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LCA options for sustainable governance assessed

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1. Introduction

This paper describes and analyses challenges for the further development of Life-Cycle Analysis (LCA) and other LCA-related tools from a governance perspective, considering their application context in policy and business and the linkages between policy and science. It will be investigated how LCA can be further developed to make it more relevant for supporting both public and private applications in a “new governance” framework. The paper furthermore attempts to elaborate what environmental information is required in sustainability-oriented decision-making, and how the relevant information for sustainability decision-making can be supplied. This applies to different levels of policies, ranging from specific environmental to broader sustainability policies as well as product policy, technology policy and innovation policy.

The paper has been developed as part of the international research project “CALCAS – Co-ordination action for innovation in life-cycle analysis for sustainability”. The analysis stems from six different sources:

- a) presentations and discussions at a workshop with experts in LCA and governance held in Brussels on September 27/28, 2007.
- b) a review of extant literature

- c) a case study about waste management in Sweden with applications of LCA tools to support policy decisions
- d) a survey on the application of Life Cycle approaches in European companies and the analysis of their internal and external drivers (Neumann 2007)
- e) a review of selected European policies regarding their consideration of Life Cycle approaches
- f) a public consultation process on an earlier version of this paper

Based on this material, we aim to outline with this report the usefulness of Life-Cycle Approaches to meet the challenges for environmental policy and at the same time to elaborate opportunities for the further development of LCA to meet these challenges. Life-Cycle Approaches can be broadly defined as Life-Cycle Thinking and the application of Life-Cycle Tools.

Life-cycle Thinking (LCT) and Life-Cycle Tools

ISO-LCA does not explicitly state its restriction to quantitative methods, but it implicitly does, witness phrases like “the compilation and quantification of inputs and outputs”, “evaluating the magnitude” of impacts, and the central role for the functional unit, the “quantified performance of a product system”. There is thus no place for non-quantified life cycle approaches in ISO-LCA. But there is definitely a need for these. UNEP’s brochure on the “life cycle approach” (UNEP 2004) sketches this: “a life cycle approach identifies both opportunities and risks of a product or technology, all the way from raw materials to disposal. To do this there is a continuum of life cycle approaches from qualitative (life cycle thinking) to comprehensive quantitative approaches (life cycle assessment studies)”. And: “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” (UNEP 2004: 3). Recognizing the variety of approach for a variety of decision-situations, it is to be defined where the place of LCA is. With UNEP and ISO, we restrict it here to those approaches that are primarily quantitative, recognizing that there are important situations (e.g., in product design) in which qualitative or semi-quantitative approaches can be more suitable.

As to terminology, the situation has been opened in CALCAS, using Life Cycle Analysis as a more general term than ISO defined Life-Cycle Assessment. Life-Cycle Thinking (LCT) would be an overarching term covering all approaches with a life cycle aspect. Use as by UNEP seems to imply that also quantitative approaches would fall under the heading of LCT. It seems wise to reduce the number of terms and concepts where possible. Equating the meaning of Life-Cycle Approaches (see Heijungs et al. 2007) and Life-Cycle Thinking therefore seems the best option.

Structure of this paper

The analysis of LCT/LCA and governance in this text is structured as follows: *Chapter 2* will give an overview about recent trends in the debate about new forms of environmental governance and the role of knowledge-based policy approaches in this context. *Chapter 3* introduces interlinkages of LCA and policy-making, highlighting several key issues that have to be kept in mind when dealing with the interface of science and policy. The ideas are accompanied with short examples from other assessment procedures like Impact Assessment and Technology Assessment. The chapter also briefly addresses the question of different levels of analysis in the case of biofuels, and the issue of reflexivity in LCT and political institutionalisation of the concept. It furthermore contains a brief analysis of the incorporation of the life-cycle concept into selected European policies (see also *Annex I* for a discussion of the role of LCA/LCT in Swedish waste policies). *Chapter 4* introduces the business

perspective and adds some thoughts about what possibilities exist to better institutionalise LCA in organisations and thus make it an effective tool for self-regulatory processes in the entire supply chain. An executive summary of a case study provides recent empirical findings about the drivers for LCA as a business application. *Chapter 5* sums up the analysis by broadening the view and reflecting about the extension of LCA in terms of sustainability analysis and new governance for sustainability.

Finally...

