Sainsbury Supermarkets is displayed here:

- For March 2003 a periodic risk assessment has been implemented to identify and prioritise issues relating to own-brand products.
- By March 2006, all livestock farms supplying into the premium meat range should have FBAP in operation. (For beef cattle this will only apply to the finishing farms). Currently, 53% have FBAP in operation.
- Enable customers to make informed choices regarding the environmental impacts of their shopping. By March 2004, ensure that all existing and new own-brand product lines comply with the Green Claims Code on environmental labelling.
- Reduce CO_2/m^2 by 10% (from a baseline of 1997/98) by March 2005.
- By March 2004, develop and implement a strategy to reduce the amount of waste sent to landfill by 10% (from a baseline of 1999/00) and to increase the amount of recycling relative to turnover. Currently, waste relative to turnover has reduced by 8.2% and recycling of plastic transit packaging was at its highest ever level.

Not only the environment has benefited from Sainsbury's environmental policy; also financial and image rewards are reported in their environmental report. For example:

- Energy savings projects have saved approximately £1¼ million in the last year and are projected to save £3.2 million in the current year.
- The reduction in distance travelled, thanks to the efficiency improvements in Sainsbury's supply chain in the last year, has delivered a saving of approximately £7½ million as well as nearly 4,800 tonnes of CO_2 by Sainsbury's HGV fleet.
- The increase in donation of food past its display-until date to charities has saved nearly £300,000 in waste disposal costs.
- J Sainsbury plc remains one of three global retailers selected for inclusion in the DJSI (Dow Jones Sustainability Index) World Index.
- Sainsbury's was awarded one silver and three bronze awards by the Considerate Constructors Scheme for works completed during 2002.
- Shaw's gained the top award in the Clean Air- Cool Planet Climate Champion Awards 2003

From the Environmental Report 'Being Greener', available on the web-site www.j-**sainsbury**.co.uk/

Analytical and practical approaches

As said in the first section of this chapter, life cycle approaches are the tools, programs, and procedures to help making decisions based on life cycle thinking. An overview of all major tools, programs and procedures is given in chapter 2.

Life cycle approaches can be split into analytical approaches and practical approaches (see also figure 2 on page 15). Analytical approaches are used to assess the effects of planned decisions in a scientifically sound way. These approaches include analytical tools such as Life Cycle Assessment or Life Cycle Costing, checklists consisting of pass-fail criteria, and a number of models & techniques (like pollutant fate or allocation models).

The practical life cycle approaches are meant to translate theory and lessons learnt from the use of analytical tools into practice. Practice consists of (governmental) policy programs, corporate programs, policy instruments, and procedural tools. Although some overlap exists, there are differences between policy programs and corporate programs. Examples of policy programs are the Integrated Product Policy programme of the European Union, or the Chemical Product Policy of the OECD. Typical corporate programs include Supply Chain Management and End of Life Management. Policy instruments are tools to support mainly the interventions of governments, for example taxes, laws, or communication. Procedural tools are procedures and guides helping to motivate and implement environmental decisions, like Environmental Performance Evaluation and Design for the Environment.

All life cycle approaches are steered by concepts, which are guiding principles (e.g. ideas, ideals) on how to achieve a life cycle economy. Examples of concepts are "sustainability" and "life cycle thinking". Both analysis and practice are supported by data and information. Examples of data and information are databases with specifications of resource use and emissions (like life cycle inventory process data) and toxic substances (like life cycle impact assessment characterisation factors), or statistical data on a country's demography.

The difference between a practical and an analytical approach is shown in the Box 3, where the "waste management hierarchy", based on a general guidance concept is compared with the "integrated waste management", based on lessons learnt from analytical tools using a quantitative analysis.

BOX 3: Waste Management Hierarchy versus Integrated Waste Management

Both Waste Management Hierarchy and Integrated Waste Management are programmes aiming to minimise the production of waste. However, these approaches have a very different set-up.

The Waste Management Hierarchy represents a chain of priorities for waste management options, stretching from the ideal of prevention and reduction to the last resort of disposal. The most basic hierarchy is:

1. Reduction
2. Reuse
3. Recovery (recycling, composting, energy recovery)
4. Disposal

Waste Management hierarchy is mainly based on concepts and can be considered a typical practical approach; it is developed to be used and implemented with ease, and requires no analytical analysis.

Integrated Waste Management, on the other hand, aims at managing waste in an environmentally and economically optimum way, and involving the best use of all available assets and treatment options at local and regional levels to meet given objectives. IWM includes a range of different waste management techniques and processes used to achieve a sustainable and effective waste management policy. The European Resource Recovery Association (ERRA) have defined IWM as; 'the management of resources and waste in an optimised way, taking into consideration environmental, economic and social aspects'. As can be seen, `Integrated Waste Management is practical, but based on an analytical approach; it is far more difficult, and requires a number of quantitative analyses.

1.3. Dealing with limitations of life cycle approaches

The limitations of life cycle approaches

Obviously, life cycle approaches also have their limitations. Some of these limitations impede further dissemination of life cycle approaches, particularly in SMEs and developing countries. Different kinds of criticism are expressed for both analytical and practical approaches.

Analytical approaches, which are generally developed by the scientific community, are said to be too much science driven. They are said to be too complicated, and not sufficiently made for easy use. While complicated tools may well be useful for large companies or governmental organisations, they are difficult to apply by small and medium enterprises (SMEs), and even more by stakeholders in developing countries. The UNEP publication 'Towards the Global use of Life Cycle Assessment', published in 1999, discusses some crucial barriers to the wider use of Life Cycle Assessment (LCA), the most used analytical life cycle tool. These barriers are:

- the absence of perceived needs
- the lack of LCA expertise/ know how
- the lack of funding for LCA
- the lack of appropriate data and methodologies.

The relative importance of these barriers differs between countries; thus, the lack of expertise and funding is particularly relevant in SMEs and developing countries. Although these barriers are described for one specific tool, LCA, they hold in fact true for all analytical tools.

Current practical approaches, which generally consist of programs developed by governmental and corporate organisations, are criticised for lacking sufficient scientific support. These programs and also the underlying procedures and policy instruments are criticized of being based on qualitative concepts and guidelines, rather than on science and lessons learnt from the use of analytical tools. These limitations of both analytical and practical tools impede a beneficial road from analysis to practice, where intended new measures are analysed, and where the results of the analysis are used in the development of practice.

With regard to life cycle approaches in general, some additional and very serious criticism is expressed by stakeholders in developing countries. The scope of many approaches is said to be one sided: tools only focus on environmental issues that are of concern in the industrial world, and criteria underlying labels are not always relevant in developing countries. It has also been argued that life cycle approaches are barriers to trade for developing countries.

Dealing with these limitations

This report is based on the assumption that the road towards the global use of life cycle approaches consists of two elements: addressing the observed limitations of life cycle approaches, and improving capacity building and dissemination.

Both analytical and practical approaches need to be improved. The first should improve their coverage of impacts, and their accessibility, reliability and practical applicability, so that their results can more easily be used in practice. The latter should improve their scientific basis, and should take up more of the lessons learned from science-based analytical studies. Hence, the aim of this report is to determine a road from ‘analysis to practice’. In addition, because stimulating the use of life cycle approaches in SMEs and in developing countries is most essential for the global use of life cycle approaches, in this report special attention will be given to the adaptation of life cycle approaches to a better fit with the respective needs.

Furthermore, the use of life cycle approaches needs to be stimulated around the world by means of awareness raising activities, by capacity building and dissemination, and by developing manuals and training. Also regarding capacity building, this report aims to give special attention to SMEs and developing countries.

The objective of the report is to establish an action plan with a comprehensive list of tasks for the improvement of the global use of life cycle approaches. Steps towards this aim imply an overview of life cycle approaches, the definition of their state of the art and the identification of the needs for the improvement of their global use.

2. Overview of life cycle approaches

2.1. A general overview

As discussed in the introduction, life cycle approaches can be split into analysis and practice; see figure 2 for an overview. The role of concepts is to inspire and guide both analysis and practice. Life cycle approaches are supported by data and information. The main message of this report is that analysis has to become more practice-oriented, and practice more science-based. To make this message more specific, an overview of different life cycle approaches will be given in the following sections of this chapter. Case studies are added to demonstrate the experience with the use of different life cycle approaches during the last 10 years. The overview is inspired by Wrisberg et al. (2002).

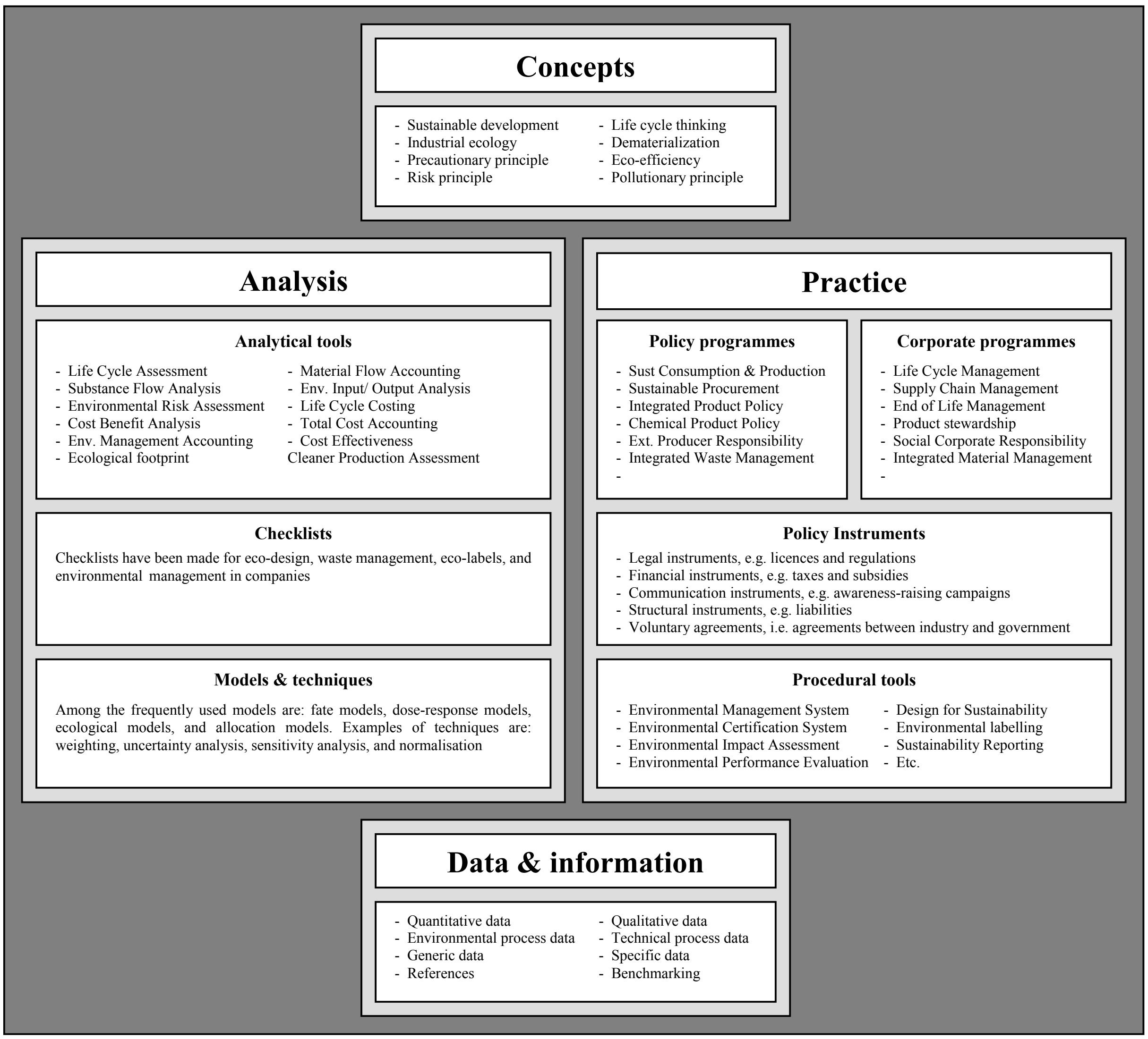


Figure 2: life cycle approaches, consisting of analysis and practice, are directed by concepts ad supported by data and information (modified from Wrisberg et al., 2002).

2.2. Concepts

Concepts can in the present context be defined as general guiding principles for life cycle approaches. The most important concepts for life cycle approaches are explained in this section.

Sustainable development
A widely used definition of sustainable development is: "development which meets the needs of the present without compromising the ability of future generations the ability of future generations to meet their needs." For development to be sustainable, it must integrate environmental stewardship, economic development, and the well-being of all people. Sustainable development is the ultimate goal of the application of all life cycle approaches.

Life Cycle thinking
Life Cycle thinking considers the cradle-to-grave implication of any action. It reflects the acceptance that key societal actors cannot strictly limit their responsibilities to those phases of the life cycle of a product, process or activity in which they are directly involved. It expands the scope of their responsibility to include environmental implication along the entire life cycle of the product, process or activity (SETAC, 1997).

Industrial Ecology (IE)
Industrial Ecology is the multidisciplinary study of industrial systems and economic activities, and their link to fundamental natural systems (Allenby, 1999). It is concerned with the evolution of technology and economic systems such that human activities mimic mature biological systems as regards being self-contained in their material and resource use (Allenby, 1994). Life cycle approaches are frequently used in Industrial Ecology.

Dematerialization
Dematerialization refers to a substantial reduction in the volume of material and energy used to meet a user's demand, whilst increasing the quality of service. The "factor X" paradigm is another synonym for dematerialization. The factor X resembles the relative increase of resource efficiency within a certain period. Factor 4, for instance, means that the productivity (the value for society from one unit of natural resources extracted) should quadruple. Life cycle approaches are often seen as one important element to monitor and make the way towards this reduction operational.

Eco-efficiency
The term eco-efficiency was introduced by the Business Council for Sustainable Development (BCSD, 1993), now World Business Council for Sustainable Development (WBCSD). It is defined as followed: "Eco-efficiency is the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, whilst progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level in line with the Earth's estimated carrying capacity". Eco-efficiency has become a synonym for a management philosophy towards sustainability; in short, eco-efficiency means producing more with less. Eco-efficiency as concept can be applied as a practical but qualitative guiding principle for life cycle approaches. An extension of this concept is given in box 4.

Precautionary, risk and pollutionary principle
The precautionary, risk and pollutionary principles are closely related. According to the precautionary principle, when the effects of a proposal are not known, it should not be executed. The precautionary principle can be followed on the environmental, social, and economic domains. The results of life cycle approaches make potential impacts visible and can help to avoid that environmental and social burdens are shifted from one life cycle stage to another. The risk principle state aims at the minimisation of risks, for all three domains (environmental, social and economic). The pollutionary principle states that all environmental pollution should be minimised.

BOX 4: Eco-efficiency and life cycle approaches

As discussed in the main text, eco-efficiency was first coined by the World Business Council on Sustainable Development (WBCSD) in 1991. Eco-efficiency is used to calculate the ratio between economy and environment. Based on whether economy or environment is in the denominator, two definitions of eco-efficiency can be distinguished:

- the environmental impact per economical unit (environment/ economy),
- the economic cost of environmental improvement (economy/ environment), also called cost-effectiveness.

According to the WBCSD, business can achieve eco-efficiency gains through a number of ways:

- Optimized processes - moving from costly end-of-pipe solutions to approaches that prevent pollution in the first place.
- Waste recycling - using the by-products and wastes of one industry as raw materials and resources for another, thus creating zero waste.
- Eco-innovation - manufacturing "smarter" by using new knowledge to make old products more resource-efficient to produce and use.
- New services - for instance, leasing products rather than selling them, which changes companies' perceptions, spurring a shift to product durability and recycling.
- Networks and virtual organizations - shared resources increase the effective use of physical assets.

In 2001, the Spanish BCSD worked with twelve companies to develop a Tool Kit to help business improve and quantify eco-efficiency. Using the tool kit to analyze its processes and products, Siemens AG managed to simplify construction, cut its energy consumption by 45 percent, extend the working lives of key machines, and save money in the bargain. Another user, TPSA Group, used the kit to analyze a water purification plant to be built in a developing country and managed to improve energy consumption by 66 percent and cut the cost of the final product by 85 percent.

Sources:
WBCSD – www.wbcsd.org
Website Eco-efficiency conference April 2004, Leiden, the Netherlands – www.eco-efficiency-conf.org

2.3. Analysis

Under the heading of analysis, we can make a distinction between analytical tools, checklists and models & techniques. Note that these three contributions to analysis are not exclusive. Because of it's importance for this report, the analytical tools will be discussed in more detail.

Analytical tools

Analytical tools are modelling the systems in a quantitative way, aiming at providing scientifically sound information for learning about the system under consideration and ultimately better decision-making. The focus of analytical tools is on computational algorithms and thus requires quantitative data.

Life Cycle Assessment (LCA)

Life Cycle Assessment aims at specifying the environmental consequences of products or services from cradle to grave. In ISO 14040, LCA is defined as the "compilation and evaluation of the inputs, outputs, and potential environmental impacts of a product system throughout its life cycle". The core application of LCA concerns product related decisions support. It can be hotspot identification in product systems, product development, product comparison, green procurement and market claims. However, LCA is also, next to other tools, important for technology choices, setting technologies into a product related chain perspective. LCA is increasingly used at a strategic level for business development, policy development, and education.

According to ISO 14040, LCA contains four methodological phases (figure 3):

1. Goal and scope definition.
2. Life Cycle Inventory Analysis (LCI).
3. Life Cycle Impact Assessment (LCIA).
4. Life Cycle Interpretation.

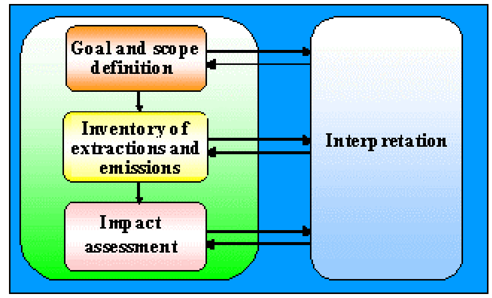


Figure 3: The four phases of LCA

In the first step of a LCA, the goal and scope of the study should be determined. This includes an exact formulation of what is to be investigated, and how this investigation is to be carried out. Furthermore, the system boundaries are chosen and argued.

The Life Cycle Inventory Analysis specifies the processes that occur during the life cycle of a product. In LCI, an inventory is made of all the inputs and outputs of industrial processes that occur during the life cycle of a product. The first task in the inventory analysis is to specify all the processes involved in the product life cycle in the form of a process flow chart. The next step is to collect data on each process, by consulting scientific literature or published data (e.g. databases). Collecting the data is the most time consuming and perhaps the most difficult part of a LCA. Once data has been collected on all processes, the critical processes can be selected for further analysis. By reducing the scope of the analysis, the LCA can be reduced to a more manageable size, but this selection introduces a risk to influence the results. In the last stage of an inventory analysis, the data will be processed. An inventory table will be created, in which all inputs and outputs have been translated into environmental inputs and outputs.

The inventory table is used in the third step, the Life Cycle Impact Assessment. In the impact assessment, the results (the quantified inputs and outputs) of the inventory analysis are interpreted in terms of the impacts they have on the environment. First of all, these stressors (inputs and outputs) are classified according to the kind of environmental problem to which they contribute. Examples of classes are: acidification, global warming, and human toxicity. Naturally, stressors can contribute to several types of problems. In the next step, the characterisation step, the contributions to each environmental problem are quantified. For this equivalency factors are used, which indicate how much a substance contributes to a problem, compared to a reference substance.

The last step of the impact assessment is the validation. It involves the overall comparison of the environmental problems. If desired the LCA study can be concluded with a single figure, or environmental index, in which each environmental problem is weighted in terms of its importance. This figure or index allows an easy and direct comparison of different products or options. The weights used are of course subjective. The results of the LCA, and all choices and assumptions made in the analysis are then evaluated, and overall conclusions are drawn. A case study of an LCA analysis is shown in box 5.

The obvious strong point of LCA is its comprehensiveness: the inclusion of the total production-consumption-waste management chain from cradle-to-grave, and of all environmental issues involved. The comparisons of different ways to fulfil one function therefore is in principle encompassing, and LCA may be regarded as the most suitable tool for this purpose. This includes all types of analysis of chains that are defined in reference to the fulfilment of a specific function: spotting the main problematical points in a chain, deriving options for chain improvement, optimising a chain, comparing alternative chains, etc.

This description of LCA has been based on the UNEP publication “LCA what is it and how to do it”. Please consult this report for more information of LCA.

BOX 5: LCA as a tool for the environmental development of the Tannery Industry in Developing Countries

Tanning is the process of transforming the animal skin to leather. The leather tanning process is composed of several batch stages associated with the consumption of large amounts of freshwater, as well as the generation of liquid and solid wastes. A representative leather tannery industry in a Latin American developing country has been studied from an environmental point of view, including both technical and economic analysis.

Three main subsystems in the tanning process have been studied:

- In the Beamhouse subsystem, salt and dung are both eliminated from the preserved hides, hair is removed (with lime), and hides are swollen and fleshed. The hides are washed between each step.
- In the Tanyard subsystem, the pelts are washed and the remaining lime is removed. PH is lowered to 4.0 for the tanning process. Subsequently, the tanned hide (or "wet blue") is dehydrated , split and shaved.
- In the Retanning subsystem, the "wet blue" is retanned, dyed, and fat-liquored.

The energy supply used for water-heating facilities is considered as the fourth subsystem: the wood furnace. Dressing and finishing were not included in this analysis, because they strongly depend on the article produced.

TABLE 6. Main Pollutants and Their Percentual Contribution to the Overall Environmental Impact

	beamhouse	tanyard	retanning	wood furnace	total
Cr		51.20	18.20		69.40
CrVI		2.84	3.92		6.76
NH_3		3.86			3.86
SO_x	2.0	0.45	0.04		2.49
CO_2	0.39	0.48	0.04	1.11	2.02
coal	0.84	1.12	0.21	0.22	2.39
natural gas	0.63	3.73	0.13	0.11	4.60
crude oil	0.35	0.30	0.008	1.33	1.99
total	4.21	63.98	22.55	2.77	93.51

Most leather is obtained with chromium salts as the tanning agent. During this tanning process, 30-50% of the chromium is lost in the wastewater. As a result, this substance is responsible for 69% of the Overall Environmental Impact (see table). Besides Chromium, CR(VI) was detected in the wastewater. Ammonia air emissions from the deliming step are also significant. The control and reduction of chromium and ammonia emissions will be critical points to be considered for improvement options. Six improvement options are analysed; the figure shows the environmental impacts and costs of these options compared to the 'classic' method. The options are:

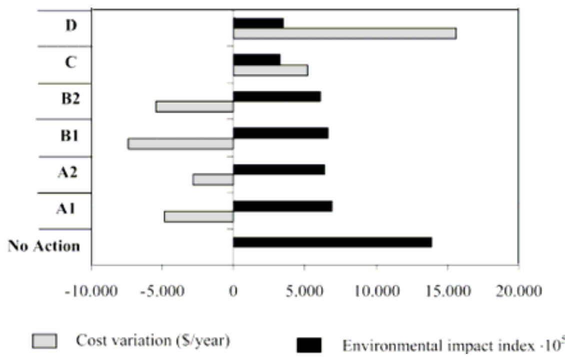
A1: improved operational conditions of the chrome-tanning process.
By optimising the operation parameters the Chromium uptake can be increased to 90%. In this case the temperature is set to 50°C, the PH adjusted to 4.5, and the float level controlled. The environmental impact is greatly reduced, while also the costs are substantially lower, due to reduced chemical consumption.

A2: improved operational conditions and auditing lime and $(NH_4)_2SO_4$ addition.
To remove the hair of the hides, and excess of lime is added. The residual lime is removed in the Tanyard subsystem with $(NH_4)_2SO_4$. Ammonium gas is formed during the last stage, which is released to the air. The auditing of both lime and $(NH_4)_2SO_4$ largely decreases the release of ammonia. The cost reduction is smaller than achieved in method A1, despite the savings in chemical consumption. The environmental impact is reduced because of the ammonia reduction.

B1: high exhaustion chrome-tanning process.
The High exhaustion chrome-tanning process is a new chrome tanning step with uses a combination of Alutan (an aluminium based compound) and basic chromium sulphate. With this action, the chrome absorption rate is 90%, and the spent solution can be reused in the 'pickling stage' in the Tanyard subsystem (the stage where the PH is lowered). This step offer the largest cost reduction, with an environmental impact comparable to A1.

B2: high exhaustion chrome-tanning process and auditing lime and $(NH_4)_2SO_4$ addition.
The combination of a new chrome-tanning method and the audition of lime and $(NH_4)_2SO_4$ results in an even lower environmental impact. Again, a substantial cost reduction can be achieved, although not as much as in B1.

Continued on next page…



C: B2 and primary treatment.
Water treatment can be used to decrease the environmental impacts even further. The solid substances can be removed from the wastewater by trash racks, sulphide oxidation, homogenisation, and chemical setting. This is called primary treatment. The table shows that primary treatment can largely decrease the environmental impact, but at great costs.

D: B2 and primary and secondary treatments.
Here, the primary system is followed by a further biological treatment. Despite that no improvement on the environmental index is achieved by the application of the biological treatment, a significant increase of costs is associated to its implication.

Rivela, B., M.T. Moreira, C. Bornhardt, R. Méndez, and G. Feijoo (2004). Life Cycle Assessment as a Tool for the Environmental Improvement of the Tannery Industry in Developing Countries. *Environmental Science and Technology* 38(6): 1901-1909.

Please note that the Life Cycle Initiative does not promote the use of any particuar weighted LCIA results like the environmental impact index.

Material Flow Accounting/ Substance Flow Analysis (MFA/SFA)
Material Flow Accounting (MFA) aims at specifying the pathways of materials in, out, and through the economy of a nation, region, community, business sector, company, or household. MFA enables one to spot the major flows and stocks, to signal future problems in an early stage, to trace the fate of inflows, to link specific pollution problems to their origins in society, and to assess the consequences of management changes for the environmental flows and stocks. Related to MFA there is the tool of Substance Flow Analysis (SFA), focussing on the metabolism of individual substances or groups of substances. Thus two complementary approaches exist:

- Material Flow Accounting (MFA), analysing the metabolism of bulk materials (e.g. steel, wood, total mass). The results can be used to set priorities for policy measures towards increased resource efficiency and sustainable supply and waste management systems.
- Substance Flow Analysis (SFA), analysing the metabolism of a single substance or of a group of substances that are associated with specific environmental effects. This allows for an effective cause-effect modelling, linking the actual industrial metabolism to specific environmental issues in a quantitative manner.

Box 6 shows a case study of an SFA analysis: the contemporary European copper cycle.

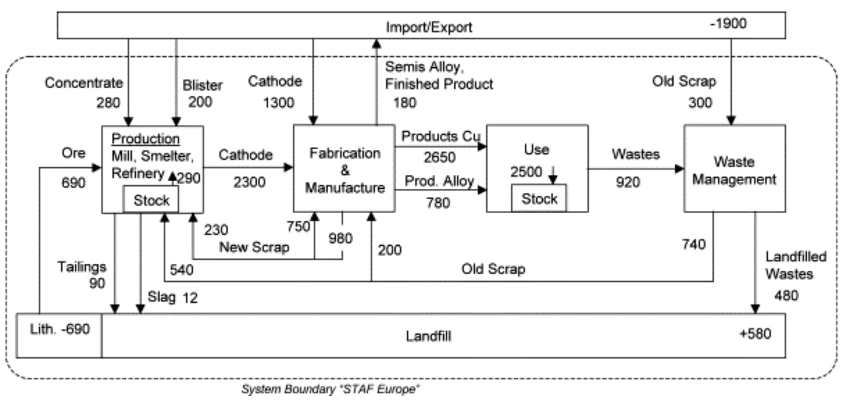
Environmental Risk Assessment
Environmental Risk Assessment (ERA) studies are carried out to study the effects on humans and ecosystems and enable a risk management decision to be made. The principles or ERA are to identify the hazards of a substance, and to characterise the risk by performing a fate and effect analysis. The result of an ERA study may lead to a risk acceptance, or to the implementation of risk reduction measures that reduce the likelihood of the event or reduce the consequences to a satisfactory level.

Box 6: SFA and the Contemporary European copper cycle

Substance flow cycles can provide a picture of resource uses and losses through a geographic region, allowing the evaluation of regional resource management and estimation of gross environmental impacts. In a special section in *Ecological Economics*, three papers discuss the contemporary European copper cycle[1].

The first paper gives a detailed description of the components of the copper cycle and the connecting flows. The components are the reservoirs in which copper resides during it's life cycle, including the lithosphere, ore and ingot processing facilities, fabricators, uses, landfills, etc. The flows consist of connections between the reservoirs, and the imports to and exports from the scrutinized region. In this paper, also generic approaches to the acquisition and evaluation of data over space and time are discussed, and data quality and utility are evaluated. Despite considerable data limitations, it is concluded that information is sufficiently available and the data sufficiently accurate to characterize copper cycles at a variety of spatial scales.

The second paper traces the flow of copper as it enters and leaves the European economy over 1 year and provides the numerical accounting of the copper reservoirs and flows discussed in the first paper. The majority of copper is mined, smelted, and refined outside of Europe. Across the life cycle, a net total of 1900 Gg/year (1 Gg= 1000 metric ton) of copper is imported into Europe. About 40% of cathode copper produced within the system is made from old and new scrap. It is estimated that approximately 8 kg of copper per person enters use in society, largely in infrastructure, buildings, industry, and private households. The waste management system in Europe recycles about 60% of the copper from waste. The copper discard flow from post-consumer waste is roughly five times higher than that from copper production waste. This ratio would decrease if we consider production wastes generated outside of the European system boundary. The net addition of copper to the stock in society in the system is about 6 kg/person. Given the in-service lifetime of the applications of copper identified in this model, most of the copper processed during the last few decades still resides in society, mostly in non-dissipative uses.



The third article describes the flows of copper to the various end-of-life reservoirs. Seven types of waste are identified, quantified and discussed. The recycling efficiency of the current waste management system in Europe was quantified and the sources of copper scrap used for secondary copper production were determined. Additionally, an assessment of copper losses to the environment from incinerators and landfills was undertaken. As a final step, select parameters were varied to test the sensitivity of copper waste generation results to the uncertainties in the data. The total flows of copper into the European waste management system consists of 920 Gg/y domestic copper waste and of 300 Gg/y imported old scrap, of which 740 Gg/y are recycled and 480 Gg/y are landfilled. In Europe 2 kg per capita of copper waste is generated annually. The overall recycling efficiency for Europe for copper in all types of waste, excluding prompt scrap and scrap imports, is 48%, with a range of 5–58% depending on the country. This shows further potential for increased recycling activities in the future. Emissions of copper to the environment are under 5 Gg/y but several new sources for emissions are not yet quantified.

[1] Three publications on the contemporary European copper cycle:

-
- Greadel, T.E. *et al.* (2002). The characterization of technological copper cycles. *Ecological Economics* 42(1-2): 9-26.
- Spatari, S. *et al.* (2002). 1 year stocks and flows. *Ecological Economics* 42(1-2): 27-42.
- Bertram, M. *et al.* (2002). Wwaste management subsystem. *Ecological Economics* 42(1-2):43-57.

The full field of Risk Assessment includes the consequences of activities, technical installations, technologies, processes or substances (or chemicals). Environmental Risk Assessment (ERA) more in particular focuses on chemicals, which are considered to be hazardous; it involves the following stages:

- the identification of the hazard
- exposure assessment

- effect assessment
- risk characterisation

The risk characterisation can be defined as “the quantitative estimation of the incidence and severity of the adverse effects likely to occur in a human population or environmental compartment due to actual or predicted exposure to a substance". More in general, risk assessment approaches often focus on the consequences of single activities or technical installations. Such approaches can be relevant from a life cycle perspective if a number of core activities along a life cycle are investigated in a consistent way, thus identifying hot spots for improvement. Box 7 shows a case study of ERA.

Box 7: The use of LCA and ERA in an Integrated Product Assessment

The environmental profiles of 2 laundry detergent products, A and B, were analysed on the basis of 2 distinct but complementary technical approaches: environmental risk assessment (ERA) and life cycle analysis (LCA). ERA provided safety reassurance for the type of chemicals used in both products while LCA provided insight in overall raw material and energy consumption as well as air, waterborne and solid waste emissions taking into account all life cycle phases (raw material production, manufacturing, transportation, packaging, consumer use and disposal). The risk assessment was performed using 2 scenarios: a gradual increase of market share from 0% to 100% for both product A and B. The results of the ERA showed that under all market share conditions, chemicals used in product A and B are well below the risk limit of 1. However, risk quotients are increasing rapidly when the market share of product A reached 100%. This increase was not observed with product B where risk quotients remained very low under all market share scenarios. The LCA analysis showed that for most of the inventory emissions and impact categories, product A had a lower potential impact than product B. In the context of comparative analysis between product A and B, the risk assessment tends to indicate that product B is the preferred option because it provides higher level of comfort to the risk manager while the LCA tends to indicate that product A is the preferred option in terms of potential impact. This study illustrates the need to use complementary tools in the context of environmental management of chemicals and products.

E. Saouter and T. Feijtel from Procter and Gamble, in Wrisberg et al., 2002

Input/ Output Analysis (IOA) and Environmental Input/ Output Analysis (env. IOA)

Input/ Output Analysis (IOA) concerns the analysis of monetary flows between economic sectors. It is mainly used to display all flows of goods and services within an economy; simultaneously illustrating the connection between producers and consumers and the interdependence of industries. The use of IO-tables is important for analysing structural adjustments in industry. Input/ Output Analysis was founded by Wassily Leontief in the 1930s, focussing on how industries trade with each other, and how such inter-industry trading influenced the overall demand for labour and capital within an economy. The basic distinction that is made in IOA is between the output of goods and services sold to "final demand" (households, governments, exports, investment), and the "total output" of the various sectors, compromising final demand, plus the output that is used as inputs into other sectors (intermediate demand).

- Environmental IOA is based on an extension of the traditional Leontief model. In environmental IOA, extractions and emissions are additional objects of analysis. In the environmental extensions, additional conditions must be included in order to enforce consistency among inter-industry production, pollution generation and pollution abatement activities.

IOA is increasingly linked to LCA, called hybrid analysis. In such hybrid analysis, process analysis data and IO-data are combined, with the aim of reducing a number of errors. For instance, conventional LCA is likely to ignore processes connected to services, small inputs, and the manufacture of complex products from basic materials. IOA methods, while comprehensive in framework, are subject to inherent errors due to the use of economic data to simulate physical flows and the aggregation of the whole economy into one relatively simple matrix.

Life Cycle Costing (LCC)

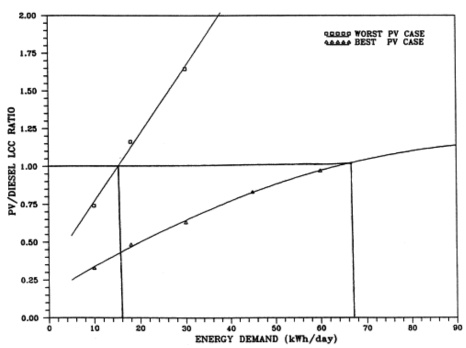
Life Cycle Costing is a tool that looks at the complete life span of a product, process or activity and calculates the entire life cycle costs. LCC is generally used for decisions about the design and development of products, processes and activities. An LCC analysis always includes all internal costs incurred throughout the life cycle of the object under investigation. Normally, it does not include external costs. The internal costs include conventional costs (such as product costing, performance evaluation costs) and less tangible, hidden, indirect company costs (such as environmental permitting and licensing, reporting, waste handling). External costs are those for which the company, at a specified time, is not responsible, in the sense that neither the marketplace nor regulations assign such costs to the firm. Case studies on LCC is shown in box 5 and in box 8. Both case studies do not include environmental costs.

Box 8: Economic viability of stand-alone solar photovoltaic system in comparison with diesel-powered system for India

In this article, the economic viability of a stand-alone solar photovoltaic (PV) system has been compared with the most likely conventional alternative system, a diesel-powered system, through sensitivity analysis using a life cycle cost computation.

It is difficult to compare PV and diesel-power system technologies fairly, since their cost structures are entirely different. A diesel-powered system has low initial cost, while a PV system is significantly more expensive for the same energy demand. However, the PV system uses no fuel and has very low maintenance costs, while the diesel generator requires a constant purchase of fuel and maintenance on a regular basis. The Life Cycle Costs of a solar PV system consists of the initial capital investment, the present value of operation and maintenance costs, and the battery replacement costs. The Life Cycle Costs of a prime diesel generator system consists of the initial capital costs, the fuel costs, the maintenance costs and the replacement costs.

The comparison has been carried out for the energy demand for different key parameters, such as discount rate, diesel fuel costs, diesel system lifetime, fuel escalation rate, solar insolation, PV array cost, reliability, etc. The graph shows the results of the sensitivity analysis for both the best and worst PV conditions.



The article concludes that PV-powered systems are the lowest cost option at a daily energy demand of up to 15 kWh, even under unfavorable economic conditions. When the economic parameters are more favorable, PV powered systems are competitive up to 68 kWh per day. These comparisons are intended to give a first-order indication of when a stand-alone PV system should be considered for application. As the cost of PV systems decreases and diesel costs increase, the break-even points occur at higher energy demand.

M. Kolhe, S. Kolhe, and J. Joshi. In *Energy Economics* 24(2): 155-165

Total Cost Accounting (TCA)

Total Cost Accounting is a relatively new approach that works from existing financial and management costing systems to identify all costs, including previously hidden and intangible, and assigns them to a specific product or process. External costs, costs which are not paid directly by the company, but which are borne by neighbours and society, can also be factored in the method. Total Cost Accounting reveals a more complete cost per process or product than traditional ledger values. These costs can then be considered by decision makers in targeting process improvements, modifying product lines, and other business strategies. TCA is useful to companies that strive to improve efficiencies and reduce costs to achieve the 'triple bottom line' results– economic, environmental and social success. Total Cost Assessment is a tool similar to LCC, but has a focus on one particular project and usually also includes intangible costs.

Environmental Management Accounting (EMA)
Management accounting is a broad term referring to the process of identification, measurement, accumulation, analysis, preparation, interpretation, and communication of financial information used by management for planning, evaluation, and control within an organisation, and for ensuring of accountability for its resources. Environmental Management Accounting serves as a mechanism to identify and measure the full spectrum of environmental costs of current production processes and the economic benefits of pollution prevention or cleaner processes, and to integrate these costs and benefits into day-to-day business decision-making.

While management accounting systems are traditionally viewed as matters internal to a firm, the potential social benefits resulting from widespread use of environmental management tools calls for active governmental involvement in promoting such systems. Government programmes and policies can play an important role in encouraging and motivating businesses to adopt environmental management accounting systems as an integral part of a firm's management accounting practices, such that all project costs (including social and environmental costs) become clearly articulated, fully inventoried and properly allocated over the life of an investment.

Source: http://www.un.org/esa/sustdev/sdissues/technology/estema1.htm

Cost Benefit Analysis (CBA)
Cost Benefit Analysis is an economic tool for determining whether or not the benefits of an investment or a policy outweigh its costs. The tool has a very broad scope, and aims at expressing all positive and negative effects of an activity in a common unit (namely money), from a social, as opposed to a firm's point of view. CBA is usually applied for major public investment projects, like infrastructure projects, and also for policy evaluation. Whole production and consumption systems can be examined, and in this way it contributes to life cycle approaches. Economic and environmental elements are expressed in monetary values – as far as possible and depending on the level of detail. In terms of methodological steps, CBA involves first of all a determination of which costs and benefits are examined, then tries to identify these costs and benefits, and finally weighs them against each other.

Cost-effectiveness
From the qualitative concept of "eco-efficiency" (see above) also quantitative performance indicators can be derived. This can be done in two different ways: either as "cost per unit of environmental improvement", or as the inverse "environmental impact per unit of costs. In order to avoid confusion, and in line with OECD and WBCSD, the unambiguous term "cost-effectiveness" may well be used, in the meaning of cost per unit of environmental improvement

Checklists
A checklist can be described as a series of questions or points of attention that can be phrased in terms of pass/fail criteria. Checklists can be made for multiple goals. Checklists for Eco-design can be used by a designer to check whether they did not forget any aspect. Likewise, organisations that want to obtain an eco-label should pass all criteria of a checklist provided by the certification organisation. Box 9 gives an overview of the checklists of the labelling programmes Forest Stewardship Council (FSC) and the Marine Stewardship Council (MSC). Whether the criteria are met or not, may then be ascertained by using for instance LCA. Special types of checklists are those based on pass/fail criteria.

BOX 9: Principles and Criteria of the FSC and MSC

The Forest Stewardship Council (FSC) and the Marine Stewardship Council (MSC) are labeling programmes for forestry and fishery, respectively. The checklists of the labeling programmes are the Principles and Criteria; they are used as a standard for the third party accreditation of the label.

The FSC discriminates ten principles. Each principle contains 3 to 10 criteria. The principles are:

1. *Compliance with laws and FSC principles.* Forest management shall respect all applicable laws of the country in which they occur, and international treaties and agreements to which the country is a signatory, and comply with all FSC Principles and Criteria.
2. *Tenure and use rights and responsibilities.* Long-term tenure and use rights to the land and forest resources shall be clearly defined, documented and legally established.
3. *Indigenous peoples' rights.* The legal and customary rights of indigenous peoples to own, use and manage their lands, territories and resources shall be recognized and respected.
4. *Community relations and worker's rights.* Forest management operations shall maintain or enhance the long-term social and economic well-being of forest workers and local communities.
5. *Benefits from the forest*. Forest management shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.
6. *Environmental impact.* Forest management shall conserve biological diversity and it's associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by doing so, maintain the ecological functions and the integrity of the forest.
7. *Management plan.* A management plan – appropriate to the scale and intensity of the operations – shall be written, implemented, and kept up to date. The long-term objectives of management, and the means of achieving them, shall be clearly stated.
8. *Monitoring and assessment.* Monitoring shall be conducted – appropriate to the scale and intensity of forest management – to assess the condition of the forest, yield of forest products, chain of custody, management activities and their social and environmental impacts.
9. *Maintenance of high conservation value forests.* Management activities in high conservation value forests shall maintain or enhance the attributes which define such forests. Decisions regarding high conservation value forests shall always be considered in the context of a precautionary approach.
10. *Plantations*. Plantations shall be planned and managed in accordance with Principles and Criteria 1-9, and Principle 10 and its criteria. While plantations can provide an array of social and economic benefits, and can contribute to satisfying the world's needs for forest products, they should complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests.

For Example, the criteria of principle 5 are:

5.1 Forest management should strive toward economic viability, while taking into account the full environmental, social, and operational costs of production, and ensuring the investments necessary to maintain the ecological productivity of the forest.

5.2 Forest management and marketing operations should encourage the optimal use and local processing of the forest's diversity of productions.

5.3 Forest management should minimize waste associated with harvesting and on-site processing operations and avoid damage to other forest resources.

The MSC distinguishes three principles. The first two principles each contain 3 criteria, while the last one contains 17 criteria. The three criteria are:

1. A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited populations and, for those populations that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery.
2. Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends.
3. The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable.

For example, the criteria of the third principle include:

3.1 The fishery shall not be conducted under a controversial unilateral exemption to an international agreement.

3.2 The management system shall demonstrate clear long-term objectives consistent with MSC Principles and Criteria and contain a consultative process that is transparent and involves all interested and affected parties so as to consider all relevant information, including local knowledge. The impact of fishery management decisions on all those who depend on the fishery for their livelihoods, including, but not confined to subsistence, artisanal, and fishing-dependent communities shall be addressed as part of this process.

3.3 The management system shall be appropriate to the cultural context, scale and intensity of the fishery – reflecting specific objectives, incorporating operational criteria, containing procedures for implementation and a process for monitoring and evaluating performance and acting on findings.

The FSC and MSC on the internet: FSC: www.fscoax.org / MSC: www.msc.org

Models & techniques

Models and techniques are methods of obtaining data, data processing and of presenting information. Models and techniques are frequently used in analytical tools. Examples of models are dose-response models, in which the effect of a certain level of pollutant on, for instance, human health is calculated, and ecological models. Furthermore, flows of toxins are often modelled to identify potential problem (high concentrations), and to research the effects of policy changes. Techniques concern generally statistical tools, for example: weighting or sensitivity analysis. Box 10 shows an example of a weighting scheme that has been endorsed by the World Health Organisation (WHO).

Box 10: The Global Disease of Burden Concept

A GBD study aims to qualify the burden of premature mortality and disability for major diseases or disease groups, and uses a summary measure of population health, the DALY/ The DALY, Disability Adjusted Life Years, is a measure that includes both the premature mortality (YLL, Years of Life Lost) and the time lived with a disability (YLD, Years Lived with Disability).

In 1996, L. Murray and A. Lopez introduced the concept in their book 'The Global Burden of Disease: a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990 and projected to 2020'. The WHO now regularly develops GBD estimates at regional and global level for a set of more than 135 causes of disease and injury. A more recent study is conducted with data over the year 2000, published *in Mathers et al. 2002* and the World Health Report 2002.

The main results of a GND study can be displayed as a ranking of diseases or risk factors (see table for risk factors). The table shows both the DALYs and the deaths for the top 15 risk factors. The most important risk factor is blood pressure, responsible for 12.6% of the total deaths. However, because mostly elder people die of the results of a high blood pressure (e.g. heart diseases), its DALY is relatively low. Risk factors that strike particularly young people, as underweight und unsafe sex do, have a relatively high DALY.

The first 15 risk factors (WHO 2002, part)

Risk factor	DALYs (thousands)	As % total DALYs	Deaths (thousands)	As % total deaths
Underweight	137 801	9.4%	3 748	6.6%
Unsafe sex	91 869	6.3%	2 886	5.1%
Blood pressure	64 270	4.4%	7 141	12.6%
Tobacco	59 081	4.0%	4 907	8.7%
Alcohol	58 323	4.0%	1 804	3.2%
Unsafe water, sanitation and hygiene	54 158	3.7%	1 730	3.1%
Cholesterol	40 437	2.8%	4 415	7.8%
Indoor smoke from solid fuels	38 539	2.6%	1 619	2.9%
Iron deficiency	35 057	2.4%	841	1.5%
Overweight	33 415	2.3%	2 591	4.6%
Zinc deficiency	28 034	1.9%	789	1.4%
Low fruit and vegetable intake	26 662	1.8%	2 726	4.8%
Vitamin A deficiency	26 638	1.8%	778	1.4%
Physical inactivity	19 092	1.3%	1 922	3.4%
Occupational risk factors for injury	13 125	0.9%	310	0.5%

Selection of sources on GBD:

- Mathers CD, et al. (2002) *Global Burden of Disease 2000: version 2 methods and results*. Geneva: World Health Organization (Global Programme on Evidence for Health Policy Discussion Paper No. 50).
- Prüss-Üstün A., et al. (2003). *Introduction and methods: assessing the environment burden of disease at national and local levels.* Geneva: WHO
- World Health Report 2002: Reducing Risks, Promoting Healthy Life: www.who.int/whr/2002/overview/en/

GBD on the internet: www.who.int/peh/burden/burdenindex.htm

2.4. Practice

The practical life cycle approaches are meant to translate the idea of life cycle thinking into practice. A distinction can be made between policy programs, corporate programs, policy instruments, and procedural tools. Again, these three contributions to practice are not exclusive. Some important examples will be given below.

Policy programs

Policy programs are programs initiated by governments to reach (parts of) a life cycle economy. Policies can be developed on different levels, from within an organisation (for example the policy to buy sustainable products), to global policies involving many organisations and countries (for instance the 10-year framework of programmes on sustainable consumption and production). In this section several of these policy programs are explained.

Policy programs use instruments that governments or organisations can use to achieve a policy. These policy instruments are generally grouped into:

1. Legal instruments: like laws or regulations to support the policy.
2. Financial instruments: like taxes to discourage, or subsidies to encourage.
3. Communication instruments: advertising to increase knowledge on the policy.
4. Structural instruments: making organisations responsible for their waste.
5. Voluntary agreements: commitments undertaken by firms or by industrial organisations with public authorities

10-year framework of programmes on sustainable consumption and production

Changing consumption and production patterns is one of the overarching objectives of and essential requirements for sustainable development, as recognised by the Heads of State and Governments in the Johannesburg Declaration. As stated in chapter 1, the WSSD Plan of Implementation calls for the development of a 10-year framework of programmes on sustainable consumption and production. The framework should strengthen international co-operation and increase exchange of information and best practices to facilitate the implementation of national and regional programmes to promote sustainable consumption and production.

The first international expert meeting on the 10-year framework took place in Marrakech in 2003, organised by UNEP and UN DESA. The meeting launched the "Marrakech-Process", including regular global and regional meetings supported by informal expert task forces and roundtables to promote progress on the 10-year framework on sustainable consumption and production. At the regional level meetings have so far, been held in Africa, Asia-Pacific, Europe and Latin America and the Caribbean, where regional needs and priorities have been identified and regional strategies on sustainable consumption and production. The CSD will consider the 10-Year framework of programmes on sustainable consumption and production patterns as one of the themes in the 2010/2011 cycle of its multiyear programme of work.

Source: UN DESA and UNEP http://www.un.org/esa/sustdev/sdissues/consumption/Marrakech/conprod10Y.htm

Sustainable Consumption

Sustainable Consumption (SC) requires the use of products and services that respond to basic needs and bring a better quality of life, while minimising the sue of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations. In recent years it has become increasingly clear that sustainable economies must be built around sustainable products and services, not just sustainable industrial processes.

Therefore, Sustainable Consumption focuses on understanding the forces that drive consumption patterns around the world and how to translate those findings into tangible activities for business (including the advertising industry) and other stakeholders. The main SC topic areas are:

1. Innovation for business by inspiring the development of new products and services that meet today's request for quality of life.
2. Innovation for governments by inspiring them to put frameworks in place that facilitate/enable consumers and producers to change consumption and production patterns.
3. Innovation for NGO's and all other stakeholders to communicate more and better about sustainability with the public at large.

Source: UNEP DTIE http://www.uneptie.org/pc/sustain/

Cleaner Production

Cleaner Production (CP) is the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner Production can be applied to the processes used in any industry, to products themselves and to various services provided to society. For production processes, Cleaner Production results from one or a combination of conserving raw materials, water and energy; eliminating toxic and dangerous raw materials; and reducing the quantity and toxicity of all emissions and wastes at source during the production process. For products, Cleaner Production aims to reduce the environmental, health and safety impacts of products over their entire life cycles, from raw materials extraction, through manufacturing and use, to the 'ultimate' disposal of the product. For services, Cleaner Production implies incorporating environmental concerns into designing and delivering services.

Therewith, Cleaner Production is the international term for reducing environmental impacts from processes, products and services by using better management strategies, methods and tools. CP is called Pollution Prevention (P2) in North America, and Produccion Mas Limpia (PL) in Latin America. Related terms include green business, sustainable business, eco-efficiency, and waste minimisation. UNEP has been providing leadership and encouraging partnerships to promote the concept of Cleaner Production on a worldwide scale, especially through the creation of National Cleaner Production Centres (NCPCs) together with the United Nations Industrial Development Organisation (UNIDO). Currently, more than 1000 cleaner production demonstration projects have been launched.