... we want to thank you all the commentators who gave us a feedback to a previous version of this paper, either at the workshop or by written comments – their contributions have been an important source of inspiration for us.

2. The changing facets of governance and new approaches in environmental policy

This chapter discusses some of the general features of the change in modes of (environmental) governance. It also critically introduces the question how decision-making at the interface of science and policy can successfully be performed and where it reaches its limits.

2.1 The Emergence of New Steering Paradigms

There is a growing body of literature attempting to classify the changing modes of governance (Knill/Lenschow 2004; Treib et al. 2005; Blumenthal/Bröchler 2006; Mayntz 2006). In order to briefly characterise the main lines of this debate, a change in the modes of governance can be witnessed on three different levels: The *first level* concerns a potential change in the use of policy instruments, aiming at the mobilisation of different actors' steering potentials. This includes elements like, e.g., the discussion about non-hierarchical instruments in environmental policy, or so-called “new instruments” (Jordan et al. 2005; Jordan et al. 2007). *Second*, it may be observed that an increasing number of non-state actors is proactively taking part in environment and sustainability discourses. This sheds light on an increasing use of scientific information in order to support different actors' interests, making the use of decision-supporting LCA-tools, Impact Assessment or similar approaches more important. A *third aspect* concerns the increasing importance of multi-level governance, i.e. rule-making on sub- and supranational levels (Héritier 2003; Hooghe/Marks 2003).

Concerning this change on level one and two, Hey et al. (2007) have similarly noted a twofold change of governance in terms of *content* (concerning a change in regulatory instruments) and *process* (concerning the modes of decision-making and the integration of different actors in the standard-setting procedures). The former includes a shifting away from the traditional way of regulatory standard setting and points at the increased use of instruments which leave more discretion to the regulated entities. Examples are a growing use of framework legislation, self-regulation or economic instruments. Changes in *process* imply a shift in the traditional way of policy-making in the European Union, i.e. away from the well-established community method with formalised decision-making rules and consensus finding procedures. While acknowledging the “impressive” decision-making capacity of this steering model, Hey et al. (2007: 1862) highlight shortcomings of traditional European regulation with its hierarchical element of binding and enforceable regulation. This applies to the implementation deficit in European environmental policy as well as to a lack in the Union's and Member States' capacity to successfully integrate environmental concerns into other sector policies. The authors argue that in the context of new governance the responsibility of private actors and Member States in policy formulation and implementation increases, and that strategies of “soft law” are gaining importance. Coming along with these changes is the intensified use of reflexive assessment procedures and the delegation of regulatory tasks.

In their discussion about old and new types of environmental policy instruments Jordan et al. (2007) have summarised the change from government to governance in a simple typology (cf. *Table 1*). They elaborate a continuum from “strong government” – where the traditional regulatory approach prevails – to “strong governance” – where societal self-steering is the predominant regulatory mode, and where societal actors determine the goals as well as the selection of policy tools.

Table 1 A simple government-governance typology for new environmental policy instruments (NEPIs) and regulation

	Government determines the goals (ends)	Societal actors determine the goals (ends)
Government selects the policy tools	Strong government (hierarchical top-down steering) traditional (command control) regulation; fiscal incentives (for certain pollution reducing technologies)	Hybrid Technology-based regulatory standards (e.g. Best Available Techniques not Entailing Excessive Cost (BATNEEC))
Selected actors select tools	Hybrid some voluntary agreements (i.e. negotiated agreements); some market-based instruments (e.g. choice between eco-taxes and tradable permits), some regulation (i.e. environmental quality objectives (EQOs))	Strong Governance (self-organising society); some voluntary agreements (i. e. unilateral commitments); some eco-labels

Source: (Jordan et al. 2007: 294)

With regard to the third level in changes from government to governance, Knill and Lenschow (2007) have recently stressed the importance of national administrations and agencies as central actors in European regulatory policies. Knill and Lenschow argue that in the light of “softer” and more flexible forms of regulation, administrative bodies are confronted with distinctly varying demands and steering patterns (2007: 223ff.). They distinguish between three ideal forms of steering mechanisms:

- *hierarchical steering* which is based on legally binding prescriptions for the national level. This model is inter alia symbolised by the process of “positive integration” in the EU
- *communicative steering* aiming at stimulating learning processes in networks on the European level. This model is mainly based on three mechanisms: providing the infrastructure for multilateral communication, providing expert knowledge, and providing for the diffusion of policy concepts
- *steering by stimulating regulatory competition* between the respective member states. In this model the rules of the game are being defined, leaving however a considerable amount of discretion to national strategies for adaptation.