Source: UNEP DTIE h http://www.uneptie.org/pc/cp/ and Hamner and Associates http://www.cleanerproduction.com/

Sustainable Procurement

Sustainable procurement (or green procurement) is the process in which organisations buy supplies or services by taking into account:

- the best value for money considerations such as, price, quality, availability, functionality, etc.;
- environmental aspects ("green procurement": the effects on the environment that the products and services have)
- the entire life cycle of products and services, from cradle to the crave;
- social aspects: effects on issues such as poverty eradication, international equity in the distribution of resources, labour conditions, human rights.

With a Sustainable Procurement policy, organisations and governments aim to stimulate the consumption of products or services that fulfil the above-mentioned requirements. Governments can choose to stimulate the consumption of these products and services by their own organisation or in their domain of influence (e.g. by tax stimulation). A number of third party organisations have developed standards and guidelines for green products and services. One form of guidelines is set up by Environment Canada (1996). It provides a checklist focussing on the four R's (reduce, reuse, recycle, and recover) in each phase of the material life cycle. The inclusion of sustainable development principles in procurement practices is already a reality in a number of countries such as Canada, Germany, Japan, the Netherlands, Norway, Switzerland, United States and South Africa. The experiences in these countries indicate that incorporating sustainable production and consumption considerations into public purchasing is not only a viable option, but also helps to develop sustainable markets. Sustainable procurement is also a corporate programme, and is increasingly implemented as business strategy. Box 11 globally discusses the steps for the implementation of green procurement in business.

Source: UNEP DTIE http://www.uneptie.org/pc/sustain/policies/green-proc.htm, Environment Canada : www.ec.gc.ca/eog-oeg

Box 11: Implementing a sustainable procurement programme

The steps involved in implementing a green procurement programme within business are outlined here:

1. Organizational support: Implementing a green procurement programme means changing policies and procedures. For it to be successful, it is essential that management support the initiative fully. In addition, those charged with making purchasing decisions must be involved in the implementation process. Their suggestions and support are critical.
2. Self-evaluation: An important step in implementing green procurement is conducting an evaluation of present purchasing practices. This process will help to clarify what is purchased, in what quantities, from where and at what price. The evaluation will provide a baseline, in order to measure future success and to focus the development of green procurement goals.
3. Set goals: A broad policy should be established, and specific priorities and targets set.
4. Develop a strategy: It is now to time to identify and implement changes, both short and long-term, identify suitable products and services, and evaluate the environmental performance of suppliers.
5. Run a pilot project: A pilot project can provide practical experience in purchasing green products and services, by applying green procurement principles to a specific product or service. Pilot projects can be used to generate more detailed guidance on purchasing practices.
6. Implementation: Implementing the green procurement programme will require an assignment of accountability, plus a well designed communications plan addressing employees, customers, investors, suppliers and the public.
7. Sustainment: As with all business practices, it is important that a systematic review of the green procurement programme be carried out, in order to establish whether the scheme is meeting its goals and objectives. The review should take into account changing environmental goals.

'Implementing a green procurement programme' is modeled on the Canadian standard for 'Environmentally Responsible Procurement', CSA Z766-95, issued by the Canadian Standards Association.
Source: http://www.bsdglobal.com/tools/bt_green_pro.asp

Integrated product policy

Integrated product policy (IPP) is a public policy that seeks to reduce the life cycle impacts of products from the total life cycle (from the mining of minerals, to production, distribution, use, and waste management). It is not, as its name might suggest, a single policy programme, but rather a framework for integrating a number of product-focussed concepts, tools, policy-, and business programmes (e.g. eco-labelling, extended producer responsibility, green procurement, etc). IPP is seen as a means by which governments and governments and authorities can encourage, facilitate, and co-ordinate the actions of stakeholders along the product life cycle to improve the environmental performance of products, whether this involves greening their design and development, production, distribution, use, recycling or disposal. The IPP of the European Union is discussed in box 12.

Chemical Product Policy

A special form of Integrated Product Policy is its application to chemicals. Chemical Product Policy (CPP) assesses and manages the impacts of chemicals throughout their life cycle (i.e., from production of a chemical substances, to distribution, use, recycling and/or recovery and final disposal of this substance). To date, most methodologies for generating and collecting data, conducting risk assessments and making risk management decisions have focused primarily on the production stage. This new approach builds off of existing methodologies and develops new ones to support a more holistic approach to chemicals management.

Source: OECD http://www.oecd.org/document/56/0,2340,fr_2649_34375_1959096_1_1_1_1,00.html

Extended Producer Responsibility

Extended Producer Responsibility (EPR) aims to extend the traditional environmental responsibilities that producers and distributors have previously been assigned (i.e. worker safety, prevention and treatment of environmental releases from production, etc.) to include management at the post-consumer stage. This general includes the transfer of the costs and/or physical responsibility of waste management from local government authorities and the general taxpayer to the producer. Environmental costs of reuse, recycling and disposal could then be incorporated into the cost of the product. Examples for the application of EPR are voluntary agreements and regulations to establish trade back systems in which producers take back the leftovers of the product after they have been used. This creates the setting for a market to emerge that truly reflects the environmental impacts of the product, and in which consumers could make their selection accordingly. EPR stimulates producers to use life cycle approaches for the incorporation of the post-consumer consequences in their product design. Box 13 will discuss the EPR programme of the OECD.

Box 12: EU Integrated product policy (IPP)

The Integrated Product Policy (IPP) program of the EU seeks to minimise the environmental degradation caused by a product by looking at all phases of a products' life-cycle and taking action where it is most effective. The life-cycle of a product is often long and complicated, and involves many different actors such as designers, industry, marketing people, retailers and consumers. IPP attempts to stimulate each part of products life cycle to improve their environmental performance. With so many different products and actors, there cannot be one simple policy measure for everything. Instead there is a whole variety of tools – both voluntary and mandatory – that can be used to achieve this objective. These include measures such as economic instruments, substance bans, voluntary agreements, environmental labelling and product design guidelines. The right balance between them all and the overall objectives for the policy are currently being developed at European level.

In June 2003, the European Commission adopted a Communication on what they will do to implement IPP. It will adopt a two-pronged approach:

- Improving the tools that already exist to make them more product-focused. These tools, known as the IPP toolbox, can be used on many different products. They include environmental management systems (such as the EU Eco-Management and Audit Scheme EMAS), environmental labelling and the provision of life-cycle information. IPP will also improve co-ordination between the different instruments to better exploit their synergies;
- Taking action to improve the environmental performance of products that have the greatest potential for environmental improvement.

This approach will result in the following concrete actions:

- in 2003, the identification and launching of pilot projects on particular products on the basis of stakeholder suggestions to the Commission, which can be provided until the end of October 2003;
- in 2005, on the basis of stakeholder dialogue, the publication of a practical handbook on best practice with Life Cycle Assessment;
- in 2005, a discussion document on the need for product design obligations on producers;
- in 2006, the development of a Commission action programme for greening its procurement;
- in 2007, the identification of a first set of products with the greatest potential for environmental improvement and the beginning of action to tackle them.

Source: European commission: europa.eu.int/comm/environment/ipp/

Box 13: OECD and Extended Producer Responsibility

The Organisation for Economic Co-operation and Development (OECD) defines the extended producer responsibility as "an environmental policy" approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle. There are two related aspects of EPR policy:

1) the shifting of responsibility (physically and /or economically; fully or partially)
2) to provide incentives to producers to incorporate environmental considerations in the design of their products.

OECD's work on EPR aims to provide governments with information on what is needed to establish effective policies and programmes. Since 1994, OECD has published four reports and a guidance manual on EPR's issues and benefits.

The EPR Guidance Manual for Governments was published in 2001. This Manual provides information about issues, potential benefits and costs associated with EPR. Drawing on the experience of OECD countries, it provides a set of principles to guide policy makers as they make decisions about EPR policy and programmes. The Guidance Manual also identifies several policy instruments for implementing EPR: take-back, economic instruments e.g. advance disposal fees, deposit-refund and a combined upstream tax/subsidy, and standards. To help governments make more informed decisions about EPR implementation, future EPR work will focus more specifically on the economic implications and effectiveness of EPR instruments

Source: www.oecd.org

Integrated waste management
Both integrated waste management and integrated materials management (discussed under the corporate programmes) manage substances through the life cycle. Integrated materials management focuses on the minimisation of the impacts related to the use of materials. Integrated waste management (IWM) aims to minimise the impacts due to the treatment of the waste by establishing an optimised system of waste management practices for a given community with available treatment options, based on the sound evaluation of site-specific environmental, energy, economic and socio-political considerations, which includes one or more waste management options. Integrated waste management includes also designing products that use fewer materials, use production techniques that produce less waste, and make waste useful by re-use, recycling, or composting.

To address environmental and economic concerns, life-cycle assessment and life cycle management methods have emerged as useful tools in helping to select IWM strategies. Currently, several life cycle based waste management models available that are designed to provide a structured framework for addressing specific aspects of waste management. A number of counties in the UK and states in the USA have an integrated waste management board (including California and New York). Except for integrated waste management programmes, also the guidance given by the waste management hierarchy aims to minimise the production of waste. The waste management hierarchy represents a pyramid of priorities for waste management, going from reduction to the last alternative of disposal. In box 3, these two programs have been discussed to illustrate how two practical programs have taken up the lessons learnt from analytical toos in a different way..

Source: Environment Canada http://www.ec.gc.ca/ecocycle/issue6/en/p3.cfm

Corporate programs

Life Cycle Management
According to the SETAC Working Group on Life Cycle Management, Life Cycle Management can be described as a system/framework for improving organisations and their respective goods and services. Decisions taken at all levels of an organisation will influence the overall impact a product has throughout its life cycle. Therefore, the framework is integrated at all levels of the organisation, effectively in marketing, purchasing, research and development, product design, strategic planning, corporate reporting and management. To reach these levels, life cycle management will have to remain flexible. In terms of implementing life cycle management, concepts, programs and techniques (tools) are all required. A life cycle framework addresses improvement to technological, economic, environmental and, occasionally, social aspects of an organisation and the goods and services it provides. Overall, the framework is for improvement that is continuous and based on a full system or life-cycle perspective. Therefore, the life cycle management concept is an integrated system for improving operations, products and services that ensures information and decisions from a life cycle perspective and, quite often, is seen to improve decision making by placing better information in front of decision makers. Due to its large scope, a number of other definitions have been formulated for LCM. Box 14 shows a cases study on the use of LCM.

Source: SETAC LCM Working Group, Life Cycle Management, 2003

LCM uses a large toolbox of existing analytical and procedural tools (life LCA and Design for Environment), business and governmental programs (like Product Stewardship and Extended Producer Responsibility) and related models and techniques. LCM will be further discussed in the next chapters of the report.

BOX 14: Life Cycle Management of Beverage Packages

Together, manufacturers of beverage cartons and suppliers of paperboard make up the beverage carton industry chain. Since 1990, these manufacturers and suppliers have associated in the Alliance for Beverage Cartons and the Environment (ACE). ACE is working to raise the awareness of the benefits of beverage cartons to consumers and the environment, and to address environmental issues. Within the beverage carton industry chain, Life Cycle Management (LCM) is used to manage a range of environmental issues up and down the value chain and to provide relevant information to stakeholders. Environmental Management Systems (EMS) are used to manage the information related to these issues and to provide the basis for the setting of goals and reporting for continuous improvement in the environmental performance over the entire life cycle. Life Cycle Analysis (LCA) is used to build inventories on specific environmental impact parameters and to identify particular steps in the life cycle where further actions are needed to improve environmental performance.

As part of LCM, different tools are used on the following life cycle stages:

- **Management of Forest Resources**. Renewable forest resources are utilized in accordance with sustainable forest management principles and are independently verified and certified.
- **Production of Liquid Packaging Board.** The production of liquid packaging board is based on maximizing product quality with minimum use of natural resources (e.g. wood and water) and limiting impacts to the environment. EMS are used to ensure continuous environmental improvement in board production and reporting of performance.
- **Beverage Carton Manufacture.** The manufacture of beverage cartons seeks to minimize packaging requirements without compromising function of the packaging to protect the product. Design for the Environment (DFE) criteria are used in the development of new packaging for new or existing products.
- **Transportation.** Transport is a major element in the life cycle of the beverage carton. From forest to board mill. From board mill to converter and then on to the packaging user. For all of these stages, efforts are made along the chain to make transport logistics more environmentally efficient and to reduce transport related impacts.
- **Recovery/Recycling of Beverage Cartons.** After use, beverage cartons can be recovered for recycling into other paperboard products. Residual wastes are increasingly recovered energetically and in some cases, in conjunction with aluminium.

With these tools, the industry has been able to make changes that enable them to produce 50% more cartons form the same amount of timber as they did in the 1980s.

Website ACE: www.ace.be

Supply Chain Management

Supply Chain Management enables companies to look upstream beyond their own company, and involve suppliers in their sustainable initiatives. Supply Chain Management includes managing supply and demand, sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, and delivery to the customer. Companies can choose their suppliers based upon their environmental performance, work together with them in creating sustainable products, or provide training and information. Besides environmental benefits, Supply Chain Management can result in costs improvement, improved risk management, and enhanced image.

End of Life Management

End of Life (EOL) Management is the downstream management of products at the time their functional life has ended, and it enters the waste phase. An example of an EOL management programme of a company or industry sector is a take back system. These take back systems can be based on voluntary agreements, but some countries also force producers to take back bottles for instance as part of their Extended Producer Responsibility. Many companies address the challenges of EOL management by design for recyclability of their products.

Product Stewardship

Product stewardship is a principle that directs all actors in the life cycle of a product to minimise the impacts of that product on the environment. What is unique about product stewardship is its emphasis on the entire product system in achieving sustainable development. All participants in the product life cycle –designers, suppliers, manufacturers, distributors, retailers, consumers, recyclers, and disposers – share responsibility for the environmental effects of products. The Green Lead Initiative is a good example of product stewardship and shown in Box 15.

BOX 15: Product Stewardship and the Green Lead Initiative

Because of the toxic characteristics of lead, the Lead Industry is faced with a significant constriction of its future markets if it fails to satisfy regulators and communities that its products will be dealt with in ways offering the highest level of safety. Legislation banning various lead products in different countries continues to expand, particularly within Europe. Denmark has a ban on most uses of lead compounds.

To address this issue, Green Lead is being created as a Product Stewardship initiative of the Lead industry. The aim of Green Lead is the identification of impacts associated with lead, establishment of standards to minimise these impacts and certification of organisations and eventually lead products that achieve these standards. The ultimate goal of Green Lead is zero harm form lead exposure to people and the environment. However, the focus will initially ben on acid lead bastteries. A five step development process is proposed:

1) **Impact identification and quantification**. This step aims to identify and quantify the environmental, safety/health and social impacts associated with lead exposure throughout the lead life cycle.

2a) **Develop Green Lead Performance Standards/Criteria**. The next step is the development of performance standards/criteria based on the results of LCA and other tools utilised for impact identification. The standards/criteria will cover areas of environmental protection, workplace health and safety and community issues associated with lead exposure.

2b) **Implement Management Systems**. To ensure a consistent standard for the implementation of each "Green Lead Partner's" management systems, it is proposed that Environmental Management Systems will need to be certified to ISO 14001 or to a similar equivalent standard including the proposed World Wildlife Fund's Certification of facilities (mine sites).

3) **Remedial Site Management Programs, Plans and Reports**. A significant part of achieving Green Lead is for these previous impacts to be addressed and remediated to site-specific standards acceptable to the communities affected.

4) **Green Lead certification**. Green Lead Certification is achieved when an operation is managing their environmental, workplace and community impacts in a way that meets established Green Lead Criteria.

5) **Product Stewardship and Sustainable Development**. It is anticipated that the concept of Green Lead-Product Stewardship will be achieved through the process of participants in the lead life cycle collectively examining their impacts, setting high standards and achieving improvements in environmental, safety and health performance

Source: www.greenlead.com

Integrated Materials Management

Both integrated materials management and integrated waste management (discussed under the policy programmes) manage natural resources through the life cycle. Integrated materials management is a framework for linking the concept of eco-efficiency with materials management strategies. Recycling is an important aspect of a materials life cycle where appropriate management strategies could enhance the eco-efficiency of the material. The current legislative emphasis on "take back" and the public push for recycle content in many products, coupled with the rightful concern about the proliferation of land fill sites, adds to the impetus for industry to encourage the reduction, reuse and recycling (three R's) of materials. This development can be turned into a business opportunity since materials can be sold as a secondary resource and can be recycled often at a lower energy cost than primary production. The goal of integrated materials management is to contribute to sustainable consumption by promoting science-based regulations and material choice decisions that encourage market access and the safe production, use, reuse and recycling of materials. Box 16 will discuss ICCM's programme of Integrated Waste Management.

Box 16: ICMM's integrated materials management programme

The International Council on Mining and Metals, ICMM, aims at a viable mining, minerals and metals industry that is widely recognised as essential for modern living and a key contributor to sustainable development. ICMM has formulated ten principles to achieve sustainable mining, falling into three categories: industry performance, international policy, and catalysing change for sector wide action. Task forces have been initiated to work on these principles.

One of the task forces works on integrated materials management. The ICMM Integrated Materials Management task force will undertake the development of a framework for linking the concept of eco-efficiency with materials management strategies and will encourage its adoption by policymakers in government and the downstream manufacturing industries. ICMM will work with UNEP and the OECD towards the development and promotion of environmentally sound recycling and will work with the commodity associations towards wider recognition of the existing and future capacity for metals recycling. The objectives of the task force are to:

- Coordinate industry engagement in international hazard/risk assessment activities.
- Under the umbrella of the UNEP/SETAC Life Cycle Initiative, develop guidance on allocation for metals recycling in life cycle inventory methodologies.
- Generate guidance on implementation of product stewardship.
- Build a policy framework to implement eco-efficiency concepts.
- Develop a mechanism to support transparency and efficiency of the working relationships among companies and associations.

Source: www.icmm.com

Procedural tools

Procedural tools aim to guide the process to reach and implement environmental decisions.

Environmental Management System

An Environmental Management System (EMS) specifies how an organisation can formulate an environmental policy and objectives taking legislative requirements and information about significant environmental impacts into account. The overall objective is a continuous overall improvement of the organisation. The EMS is described in EN ISO 14001 and EMAS II (European Co-management and Audit Scheme, 2001 revision).

According to EN ISO 14001, the EMS makes a distinction between five different decision steps: environmental policy, planning, implementation and operation, checking and corrective action, and management review. EMAS goes beyond EN ISO 14001 in a number of ways, requiring the undertaking of an initial environmental review, the active involvement of employees in the implementation of EMAS, and the publication of relevant information to the public and other interested parties.

Within Environmental Management Systems, two major groups can be distinguished: OOEMS and POEMS. Organisation-Oriented Environmental Management Systems (OOEMS) focus on sites or organisations, while Product-Oriented Environmental Management Systems (POEMS) focus on the environmental impacts of products and services over their life cycles, and with environmental labels and declarations. More details on POEMS will be given in box 17.

Box 17: Product Oriented Environmental Management System (POEMS)

A Product-Oriented Environmental Management System (POEMS) is a type of Environmental Management System focussing on products. POEMS does not only focus on plants or production sites of a firm but takes the life cycle of the products and substances into account that pass through the company's operations. This life cycle based approach thus requires interaction with stakeholders, both upstream and downstream.

The main drivers for companies for using POEMS are:

- competitive advantage, particularly among larger firms;
- a desire to better understand and manage product supply chains, both upstream and downstream;
- an awareness of the increasing strategic importance of environmental issues;
- an awareness that management commitment and an organised process or management structure is essential, which embraces all functions in the company (marketing, product design, production, environmental affairs, etc);
- the existence of a product-focused quality management systems (e.g. ISO 9001).

The implementation of a POEMS can involve changes in the company, like: new marketing targets, new organisation procedures (who is in charge of what?, when, how ?), new stakeholders, or new tools. It is thus important to determine the successes factors of these POEMS (eg. involvement of the managers and the definition of an product environmental policy) and the pitfall to avoid during their implementation (e.g. co-ordination problem between two services of the company).

Design for Sustainability (or Design for Environment / Eco-design)

Two closely related procedural tools are Design for the Environment (DfE) and Eco-design that are summed up here under the general heading design for sustainability. In eco-design, products are made based upon causing minimal environmental damage over their life cycle. Several manuals have been edited with the aim to provide guidelines for industrial business to systematically introduce eco-design. These manual usually include a step-by-step plan which considers environmental issues at all stages of product development with the aim to design products with the lowest possible environmental burden at all stages of the product life cycle. The eco-design manual edited by UNEP, in 1997, provides State of the Art and practical "how to do it" information about eco-design. The backbone is a seven-step plan with integrated analytical tools and idea generation techniques. With the help of a strategy wheel all possibilities for environmental improvement can be explored. The manual includes many examples, checklists, figures, and rules of thumb, and is structured to be compatible with assessment procedures and with the traditional, systematic product development process.

Design for Environment (DfE) goes one step further then eco-design, including also health and safety topics. DfE can be defined as a: systematic consideration of a design performance with environmental, health, and safety objectives over the full product and process life cycle (Fiksel, 1996). ISO 14062, a technical report, discusses concepts and practices relating to the integration of environmental aspects into product design and development. Box 18 discusses US EPA's Design for Environment Programme.

Box 18: US EPA Design for Environment program

For a typical product, 70% of the cost of development, manufacture and use is determined in its design phase. By integrating environmental considerations into the upfront product design, a company can increase efficiency, reduce waste of materials and energy, and reduce costs.

The US EPA Design for the Environment (DfE) Program is a voluntary partnership program that works directly with industry to integrate health and environmental considerations into business decisions. The DfE process promotes voluntary environmental improvement by addressing industries' need for key information on how to incorporate environmental concerns into business decisions. The process systematically:

- Identifies the array of technologies, products, and processes that can be used to perform a particular function within an industry and related pollution prevention opportunities.
- Evaluates and compares the risk, performance, and cost tradeoffs of the alternatives.
- Disseminates this information to the entire industry community.
- Encourages and enables use of this information by providing mechanisms and incentives to institutionalize continuous environmental improvement

The DfE partnerships projects include:
Adhesives, Automotive Refinishing, Computer Display, Flexographic Printing, Formulator, Garment & Textile Care, Gravure Printing, Industrial & Institutional Laundry, Integrated Environmental Management Systems, Lead-Free, Solder Partnership, Lithographic Printing, Nail Salons, Printed Wiring Board & Screen Printing.

The DfE Computer Display Partnership, along with the electronics industry, evaluated the life-cycle environmental impacts, performance, and cost of technologies that are used in desktop computer monitors—namely, cathode ray tubes (CRT) and liquid crystal displays (LCD). This project generated data to assist original equipment manufacturers (OEMs) and suppliers in the electronics field in incorporating environmental considerations into their decision-making processes and identify areas for improvement. This project combined both the Life-Cycle Assessment (LCA) and the Cleaner Technologies Substitutes Assessment (CTSA) approaches to analyze the environmental impacts, performance, and cost of both CRT and LCD desktop monitors.

Source: www.epa.gov/dfe

Environmental Labelling and Environmental Certification System

The Environmental Labelling tool provides guidelines for the use of environmental labels and declaration. These provide communication of information on environmental aspects of products and services, to encourage the demand and supply of those products and services that cause less stress on the environment, and is especially relevant for the needs of consumers. ISO provides standards for three different types of labels: environmental claims (ISO 14021) and the type I and III environmental labelling scheme. The type I is a multiple criteria-based third-party environmental labelling programme aiming at yes/no decisions whether products will obtain a label or not. An overview of the criteria of two labelling programmes, the Forest Stewardship Council and the Marine Stewardship Council, are given in box 9. Type III labelling (or environmental product declarations) aims at more detailed information on a number of criteria attached to a product, without a yes/no decision regarding the provision of a label. No standards are available for Type II labels, which are self-declared labels. Environmental Product Declarations (EPDs) are discussed in more detail in box 19.

Whereas labels provide information on products, certification systems provide information on companies. A single certification system can cover all of the products produced by a company or an industrial sector. Environmental Certification Systems give information on process and production methods (PPM) of a company.

Box 19: Environmental Product Declarations

Environmental Product Declarations are described, together with the process for developing them, in the ISO Technical Report 14025. An EPD, or type III label is described as "quantified environmental life cycle information, provided by a supplier, based on independent verification (e.g. third party), (critically reviewed) systematic data, presented as a set of categories of parameter (for a sector group)." The overall goal of an EPD is, "through communication of verifiable and accurate information that is not misleading, on environmental aspects of products and services, to encourage the demand for and supply of those products and services that cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement".

A Global Type III EPD Network – GEDNET – has been created to encourage information exchange between parties operating or developing Type III environmental declaration programs and to discuss key issues in developing such programs. Currently, nine countries are GEDNET members; they are: Canada, Denmark, Germany, Italy, Japan, Norway, South Korea, and Sweden. These participating countries each have their own EPD programmes, for example: the Swedish Environmental Management Council and the Japanese EcoLeaf programme.

The Japanese EcoLeaf programme was launched in the first half of 2002 by Jamai (Japan Environmental Management Association for Industry), supported by the Japanese Ministry of Economy, Trade and Industry. The EcoLeaf programme consists of three parts:

- **P.E.A.D. Product Environmental Aspect Declaration.** The PEAD provides representative information on the product, including point of environmental impacts. It should be prepared concisely but in a highly uniform and visual way that product purchasers and consumers can easily understand.
- **P.E.I.D.S. – Product Environmental Information Data Sheet.** Overall results of the LCA is presented on the PEIDS to clarify the basis of the PEAD and to summarize the results of inventory analysis, impact assessment, and energy consumption. Inventory analysis, based on the LCA method, calculates and evaluates the amounts of energy, raw materials, and environmental contaminants associated with a product during its life cycle. Impact assessment correlates the results of inventory analysis with indicators such as the consumption of exhaustible resources and the emission loads that indicate the level of global warming and ozone depletion, enhancing the ease of understanding for the general public.
- **Product Data Sheet.** The product data sheet records the underlying data used in the preparation of the PEIDS. The company introducing EcoLeaf label prepares the product data sheet by describing the inputs and outputs of energy, raw materials, and environmental contaminants per product unit based on actual measurements within its direct range of influence (e.g., within its factory).