2.2 Changes in environmental governance

Transferring these general assumptions of changing steering patterns to environmental governance, it can be noticed that environmental policies are facing a number of particular steering challenges that are inherent to the nature of the problems at stake. In a concise overview, Jacob et al. (2007) have highlighted several of these challenges affecting especially the possibilities of environmental policies (but also the possibilities of other policies) to secure the efficient, effective, and equitable provision of public goods:

- 1) *target conflicts* with other governmental tasks: environmental policies are cross-sectional policies aiming at the control of long-term problems. Their efforts must therefore not be thwarted by contrary measures in other policy areas
- 2) *self-restriction of governmental interventionism*: environmental policies aim at shaping single actors' activities, naturally risking to cause conflicts with property rights without being able to justify these actions with short-term causalities
- 3) *co-ordination on an international scale*: environmental problems occur on a trans-national scale and therefore necessitate trans-national solutions
- 4) *multi-level governance*: especially in the European Union environmental policies take place on several levels of policy-making, either sub- or supranational
- 5) *limited availability of knowledge*: the importance of knowledge is extremely important for environmental policies, where it is often neither feasible to identify the polluter in cases of diffuse sources of pollution nor possible to determine clear causal-effect chains for a large number of problems.
- 6) *the long-term character of environmental problems* constitutes a challenge for policies that are largely determined by short and mid-term logics, as in the case of election and budget cycles.

Against this backdrop two issues need to be kept in mind. The above cited considerations first leave open the question of how far the replacement of old environmental governance modes has in fact proceeded. This also raises the question whether the overall goal should indeed be to move towards a systematic application of “new”, especially soft instruments of environmental governance. The mixed record of, e.g., voluntary agreements and their contribution to strict environmental targets underlines the problems associated with less hierarchical steering (cf. OECD 2003). The concentration on certain instruments also neglects the question how the interaction of so-called new and old types of governance works apart from theoretical considerations. Regarding the former, it can be stated that in the case of product policies new forms of environmental governance are supposed to play an important role (Scheer/Rubik 2006), a fact that has, e.g., been analysed regarding industry-government relations in the making and the implementation of the European EuP directive (Dalhammar 2007; Kautto 2007). However, Töller (2007), in her examination of the importance of cooperative steering modes in German waste policies during the last 15 years, concludes that no clear evidence for a shift towards less authoritative steering types can actually be found. The supposed “withdrawal of the state”, symbolised by deregulation, privatisation, or an increased intensity of societal self-regulation can at least not be witnessed in the case of German waste policies. Instead, Töller argues that authoritative measures have returned, and that that the state plays an even more authoritative role than in the 1980s. These findings clearly correspond to the analysis of Holzinger et al. (2006) who conclude that “a broad gap between the political and scientific advocacy of new ideas and their actual implementation through corresponding changes is underlying policy instruments.” In contrast, they state that there has yet been no substantive shift from interventionist to context-oriented or economic instruments in European environmental policy.

However, since governance patterns obviously change, but at least the complete replacement of old modes of governance remains an illusion, the question must be raised how these different modes of governance interact in reality. Hey et al. (2007; cf. also Jordan et al. 2007) have coined this interplay of different governance types “governance hybrids”, where cooperation and conflict as well as hierarchy, co-operation, and self-regulation are effectively

combined in diverging constellations¹. Nevertheless, the authors thereby also voice concerns about legitimacy and functionality of certain aspects of hybrid regulation, especially the question whether "the cooperative networks established under the regulation risk to be overburdened to solve politically contentious questions, which should be solved at the political levels" (2007: 1871). It should furthermore be kept in mind that in terms of effectiveness the delegation of regulatory tasks in procedural law and self-regulatory processes (like, e.g., the elaboration of technical specifications in a number of implementation projects for the new European chemicals legislation – REACH) bear serious risks of provoking stalemates, notwithstanding concerns of legitimacy.

2.3 A New Role of Knowledge

It is thus an important feature of new modes of governance that the articulation of problems, the decision-making process, and policy implementation increasingly rely on an interaction between political decision-makers, business, and epistemic communities. However, the changing role scientific information and knowledge can play in decision-making processes creates new expectations of those actors producing the knowledge. Under conditions of new governance, delivering reliable scientific-technological information is no longer the only value demanded of science. Additionally, criteria like potential societal use or social relevance of knowledge have gained substantial importance (Nowotny et al. 2001). Several authors have coined this new understanding of science "post-normal science" (Funtowicz/Ravetz 1993), "mandated science" (Salter 1988), or "mode 2" (Gibbons et al. 1994). Bechmann and Beck (2003) stress that this type of knowledge production neither forms part of basic research nor application-oriented research. The increasing complexity of research as well as the pressure resulting from high public expectations create a new environment for science and its role for societal development. For example, by identifying environmental problems and creating further „environmental knowledge“, environmental policy research constantly creates pressure to act on the political actors. In return, an increasing number of actors in a changing governance sphere demands problem-oriented knowledge from its scientific counterparts in order to legitimise the respective interests and actions. Political actors demand reliable scientific evidence, but are faced with a process of scientific evolution in which knowledge is constantly being challenged by counter-expertise (Kusch 2002a; Kusch 2002b). Finally, controversy and conflict emerge between science, politics and society. Research and research-based expertise produce new knowledge for decision-making processes, but at the same time they export uncertainties and ambiguities of scientific research into society.

Such considerations about the use of knowledge in authoritative decision-making and information-based governance approaches lead to the discussion about the political application of quantitative tools to measure material flows, in particular life-cycle analysis (LCA). In a recent work on the incorporation of the life-cycle concept in European environmental policies, Dalhammar (2007) summarises a number of criticisms against LCA as a tool for decision-making underlining the assumptions from above (cf. also Vagt et al. 2007):

- the political neutrality of the analysis (cf. Bras-Klapwijk 1998)
- the fact that LCA seems unsuitable to support certain stakeholder positions, especially those that put special emphasis on the precautionary principle
- the statism of the approach in term of time frames and especially its tendency to neglect long-term issues

¹ In their analysis Hey et al. (2007) refer to the reform of European chemical legislation and the introduction of REACH as an archetype of hybrid governance.

- the controversy about the weighting of environmental impacts
- the quality of the data in LCAs based on average industrial data

Some of these aspects can be further highlighted by referring to an analysis by the European Environment Agency (European Environment Agency 2006) that stresses the problems of a variety of LCA-tools (in particular LCA and Cost-Benefit Analysis) in decision support. Taking recovery and disposal of paper and cardboard as an example, the analysis comes to the conclusion that especially in the case of Cost Benefit-Analysis (CBA) the uniformity of results leaves a lot to be desired. While the case for LCA in the study is more uniform than for CBA, it well depicts the high amount of uncertainty that goes along with decision-making based on allegedly “solid” scientific evidence. In the case of the LCA studies observed differences in results can be traced back to the different methodological approaches applied, such as the definition of system boundaries. The EEA study also underscores that going beyond the technosphere by also encompassing socio-economic values bears more risks of creating uncertainties, especially as regards the interdependency of systems and causal-effect chains (European Environment Agency 2006: 53). The use of LCA and other life-cycle oriented analyses has accordingly been subject to criticism, and there has been (and clearly will be in the future) a multitude of cases where opposing actors doubt the validity of certain analyses or initiate assessments that support their respective positions (exemplary ENDS 2004; ENDS 2005; exemplary ENDS 2006).

In addition, the critique of new forms of governance and especially life-cycle methods should not focus on the input side alone, but also keep in mind the effectiveness of these types of instruments to achieve the predefined goals. On a corporate level, this raises the question of how and to what extent life-cycle based initiatives, in particular approaches for integrated product policy (IPP) or sustainable consumption and production (SCP), can indeed pave the way for cleaner production or environmental innovations in companies. Analysing the effects of IPP tools on corporate environmental innovation Rehfeld et al. (2007) come to the conclusion that especially environmental management systems like ISO 14001 or the European EMAS scheme account for a high significance in the determination of environmental innovation. The authors argue that for LCA-types of activities the correlation with environmental innovations are, however, rather weak. Therefore, they conclude that soft environmental policy instruments can trigger environmental innovations only to a certain extent (cf. also Hertin et al. 2004). According to the authors final incentives are set by prices, thus making more coercive instruments like taxes or ambitious green public procurement policies indispensable. Similarly, but with a more life-cycle oriented perspective and a stronger focus on eco-design, Kautto (2006) argues in the case of environmental management systems (EMS) and extended producer responsibility (EPR) that the effects on product design are weak and have to be designed with a view on continuous improvement (in the case of EPR) or with an explicit product focus (in the case of EMS).