To ensure the objectivity and consistency of the information declared, which allows consumers or purchasers to make a solid judgment, there should be an uniformity in the definition of products, the requirements and rules of the LCA calculation, the scenarios of product use and disposal, the methods of data collection, processing and use, and the data to be disclosed. The Product Specification Criteria (PSC) functions as a criteria by which to set rules for LCA calculations for each product category, originally developed by PSC working group (PSC-WG) following to the "requirements for the EcoLeaf PSC", then reviewed/authorized by the PSC committee. The PSC works as the cornerstone of the EcoLeaf.

Sources:

GEDNET	www.gednet.org
Swedish Environmental Management Council	www.environdec.com/
Japanese EcoLeaf:	www.jemai.or.jp/english/ecoleaf

Environmental Impact Assessment

Environmental Impact Assessment (EIA) is a procedural tool used to identify the environmental, social and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers. EIA focuses on the entire life cycle of a project. By using EIA both environmental and economic benefits can be achieved, such as reduced cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations.

The key elements of an EIA are:

(a) Scoping: identify key issues and concerns of interested parties;
(b) Screening: decide whether an EIA is required based on information collected;
(c) Identifying and evaluating alternatives: list alternative sites and techniques and the impacts of each;
(d) Mitigating measures dealing with uncertainty: review proposed action to prevent or minimise the potential adverse effects of the project; and

(e) Issuing environmental statements: report the findings of the EIA.
Source: www.uneptie.org

Environmental Performance Evaluation
The Environmental Performance Evaluation tool provides guidelines for the choice, monitoring and control of environmental indicators representing the performance of a company. It is used to support internal decision-making as well as to meet the demands of ever more sophisticated stakeholders (Bennett and James, 1998). The ISO 14030 standard makes a distinction between three basic indicator categories: environmental condition indicators (involving both midpoint and damage indicators as described in section 3.4 of this report), operational performance indicators and management performance indicators.

Sustainability reporting
Being able to communicate a organisations' results on sustainability to, among others, stakeholders is essential. The Global Reporting Initiative (GRI) is an organisation that aims to develop and disseminate globally applicable Sustainability Reporting Guidelines. The GRI has developed a framework to help organisations with reporting on the economic, environmental and social dimension of their activities, products and services. An important topic is to define adequate system boundaries. Users of life cycle approaches will find these guidelines useful for reporting their progress.

2.5. The Focus of the report

As indicated in the introduction, the final aim of this report is to establish an action plan with a comprehensive list of tasks for the improvement of the global use of life cycle approaches. The previous section discussed a large number of these approaches. Because it is sheer impossible to discuss the improvement of all these approaches, this report will focus on three main topics: Life Cycle Management, Life Cycle Inventory Analysis and Life Cycle Impact Assessment. Furthermore, special attention will be given to the improvement of life cycle approaches in SMEs and in developing countries.

Life Cycle Management (LCM) has been chosen because it is the overarching corporate programme. LCM makes use of a variety of both analytical and practical approaches. LCA is considered the most frequently used analytical tool to cover all life cycle stages of a product and service system that are in centre of attention for changing unsustainable consumption and production patterns. Two core steps are discussed: Life Cycle Inventory Analysis (LCI) and Life Cycle Impact Assessment (LCIA). Both steps are very different, and have their own potentials and limitations.

The introduction showed that, besides the more specific criticism on the content and technical aspects of life cycle approaches, more general criticism was raised by stakeholders in SMEs and developing countries about the usefulness of these approaches. Because stimulating the use of life cycle approaches in SMEs and developing countries is most essential for a global use of these approaches, special attention will be given in this report to tackle the latter criticism. This report will focus on a number of topics that are relevant for a broad range of life cycle approaches, such as in particular: the use of simple tools, data availability, the scope extension, the removal of trade and cost barriers, and capacity building.

To be able to formulate a comprehensive action plan, first the current state of the art of the selected approaches will be described and next the needs for the improvement of life cycle approaches will be identified. Then, based upon the state of the art and the user needs, an action plan will be formulated. The state of the art will be discussed in the next chapter, the user needs in chapter 4, and the action plan in chapter 5.

3. State of the art of life cycle approaches

3.1. Identifying the state of the art

In this chapter, the state of the art will be described for the three selected approaches: Life Cycle Management (LCM), Life Cycle Inventory Analysis (LCI), and Life Cycle Impact Assessment (LCIA). Within these, the focus will be on the topics that are criticised by their users, namely the lack of practicability of analytical approaches, and the lack of scientific background of current practical approaches.

With regard to the analytical approaches, this chapter will focus on the current performance of life cycle assessment and the needs to increase its practicability. In the field of LCI, the state of the art will be discussed of the following topics: 'data availability and validation' (section 3.2) and 'methodological consistency' (section 3.3). In the field of LCIA the state of the art will be discussed on: 'LCIA framework and terminology' (section 3.4) and 'damage and impact categories' (section 3.5). With regard to LCM, this chapter will thus focus on the state of art of LCM framework and will also consider the way how lessons learnt from analytical tools are used in LCM. These topics are: 'the definition of LCM' (section 3.6) and the 'LCM toolbox' (section 3.7).

Section 3.8 will focus on the state of the art of life cycle approaches in SMEs and developing countries, in line with the special attention this reports aims to give on ideas for improving the use of life cycle approaches in SMEs and in developing countries. In addition, this section will also discuss some activities aiming at capacity building in developing countries.

The state of the art on LCI, LCIA and LCM, as described in this report, is largely based on the results of Working Groups of the Society of Environmental Toxicology and Chemistry (SETAC). These are, respectively, the SETAC International Working Group on Data Quality and Data Availability, the SETAC Europe Second Working Group on Life Cycle Impact Assessment, and the SETAC Europe Working Group on Life Cycle Management. These Working Groups will be discussed shortly, later in this section. Other sources, on which the description of the state of the art has been based, include a number of workshops involving different industry branches, as well as the results of the European CHAINET programme. The state of the art for these three topic areas has been published in the respective Definition Studies. The Definition studies can be downloaded at the web-site of the Life Cycle Initiative: **www.uneptie.org/pc/sustain/lcinitiative/**

Main characteristics of the three above-mentioned working groups are the following:

- SETAC International Working Group on Data Quality and Data Availability
  At the end of 2003, this working group on LCI published its results in the book "Code of Life Inventory Practice". The main goal of this book is "to provide Life Cycle Assessment practitioners with recommendations and guidelines to improve the availability of Life Cycle Inventory data". Three key features are addressed in this book:
  - Improving the efficiency of data collection;
  - Facilitation of LCI data exchange and collection;
  - Assessment of data quality.

- SETAC Europe Second Working Group on Life Cycle Impact Assessment
  In its recent publication "Life Cycle Impact Assessment: Striving Towards Best Practice" the results of this SETAC Working Group are presented. This book aims to make the first steps towards the identification of best available practice in the field of LCIA, building on the work of the International Organisation for Standardization (ISO). The main questions addressed in this book are:
  - What types of impact categories should be defined?
  - What are the best available methods, and what are the best available data?

- To what extent can a general best practice be defined, and to what extent will this depend on the type of location or application?
- How should be dealt with the choice between average and marginal modelling?
- Should category indicators be chosen in the environmental mechanism (the impact pathway) of an impact category at midpoint or at damage level?

- SETAC Europe Working Group on Life Cycle Management
  This Working Group was charged to examine whether Life Cycle Management can be a tool to alleviate the existing difficulties in the implementation of life cycle approaches. The results of this Working Group are discussed in the SETAC publication “Life Cycle Management”. This book aims to address both the existing difficulties, and present current practice. The main points addressed in this book are:
  - What is the definition of Life Cycle Management?
  - What should Life Cycle Management be and what should it not be?
  - What is the current practice of Life Cycle Management?
  - What are the entry gates to and drivers for Life Cycle Management?

The description of the state of the art of life cycle approaches in SMEs and developing countries is based on experiences in SMEs and in developing countries, together with the results of programmes like UNEP’s Cleaner Production Program and UNEP’s Sustainable Consumption Programme.

3.2. LCI data availability and validation

A large number of national and multi-national LCA projects are at various stage of progress around the world. Besides that, LCA practitioners in industry, government, research institutions, or consultation offices currently rely mainly on databases provided by private or academic database developers for LCA work and decision-making. A number of existing LCI databases and actual projects are listed in table 1.

Table 1: Rough overview of existing types of projects and databases with relationship towards LCI data issues (selection).

Established LCI databases widely used in LCA practice	GaBi, KCL-Eco, LCAit, SimaPro, SPINE, TEAM, Umberto, etc.
Actual national LCI database projects	Australia, Canada, Germany, Italy, Japan, Switzerland, USA, etc.
Multinational LCI database projects	Cost Action 530, eLCA, etc.
LCI databases that are made publicly available, but were developed within or for industry associations	APME database, etc.

However, there is currently a lack of access to general, publicly available databases. Such a portal for the access to databases should be designed to complement, strengthen, and augment all these important initiatives and databases, and at the same time, avoid duplicating their deliverables.

On the EU level, but also within countries such as Germany or Switzerland, which have been active in LCI data development for a number of years, the current challenge is one of integrating and ensuring comparability and exchangeability of a wide variety of LCI databases. Such a process of integration to make the best data publicly available should be accompanied by a quality assurance system leading to a continuous improvement of the data quality because the reliability of LCI analysis results depends mainly in the quality of the LCI data. For example in Germany, a preliminary study called “Quality control and availability of life cycle data for practical use” has been carried out. In this study, a better long-term general concept for practice-oriented use of life cycle data was elaborated with the help of external experts.

In addition, there are an increasing number of LCA databases available that are based on Input-Output Analysis (IOA). Efforts are going on in a joint SETAC-ISIE (International Society for Industrial Ecology) to summarise the state of the art in this emerging field of LCA.

This wide range of LCI databases bring about an equal variety in design, format and quality. This lack of consistency and transparency makes validation and documentation of the databases difficult.

3.3. LCI methodological consistency

International standards, like ISO, have provided a set of guiding principle to use Life Cycle Assessment, including for Life Cycle Inventory (LCI) questions. For some cases, these standards give specific guidance and rules that should be followed. However, on many other fields, these standards are silent, ambiguous, or self-referencing (referring to the goal and scope of the study). This leaves room for an extensive range of methods, approaches, and applications. Many of these methods lack transparency on several core methodological issues, making it difficult to compare them with other methods. An improved transparency, would positively influence the compatibility and consistency in LCI, and may even lead to the development of better methods.

An important part in the inventory analysis is the definition of the system boundaries. These system boundaries are formulated based upon the scope of the LCA, and an initial collection of data. The results of an LCI analysis can be substantially influenced by the definition of the system boundaries; the achievement of methodological consistency on this core topic is considered a high priority

Three types of boundaries are distinguished in an LCA inventory:
- Boundaries between the system and the environment;
- Boundaries between the system under study and other related systems (or allocation);
- Boundaries between relevant and irrelevant processes (or cut-off):

The first type of system boundaries formulates the types of environmental and economic processes that are included or excluded. It is very important to clearly describe and comment the boundaries, because they may greatly influence the results of the study.

The second type of system boundaries is related to how the environmental load is allocated in a 'multi-functional process'. Many processes generate several different products as a result of co-production, recycling or waste processing. Such a process is called a 'multi-functional process', e.g. petroleum refining. Emissions and resource extractions of such process have to be adequately distributed or 'allocated' over the different functions which such a process provide. It depends on the defined boundary whether all products of a certain process are included in the analysis, or whether just one or a few products are included. The allocation can be based upon mass, commercial value, energy content, or similar product features.

The third type of system boundaries concerns the removal of processes, which lie within the defined boundaries, from the LCI analysis. Processes are removed (or cut-off) for two reasons:
- For simplicity reasons; processes that does not represent a large part of the cash flow or are found top have insignificant environmental consequences are not analysed;
- Due to lack of (accessible) data, a process cannot be quantified.

Besides the range of LCA methods and tools due to these three types of system boundaries, there is a substantial range of guidance documents available. Some of those are of very high quality and provide detailed information, however most guidance documents are based around individual groups, countries or regions. Therefore, the applicability of these documents is limited on the international levelMost guidance material has not had involvement from a broad cross section of regions and stakeholders, and therefore do not address situation dependency issues, which makes it more difficult to use in different conditions than for those they were developed for. The development of more consistent guidance would help a lot to overcome these shortcomings in LCA methodology..

3.4. LCIA framework and terminology

In Life Cycle Impact Assessment (LCIA), the environmental impacts of all emissions and extractions are analysed. Basically, it studies the potential environmental damage of the results from the Life Cycle Inventory results. This is done on the basis of impact pathways, which are composed of environmental processes (like chemical reaction in the underground). To achieve this, it has proven useful to group types of LCI results with similar impact pathways into impact categories at midpoint level (also called midpoint categories; see next paragraph for these categories). The term 'midpoint' expresses the opinion that this point lies somewhere in the middle on the impact pathway; between the LCI results and the damage or end of the pathways. A further step may allocate these midpoint categories to one or several endpoints, the so-called damage categories. Damage categories represent quality changes of the environment; the ultimate objects of human societies concern. A damage indicator is the quantified representation of this quality change.

Figure 4 shows the overall scheme of the proposed framework, linking all types of LCI results via the midpoint categories to the damage categories. An arrow means that a relevant pathway is known or supposed to exist between the two corresponding elements. This general framework has been mostly developed in the SETAC working group on Life Cycle Impact Assessment, and during the LCIA Definition Study.

With a standardised framework, there ought to be a standardised terminology. Besides differences in terminology between the ISO standardisation and the European Environment Agency's DPSIR model (stands for Drivers, Pressures, State indicator, Impact, Response), often common terms are used. Proposed terms for the LCIA framework are LCI results, midpoint (impact) category, damage (impact) category, damage indicator, and Areas of Protection (AoP). The definitions of these terms can be found in table 2.

Table 2: Overview of proposed terms for the LCIA framework.

Proposed terms for LCIA framework	**Definition**
LCI results	Outcome of a life cycle inventory analysis that includes the flows crossing the system boundary and provide the starting point for life cycle impact assessment (ISO 14042). LCI results are pressures of the three following types: emissions, resource extraction & uses and physical changes
Midpoint Impact category (Midpoint category)	Class representing environmental issues of concern to which LCI results may be assigned (ISO 14042), involving common or similar processes
Midpoint Indicator	Quantifiable representation of a midpoint impact category (ISO 14042)
Damage Impact category (Damage category)	Class representing damages on an ultimate Areas of Protection to which state/midpoint categories may be assigned (ISO 14042). A benefit is defined as a negative damage
Damage indicator	Quantifiable representation of a damage category
Impact pathways	System of processes, linking the LCI results to state/midpoint indicators and to damage indicators (adapted from ISO 14042)
Areas of Protection	Operational group of items of direct value to human society.

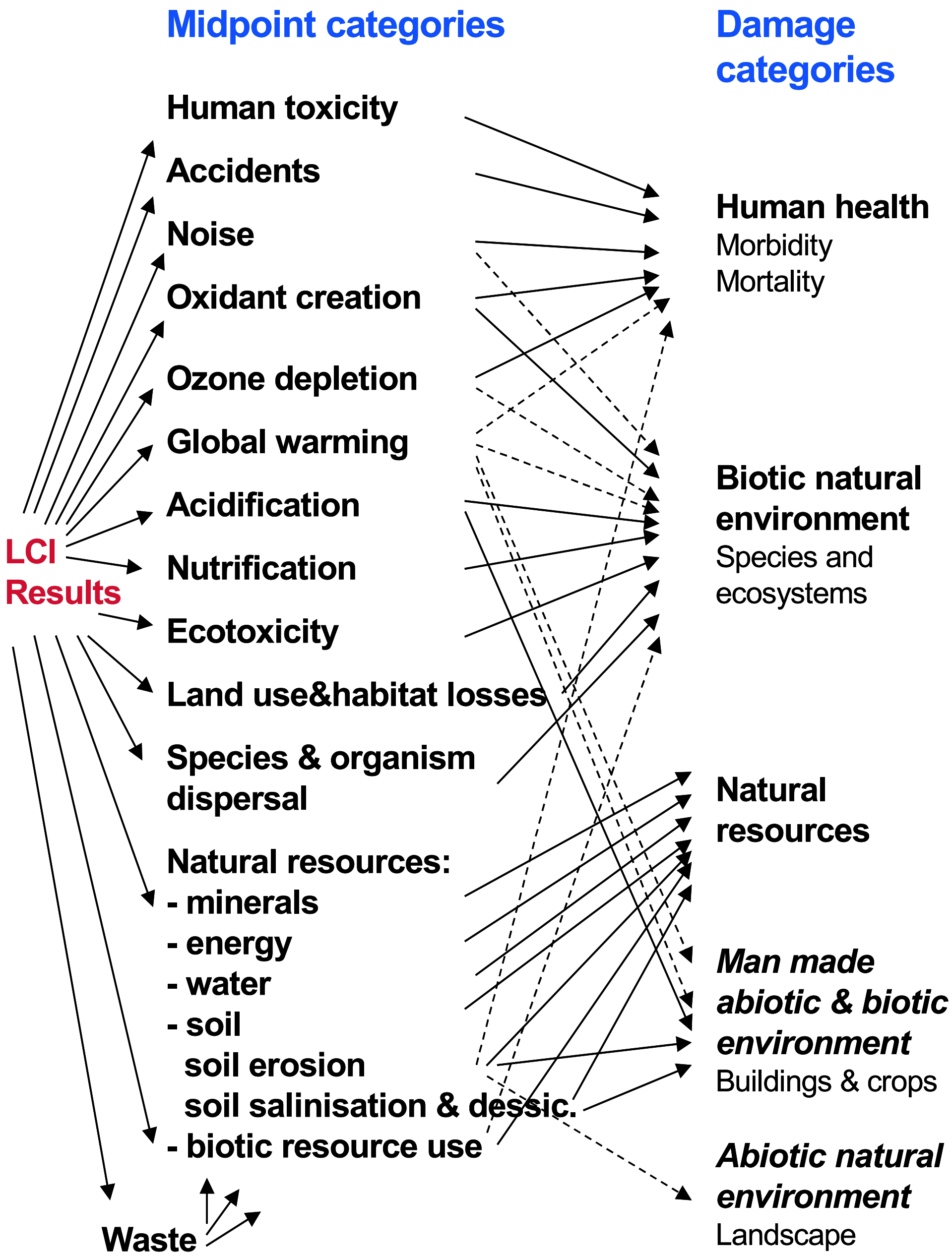


Figure 4: General structure of the LCIA framework. Dotted arrows: currently available information between midpoint and damage levels is particularly uncertain.

3.5. LCIA midpoint and damage categories

The proposed framework, discussed in the previous section, distinguishes impacts on two levels: at midpoint and at damage (endpoint) level. Please consult table 2 in the previous section for the definitions of the terms discussed here.

Midpoint categories

The proposed LCIA framework now describes 13 midpoint categories. These categories can be grouped into three topic areas: natural resources and land use, toxic impacts, and transboundary impacts. Each midpoint category is described in more detail in Annex 4.

- The group natural resources and land use include water resources, minerals resources, energy carriers, soil resources and erosion, land use, salinisation and desiccation, and biotic resources. Dissipation of resources and especially water resources is of significant importance in the development of sustainable industrial and consumption practices.
- The group toxic impacts, contains the impact categories ecotoxicity, human toxicity and related categories with direct effects on human health (like ionising radiation, accidents, and noise).
- Transboundary impacts are: climate change, ozone depletion, aquatic and terrestrial eutrophication, and acidification.

Damage Categories

Five damage categories are proposed in the framework: human health, biotic natural environment, abiotic natural resources, man-made abiotic &biotic environment, and abiotic natural environment.

Human health

Environmental damages to the human population could be expressed in several ways: diminution of joy of life, loss of labour productivity, cost of medical interventions, diminution of the population size, etc. However, there is a reasonable agreement that the environmental damage to humans is essentially represented by the observable or expected damage to the human health, hereby including all individuals of the present and future generations. Individual human health may be impaired either by a reduction of the number of life years of an individual, or by the deterioration of the years lived due to diseases or accidents. Frequently used measures or the human health are DALY (Disability Adjusted Life Years), HALE (Healthy Years Life Expectancy) and QALY (Quality Adjusted Life Years). A case study using DALYs is discussed in box 10.

Biotic natural environment

The natural environment consists both of living parts (biotic) and non-living parts (abiotic). As far as the living part of the natural environment is concerned, a damage indicator should measure how far the anthropogenic processes affect the natural development of the occurrence of species (or habitats). The focus here is on the species population dynamics, and not on the wellbeing of the single individual. To use the occurrence of species as a damage indicator, both the global population size and geographic dispersion over the globe should be used. Even through increase of population size and geographic dispersion may be considered as a benefit to the biotic natural environment, in some cases (species with a historical trend towards extinction, or proliferating invasive species) this increase is a damage. Currently, indicators like PAF (Potentially Affected Fraction of species) and SSD (Species Sensitivity Distribution) are used to integrate impacts on biodiversity in LCIA. The damage category includes both the impacts due to the consumption of biotic resources and the impacts of emissions on the natural environment.

Abiotic natural resources

Depletion of non-renewable abiotic natural resources, due to human use with the consequence of destruction or dissipation, is generally considered as a damage to be treated in LCA. The damage consists in the reduced availability of the corresponding type of resource in the future. A damage indicator for these depletable abiotic resources should express both the quantity and the accessibility (or usability) of the resource. An agreement on such a damage indicator is not yet available, further research is required to collect more data. As a provisional starting point, the increase of energy requirement for future procurement of the currently used quantities of abiotic resources can be taken as a damage indicator.

Man made abiotic & biotic environment

The quality status of man-made biotic (like agricultural and silviculture crops, domestic animals, aquacultures) and abiotic (like buildings, equipment, traffic structures, mines, land surface modifications for human purposes) environment can also be adversely influenced by environmental impacts. Fish production, for example, may be damaged by polluted water, and buildings are damaged by acidifying emissions. “Man-made hereby” means that materials, land areas, and other subjects of nature are transformed by man into artefacts, which nevertheless may maintain some content of naturalness.

Unlike the case of wild animals and plant described above, the development of the population size of a species would not be an adequate damage indicator, because human activities (like artificial reproduction, feeding, and medical prevention) can mask the extent of the damage. The cost in money units for damage prevention activities, or to maintain production quantities appears to be an adequate initial proposal for a damage indicator. For the abiotic man-made environment, the economical cost of the repair work is, in general, a practicable damage indicator.

Abiotic natural environment

The abiotic natural environment encompasses the non-living natural materials and structures, like geological structures, landscape forms, glaciers, crystal holes, waterfalls, etc. Generally, these materials and structures only possess an intrinsic value; they are not used as a resource. Therefore, damage as a result of anthropogenic processes will results in a loss of this intrinsic value. A number of methods have been developed to include the effects of pollution on the abiotic natural environment in an LCA analysis, but are often difficult.

3.6. Defining Life Cycle Management

Life Cycle Management can be described as the application of life cycle thinking in practice. LCM is a rather new umbrella concept that integrates a variety of elements and methods that are used in existing practice. As said in the introduction, a large variety of life cycle approaches have been developed in the last few years. The main reason for this variety of approaches in the implementation of sustainable product management in a life cycle perspective lies in the structural differences within individual organizations and among world regions and industry sectors responsible for different product groups.

As the following examples show, the concept life cycle thinking is used differently in different sectors of industry:

- In the chemical industry, years of experience with product safety and risk assessment are used in conjunction with life cycle thinking, product stewardship and eco-efficiency to inform decision-making processes.
- In raw material industries, particularly in metals and mining, Life Cycle thinking is part of integrated material management strategies, and LCA is used in complementary to Substance Flow Analysis (SFA) and Material Flow Analysis (MFA).
- For durable consumer products, current regulatory pressures, such as end of life regulations in Europe, drive the application of Life Cycle thinking in conjunction with either recycling assessments, design for recycling or design for environment. In addition, material restrictions and supply chain management are used jointly with, or supported by, LCA.
- For capital goods and in the retail industry, life cycle thinking is often used with Total Cost Assessment or Life Cycle Costing.

Across many sectors and world regions, life cycle thinking can been found behind the regular business and administration activities and resulting decisions of organizations. These activities include:

- The use of life cycle applications to support the formulation of corporate policy and strategy
- The development of sustainability initiatives and the implementation of sustainability programs;
- The integration of life cycle thinking and tools into
  - ⇒environmental management systems (EMS)—for example, product-oriented environmental management systems (POEMS);
  - ⇒environmental reporting—for example, green accounting and environmental reporting;
  - ⇒integrated management systems —for example, by combining quality, occupational health and safety, risk, environmental management into one system;
  - ⇒product design and development processes;
  - ⇒purchasing decisions and (public, retail and private) green procurement;

- The use of life cycle thinking and tools in
  ⇒communications programs, including marketing and product labeling and declarations;
  ⇒conjunction with total cost assessment or Life Cycle Costing approaches and financial accounting.

Existing definitions for LCM show a certain variety in expectations and experiences. The following definitions show the variety and breath:

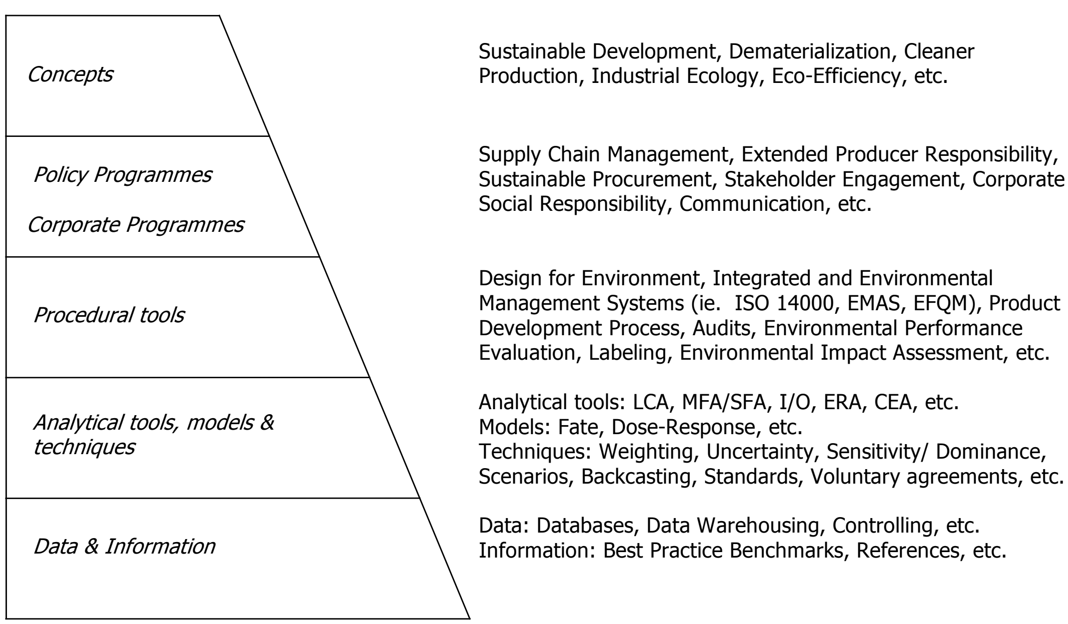
- LCM is a flexible integrated framework of concepts, techniques and procedures to address environmental, economic, technological and social aspects of products and organizations to achieve continuous environmental improvement from a Life Cycle perspective. - *SETAC Working Group LCM, 2003*
- LCM assures that the processes used across projects are consistent and that there is effective sharing and coordination of resources, information and technologies. This Life Cycle spans the conception of ideas through to the retirement of a system. It provides the processes for acquiring and supplying system products and services that are configured from one or more of the following types of system component: hardware, software and humans. In addition, this framework provides for the assessment and improvement of the Life Cycle. - *ISO/IEC 15288 CD 2, 2000*
- LCM is business management based on environmental Life Cycle considerations. - *Petersen, 2001*
- LCM is the extension of the technical approach towards cleaner products and production though amending stakeholder views, by communication and regulatory tracking. - *Remmen, 2001*
- LCM is a concept of innovation management towards sustainable products, by supporting strategic decision making and product development. - *Saur, 2003*

However, we can take the definition provided by the SETAC working group as a start to further promote the application of life cycle thinking in management practice. The major effort is therefore to develop and refine a concept for LCM that is generically applicable, globally relevant, practice oriented, technical valid, scientifically sound and accepted by all stakeholders. This new concept should integrate all approaches, topic areas, and tools mentioned. By integrating the lessons learnt from a large range of LCA studies and other efforts based on life cycle thinking, LCM provides a brilliant possibility of bridging between policies, tools and programs.

3.7. The LCM framework and toolbox

LCM is being positioned as a framework that builds on existing structures, systems, tools and information (the LCM toolbox). LCM is not meant to replace existing concepts, programs and tools, but rather offers a novel synthetic approach for improving the application of these different concepts, programs and tools in a

Life Cycle Management Framework



life cycle or systems perspective. Figure 5 shows the LCM framework.

3.8. Life cycle approaches in SMEs and developing countries

The growing acceptance and application of the life cycle concept by industry in many developed countries confirms the high potential of using life cycle approaches. This has also been acknowledged by the Malmö conference of global environment ministers in 2000 as well as the World Summit for Sustainable Development in 2002.

Most engagement in life cycle approaches is observed in large companies in the industrialised world, with a focus on Europe and Japan as well as North America and Korea. There is relatively little use of life cycle approaches by SMEs, and even less so by companies in developing countries. Nevertheless, with closer inspection this appears not to be a black and white dichotomy.

Indeed, SMEs do have less staff and less organisational opportunities to take up life cycle management activities. This particularly will be true for the use of LCA, which asks for high expertise, sufficient budget and availability of data. However, on this point there appear to be exceptions. The potentials for the use of LCA by SMEs particularly increase if the initiatives are taken up at branch level (several SMEs together).

Even more opportunities for SMEs exist for agreements along the life cycle, which do not use LCA or other analytical tools. Thus, SMEs can be engaged in agreements with larger downstream companies, which set requirements on production processes. For instance, food-processing companies like Unilever (see box 1) can make agreements with farmers on the use of pesticides, fertilisers, energy water and other resources. Comparable requirements can be set by large retailers; Sainsbury, for instance, aims to "…influence our suppliers to reduce their direct environmental impacts…" (box 2). As will be clear from these examples, these requirements need not be limited to environmental criteria, but can also include a number of social issues.

Unfortunately, these agreements may also result in continually increasing requirements that these SMEs have to tackle if they want to remain part of the supply chain. It is therefore not only a business opportunity for SMEs to include environmental and social variables in their product quality considerations, but it might also be an economic need to comply with these standards if they want to retain their market share.

Simple or streamlined life cycle tools are being developed to assist SMEs in the use of life cycle approaches. The European EMAS (Eco-management and Audit Scheme), for example, has developed a toolkit for small organisations, which include easy interactive environmental management tools and a collection of case studies. Another example concerns an LCA-like tool developed by the Hungarian Association for Environmentally Aware Management (KÖVET-INEM Hungäria), which is based on a qualitative analysis. For all stage in the product's life cycle, five environmental impacts (like energy consumption and waste generation) are rated with a 1,2, or 3 (respectively slight, medium or large environmental impact). In this way, small organisation can more easily visualise points with a large environmental impact.

For developing countries, a comparable picture arises. Also here initiatives to use LCA or other analytical tools have particularly been carried out at branch level. See for example box 8 on the use of life cycle costing of photovoltaic cell systems in India. In such cases, these tools are used to support the modernisation of the technology used. Another example concerns the use of LCA for aquaculture shrimp production in Thailand, focusing on criteria such as the use of food sources, fossil fuels and pesticides.

And also here, local companies are invited to make agreements with large downstream companies in the industrialised world about the production of resources with specific sets of requirements aiming at sustainable development. A recent example concerns the production, trade and use of UTZ Kapeh coffee, which is discussed in box 20.

Box 20: The UTZ Kapeh Foundation

In 1999, three Guatemalan coffee producers / exporters gathered at the exporting company Café de Origen with coffee roaster Ahold Coffee Company in the Netherlands with whom they had a long commercial relationship. This group set out to develop a program to guarantee responsibly grown mainstream coffee as a means of recognizing and differentiating progressive growers. They decided to create a foundation that could act fully independent from the exporting company and the roaster.

The UTZ Kapeh Foundation, which means "good coffee" in a Guatemalan Maya language, is an independent, world wide non-profit organization, with headquarters in The Netherlands and Guatemala. The foundation has developed a standard for coffee production that ensures good, efficient, responsible farm management and full traceability. Coffee producers certified by the UTZ Kapeh Foundation comply with the UTZ Kapeh Code of Conduct. This Code of Conduct is based on the EUREPGAP Protocol for Fruits and Vegetables. This Protocol was developed by the leading European retailers to provide basic assurance for food safety and environmentally and socially appropriate growing practices. UTZ Kapeh translated the EUREPGAP Protocol to the specific conditions of coffee production. In addition, relevant chapters and criteria are added from the ILO (International Labour Organization) Conventions and the Universal Declaration of Human Rights. The result is an International accepted Code of Conduct for responsibly grown coffee. The Code of Conduct sets requirements on the social and cultural, environmental, managerial and economical conditions of coffee farmers. In February 2004, 41 coffee producers in 12 countries were UTZ Kapeh certified producers. Moreover, seven roasters and 12 coffee trading companies currently use certified coffee.

For more information: www.utzkapeh.org

From these examples, it will be clear that a main driving force for agreements with SMEs in developing countries consist of large companies in industrialised world, who take a serious stand in sustainable development. Also a stimulating role can be played by intergovernmental organisations. For this, UNEP can stand as an example. Since 1994, UNEP has initiated with the United Nations Industrial Development Organisation (UNIDO) 24 Cleaner Production Centres to help achieve adoption and further development of the Cleaner Production concept at the national level.In addition, in 1998 the Sustainable Consumption Programme was initiated focusing on understanding the forces that drive consumption patterns around the world and how to translate those findings into tangible activities for business and other stakeholders. Now these programmes have been integrated in the 10-year framework of programme on sustainable consumption and production. The integration is based on a life cycle approach. SMEs in developing countries are in the centre of the attention in related work on sustainable innovation.

3.9. Summary of the state of the art

This section will give a short summary of the study on the state of the art of LCM, LCI and LCIA. The present overview of these approaches undoubtedly confirmed the criticism, raised by the users of these approaches discussed in the introduction.

The sections on the state of the art of LCI revealed two major limitations of LCI: the lack of access to general, publicly available databases, and the large variety in the available methods, without consistent guidance when to use which method. Both drawbacks do not benefit the practicability of LCI.

Regarding LCIA, a proposed framework is described. This framework is a significant step towards making LCIA more consistent and more practicable. A lot of work still has to be done to further fill-in this framework. For instance, the framework still lacks recommendations about the inclusion of impact categories in different application contexts, and recommendations about calculation methods and characterisation factors.

The description of the state of the art of LCM showed that LCM is used in different ways, due to the differences among world regions, industrial sectors and product groups. A number of definitions are used, the overall idea is to promote the application of life cycle thinking in management practice. A toolbox on

LCM is being developed, containing a number of tools and programmes. The analytical elements of the toolbox are to stimulate the scientific foundations of LCM.

Life cycle approaches are relatively little used by SMEs, and even less so by companies in developing countries. A large driving force of the use of life cycle approaches seems to come from agreements with large companies in the industrialised world. A capacity building role can be played by intergovernmental organisations like UNEP.

Fore more specialised readers, a detailed extension of the state of the art is discussed in the first annex of this report. The topics discussed there are:

- overview of LCM project topics
- current LCI databases in the world
- LCIA impact categories
- experiences with LCA case study libraries.

Now that the state of the art of the three selected approaches has been described, the next issue concerns the assessment of user needs in order to discover what aspects of the life cycle approaches users want to see improved. The user needs assessment concerns the second step on the road to the establishment of a comprehensive action plan for the improvement of the global use of life cycle approaches.

4. The user needs assessment

4.1. Assessing the user needs

Before one is able to develop an action plan for the improvement of the global use of life cycle approaches, the needs of the current and potential users of these life cycle approaches have to be examined. A large scale user needs assessment will help to avoid a bias towards participating organisations, which in practice generally appear to be science based. A user needs assessment will furthermore help to assess the needs of the future users.

For this report, the following sources have been used. For LCM, LCI and LCIA priority topic areas were identified in two ways:

- With a questionnaire (the User Needs Survey). This questionnaire was first mailed to the interest group and later placed on the web site of the Initiative. Only the results of the mailed group are used in this report;
- Through interaction with the user community through forums and workshops (consultative process).

The needs from users in SMEs and developing countries concerning the three above programs are included in the User Needs Survey itself. An overview of the more general, organisational and not methodology-bound needs within SMEs and developing countries are discussed in a separate section.

4.2. The User Needs Survey

The results of the user needs assessment published in this report (and in the definition studies) date from 2003. Presently, the questionnaire is continued on the internet.

In total, 317 usable responses on the User Needs Survey were counted. The majority of responses came from Europe (186 out of 317 responses). North America and the Asian/ Pacific regions were second (46) and third (36) respectively. More diversity can be found when the responses are categorised according to their work sectors. Most respondents had an academic background (100 respondents), followed by industry (81) and consulting (40).

These results show a strong bias towards a European and academic background. This bias might have influenced the results on all three topic-areas. The consequences of this bias for the results of the Life Cycle Management survey can be extensive, because the topic of LCM is very broad, and only a small portion of users reacted (who were generally science-based). More information of user profiles is displayed in Annex 2, and in the corresponding Definition Studies.

4.3. Life Cycle Management

The main needs of the LCM interest group were:

- the need of linking LC related tools with procedural approaches, such as Management Systems, the product development process, etc.,
- the desirability of linking corporate and governmental life-cycle based strategies with communication tools,
- the need of developing performance based stakeholder communication, and
- development of training material and case studies.

The user needs assessment suggested also a practical approach for implementing a LCM framework:

- the implementation should start with the questions “Who are the key players in LCM?” and “What are key enables for LCM?”,
- from the answers to these questions, one can derive how to identify environmental, social and economic relevance and the respective significance of individual life cycle stages and environmental impacts,
- on this basis, after actors with influence and control are recognised, possible areas for interaction and implementation can be identified, and
- a suggested process for implementation is to use existing best practice case studies on specific sectors or products

4.4. Life Cycle Inventory Analysis

One part of the assessment identified a set of candidate needs. Three needs were considered very important:

- the need for data characteristics (for example: documentation, verification, inclusion of statistical and quality data information)
- the need for more representative data sets (for example: country or region specific data sets, data to address new material or processes)
- the need to increase the capacity for performing LCIs globally (for example to provide skills and training, better access to data, etc.)

Besides the most important needs, the survey also revealed two less, but still important needs. These concern the needs for further LCI methodological guidance and consistency and the need to be able to judge or validate LCIs.

A second part of the assessment was the identification of key user themes and design principles. The users prompt the following three design principles:

- needs for resources, such as compilation of case studies, and perhaps basic LCI data in non- OECD countries, can be addressed through structured processes that link teams (of experts and students) in “LCA-mature” countries with teams in “LCA-new” countries
- in this practice-and-product-oriented capacity-building approach, the needs for capacity development is addressed through international activities that address common information resource needs of the global LCI community
- the initiative should promote explorations that may lead to consensus on recommended methodology practice, by convening method illustration studies and practical methodological workshops

Among the interest group, a discussion took place on the inclusion of biotic resource extraction in LCI, which has to been as a priority due to its implications for biodiversity.

4.5. Life Cycle Impact Assessment

In the LCIA User Needs Assessment, the following key user themes were identified:

- the need for transparency in the methodology
- the need for scientific confidence
- need for scientific co-operation
- a recommended set of factors and methodologies should be developed

In second priority, the initiative should look at developing an adaptive framework compatible with other dimensions of sustainability, providing easy interpretable indicators, providing recommended factors, and guidance for weighting an improved ease of use.

A second part of the User Needs Assessment concerned the selection of impact categories that should be included in LCIA. Traditional impact categories (like climate change, ozone depletion, and habitat loss) seem to be preferred; however, the needs obtained from non-traditional LCA countries are different then needs obtained from traditional LCA countries (Europe, North America as well as Korea and Japan). The impact categories were classified into three groups: required (required by more then 50% of the users), nice to know ("required" or "nice to know" by more then 70% of the users) and low priority (all other impact categories).

Table 2: significance of LCIA impact categories

Required	**Nice to know**	**Low priority**
• Climate Change • Ozone Depletion • Habitat loss as result of deliberate actions • Human toxicity • Eco-toxicity • Acidification and Eutrophication • Photo-oxidants • Extraction of Minerals • Energy from Fossil Fuels • Nuclear Radiation	• *Salination • *Erosion • *Soil Depletion • Habitat loss as a result of indirect actions • Noise • Use of GMOs	• *Health of workers • **Safety • Landscape • Extraction of biotic resources

* classified as "required" if only answers from non-traditional LCA countries are considered
** classified as "nice to know" if only answers from non-traditional LCA countries are considered

In addition, on the international policy level water consumption is seen as a big issue. For UNEP, in particular also the impact of the extraction of biotic resources and its on impact on biodiversity such in the case of fishery are seen as high priority.

4.6. User needs in SMEs and developing countries

The introduction showed that, besides the more specific criticism on the content and technical aspects of life cycle approaches, more general criticism was raised by stakeholders in SMEs and developing countries about the usefulness of these approaches. Because stimulating the use of life cycle approaches in SMEs and developing countries is most essential for a global use of these approaches, special attention will be given in this report to tackle the latter criticism. In section 3.8. the current use of life cycle approaches in SMEs and developing countries is discussed. This section will focus on the criticism expressed by these stakeholders, and on their needs for improvement.

Because of this topic's large scope, and very large target area, a User Needs Survey amongst stakeholders from SMEs and developing countries would give limited and probably also very biased results. As an alternative, a consultation has taken place with UNEP's Cleaner Production Centres, the Cleaner Production Programme and the Sustainable Consumption Programme in order to gather "field experiences". This consultation took place in the preparation phase of the WSSD in Johannesburg in September 2002.

During the WSSD PrepComs meetings opposition emerged from delegates from developing countries against life cycle approaches in general, and in particular against the use of LCA. Tools like LCA were seen as too complicated as well as too one-sided, i.e., with too much focus on environmental problems as seen through the eyes of the industrialised countries. And, above all, life cycle approaches were not seen as being in line with the interests of developing countries. Market opportunities were seen as negative, and costs barriers were stressed.

Based on the outcome of this consultation and the PrepComs four issues will be discussed in a broader context: the need for simple tools and better data availability; the need for broadening the scope of life cycle tools; the need for the removal of trade and cost barriers; and the need for capacity building. The discussion on simple tools and capacity building is also relevant for SMEs, both in industrialised and developing countries

Simple tools and data availability

The first issue concerns the criticism on the too complicated methodology, particularly of LCA. The ISO standards on LCA can be regarded as a first step towards a solution, but these standards give insufficient methodological guidance at the level of the methods, they do not simplify the methods and they by themselves do not lead to better data availability. But also other developments can be mentioned here. For life cycle inventory analysis the development of hybrid LCA can be mentioned, consisting of traditional process-LCA for foreground processes and Input-Output LCA for background processes. The data needs for the IOA-part are much lower than for the process-LCA part. For life cycle impact assessment the European OMNIITOX project can be mentioned, in which a simplified model is developed which can deal with large numbers of toxic substances. But although these methodological developments indeed aim at a simplification of the LCA methodology and the lowering of data needs, they do not remove the need for simplification as perceived by the end-user. Rather they enlarge the scope of substances and processes to be included in LCA, than that they make the application of LCA more easy. Therefore, there remains a high need for better guidance on LCI and LCIA methodology that will facilitate the use of LCA, a need for (further) simplification of LCI methodology and supporting tools, and a need for better data availability in the form of regularly updated databases importable in these tools.

Broadening of the scope

The other main methodological criticism in Johannesburg was that most tools are too one-sided, dealing only with environmental issues as defined by - and consequently also relevant for - the industrialised world. This criticism is not fully true, however. Environmental issues like climate change, air pollution, water pollution, toxic impacts and waste production are in general worse in developing countries than in industrialised countries. But in part it is true indeed. Due to the input-output based structure of LCA, it is difficult to include impact categories that are related to land use particularly important for biodiversity, such as soil erosion, soil fertility and water scarcity. These types of impact are very relevant for developing countries. A solution must be sought in the use of other tools in addition to LCA, which can better cope with these types of impact. Examples include the certification of land management practices, such as the certification of sustainable forestry, of fisheries, of mining and of agriculture, and the labelling of their produce.

Another aspect of the too one-sided nature of the various tools is the fact that they focus only on the environmental dimension of sustainability. Some of the certification schemes mentioned above, but not all of them, receive the same criticism. More in particular, there is a need for the inclusion of economic and social criteria in these approaches. A certain maturity of development has been reached with regard to Life Cycle Costing, especially in the SETAC Working Group on that topic. Social criteria include issues like human safety, child labour, employment, education and the preservation of cultural identity. In particular, in the emerging research in developing countries the inclusion of social aspects in LCA has become a centre of attention. Clearly, at the moment there is more room for such criteria in certification schemes than in LCA, again stressing the need for the use of various tools in combination with each other.

Removal of trade and cost barriers

The last point that arose during the WSSD PrepComs meetings, i.e. the feeling that life cycle approaches are not in the interest of developing countries, constitutes in fact the most serious criticism. A couple of factors do play a role here. Industry in developing countries in general is less modernised than in the industrialised countries, and consequently, the environmental burdens in developing countries may, per functional unit, well be higher than those in industrialised countries. If investigated by LCA products or materials from developing countries may therefore score relatively bad or may have problems to fulfil certain eco-labelling criteria; the application of these tools may consequently select against the use of the given products or materials. Further, there indeed are examples that criteria which are used in certification and labelling schemes are very relevant for industrialised countries, but not so for the conditions in many developing countries. In this respect, they act as barriers to trade (Vitalis 2003).

In addition to this, the participation in eco-labelling schemes may be quite costly for small enterprises in developing countries. Apart from the costs for the required improvement of the technology, there are costs for maintenance of the labelling schemes themselves. Moreover, the increase of sales through labelling schemes often appears to be quite limited. Both factors set limits on the desired increase of market share of goods from developing countries. This indicates that the reluctance of developing countries to participate in life cycle approaches will not easily be removed just by better explanation of its purposes and activities.

A way forward may be found in further enhancing LCA's capacity to take into account the health benefits of increased income especially by production in developing countries (Norris, 2003). Then these benefits outweigh the stronger negative environmental impacts in developing countries due to less modernised technology.

Capacity building in SMEs and developing countries

The state of the art analysis (section 3.8.) observed a relatively little use of life cycle approaches by SMEs and developing countries. A large factor concerns the lack of expertise and organisational opportunities. With regard to SMEs, opportunities for using life cycle approaches increase when the analysis is done at branch level, or is based on agreements with large companies. To further increase the use of life cycle approaches by SMEs and developing countries, there is a need of training and capacity building.

With regard to SMEs, the capacity building should focus on training activities, manual development, and technology transfer. Pilot projects and case studies should demonstrate the use of life cycle approaches. Furthermore, there is a need within SMEs for training on the communication of environmental performance, in order to improve their competitiveness. Branch organisations are to play a important role in these capacity building activities.

With regard to the developing countries, capacity building activities should address a broad spectrum of stakeholders, including SMEs and political institutions. Within governments of developing countries, there is a need for training on the use of policy tools for the promotion of life cycle approaches, as well as on the development of policies like integrated product policy. The training of students in universities and high schools will both benefit government and companies in developing countries.

SMEs and stakeholders developing countries need to be supported by national and regional initiatives. A good medium is available in the form of the existing global network of UNEp/ UNIDO National Cleaner Production Centres. Finally, all capacity building activities should be supported by adequate tools and data.

5. The action plan

5.1. Defining an action plan

In the introduction, it was stated as the main objective of this report to establish an action plan with a consistent and comprehensive list of tasks for the improvement of the global use of life cycle approaches. After an extensive overview of these approaches and a description of the state of the art and the user needs for those life cycle approaches that refer to product systems, in this chapter an action plan will be presented. This plan builds on the discussed state of the art and user needs.

The road towards improvement consists of two elements: addressing the observed limitations of present life cycle approaches, and improving current capacity building and dissemination. Section 5.2. will discuss a number of tasks for the improvement of LCM, LCI, and LCIA. A number of tasks to stimulate the capacity building and dissemination of life cycle approaches, particularly in SMEs and developing countries, will be discussed in section 5.3. To conclude, section 5.4. will outline some perspectives, including the need to assess the user needs for other life cycle approaches focusing for example on the life cycle of materials at a later stage.

A number of these tasks will be dealt with by the Life Cycle Initiative. In the framework of this initiative, Task Forces have been initiated, which have started their work on a number of the identified topics or parts thereof. An overview of the present Task Forces is given in Annex 3. Since the aim of the Life Cycle Initiaive is to promomte the use of life cycle appraoches, it is expressively stated that also other actors are warmly invited to work on these action topic areas.

5.2. Addressing the limitations of life cycle approaches

Formulating the LCM toolbox in detail
The user needs assessment resulted, among others, in the need for a toolbox for LCM. For this toolbox, the following needs were observed: the need to link life cycle related tools to procedural approaches, the need to link corporate and governmental life-cycle based strategies with communication tools, and the need to develop performance based stakeholder communication.

Priority topics in the field of LCM
A number of priority topics can be identified as a way to structure the field of LCM:
- LCM handbook. This extensive handbook should include the LCM framework, describe the links within the different tools, success factors and a number of case studies.
- Life cycle based product development. The integration of environmental and life cycle related information in the product development process is seen as one of the most promising approaches towards improved environmental performance of products and service systems.
- Communication of life cycle information. Communication of life cycle information is one of the key approaches discussed in industry and the public sector to promote sustainable patterns of consumption and production. The target group of the communication include consumers, regulators and value chain actors.
- Management and stakeholder engagement along the life cycle. Management systems are often used to achieve business goals, objectives and targets. Integration of life cycle aspects into these management systems is seen as an important tool to incorporate sustainability in business. The management of product life cycle impacts along the life cycle involves multiple stakeholders. Among the elements of stakeholder engagement that need to be explored are the needs and expectations of different

stakeholders and their information requirements as well as the identification of key player and the development of management models along the life cycle among various actors.

- Inclusion of social and economic aspects under LCM. One of the criticisms displayed by participants of the developing countries was that tools focus only on the environmental dimension of sustainability as explained in section 4.6. One priority for LCM is the inclusion of social and economics aspects in the LCM toolbox in line with the described ideas on broadening the scope. For the consideration of the economic aspects the Life Cycle Costing (LCC) tool will be promoted. The inclusion of social aspects needs particular attention. This is also in the interest of companies for their Corporate Social Responsibility (CSR) activities.
- Integrated resource and waste management. There is a need for a new approach on this topic. The focus must be upon the entire product chain and not only on the waste end-of-life phase of products, substances and materials in order to establish life cycle or circular economies that are eco-efficient. Linkages should increase between existing integrated resource and waste management strategies including the 3Rs (reduce, reuse, recycle) concept with the other work on life cycle approaches and for products and services.