Summing up, from these assumptions about new governance two main lines of discussion will be derived for further analysis in the following chapters:

- 1) New governance is based on changing actor constellations between public and private actors, and the increasing use of “new”, often less hierarchical instruments in political steering. However, it would be misleading to conclude either that traditional regulatory measures have substantially lost importance or that non-hierarchical instruments can always provide for the desired results. As regards the set of non-hierarchical instruments, one important element of new governance and especially private participation in rule-setting concerns self-regulation of economic actors. The issue of self-regulation is furthermore a key element of life-cycle thinking, where the consideration of different stages in the product life cycle forces companies to mobilise

substantial resources in order to control their supply chains. The analysis will therefore put special emphasis on this aspect of self-regulation.

- 2) Changes in governance have led to a new perception of the role of knowledge in decision-making. This includes a change in the importance of knowledge leading to high expectations of science to serve as a strong input into policy. Consequently, successful knowledge-based environmental policies rely on appropriate methods and tools to create a reasonable amount of certainty for decision-making, but at the same time expose themselves to several new problems. As a tool designed to assist decision-making for sustainability, LCT and LCA have to face these challenges, and research is needed to help adapt tools and methods of analysis to their changing societal environment.

3. LCA and policies - Opportunities for evidence-based policy-making

The background presented in the previous chapters hints at a changing and new approach in policy-making and the increasing relevance of decision-supporting tools. Accordingly, Weingart (1999) stated an increasing science-based degree of policy, a politicization of science and a reciprocal relationship between both spheres.

In recent decades, the role of science within society has changed. This has been influenced by two factors: first, within different sciences, the possibilities to integrate bulky data, to simulate and model complex issues and to theoretically analyse problems on both basic and holistic levels have considerably increased (Gooding 2002). Secondly, the expectations of society with respect to science have mutated. Beside – or perhaps instead of – the “traditional” scientific-technological reliability, criteria of public problem orientation and – in general: social relevance of science – appear (Nowotny 1999). The combination of increased complexity of science and increased expectations of policy and society result in a new constellation. Research and research-based expertise are producing new knowledge for decision-making processes, but they are exporting uncertainties and the ambiguities of scientific research into society at the same time (Turner 2001).

3.1 Knowledge for policy – sustainability oriented decision-making and New LCA

The above presented changes refer to knowledge production by science and science-based expertise as well as to knowledge communication between knowledge “producers”, knowledge “applicants” and actors resp. stakeholders concerned, and finally also to learning processes which treat unexpected problems and impacts both scientifically and politically.

This transformation of science is especially relevant in areas close to policy. For sure, environmental policy and also the broader area of sustainability are confronted with these changes. Environmental policy and environmental science are in a close interdependency since the genesis of this policy area (Küppers et al. 1978). LCT and LCA-tools are embedded in these observations and discussions. They support the knowledge base of political decision processes, but they are also “practical” outcomes of knowledge production which contain ambiguities and disappointments of open research processes. Policy needs scientific knowledge generated by LCA-tools at different stages of political processes. Political sciences² have elaborated the policy cycle concept. We divide it into several stages, namely problem perception, policy formulation, policy implementation, policy adoption and policy revision. This concept is useful for illustrating relevance of LCT and applications of LCA

² Cp. e.g. von Beyme (1997), Jann/Wegrich (2003), May/Wildavsky (1978).

within policy, increasing the knowledge basis³. There are some examples where negotiations between political actors like environmental agencies or ministries and business (including industrial organisations) are shaped by, and based on, the results of life-cycle based approaches, e.g. the German Packaging Ordinance, or different eco-labelling schemes. Learning processes among diverse target groups are initiated by LCT, including governmental

Box II: Inputs of LCA into Politics: The Case of Swedish Waste-Management Policy

The choice of waste management options in Swedish waste policies has for a long time been closely connected with life-cycle analysis. Especially in the 1990s, several commissions were set up in order to analyse environmentally superior waste treatment options and give support for policy and decision-making. Both the Swedish Commission on Packaging and the REFORSK foundation concluded (with differing emphasis) that recycling strategies were to be preferred to waste incineration from an environmental point of view. Swedish policies to introduce the extended producer responsibility (EPR) principle, mainly established in 1994, were being designed in accordance with results from these and other LCA studies to detect the most eco-efficient waste treatment option.