Consistency in LCI and LCIA: an LCA information system

The state of the art of LCI revealed a large variety of practice: an extensive range of methods, approaches, and applications has been mapped. Currently, databases are being developed according to their own individual protocols, which specify aspects such as nomenclature, documentation contents and format, and the treatment of data quality and uncertainty. The ISO 14040 series of standards provide guidance on some aspects of these issues, but leave room for variation on many important issues. Besides, not all database projects fully adhere to the ISO standards.

A growing number of nations are investing resources in projects to make LCI data publicly available. These databases are as of yet poorly networked, if at all. At the same time, a growing number of industry associations and private sector interests have invested in developing LCI databases, researchers are developing process LCI databases, and LCA software providers continue to expand and update the databases that are bundled in their software.

The development of a recommended practice is envisaged to improve LCI data quality and consistency. Following from the state of the art, the priority actions to be taken in this subject are the development of LCI data characteristics (documentation, verification, inclusion of the quality of data information), and the development of more representative LCI data sets. An information system should provide users with access to the existing knowledge base, the developed recommended practice and representative LCI data sets, available in an agreed common exchange format. Furthermore, the growing wealth of data resources has not yet been comprehensively surveyed. The world LCA community needs a comprehensive system for easy access to the available databases. It further needs such a summary to be self-updating, since the total of LCI data continues to evolve and to grow.

The user needs survey on LCIA has shown high expectations for the development of transparent and available recommended methods and factors, enabling better impact assessments. Therefore, the further development of the framework discussed, in section 3.4, should be a priority activity. Based on this framework a list of impact categories with corresponding characterisation factors and methodologies for the calculation of the characterisation should be recommended, starting wit a global default practice for transboundary impacts. Particular attention should be paid to the inclusion of impact categories that are significant in developing countries like land use impacts on biodiversity and water scarcity (in line with the points mentioned in section 4.6).

For LCIA, an information system was requested by the users to enable easy access to recommended practice and new LCIA developments. This information system should include LCIA guidelines, downloadable recommended factors, downloadable models to calculate new characterisation factors, and an adequate description of key aspects of the impact pathway, and proper documentation of the applied models.

5.3. Capacity building and dissemination

An important task in the road to global use of life cycle approaches concerns capacity building in SMEs and developing countries. Capacity building is a core task of UNEP, in particular in support of the 10 year framework of Programmes on Sustainable Consumption and Production Within this framework, programmes should establish clearing houses to provide assistance and information regarding the engagement in life cycle approaches. With regard to capacity building, different tasks can be formulated for SMEs and developing countries.

SMEs need to the assisted in meeting the environmental requirements that are asked by companies in their supply chain. They furthermore need to be able to effectively communicate their environmental performance. Main capacity building activities with regard to SMEs should include the provision of information material, such as reports, software and links to databases; the organisation of courses; the provision of advises with respect to the local filling in of criteria for certification and labelling schemes; contacts with governmental agencies or industries to obtain subsidies for technology improvement; and many more. Branch organisations and regional initiatives need to be actively engaged to promote the use of life cycle approaches.

Efforts should furthermore be made to build capacity within political institutions in developing countries. These efforts include the development of training material, and the transfer of knowledge on the use of policy instruments and policy programmes for the promotion life cycle approaches. Quite much is expected from Multilateral Environmental Agreements (MEA) to increase participation in developing countries. MEAs are agreements between states to work together on global environmental issues, and may take the form of “soft-law”, setting out non-legally binding principles which parties will respect when considering actions which affect a particular environmental issue, or “hard-law” which specify legally-binding actions to be taken to work toward an environmental objective. Examples of MEA are the Climate Change Conventions (e.g. Kyoto Protocol) or the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and Their Disposal).

Following the line of the state of the art and user needs section, also here some topics will receive special attention. These topics are: training material and courses, simple tools and data availability, broadening the scope of life cycle tools, and removal of trade and cost barriers.

Training material and courses
An utmost necessity for capacity building on life cycle approaches is the availability of training material and courses on these approaches. The need for these material and courses was clearly expressed in the user needs survey of LCM, LCI and LCIA. After assessing the training needs, the development of training material should be a priority activity. This material should include:

- awareness raising documents
- introductory material/ information booklets
- training material in multiple languages
- manuals/ handbooks
- pilot/ demonstration projects
- (university) courses

Simple tools and data availability
Among the needs reported by, among others, representatives from developing countries were the needs for simple tools and data availability. Also for SMEs, the lack of simple tools and data availability is seen as a core issue.

A first way to simplify tools is to provide better manuals and training courses as discussed above. Further help can be provided by the development of a case studies library on the application of different life cycle approaches. This library should aim at including results at a meta-level about environmental impacts coming from different product systems. Bringing together information on energy and materials that is based on different methodological approaches, may help to lay a basis for the further simplification of LCA methodology. In addition, such a library could provide information about the functioning of a learning curve; this means the use of simple criteria for product design, the validity of which is validated after completion of the product in question.

Developing recommended practice and a framework for requirements of user-friendliness are ways to make tools more simple. An LCA information system, as described above, will not only work as source for data, but will also contain the recommended practice and indications on how to make tools user-frendly.

The direct development of simple tools, new or by stripping existing tools, is another way to fulfil this need. These tools, however, will often be more application-specific than the current generally applicable but more difficult tools discussed in this report

Broadening the scope of life cycle tools
The third main criticism was that most tools are too one-sided. As discussed in the user needs, there were two aspects of this criticism: tools only deal with environmental issues relevant for the industrialised world, and tools focused only on the environmental dimension of sustainability.

Regarding the first aspect, within the development of the LCIA framework special attention should be paid to the development of impact categories that are relevant for developing countries. These are mainly related to different aspects of land use. However, as has been said already above in section 4.6, the structure of LCA sets also its limits here: impacts in the area of land use should preferable be assessed by other types of tools, at least for the immediate future. However, undesired resource consumption of endangered species, e.g. tropic timber, can be monitored by resource consumption data in the life cycle inventory.

Regarding the second aspect, the economic dimension has been covered by LCC. An aim should be to develop LCC in line with the formal structure of LCA so that the results of the two tools can be compared and also related to each other. A combination of information of LCA and LCC in one way or another enables the basis for measures of eco-efficiency. Social dimensions should get more attention. As a first step, a feasibility study should be performed to examine ways to include these dimensions in LCA, and to determine the implication for LCI and LCIA. This can be seen as a very significant broadening of the scope of environmental life cycle assessment, although it not specifically targeted at SMEs and developing countries.

Removal of trade and cost barriers
On the last point of criticism, it may be suggested that a solution for the cost barriers can only be found if environmental (or social) requirements as calculated by LCA or included in labelling schemes, will be combined with technical or financial support from the industrialised world. There would be several options for that. The costs of the implementation of labelling schemes could be funded by the industrialised countries, because it is in fact these countries that ask for them. Assistance could be given for validation in the field, checking whether the respective criteria are met. It can be important that the criteria used in the certification and labelling schemes are set in close correspondence between stakeholders in the industrialised and developing countries, in order to avoid spurious and unjustified requirements. And, perhaps most importantly, funds may be provided for the transition of the existing into more modern, efficient technology. This is not just wishful thinking. Quite some of these points are becoming included in sales contracts between small firms in developing countries and large companies in industrialised countries. Although no real tasks can be formulated here, it is important that these suggestions are incorporated in activities aiming at training and capacity building. Knowledge of life cycle approaches increases the competitiveness of a company and the respective country, thus providing business opportunities

5.4. Some perspectives on life cycle approaches

Life cycle approaches aim to contribute to sustainability over chains of production, consumption and waste management processes. They complement to a focus on specific, localised activities. Life cycle approaches try to reach this aim by shaping relationships between activities and connected stakeholders in the life cycle chains, thus realising life cycle management. The stakeholders can vary, including extracting and manufacturing industries, retailers, consumers, and waste management companies.

In shaping the relationships along life cycle chains, a core element concerns the flow of information between the different stages along a products' or materials' life cycle. Information of these different stages is brought together, either in quantitative or qualitative terms, using analytical tools or more qualitative means, in order to support a given decision at any stage of a life cycle.

Regarding the role of companies, increasingly life cycle management activities are undertaken by branch organisations, thus strengthening the pre-competitive aspect. Present examples of branch organisations involved in life cycle management include the beverage cartons, the mining and metals and the plastics manufacturing industries. Branch organisations are also of particular interest when SMEs are involved, because these companies in general lack the opportunity to play an independent role in this context. Of particular interest is that stakeholders in developing countries, often producers of natural resources and derived materials, will become more engaged in life cycle management. Here lies one of the main bottlenecks, which must be consistently addressed.

At present life cycle management focuses on environmental issues; it is of core interest that this scope will be widened, and will include also the other dimensions of sustainability. Thus, also social and economic aspects of the activities in the life cycle chains should get full attention.

Drivers for the implementation of life cycle approaches can be of various nature. They can be legal, based on directives or other requirements set by governmental bodies; often such legal requirements pertain to the avoidance of direct risks to consumers, such as particularly occur in the food chain. Drivers can also be derived from the market, steering eco-design of products or of production processes in a more sustainable direction. With market drivers, the relevant demand can be expressed by the consumers themselves; but it can also be expressed by retailer companies, or even by the manufacturing industry, who become engaged in life cycle management in order to strengthen their corporate image. Thus, life cycle management fits well in the modern concept of responsive entrepreneurship and can therefore be expected to gain in importance.

An essential condition for life cycle management is that co-operation between the stakeholders will only come off the ground if it is in the interest to all relevant parties in the life cycle chain. For example, in order to involve companies in developing countries in life cycle management, they should gain through higher prices and more stable market conditions, without having the load of organisation and quality assurance. Another condition for successful life cycle management is that in a product life cycle one party must take the lead; usually that will be the party which expects the highest gain in the process. It is critical that these simple points get more attention. Top-down imposing of life cycle management, without observing the benefits and responsibilities for the single companies does not work.

UNEP has to play an important role in the further development of life cycle management as one of the key elements for enhancing sustainable consumption and production within industry. Therefore, National Cleaner Production Centres should be asked to promote and disseminate the use of life cycle approaches. New activities on the promotion of life cycle approaches are to be established that fit into the UNEP/UN DESA Ten Year Framework Programmes on Sustainable Consumption and Production. At a regional scale, also centres and networks are in development, mainly aiming at capacity building. Such networks are starting up in Africa, Latin America and Southeast Asia, and are likely to increase their coverage. In addition to capacity building, these networks also may well play a role in facilitating fair agreements between stakeholders in industrialised and developing countries.

Last but not least, life cycle approaches aim at a providing a bridge between analysis and practice. Analysis is well developed in scientific communities like SETAC, pertaining to analytical tools such as LCA, LCC and IOA, which in a formal, quantitative way integrate information of all activities in the life cycle. Practice can also take many forms. It can pertain to eco-design, where manufacturers select materials on basis of life cycle information. Or it can be in the form of co-operation between companies and other stakeholders in life cycle chains, using company certificates or product labels to inform customers about production processes.

A main problem in the relationship between analysis and practice is that they lack sufficient exchange. The analytic approaches are often not sufficiently focused on their practical application, thus remaining academic activities. In contrast, the practical approaches are often not sufficiently based on results of scientific research, thus disregarding available information about the consequences of activities in product or material life cycles.

However, there are also good examples. One example concerns waste management; where a rather intuitive strict hierarchy is being replaced by a more flexible integrated approach, based on scientific information about eco-efficiency of the processes involved. Comparable developments are now taking place in the building industry, regarding the selection of building materials on basis of their upstream and downstream environmental characteristics. More branches are likely to follow, such as the metals industry in connection with the automotive industry.

Starting from available knowledge and tools, the present report puts a main responsibility on the scientific community to bring its results into action in order to put life cycle thinking into practice. In this context the UNEP/ SETAC Life Cycle Initiative can be mentioned, the main mission of which is to facilitate this process through its programmes on life cycle management and life cycle assessment. But likewise the opposite holds true: stakeholders involved in decision on product life cycles should become more open to the provided information and adapt their activities correspondingly. The present report aims at contributing to this two-way process, thus building on "the road from analysis to practice" and at the same time supporting the establishment of a life cycle economy.

Where will we be in five years time? LCA databases will be linked and will be available throughout the world, together with guidance about their use. Recommended practice with de established about the most relevant analytical tools, particularly including LCA, LCC and MFA. Different ways to simplify analysis in a scientifically acceptable way will be identified and further elaborated. Information will be available on the success and failure factors when using life cycle approaches in practice; for a number of products and materials meta-studies will provide lessons learnt that will be implemented with regard to their environmental characteristics, thus further guiding practice. Different sectors will exchange information and thus learn from each other. And in a number of developing countries regional networks will have come of the ground engaged in capacity building on the analysis and practice of life cycle approaches.

Annexes

A1. Extension of the state of the art

Life Cycle Management priority topics

Based upon the user needs survey, a series of workshops, and communication with interested parties, a number of priority topics have been identified for LCM. The state of the art of these priority topics will be discussed in this chapter. The topics are more thoroughly discussed in the LCM Definition Study.

Life cycle based product development
The interest of customers, manufacturers, and other stakeholders in the environmental aspects and impacts of products is increasing. This can be seen at the increasing level of discussions taking place between businesses, governments and non-governmental organisations on topics like sustainable development, and eco-efficiency and the growing number of international agreements, trade measures, national legislation, and sector-based voluntary initiatives. This interest is being driven by the increasing awareness that there are substantial benefits in the integration of environmental aspects. These benefits include (after ISO/TR 14062): resource and process efficiencies, cost savings, and the improvement of image.

However, there are a number of common obstacles that organisations encounter as they implement eco-design. These include:
1) the level of awareness of the environmental issues at different levels within the organisation
2) levels of environmental knowledge and competence
3) organisational structure and internal routines
4) availability of, or familiarity with, tools for handling environmental issues within the whole value chain.

In general, Life Cycle Management allows to identify life cycle stages, processes or single contributions that contribute most or have the highest potential for improvement. As a consequence, the leveraging points of the systems can be identified. In this way, LCM offers a valuable approach to identify opportunities of improvement and support the realization thereof.

Ideally such life cycle considerations are used systematically and as an integral part of the product development process and not accidentally and outside the core process.

Communication of life cycle information
Companies have three types of environmental labelling schemes to choose from – ISO type I, II, and III labels – depending on their intended use for the labels needs of their stakeholders. In principle, a company that has well developed LCA capabilities will want to move towards a Type III label (environmental product declaration - EPD). The use of this kind of labelling, suitable for sharing environmental information on products and services along the supply chain, enables faster and more accurate LCA analyses, more effective DfE practices, and "greener" purchasing mechanisms. Type I and II labels are other forms of environmental information covered by the ISO labelling standards. Whereas Type I labelling identifies products as being less harmful to the environment compared to other, similar products fulfilling the same function, type II labels are self-declared environmental claims which allow statements about the environmental performance of a product by the manufacturer itself. Unlike EPDs, which are primarily a business-to-business tool, Type I and II labels inform end consumers.

Recent years have seen the emergence of certification schemes, such as the Forest Stewardship Council (FSC) and the Marine Stewardship Council (MSC), which provide assurance to stakeholders and consumers that certain performance standards were met in the production of raw materials. Because these standards were developed with the participation of a broad group of stakeholders, companies can be confident that their certified products comply with the expectations of these interest groups. This whole array serves as a very important part of an organizations overall communication and reporting practice.

Management and Stakeholder engagement along the life cycle
From the point of view of ISO, LCM represents an approach for ensuring that the processes used across the life cycle of projects are consistent and that there is effective sharing and co-ordination of resources, information and technologies.

Three steps should be taken towards the implementation of LCM within a company. The first should consist of defining the roles and responsibilities of individuals; in other words, it should define the organisational structure. The second step should involve establishing an environmental management system (EMS), or a social responsibility system (SR). Switching from a site-or facility focussed approach to a product-oriented approach should be the third step towards implementing a LCM approach.

The systems theory speaks of leverage points: places within a complex system (such as a corporation, economy, living organism, city, or ecosystem) where a small intervention produces big changes in the rest of the system. The system of the product life cycle has many such leverage points, which can be identified in order to understand how to best intervene with the system to achieve the desired change. Typical leverage points for intervention include the expectations from different stakeholders, the various functions within the organisation, and individual incentives or motivations. More concretely for LCM, places to intervene in the system include:

- the product life cycle: from life cycle stages to individual process changes
- the public sector: from producer responsibility regulations to green procurement programmes
- the various business functions of the company: procurement, product development, marketing
- stakeholders expectations: financial sector, consumers, special interest groups

While the overall goal is to integrate LCM into all functions and levels within the organisation, implementation will likely start slowly from one or more points in the firm. These “entry gates” are: the upper levels of management, the marketing level, the product design (manufacturing) division, and the research and development division.

Capacity building in developing countries
Life Cycle Management is emerging as one of the most powerful environmental programmes in the developed countries. In most of the developing countries, LCM stands a different posture. On the one hand, LCM is perceived to be a vague concept in these countries, which creates uncertainty over its proper placement and role within the hierarchy of available environmental tools. On the other hand, unlike developed countries, where clients and end users are the strongest drivers for LCM, in developing countries such driving forces do not exist. As well, many of requisite components for LCM, such as green procurement, environmental databases, eco-labelling schemes, and other related tools are barely known or non-existent in the vast majority of developing countries. Furthermore, one of the most important obstacles to implementing LCM in developing countries is the complexity and difficulty of the many of the methods in the LCM toolbox, which tend to require special training and experience.

Integrating economic and social aspects into LCM
While the inclusion of economic aspects in LCM has been identified as a major area of interest, research in this area is still at an early stage. Until now, the SETAC Working Group on Life Cycle Costing (LCC) is spearheading the work on this topic. LCC is one of the most useful, if not most important, concepts for linking environmental life cycle approaches to management decisions. While there are several definitions of LCC, the definition by Blanchard and Fabrycky (1998) is consistent with SETAC’s definition of LCM and therefore can serve as a useful starting point: “life cycle costs refer to all costs associated with the system as applied to the defined life cycle.” The following areas and activities have been identified by the SETAC working group:

- Life cycle costing methodology
- Life cycle costing in business
- Life cycle costing and its link to life cycle inventory

- Life cycle costing and its link to sustainability and externalities

Increasingly, stakeholders (shareholders, investors, communities, regulators, employees, customers, and non-governmental organisations) are taking a broader perspective of corporate responsibility that incorporates not only economic performance, but also social, governance and environmental performance factors. Evidence of this broader perspective on corporate performance can be found in a variety of guidelines and standards (e.g. United Nations' Convention on the Rights of the Child) and in emerging financial sector rating schemes which try to identify best-in-class performers.

In response to, and in some cases in advance of, the current situation, a growing number of private and public sector organisations are adopting the term corporate social responsibility (CSR) to describe an organisation's overall commitment to meeting stakeholder expectations on economic, environmental, social and governance performance. CSR, emerging from socially responsible investing, has become a preferred implementation approach for corporate sustainability.

There are already a number of initiatives that seek to improve reporting and certification of social responsibility issues. The Ethical Trade Initiative, Rugmark, and SA8000, among others, focus on human rights issues for employees and in some cases also wage issues. Indigenous people rights are included in the standards of Forest Stewardship Council, while Business in the Community touches upon the issue of income distribution. Initiatives that cover a wider range of issues include fair trade associations and the Global Reporting Initiative. However, these broader initiatives typically do not seek to quantify or certify the issues involved.

Integrated waste and materials management

In the last few years, integrated waste and materials management has gotten high on the political agenda. Here are some examples:

- The Europeans Commission's communications 'Towards a Thematic Strategy on the Sustainable Use of Natural Resources' and 'Waste prevention and recycling strategy' provide an integrated approach to resources use and waste management in interrelation with the EU initiative on Integrated Product Policy. All these initiatives together will look at the environmental impacts across the life cycle of products, services and materials, to reduce pollution, facilitate recycling whenever economically justified, and reduce the costs of waste disposal. UNEP has also taken an integrated approach in its work on sustainable consumption and production.
- The Government of Japan published a basic plan whose purpose is to promote comprehensive and systematic policies for establishing a recycling-based society. Recycling-based society means a society where the consumption of natural resources is at a low level and the environmental load is reduced as much as possible by preventing products from becoming wastes, thereby promoting the appropriate recycling of products and securing appropriate disposal. Furthermore, the plan serves as a ten-year programme aimed at changing unsustainable patterns of production and consumption into sustainable ones based on the WSSD plan of implementation.
- The International Solid Waste Association (ISWA) has identified the prevention of waste as one of the major challenges for the waste management sector in its ten-year perspective report. In order to prevent waste, there is a need for a new approach. Focus must be upon the entire product chain and not only on the waste end-of-life phase of products, substances and materials. Important decisions in relation to the amounts of waste generated are taken, both at the concept and design stage and, further on, during the production process. There is a need for dematerialisation of the economic process: still consuming the same amount of products, but products produced with fewer materials and generating less waste. ISWA is an independent, non-governmental, non-profit making association. ISWA's objective is the maximum exchange of information and experience worldwide on all aspects of solid waste management.

Current LCI databases in the world

This section gives an overview of current LCI databases in the world. The focus is on publicly available rather then privately-held, commercial, proprietary, or restricted-access databases. The two tables come from the report "current availability of LCI databases in the world" written by G. Norris and P. Notten. A frequently updated version is available from www.sylvatica.com/unepsumm.

The first table (table 3) gives an overview of the project status and the class of the managing organisation of the database, wile the second table (table 4) displays the country and the class of managing operations.

Table 3: Matrix of LCI databases by project status and class of managing organisation.

Status: *Managed By:*	*Completed (may be updated)*	*Ongoing, with data gathering underway*	*Planned or underway, but data gathering not yet underway*
National and multi-government[1]	Italy, Switzerland (BUWAL 250)	Australia, Canada, Chinese Taipei, Japan, Korea, Sweden (SPINE), Switzerland (EcoInvent 2000),	USA
Consultants and Research Institutes[2] *(data made available)*	Denmark (EDIP), Sweden (CPM)	Austria, Denmark, France, Germany, Sweden, Switzerland, UK, USA	
Industrial (data made available)[3]	IISI, EAA, FEFCO, APME and PWMI, NiDI		
Academic / Decentralized[4]		Belgium, China, Chile, Estonia, Finland, India, Norway, The Netherlands, Portugal, Poland, South Africa, Spain, Vietnam	Argentina, Malaysia, Thailand

Table 4: matrix of LCI databases by country and class of managing organisation

Country	*Government / National level*	*Info sharing (LCA society)*	*Academia (Research)*	*Industry and consultants*
Argentina	stalled		few	?
Australia	underway	ALCAS	yes	yes
Austria	?		yes	yes
Belgium	?		yes	yes
Canada	near completion	Nat'l Round Table on Env. & Economy	?	yes
Chile	no	?	yes	?
China	no	no	yes	no
Chinese Taipei	on-going, not yet peer reviewed	TEMA	yes	no
Denmark	not sure of status (EDIP?)		yes	yes
Estonia (Eastern Europe)	no		few	?
Finland	?		yes	yes
France	not sure how representative or complete		yes	yes
Germany	fragmented (GEMIS?)		many	many
India	no	ISLCA	yes	no
Italy	yes (not sure how representative)		?	yes
Japan	yes (underway)	JSLCA	yes	yes
Korea	on-going	KSLCA	yes	yes
Malaysia	no	fledgling	few	no
Norway	?		yes	yes
The Netherlands	?		many	many
Portugal			few	?
Poland			few	?
South Africa	no	SALCANet	yes	yes
Spain	?		yes	yes
Sweden	status? (CPM)	SPINE	many	many
Switzerland	yes (EcoInvent 2000)		many	many
Thailand	no	no	single? (electricity)	no
UK	?		yes	yes
USA	planned	SETAC-NA	yes	yes
Vietnam	no	fledgling	yes	no

1 Co-ordinated effort to produce nationally representative and accessible database. Typically involves collaboration between several organisations and some degree of government funding.

2 Inventories produced by research organisations or consultants and made publicly available in a database, sometimes for a fee (e.g. databases included with LCA software).

3 Inventories produced and published under the auspices of a particular industry organisation. Includes cases where data made only partially available (e.g. for a fee, or only to parties with sufficient motivation for requesting the data). Most often data compiled by consultants, but includes cases where LCI development is done in-house, or by academic or other research organisations.

4 Includes inventories compiled by academic or other research organisations, made either partially or fully available on an ad-hoc basis (e.g. through journal publications). Countries may have some degree of information sharing (e.g. an LCA society), but no co-ordinated datagathering effort (i.e. studies are not organised into an accessible database).

ALCAS – Australian LCA society
TEMA -
ISLCA – Indian Society for LCA
JSLCA – Japanese Society for LCA
KSLCA – Korean Society for LCA
SETAC-NA – SETAC North America
SALCANet – South African LCA Network
SPINE – Sustainable Product Information Network for the Environment

LCIA midpoint categories

The state of the art has been identified for thirteen midpoint categories. A summary will be given for each midpoint category. The detailed state of the art can be found in the third background document of the LCIA Definition Study.

2) Ozone depletion
Several dozens, mostly man-made, compounds released to the air, have a known effect of reducing stratospheric ozone concentrations. These compounds are characterised by high chemical stability and by containing Fluor, chlorine and bromine. The consequence is an increase of solar radiation, particularly UVB, on earth's surface. Increased UVB radiation over long periods (years or decades) is known to have a detrimental influence on human health (e.g. (non)lethal types of skin cancer). To the natural environment and the man-made environment, no significant impacts are suspected. Although global production of these components has been reduced substantially, emissions still continue and may appear in LCIs.

1) Climate change
Greenhouse gases have many types of impacts: temperature rise, changes in precipitation, sea level rise, change of ocean currents, storms, hurricanes, and possibly others eventually leading to impacts on human health and on biotic natural resources. All of these types of impacts depend on changes in radiative forcing (expressed as W/m^2). Therefore, this category offers the opportunity for a science based midpoint indicator, the well-known Global Warming Potential (GWP). If weighting is performed at midpoint level due to too high uncertainty in the description of further impact pathways, climate equilibrium can be considered as a life support function to be protected as such: the capacity of the environment to provide the conditions for a long term stable climate on earth. This helps making explicit the values behind such a midpoint indicator.

6) Human toxicity
Three types of information are relevant when assessing toxicological impacts on human health: chemical fate (transport in the environment), human exposure, and toxicological effects. The results are reported in terms of equivalents of a reference substance, such as toluene equivalents. A growing number of methods account for differences in the potential consequences of toxicological impacts on human health (like Quality Adjusted Life Years (QALYs) and Disability Adjusted Life Years (DALYs). In spite of advances in terms of accounting for differences in the emission scenarios (e.g. location, dispersion), current estimates generally provide preliminary or screening insights only. While the calculation of characterisation levels allows for complex calculations (like non-linear low dose response curves, biological thresholds), the required data remains too limited in practice.

11) Accidents
Very few LCA have considered accidents by physical impacts. However, neglecting damages on human health due to accidents over the life cycle of a product, could lead to biased decisions. The scope of this category needs to be discussed further.

5) Photochemical smog indicators
Photochemical smog is caused by the reaction of atmospheric substances, both natural and man-made, in the presence of sunlight. Ozone (one type of smog) is a toxic gas which has been shown to cause respiratory distress in people and other mammals, as well as causing reduction in the primary production rates of plants. Ozone acts through the creation of free radicals, which are implicated in carcinogenesis and in the destruction of cellular membranes. Two types of models have been developed to analyse midpoint indicators for smog. The Northern European model is based on the calculated photochemical ozone creation potential (POCP), and measured in units ethylene. The model used in the United States is based on the Maximum Incremental Reactivity (MIR), and is measured in units of O_3.

Traffic noise
Environmental noise emissions from traffic systems (road, rail, air) exert a heavy load on an important proportion of most country populations, in levels that affect their well-being. In general, health effects of

noise are caused continuous noise caused by all vehicles using a certain traffic channel within an extended period of time. The effect of a single vehicle or transportation task can be calculated by generally accepted calculation methods. Effects are found on the Areas of Protection human health (sleep disturbances), natural environment (well being of animals).

3) Acidification

Through oxidation and photochemical reactions, a number of atmospheric substances like sulphur dioxide and nitrogen are transformed to acidifying substances like sulphuric acid and nitric acid. These acids can be deposited as dust (dry deposition) or dissolved in precipitation (wet deposition). These depositions may cause undesirable effects on terrestrial and aquatic ecosystems (decrease PH, detrophication of soils), man-made resources and even human health.

4) Eutrophication

Nitrogen and phosphorus are essential nutrients for life, but in excess these substances cause eutrophication. The increase of these nutrients in water areas contributes to the generation of phytoplankton, and may cause algae blooms. Reduced oxygen availability and decreased transparency of the water influences causes reductions in a/o. fish. A surplus of nitrogen in the ground may disturb the nutrient balance of nutrients in plants. Animal husbandry, agriculture and the food industry are considered as main producers of these nutrients.

7) Eco-toxicity

Although in many respects eco-toxicity is treated similarly as human toxicity, there are a few differences. The level of concentration for eco-toxicity is taken as interface between fate (chance and dose of exposure) and effect (effect of dose). Exposure is generally implicitly taken into account in the effect factor. The fate factor makes it possible to relate emissions to a concentration increase in the environment. The endpoint level chosen for eco-toxicity is generally mortality percentage.

9) Land use, habitat conservation, bio-diversity

Many studies show that terrestrial species extinction is primarily driven by loss of habitat. The factors that appear to be important in preserving populations include the total area of each type of ecosystem, the size, shape and interconnectedness (or fragmentation), and the integrity of the land/ water interface. In the oceans, over-fishing seems to be as much a source of species extinction as habitat destruction. A wide range of habitat conservation indicators have been developed in the context of conservation biology (e.g. by UNEP, WWF, SETAC). Relatively little has been done to evaluate bio-diversity indicators in aquatic systems.

Dispersal of invasive species and GMOs

Increased dispersal of invasive species (which are alien to the local ecosystems), may happen as a result of intentional (plaque combat) or unintentional (new dispersal vectors) introductions. The largest impact is due to transport vectors, such as ballast water of freighters, soil sticking to trucks and souvenirs. The dispersal of genes introduced via genetically modified organisms is generally a more limited problem due to stricter legal approval procedures, but its potential impact can be modelled in the same way as dispersal of natural species. The resulting direct impact (midpoint category) is an altered species composition and population volumes, with the indicators primary production and biodiversity-weighted area. The biodiversity indicator should reflect the relative number of native species negatively affected by the introduction. The problem of dispersal of invasive species has not been described systematically in the context of LCIA so far, the initial efforts should focus on the description of a generic model, and the collection of data and quantification of the relationships in the model.

8) Use of natural resources

Most natural resources have only a functional value to humans; i.e. they are valuable because they enable us to achieve goals that have an intrinsic value, such as welfare or health. Few resources also have a intrinsic value, like unique landscapes. The use of natural resources may indirectly have an impact on other damage categories with intrinsic value. The use of scarce freshwater may reduce the availability of freshwater for human use, and may lead to disease. When using natural resources, four types of outputs can be expected:

directly reusable material, not directly reusable material (of lower functionality than input), material made unavailable in disposal, and material made unavailable in use.

11) Waste
Indicators for waste have a special position, since they are, from their concept, positioned between LCI results and the conventional midpoint categories. Waste indicators are very relevant in environmental management, Life Cycle Management, and in sustainable activities. At the level of LCI results, several options and procedures exist. Usually LCI data relating to waste are outputs to the technosphere, and are characterised based on generic, regulatory, or technology criteria. A significant number of waste classifications according to different criteria (and therefore many options for waste equivalents) exist and are applied. There is no common practice or agreement on choosing equivalency indicators and factors; it might even be advisable to choose different classification and characterisation schemes for different branches or applications.

Experiences with LCA case study libraries and meta studies

One of the most important needs expressed by users of life cycle approaches was the need for and LCA case study library. Building a comprehensive 'library' of case studies is a very large undertaking, it will require many person-hours, and it will need to be maintained. Fortunately, the work does not need to start from 'scratch'. In recent years, expert teams at several universities, research groups and consultants have undertaken meta-studies of existing LCAs on several different product groups or life cycle states. This chapter will provide a short, and far from incomplete, overview of LCA case study libraries.

French studies on compilation on waste recycling LCAs

ADEME, France's Environment and Energy Management Agency, gathered results from life cycle studies that had been conducted on 11 different products and types of packaging, such as paper, aluminum, and plastic packaging. ADEME compared the environmental impacts from recycling the product or packaging with impacts from incinerating it, landfilling it, or otherwise disposing of it. For example, ADEME's comparison showed that recycling plastic is environmentally beneficial if the recycled plastic is used in a product in place of virgin plastic. However, if the recycled plastic is used in place of wood, it would have been more environmentally beneficial to incinerate that plastic and recover the energy from the incinerator (i.e., recycling is not favourable). The French government has used this life cycle information to inform their laws on recycling, waste prevention, and responsible "end-of-life" management for products and packaging. In France, it may soon "…become the responsibility of producers, importers and distributors of products (and materials in those products) to manage or contribute to eliminating waste from those products…" (translated from ART L541-10 du Code de l'Environnement).

National Risk Management Research Laboratory's Life-Cycle Assessment (LCA) website - www.epa.gov/ORD/NRMRL/lcaccess/

The site is divided into six primary areas to help educate people new to the concept of LCA while serving as a focal point for LCA practitioners and decision-makers to stay current with the field of LCA. LCAccess provides information on why one would want to perform an LCA, an overview of LCA, how to find LCI data sources, available LCA resources, on-going efforts in the field of LCA and upcoming LCA events.

A2. User Needs Survey profiles

Life Cycle Management

119 surveys were received on LCM; of which 78 were submitted by individuals, 23 from organisations and interest groups (representing a multitude of individuals), and 17 from a variety of organisations in which it was unclear to which extent the organisation or the individuals provided feedback. Responses were received from 33 different countries. Figure 6 shows the breakdown of the respondents in both regions and work sector.

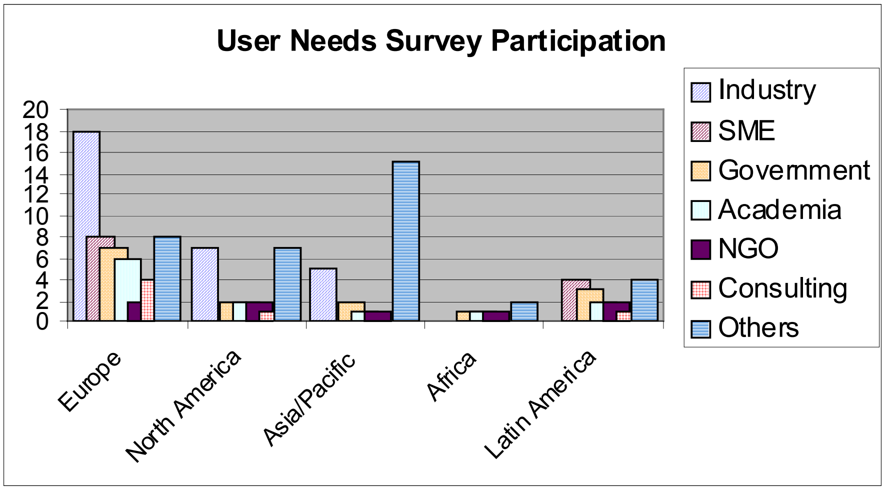


Figure 6: Participation in the LCM User Needs Survey

From this figure, the following observations can be made:

- the major interest is from the business side
- since LCM is a rather new field, governments and research are not as dominant
- Asian and Latin American industry participation mainly cane through industry association
- SMEs in Europe and Latin America participated, not from North America

Life Cycle Inventory Analysis

122 responses were received of the LCI User Needs Survey, which was send to thousands of contacts. 107 of them were complete, and usable for further analysis. Results came from a total of 28 countries. Two figures are included; figure 7 shows the geographical breakdown of the respondents per continent, figure 8 shows the breakdown in prime work sector.

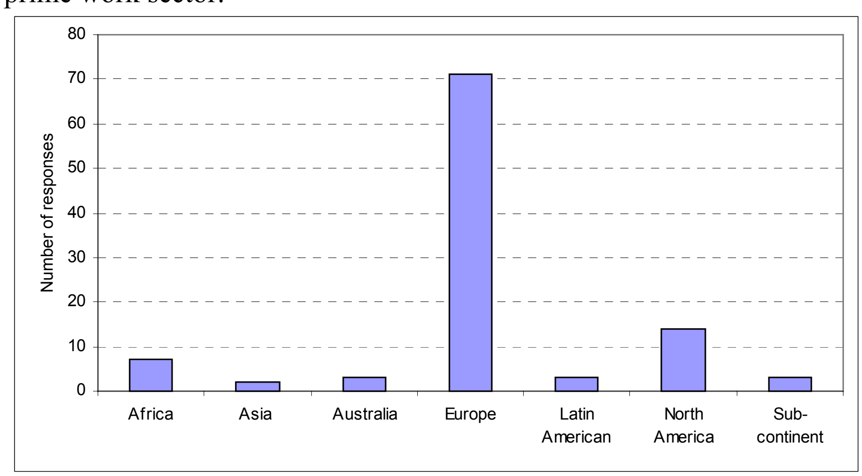


Figure 7: Breakdown of responses according to geographical region

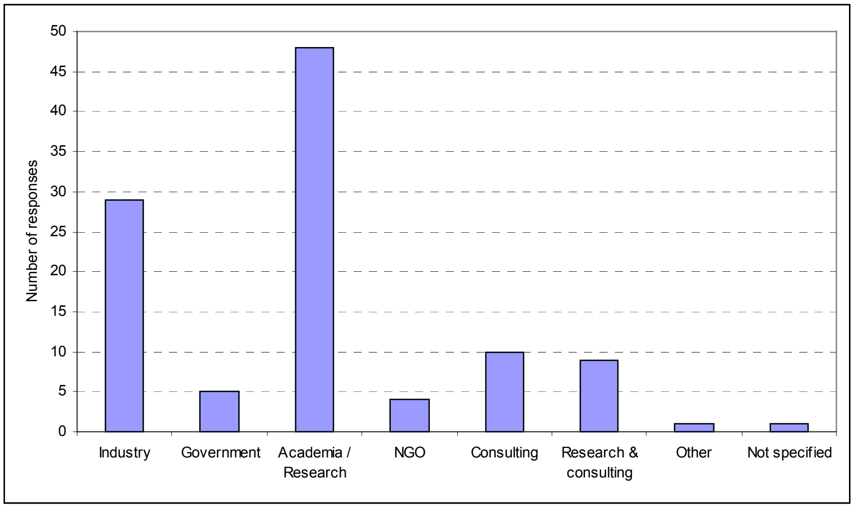


Figure 8: Breakdown of responses according to prime works sector

From these two figures, the following observations can be made:

- Europe dominates, accounting for 69% of the responses
- Third world countries are barely represented
- Academia dominates considerably, with 45% of the respondents indicating they are active in research, increasing to 53% if both research and research & consulting is included.

Further questions regarding the user profiles were about the use of LCA, the stage of LCA users base their decisions (LCI/ LCIA), and the industry use of LCA. The majority of the respondents use LCA for decision-making (61%) or conduction of LCAs (20%). A combination of LCI and LCIA is most often used to base decisions on (72%). Finally, nearly all respondents using LCA in industry work in a department of environment, health and safety (59%), or research and development (24%). An additional 7% indicate they work in both these departments.

Life Cycle Impact Assessment

The analysis of the LCIA User Needs Survey is based on 91 independently completed surveys from various countries around the world. The table shows the breakdown of the respondents in regions; the pie chart shows the breakdown in work sector.

Table 5: Regional split of the survey respondents.

UN Regions	**Number of Respondents**
Africa	5
Asia and the Pacific	7
Europe	61
Latin America and the Caribbean	5
North America	11
Not Specified	2
Total	**91**

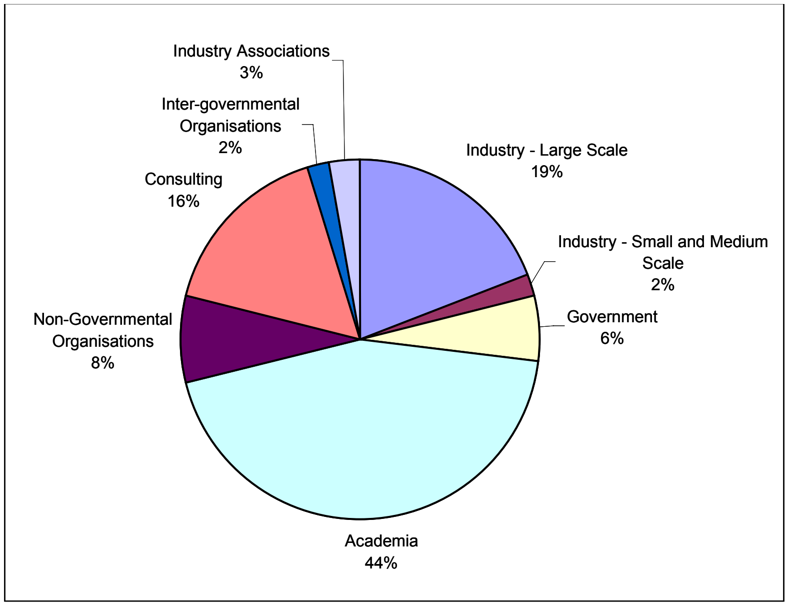


Figure 9: Breakdown of LCIA respondents in work sector

Overall evaluation of survey

The survey results discussed in this report are obviously dominated by responses received from Europe. This reflects to some extent the fact that a significant amount of global LCA activity is centred in Europe. Notable in their absence are responses from certain Asian counties like Japan. Survey results are dominated by input received from academia; however, the spread of sectors from which responses were received is relatively wide.

A3. Overview of task forces

Within the Life Cycle Initiative, task forces will be initiated to work on a number of tasks that were discussed in chapter 5. These task forces will initiate activities to reach their deliverables. These activities include self-organised activities (like workshops), projects together with industry (cases), and participation in external activities (like workshops organised by others, or other projects like eLCA). All task forces will be lead by a chair and a co-chair who are responsible for work progress and quality. For more information on the on the task forces, see the Life Cycle Initiative publication "Task Forces: Overview and Terms of Reverence", which is available for download from the Initiative's website.

Three types of task forces will be distinguished within the Life Cycle Initiative:

- Experience-sharing and guidance oriented task forces, or 'guidance TF';
- Practice and training oriented task forces, or 'practice TF';
- Task forces on crosscutting issues.

'Guidance' TFs will aim at sharing experiences and achieving recommended practice, while the 'practice' TFs will aim at practical involvement of stakeholders, training and capacity building, hereby involving as many regions as possible. All 'guidance' and 'practice' task forces will be conducted within one of the three programmes of the Initiative (LCM, LCI, LCIA), as is shown in the abbreviation of the task forces.

The task forces on the crosscutting issues address questions in relation to life cycle approaches that have been identified as relevant in the overall user needs assessment, but that have not been further developed as part of the three programmes, since they include topics that concern more then one programme. Most crosscutting issues are related to the SMEs and developing countries, and were discussed in the main text under the heading 'life cycle approaches in SMEs and developing countries. The task forces on crosscutting issues are currently under proposal; a feasibility study will first be prepared on these topics.

Experience-sharing and guidance oriented task forces

LCM TF 1: LCM handbook, framework and coordination
In absence of an agreed upon definition for LCM, the handbook will introduce the LCM framework, discuss the drivers and needs, describe the major underlying approaches, and provide selected illustrative examples and successes while introducing and using LCM in practice. This first LCM Task Force will be responsible for the framework and co-ordination of this LCM handbook.
The Task Force will be active in the fourth quarter of 2003, and will conclude with the presentation of the final draft handbook, ready for publication. By December 2003, a draft outline of the handbook will be presented to the programme and the initiative leadership. Herein concluded are contributions from other Task Forces (LCM TF 2-5), that supply state-of-the-art descriptions of their respective fields. The draft handbook will be completed by June 2004 in the form of an introductory booklet. Then for 2005, a more comprehensive handbook can be published.

LCM TF 2: Life cycle based product development
This Task Force will work on the integration of environmental aspects (of the total life cycle) in the product development process. This integration is being viewed as one of the most promising approaches to change products and service systems towards improved environmental performance. The emphasis is on the continuous improvement mode, rather then on step-change improvement. The deliverables of this Task Force include a chapter in the LCM handbook, the organisation and documentation of a number of workshops, and a report on recommended practice on the integration of environmental aspects into product development.

LCM TF 3: Communication on life cycle information
Communication of life cycle information is one of key approaches discussed in industry and in the public sector to promote sustainable patterns of production and consumption. Different approaches have been developed in the field of communications, including type I, II, and III labels. The task force will position the

existing tools and identify the best options to initiate changes of consumption and production patterns. In particular, the task force will examine the mutual reinforcement amongst the tools and within the larger LCM framework, specifically within management systems, with other tools. The deliverables of this Task Force include a chapter in the LCM handbook, the organisation and documentation of a number of workshops, and a report on recommended practice on the communication of life cycle information.

LCM TF 4: Management along the life cycle
Management along the life cycle means approaching and applying life cycle thinking from a management point of view. In particular for the private sector, management systems and business processes are the key elements to achieve business goals, objectives and targets. This Task Force aims to approach and implement life cycle thinking from these management systems and business processes. This Task Forces will build on the ISO standards (e.g. 14001 and 14004) and EMAS. Besides providing a chapter in the LCM handbook, other deliverables include the organisation of one or more workshops, and the development of a report on the state of the art of this topic.

LCI TF 1: LCI database registry
This Task Force will update and expand the working summary of available LCI databases (produced during the Definition Study), including both public/national databases as well as LCI databases being made available by industry as well as LCI databases being made available by industry associations. The results will be used to create a web-based, UNEP LCI Data Registry, which provides basic meta-data and web links to the appropriate sites. The deliverables of this Task Force include a document describing the available LCI databases, the content for the web-based registry, and a plan for updating and maintaining both web-portal and document. These deliverables will be published in 2004.

LCI TF 2: LCI database characteristics and quality
In keeping with the aims of the Life Cycle Initiative, and responding to input received during the LCI User Needs Assessment, the aim of this Task Force is to facilitate voluntary and practice-oriented movement towards consistency and commonality of database properties, while avoiding the role of drafting "standards" per se. Consistency will be pursued on four core issues: data quality assessment and documentation, documentation format, data exchange format, and nomenclature. Activities organised to reach this task include a writing period of white papers, a web-mediated discussion period, and a number of concluding workshops. One workshop will be held on 19 and 20 November 2003, in Forschungszentrum Karlsruhe, Germany. On each core issue a concluding report will be published, which should be finished in 2004.

LCI TF 3: LCI Methodological consistency
The aim of this Task Force is to initiate and stimulate processes, studies, and forums that facilitate voluntary and practice-oriented movement towards transparency, ultimately contributing to improved consistency and commonality of LCI methodological practice. The main deliverables are: a summary of current state, an agreed framework for the classification and comparison of LCI methods, a guidance document on methods choice in relation to application, and a plan of dissemination. Workshops, scientific papers, and (online) discussions are the tools for the development of consistency. This Task Force will be active for two years.

LCIA TF 1: LCIA Information System
Towards the enhancement of the availability of sound LCIA data and methods, this Task Force aims to develop an LCIA information system on the one hand and to finalise and extend the general framework on the other hand. This TF is of the highest importance, as it will provide the necessary tools and guidance to users to take profit of the three TFs on recommended practice (coming next). The world-wide accessible information system should include:

- LCIA guidelines, as described under the framework development
- Downloadable recommended factors in midpoint and damage categories
- Downloadable models to calculate new characterisation factors
- An adequate description of key aspects of the impact pathway, and proper documentation of the applied models.

Further deliverables include a scientific paper on the LCIA framework, and a commented list of selection criteria, recommended indicators, models, and practice.

LCIA TF 2: Natural resources and land use
This Task Force aims at establishing recommended practice and guidance for use for natural resources and land use categories. These categories are: water resources, minerals resources, energy carriers, soil resources and erosion, land use, salinisation and desiccation, and biotic resources. It will address both midpoint categories and their relation to damage categories, such as the biotic and abiotic natural environment. A workshop on LCA and natural resources and an workshop on land use and biodiversity are organised by this Task Force in 2004. The deliverables include a recommended list of impact categories and category indicators, recommended methodologies, and recommended characterisation factors.

LCIA TF 3: Toxicity categories
Largely similar to Task Force 2, this Task Force aims at establishing recommended practice and guidance for use for the ecotoxicity, human toxicity, and related categories with direct effects on human health, like ionising radiation, accidents and noise. Photochemical smog and respiratory inorganics will be co-ordinated with Task Force 4. This Task Force will address midpoint categories and Like with the previous TF, the deliverable include a recommended list of impact categories and category indicators, recommended methodologies, and recommended characterisation factors.

LCIA TF 4: Transboundary impacts
This Task Force aims at establishing recommended practice and guidance for use in transboundary categories, namely: climate change, ozone depletion, aquatic and terrestrial eutrophication, and acidification. The topics photochemical smog and respiratory inorganics will be co-ordinated with Task Force 3. This Task Force will address midpoint categories and their relation to the damage categories human health and biotic natural environment. Main deliverables are a finalised state of the art, a set of recommended generic characterisation factors, and recommended methodologies.

Practice and training oriented task forces

LCM TF 5: Stakeholder responsibility along the life cycle
Life cycle thinking in practice requires the involvement of multiple market actors and related stakeholders. One of the most important challenges has been the management of product life cycle impact along the value chain. This Task Force aims to explore three elements related to stakeholder responsibility along the life cycle: the roles and expectations of different stakeholders, their information requirements and the processes and tools by which this information is gathered and transmitted or communicated. Among the deliverables are a chapter in the LCM handbook, the organisation and documentation of at least one workshop, and a report on recommended practice.

LCM TF 6: Capacity building for developing countries and SMEs
The aims of this Task Force are to assess the training needs, to identify further key partners and target groups, to develop training material, and to evaluate the knowledge and to disseminate the prepared material and acquired experiences by courses and other means. Networks will be established in different regions to maintain exchange of information and continuously contribute to capacity building for the identified target groups. The deliverables of this TF include: practical step-by-step training kits, information booklets, and the establishment of regional networks.

LCI TF 4: LCA case study library for meta-analyses
The aim of this TF is to create an “LCA case study library” which contains two types of information:

- compilations of LCAs on specific topic areas
- meta-analysis of the LCAs in these topic area compilations

This information will provide a practical input to efforts at the identification of hotspots and product design. In addition, generating this information is a task that provides and excellent opportunity to provide guidance and build capacity in the critical assessment and comparison of LCA studies and in making use of their results in drafting summaries for decision support. The work will be carried out in two phases: the first phase will set the specifics of the follow-on process, while in the second phase product topic teams will be formed on separate product group topics. The main deliverable will include a compilation of studies, and a group meta-analysis report.

LCI TF 5: LCI databases and capacity building
The aim of this TF is to create a "starter" LCI database within countries that do not have them yet, making maximum possible practical use of the guidance on database consistency and methodological consistency coming out of LCI Task Forces 2 and 3. A further aim is to build, through "on the job training" involving teams that include both experts and novices, the capacity to develop LCI databases. A third aim of this Task Force is to provide operational "field tests" of the strengths, weaknesses, applicability and practicability of the results of TF 2 and 3. The work of Task Force 5 will proceed through 2 phases: a planning phase of on year, and a design phase of several years. The main deliverables are the "starter" LCI databases, and an increased capacity to develop LCI databases.