In total, results from LCAs and CBAs can be said to have affected Swedish waste-management policies. This included cases in which the analyses confirmed the path already taken by policy-makers (like in the case of choosing recycling instead of incineration options), but there have also been cases where the analyses did not match the decision-makers' expectations, and instead led to a change in mind (like in the case of kerbside collection of waste). LCA has not only informed decision-makers, but has also assisted the public debate in focussing on important issues in waste management. However, the case of waste management also highlights some of the basic shortcomings in using LCA data for policy-making. These include the narrow time frame of the studies which do not fit to the sometimes high investments in waste treatment techniques, the geographical limitation of the analysis which is unable to predict local effects of waste treatment, or the approach's statism in terms of quantitative assessment, not being able to model changes in the quantities of waste generated.

as well as nongovernmental actors (creating a knowledge base for environmental policy measures), consumers (in case there is a successful transformation of information, e.g. via eco-labelling) as well as manufacturers (decisions about strategic adaptations in the product portfolio).

It seems as if in the early years of LCT and LCA-tools more optimistic views and expectations were connected with them. An outcome of the SETAC workshop of 1995 dealing with the "Application of Life-Cycle Assessment to Public Policy" (Allen et al. 1997) reported: "Application of the life-cycle concept may improve the public process by providing more information to decision-makers in a comprehensive manner" (Allen et al. 1997: 14). However, we think that behind this statement, a certain degree of "optimism" in the persuasiveness of science dominated. It might be interpreted as a confidence in the objectivity of science, in the unambiguousness of research results, in the unambiguousness of LCA-studies. However, LCA results are embedded in a context: the example of biofuels (see *Section 3.2*) demonstrates that results strongly depend on the level of analysis chosen and the questions that are to be answered. Results could be either complex by not aggregating and weighting different areas of concerns or they could be single scores hiding the values and interests behind the applied methods and tools. The example of the German Packing Ordinance illustrates that LCA-studies are embedded in a conflict of interests. Several studies have been prepared on behalf of different stakeholders (public authorities, business associations, some companies), results have been challenged, decisions on factual issues (like data, allocation procedures etc.) have been doubted, different – normative – values have been

³ See also *Section 4.3* for a stocktaking of some policy programmes and tools.

Box III: Experiences from Impact Assessment

Impact Assessment (IA) has gained considerable importance at the European level as well as in the Member States. Almost all countries have introduced formal procedures to systematically collect information about the likely impacts of a planned regulation (Jacob et al. 2007). Such procedures aim to improve the evidence base of decision making by a quasi scientific process. In some countries as well as the European Commission IA is designed and expected to be an instrument to integrate concerns of sustainable development in decision making by demanding a comprehensive assessment of the various dimension of SD. However, there has been some disappointment so far with the actual effects of formalised IA on both the use of knowledge as well as the integration of cross cutting issues. Evaluation of IA practice show that such procedures are also used as an additional venue for bargaining (e.g. the REACH assessments (Hey et al. 2007; Vagt 2007b). In other cases, the process is applied in a formalised and symbolic manner only to fulfil the formal requirements. Few examples demonstrate the potentials of IA for the policy development and policy integration.

Such shortcomings cannot be overcome simply by providing more elaborated guidelines, training or sophisticated tools. Instead, IA needs an institutional backup that ensures venues, allocates resources for IA and ensures a demand for the knowledge gathered during the IA process. The study of IA processes also reveals the many different functions of such efforts during the policy process ,including a stakeholder participation, interdepartmental coordination, communication, etc..

Impact Assessment is nevertheless much better integrated into the European policy process than LCA. However, the finding that several LCA studies have in the past led to an instrumentalisation of the results is even more valid for Impact Assessment – the REACH case has prominently underlined this issue. This also constantly raises the question whether IA – in case it really proves to be impossible to cover all key issues and acceptably address questions of proportionality – should in fact be performed at all, facing the risk of being incapable of adding sufficient additional value (Ten Brink 2007). Finally, the Impact Assessment example clearly shows that it will never be able to receive a “perfect” answer for decision-making, and that the answer is strongly influenced by what is to be analyzed and how it is analyzed.