LCIA TF 5: Distance learning courses & materials
Towards the enhancement of capacity building in Life Cycle Assessment and Management, this TF aims to provide access to tuition and information material. A special emphasis is given to take profit of the opportunities offered by the development of ICT towards capacity building in emerging and developing countries. In this domain, profit could be taken of different ongoing initiatives to provide distance learning courses and materials, identifying interesting material and offers in a first step, and providing links to them. In a second step, joint ventures could be carried out with institutions and involving different partners to have an official SETAC/UNEP distance learning course. The deliverable are thus: information systems providing access to existing courses and materials, offer joint SETAC/UNEP distance learning courses, and development of new tuition material.

Task forces on crosscutting issues

CCI TF1: Integrated resource and waste management
The aims of this Task Force will include:

- to increase the linkages of existing integrated resource and waste management strategies with the work on life cycle approaches for products and service within the Life Cycle Initiative
- to provide an overview of integrated resource and waste management strategies
- to propose items of collaboration with TF of the LCM, LCI and/ or LCIA programme
- to identify further key partners and target groups and establish an adequate network
- to provide an international forum for the sharing of experiences with integrated resource and waste management strategies
- to give guidance on integrated resource and waste management strategies for different target groups in a global context.

CCI TF2: Integration of social aspects into LCA
The aims of this Task Force will include:

- to convert the current environmental tool LCA into a triple-bottom-line sustainable development tool
- to establish a framework for the inclusion of socio-economic benefits in LCA
- to determine the implications for LCI analysis
- to determine the implications for LCIA
- to provide an international forum for the sharing of experience with the integration of social aspects into LCA

CCI TF3: Function based approach
The function-based approach (FBA) has the meeting of human needs as its focus. It is about helping communities and societies to confront and resolve tradeoffs in achieving greater sustainability of consumption and production. The aims of this Task Force will be:

- to build a network among experts who work on questions related to FBA
- to further develop this approach starting from LCA
- to share experiences on applications of the FBA and related approaches

CCI TF4: Simple life cycle based tools

The aims of this Task Force will be:

- to provide an overview of simple life cycle based tools
- to identify key partners and target groups
- to evaluate the most promising tools for the different target groups
- to negotiate the conditions for use of the identified tools with the key partners
- to disseminate the identified tools among the different target groups
- to prepare training material and provide capacity building on the use of the tools

A4. References and further reading

Publications of the UNEP/ SETAC Life Cycle Initiative

The following documents are published by the UNEP/ SETAC Life Cycle Initiative. Most documents can be downloaded from the web site of the initiative: www.uneptie.org/pc/sustain/lcinitiative. Other documents can be ordered by contacting the secretariat of the initiative.

Documents from the Definition Studies

These documents are all available on the web site of the initiative.

- Definition Study Life Cycle Management program
- Terms of Reference for the LCM Definition Study
- Definition Study Life Cycle Inventory program
- Terms of Reference for the Life Cycle Inventory Definition Study
- Definition Study Life Cycle Impact Assessment program
- Background documents for the Life Cycle Impact Assessment Definition Study.
- Terms of Reference for the Life Cycle Impact Assessment Definition Study

Meeting Reports:

These reports are all available on the web site of the initiative:

- Report on the Vienna meeting, May 16, 2002.
- Report on the Johannesburg meeting, June 12, 2002.
- Report on the meeting of the Definition Studies, Barcelona, December 1, 2002.
- Report on the 13th SETAC Europe Annual Meeting, 'Results after one year', 29 April 2003.
- Report on the Lausanne meeting, December 2, 2003.
- Report on the Prague meeting, April 22, 2004.

Other Life cycle initiative documents:

- Terms of Reference for the Task Forces
- Marketing brochure 'Why take a life cycle approach'

Publications from UNEP

UNEP (1996). *Life Cycle Assessment, what is it and how to do it*. United Nations Environment Programme, 92 pp.

UNEP (1999). *Towards the Global Use of Life Cycle Assessment.* United Nations Environment Programme, 71 pp.

UNEP (2003). *Evaluation of Environmental Impacts in Life Cycle Assessment*, Meeting Report. United Nations Environment Programme. 96 pp.

UNEP (2004). *Sustainable Consumption and Production: Making the Connection.* Background Paper. United Nations Environment Programme. Available for download at: www.uneptie.org/pc/cp/library/training/cdgpack/cpsc.htm.

Other used publications:

Allenby, B. (1999). *Industrial Ecology.* New Jersey: Prentice Hall.

Aloisi de Larderel, J & Fava, J. (2002). *International* J LCA – Associated Journal of the UNEP/SETAC Life Cycle Initiative (Editorial). *International Journal of LCA* **8**(3) 117.

BSCD (1993). *Getting Eco-efficient – report of the Business Council for Sustainable Development, First Antwerp Eco-efficiency workshop, November 1993, BCSD, Geneva.*

Danish EPA. (2003). *An Introduction to Life Cycle Thinking and Management*, Danish Environmental Protection Agency, Environmental News No. 68, 2003

EEA (1998). *Life Cycle Assessment (LCA) – A Guide to approaches, experiences, and Information Sources.* Enviromental Issue Report 6.

G8 (2003).*Science and Technology for Sustainable Development – a G8 Action Plan*. Evian Summit 2003.

Guinee J.B. (ed.). (2002)*. Handbook on Life Cycle Assessment.* Dordrecht: Kluwer Academic Publishers.

Malmö Ministrial Declaration Sweden 2000.

SETAC CPR (1997). *Life Cycle Assessment and Conceptually Related Programmes.* Report of SETAC Conceptually Related Programmes Working Group.

SETAC (2002). *Life Cycle Impact Assessment: Striving Towards Best Practice.* Report by SETAC Europe Second Working Group on Life Cycle Impact Assessment. Edited by Udo de Haes, Finnveden, Goedkoop, Hauschild, Hertwich, Hofstetter, Jolliet, Klöpffer, Krewitt, Lindeijer, Müller-Wenk, Olsen, Pennington, Potting, & Steen.

SETAC (2003). *Code of Life Cycle Inventory Practice.* Report by SETAC International Working Group on Data Quality and Data Availability. Edited by Beaufort-Langeveld, Bretz, Hischier, Huijbregts, Jean, Tanner, van Hoof.

SETAC (2004). *Life Cycle Management*. Report by SETAC Europe Working Group on Life Cycle Management. Edited by Hunkeler, Saur, Rebitzer, Finkbeiner, Schmidt, Astrup Jensen, Stranddorf, Christiansen.

Vangelis , V. (2002). *Private voluntary Eco-labels: trade distorting, discriminatory and environmentally disappointing.* Background paper for the Round Table on Sustainable Development meeting, December 6, 2002, Paris

WBCSD (2000). *Measuring eco-efficiency: a guide to reporting company performance.* Report by H.A. Verfaillie and R. Bidwell. Geneva.

White, P.R., M. Franke, and P. Hindle (1995). *Integrated Solid Waste Managemen: a Lifecycle Inventor.* Kluwer Academic Publications

Wrisberg, N. et al., 2002. *Analytical tools for environmental design and management in a systems perspective (CHAINET publication).* Dordrecht: Kluwer Academic Publishers.

WSSD Johannesburg 2002 – plan of implementation

A5. DAT/PRG member details

Explanation of the used abbreviations:

ILCP Member of the International Life Cycle Panel
PM Programme Manager and member of the Executive Committee
DAT Member of the Draft Author Team
PRG Member of the Peer Review Group

Life Cycle Management Programme

Group	LastName	FirstName	Organisation	Country	Email
ILCP	Quiros	Ana	Ecoglobal Advisors	Costa Rica	aquiros@ecoglobaladvisors.com
PM	Saur	Konrad	Five Winds International	Germany	K.Saur@fivewinds.com
DAT	Breedveld	Leo	CESD, University of Venice	Italy	Breedveld@unive.it
DAT	Cobas-Flores	Elisa	ITESM, Campus Monterrey	Mexico	ecobas@itesm.mx, ecobas@prodigy.net.mx
DAT	Cowell	Sarah	University of Surrey	UK	s.cowell@surrey.ac.uk
DAT	Donato	Gianluca	ABB Group Service Center	Italy	gianluca.donato@it.abb.com
DAT	Frankl	Paolo	Ecobilancio Italia	Italy	paolo.frankl@ecobilancio.com
DAT	Jensen	Allan Astrup	dk-teknik energy & environment	Denmark	aaj@dk-teknik.dk
DAT	Koroneos	Christopher	Lab of Heat Transfer and Environmental Eng.	Greece	koroneos@aix.meng.auth.gr
DAT	Kuhndt	Michael	Wuppertal Institute	Germany	mkuhndt@cityweb.de
DAT	Pesonen	Hanna-Leena	University of Jyväskylä	Finland	hpesonen@tase.jyu.fi
DAT	Seuring	Stefan	University of Oldenburg	Germany	Stefan.seuring@uni-oldenburg.de
DAT	Swarr	Tom	United Technologies Corporation	USA	swarrte@corphq.utc.com
DAT	Tawfic Ahmed	Mohamed	Suez Canal University, Ismailia, Egypt	Egypt	motawfic@gega.net
DAT	Tukker	Arnold	TNO	The Netherlands	Tukker@stb.tno.nl
DAT	Weidema	Bo	Aalborg University	Denmark	bow@lca.dk
PRG	Bauer	Christian	University of Technology, Aachen	Germany	cbauer@lih.rwth-aachen.de
PRG	Bradley	Kevin	ACE	Belgium	Kevin.Bradley@ace-inter.net
PRG	Cooper	Tim	Sheffield Hallam University	UK	t.h.cooper@shu.ac.uk
PRG	Dahl	Gry	GRIP Centre for Sustainable Production and Consumption	Norway	gry.dahl@grip.no
PRG	Elghali	Lucia	TRL Limited	UK	lelghali@trl.co.uk
PRG	Franke	Marina	Procter & Gamble	Germany	Franke.m@pg.com
PRG	Haaf	William	DuPont	del	William.c.haaf@usa.dupont.com
PRG	Haake	Julia	O2 France	France	j.haake@o2france.com
PRG	Jürgens	Gunnar	Fraunhofer Institute for Industrial Engineering (IAO)	Germany	gunnar.juergens@iao.fraunhofer.de
PRG	King	Henry	Unilever	UK	Henry.King@Unilever.com
PRG	Kituyi	Evans	Industrial Ecology Institute	Kenya	iei@avu.org e.Kituyi@cgiar.org
PRG	Levy	Mike	Environmental Strategies & Solutions	USA	envstrsol@erols.com
PRG	Lindfors	Lars-Gunnar	IVL Swedish Environmental Research Institute	Sweden	Lg.lindfors@ivl.se
PRG	Papasavva	Stella	General Motors, R&D Chemical and	USA	stella.papasavva@gm.com
PRG	Zapp	Petra	Forschungszentrum Juelich	Germany	p.zapp@jz-juelich.de

Life Cycle Inventory Programme

Group	LastName	FirstName	Organisation	Country	Email
ILCP	Inaba	Atsushi	Agency of Industrial Science and Technology - AIST	Japan	a-inaba@aist.go.jp
PM	Norris	Greg	Sylvatica/ Harvard University/ Athena Institute	USA	norris@sylvatica.com
DAT	Arena	Pablo	Universidad Tecnológica Nacional	Argentina	aparena@lab.cricyt.edu.ar
DAT	Carlson	Raul	Chalmers University of Technology	Sweden	raul.carlson@imi.chalmers.se
DAT	Chareonpanich	Metta	Kasetsart University	Thailand	fengmtc@ku.ac.th
DAT	Frischknecht	Rolf	ESU-services	Switzerland	frischknecht@esu-services.ch
DAT	Grant	Tim	RMIT University	Australia	Tim.grant@rmit.edu.au
DAT	Huppes	Gjalt	CML	Netherlands	huppes@cml.leidenuniv.nl
DAT	May	Thomas	DuPont Performance Coatings GmbH & Co. KG	Germany	Thomas_may@wuppertal.herberts.de
DAT	Pardave	Marco	AMIME-DGN	Mexico	mapardave@hotmail.com
DAT	Ramjeawon	Toolseeram	Univesity of Mauritius	Mauritius	ramjawon@uom.ac.mu
DAT	von Blottnitz	Harro	University of Cape Town	South Africa	hvb@chemeng.uct.ac.za
DAT	Wendin	Marcus	Volvo Technological Development Corporation	Sweden	Marcus.Wendin@volvo.com
DAT	Wolf	Marc-Andree	University of Stuttgart, IKP (Institute for Polymer Testing and Science),	Germany	wolf@ikp2.uni-stuttgart.de
PRC	de Beaufort	Angeline	FEFCO (European Federation of Producers of Corrugated Board)	The Netherlands	beaulang@wxs.nl
PRG	Ciroth	Andreas	GreenDeltaTC	Germany	Ciroth@greendeltatc.com
PRG	Curran	Mary Ann	US EPA	U.S.A.	Curran.Maryann@epamail.epa.gov
PRG	Ekvall	Tomas	Chalmers University of Technology	Sweden	tomas.ekvall@me.chalmers.se
PRG	Hischier	Roland	Swiss Federal Laboratories for Material Testing and Research (EMPA)	Switzerland	roland.hischier@empa.ch
PRG	Hischier	Roland	Swiss Federal Laboratories for Material Testing and Research (EMPA)	Switzerland	roland.hischier@empa.ch
PRG	Katajajuuri	Juha-Matti	VTT Processes	Finland	Juha-matti.katajajuuri@vtt.fi
PRG	Krewitt	Wolfram	German Aerospace Center (DLR), ITT	Germany	wolfram.krewitt@dlr.de
PRG	Krewitt	Wolfram	German Aerospace Center (DLR), ITT	Germany	wolfram.krewitt@dlr.de
PRG	Mälkki	Helena	Technical Resesarch Center of Finland	Finland	helena.malkki@vtt.fi
PRG	Matthews	Scott	Carnegie Mellon University	USA	hsm@cmu.edu
PRG	Moriguchi	Yuichi	National Institute for Environmental Studies	Japan	moriguti@nies.go.jp
PRG	Notten	Philippa	Independent Consultant, affiliated with the University of Cape Town, South Africa	U.S.A.	pnotten@netzero.net
PRG	Sangwon	Suh	CML	Netherlands	Suh@cml.leidenuniv.nl
PRG	Schischke	Karsten	BeCAP Berlin Center of Advanced Packaging	Germany	schischke@izm.fraunhofer.de
PRG	Trusty	Wayne	Athena Sustainable Materials Institute	Canada	wbtrusty@fox.nstn.ca
PRG	Wester	Margareta	Chalmers University of Technology	Sweden	Margareta.wester@cpm.chalmers.se
PRG	Wheeler	Candace	General Motors Research and Development	USA	candace.s.wheeler@gm.com

Life Cycle Impact Assessment Programme

Group	LastName	FirstName	Organisation	Country	Email
ILCP	Bare	Jane	US EPA	U.S.A.	bare.jane@epa.gov
PM	Joillet	Olivier	Ecole polytechnique fédérale de Lausanne	Switzerland	olivier.jolliet@epfl.ch
DAT	Brent	Alan Colin	University of Pretoria	South Africa	abrent@eng.up.ac.za
DAT	Goedkoop	Mark	PRé Consultants BV	The Netherlands	Goedkoop@pre.nl
DAT	Heijungs	Reinout	Leiden University	The Netherlands	heijungs@cml.leidenuniv.nl
DAT	Mueller-Wenk	Ruedi	University of St.Gallen	Switzerland	Ruedi.mueller-wenk@unisg.ch
DAT	Mungcharoen	Thumrongrut (RUT)	(1) National Metal and Materials Technology Center	Thailand	fengtrm@ku.ac.th
DAT	Peña	Claudia Antonieta	Chilean Research Centre for Mining and Metallurgy	Chile	cpena@cimm.cl
DAT	Schenck	Rita	Institute for Environmental Research and Education	USA	rita@iere.org
DAT	Stewart	Mary	Sydney University	Australia	mary@chem.eng.usyd.edu.au
DAT	Suppen	Nydia	Tec de Monterrey	Mexico	nsuppen@campus.cem.itesm.mx
PRC	McKone	Tom	University of California, Berkeley	USA	temckone@LBL.gov
PRG	Adams	William	Rio Tinto	USA	William.adams@riotinto.com
PRG	Aguiñaga Galleg	Edna	IHE Delft	Netherlands, Mexico	ednaag@yahoo.com
PRG	Castells	Francesc	Environmental Management and Analysis Group (AGA)	Spain	fcastell@etseq.urv.es
PRG	Dubreuil	Alain	Natural Resources Canada	Canada	Dubreuil@nrcan.gc.ca
PRG	Finnveden	Göran	Fms/FOI	Sweden	finnveden@fms.ecology.su.se
PRG	Hammerschlag	Roel	Institute for Lifecycle Energy Analysis	USA	roel@ilea.org
PRG	Hauschild	Michael	Technical University of Denmark	Denmark	mic@ipl.dtu.dk
PRG	Hofstetter	Patrick	Harvard University	Switzerland	phofstet@hsph.harvard.edu
PRG	Jungbluth	Niels	ESU-services	Switzerland	jungbluth@esu-services.ch
PRG	Kloepffer	Walter	C.A.U. GmbH	Germany	w.kloepffer@cau-online.de
PRG	Lewis	Kathleen Anne	University of Hertfordshire	UK	K.A.Lewis@herts.ac.uk
PRG	Lindeijer	Erwin	TNO Industrial Technology	The Netherlands	e.lindeijer@ind.tno.nl
PRG	Mattsson	Berit	Swedish□□Institute for Food and Biotechnology	Sweden	bm@sik.se
PRG	Potting	José	National Institute of Public Health and the Environment (RIVM)	Netherlands	Jose.Potting@rimv.nl
PRG	Wiertz	Jacques	University of Chile	Chile	jwiertz@ing.uchile.cl

UNEP/SETAC Life Cycle Initiative

The UNEP/SETAC Life Cycle Initiative was officially launched in April 2002 during UNEP's 7th International High-level Seminar on Cleaner Production, in Prague. It consists of a co-operation between UNEP's Division on Technology, Industry and Economics (UNEP DTIE in Paris) and the Society of Environmental Toxicology and Chemistry (SETAC, Pensacola, US). The main aim is to bring sound life cycle approaches into practice. For the achievement of this overall aim, three programs are developed within the initiative. The first program concerns Life Cycle Management (LCM) with a focus on the full scope of tools and processes that enhance sustainability along production-consumption-waste management chains. The second and the third program focus on LCA, the second program dealing specifically with Life Cycle Inventory (LCI) databases and methods, the third program with Life Cycle Impact Assessment (LCIA) data and methods. In addition, the initiative initiated joint programs that exceed the subject of the individual topic areas. Special emphasis is given here on the enhancement of life cycle approaches in developing countries. The structure of the Initiative is shown in Figure 10.

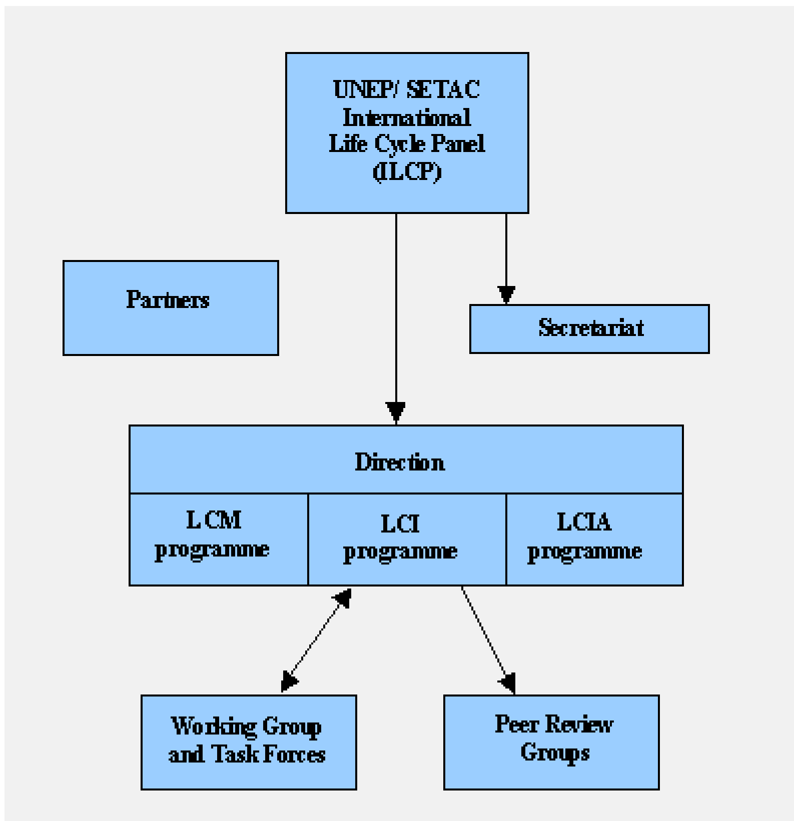


Figure 10: Structure of the Initiative

Institute of Environmental Sciences, Leiden University (CML)
The Institute of Environmental Sciences of Leiden University was founded in 1978. It is an interfacultary institute, directly positioned under the board of the university. It has three departments: "Industrial Ecology", "Environmental Biology" and "Environment and Development". The total staffs amounts to 35 fte, some 45% of which based on contract research.

CML's contribution to the UNEP/SETAC Life Cycle Initiative is linked to the department of Industrial Ecology. The research of this department focuses on the development and application of analytical tools, particularly including Life Cycle Assessment (LCA), Substance Flow Analysis (SFA), Input-Output Analysis (IOA) and Eco-Efficiency (E/E). Important commissioners for research projects include the European Commission, Dutch ministry departments, and a number of companies. Often, the department is selected to perform a peer review for studies performed by other institutes.

Each of the three departments of CML is engaged in bachelor and master programmes. The department of Industrial Ecology will start an MSc in Industrial Ecology in September 2004, together with Delft Technical University and the Erasmus University of Rotterdam.

Five Winds International
Five Winds International, a management-consulting firm, helps organizations improve the business, environmental and social performance—the sustainability—of their projects, products and services. The strength of Five Winds International is in helping integrate environmental and social considerations into the core business activities of organizations.

In the public sector, core business activities include policy and program development, service delivery, operations and procurement. For private sector companies, these activities include environmental and sustainable strategy development, sustainable design, operations, supply chain management and capital investment.

The Five Winds International team has expertise in sustainable business strategy, engineering and material science, environmental management, industrial design, environmental science, resource economics, and government policy. Our people help organizations build knowledge and understanding of the competitive opportunities associated with sustainability. We work in partnership with our clients to develop and implement the strategies, management systems, programs and tools necessary to effect long-lasting and meaningful change. The firm provides a global perspective through offices in the United States, Germany and Canada, and an established network of experts throughout the world.

Sylvatica
Sylvatica was founded by Greg Norris in 1996. Through corporate consulting and user-friendly products, Sylvatica has helped hundreds of companies improve their environmental record while improving their bottom line. Working with government and non-government organisations has helped spread the reach of Sylvatica to more manufacturers, the building industry, and elsewhere. Sylvatica's areas of specialisation are Life Cycle Assessment, Industrial Ecology, Sustainable Consumption, and Uncertainty/Risk/Decision/Scenario Analysis. The organisation also works in partnership with other consultants and non-profits in many projects leading to increased sustainability.

EPFL (Swiss Federal Institute of Technology)
The "Life Cycle Systems Group" of EPFL-GECOS (Ecosystem Management Laboratory) aims to link technological and environmental aspects of sustainable development, providing a better understanding of natural cycles as well as of product life cycles. In the field of Industrial Ecology, the Life Cycle Systems group of GECOS brings understanding and knowledge to help prevent and reduce environmental life cycle impacts of industrial systems and services. Their research focuses on Life Cycle modelling and modelling of toxics. As part of the Life Cycle Initiative of the United Nations Environmental Program (UNEP) and the Society for Environmental Toxicity and Chemistry (SETAC), the laboratory also co-ordinates the development of guidance and methods for best available practice in Life Cycle Impact Assessment.

UNEP/ UNEP DTIE

The United Nations Environment Programme (UNEP) mission is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and people to improve their quality of life without compromising that of future generations. UNEP is in an unique position to influence activities on business and sustainable consumption issues around the world. UNEP works closely with stakeholders to provide common information and knowledge bases, which assists governments and industry.

The mission of UNEP's Division of Technology, Industry and Economics (UNEP DTIE) is to help decision-makers in government, local authorities and industry develop and adopt policies and practices that:

- are cleaner and safer,
- make efficient use of natural resources,
- ensure adequate management of chemicals
- incorporate environmental costs,
- reduce pollution and risks for humans and the environment.

UNEP DTIE's activities focus on raising awareness, improving the transfer of information, building capacity, fostering technology co-operation, partnerships and transfer, improving understanding of environmental impacts of trade issues, promoting integration of environmental considerations into economic policies, and catalysing global chemical safety.

SETAC

The Society of Environmental Toxicology and Chemistry (SETAC) is a professional society – in the form of a non-profit association – established to promote the use of a multi-disciplinary approach to solving problems of the impact of chemicals and technology on the environment. Environmental problems often require a combination of expertise from chemistry, toxicology, and a range of other disciplines to develop effective solutions. SETAC provides a neutral meeting ground for scientists working in universities, governments, and industry. They meet, as private persons not bound to defend positions, but to develop and use the best science available. Three activities of broad interest have been initiated by SETAC. A group on ecological risk assessment has the mission to advance the science, practice and application of this field. Another group focuses on pesticides and soil microbiology. Thirdly, SETAC has taken a leading role in the development of the methodology of Life Cycle Assessment (LCA). The organisation is often quoted as a reference on LCA matters.