confronted each other referring to based on different interpretations of sustainability (strong versus weak), different governance concepts (self regulation versus strong regulation), different scientific concepts (Mode 1 versus Mode 2), or different valuations of the precautionary principle. And, interest based science seems to gain in importance (Huppel 2007a). A similar case could be observed in the discussion of REACH and the role of impact assessment (see *Box III*). These examples demonstrate that the confidence in science has been shaken by the interaction between expertise and counter-expertise and problematic prognoses (Kusch 2002a and 2002b). On the other hand, the German Federal Environmental Agency elaborated a manual (Umweltbundesamt 2007) for the economic evaluation of environmental damages, supported by research projects, in order to structure economic impacts of industrial processes. This approach – even though for the assessment of economic impacts of different environmental policies – is an interesting inspiration for further research in LCT to include other dimensions and goals of sustainable development as well.

Cowell et al. (2002) similarly base their scepticism about the use of LCA in decision-making on five aspects: philosophical, referring to the questions how different environmental aspects can be weighted against each other; uncertainties about quantitative data; stakeholder participation referring to the debate about different values in interpretation; the non-qualitative nature of the results; and finally the usefulness of results in relation to time and financial resource requirements. This dealing with scientific uncertainties in decision-making has also been analysed in the case of risk assessment for chemicals (cf. Ruden 2002; Tukker 2002; Chapman 2006; for the role of values in scientific assessments cf. Enick/Moore 2007).

These examples demonstrate that policy is based on LCA-tools improving the knowledge and the decision basis. But does an improvement of the knowledge basis reduce uncertainties?

Does policy become more “rational” and more “objective”? Do decision-makers receive the needed information and the “right” format and level of aggregation? Are there limits to the rationalisation of policy processes? Can expertise stemming from LCT and LCA-tools ever claim to create knowledge that is both undoubted and based on completely reliable forecasts? Is it politically and legally legitimate to build policy on them?

Answers to these questions are not easy to give. Within the strict and rigid “old” mode of governance, policy formulated not only objectives, but prescribed also the (technical) paths to fulfil them. This “top-down” approach of hierarchical governance changed (see *Chapter 2*). Therefore, a process, reflexive and learning orientation within decision processes seems to be more appropriate. What does this mean? Knowledge and learning may fulfil very different functions in political decision making and accordingly tools to support the gathering, the integration and the use of knowledge have to be designed and applied in different modes. The following functions provide an overview on different needs and functions of knowledge – they are ideal types and in real decision making situations, several functions may merge in a certain situation.

- **“Heuristic function of questions”**

The questions to science have to be framed (Huppes 2007a). The information provided is also an outcome of the questions asked, as the example of biofuels demonstrates (see *Section 3.2*)

- **“Scoping information needs”**

It must be clarified which level of information is needed which is linked to the first point. Different decision contexts, intervention possibilities, time horizons, external and internal drivers – and other factors – restrict the questions and the information needed. The recently introduced distinction between consequential and attributional LCA (e.g., Ekvall 2002, Ekvall et al. 2004) is of relevance in this context due to the hints to their reference to the decision context and the distinction between average and marginal data. Decision making in the context of sustainability needs to clarify a number of indicators/parameters and also data required, the broader set of sustainability-related information, the scope of the analyses and – to list another, but not final aspect – the prospective/retrospective as well as the consequential/attributional character of information. These points need to be discussed and decided before knowledge production starts.

The transmission from retrospective to prospective views increases uncertainties. There is not one – certain – future, there are – from nowadays – different futures thinkable, which are contested. Futures are constructions based on present knowledge, hypotheses, values, premises etc. (Grunwald 2007).

- **“Decisions for weighting and aggregating LCA-Data”**

Weighting different priorities and contradictory goals in decision making is a primary topic in current discussions and must be kept in mind when dealing with LCA-tools and politics (Huppes/Ishikawa 2007). The level of data and information aggregation resp. weighting has to be clarified, which is related to the first two points, too.

- **“Participation and political discourses as methodological approach”**

One answer to overcome inherent obstacles mentioned above is to look for other approaches of decision making. Public discourses have been considered as a strategic answer which could both take account of complexities in political decision situations and back up a decision’s legitimacy (Zilleßen/Barbian 1997, Huppes et al. 2007b). “Governing by discussion” is seen as one response to governments’ loss of steering capacities and their concurrent loss of acceptance (van der Daele/Neidhardt 1996). In the aforementioned interrelation between

knowledge production and governance, such practices of political discourse can also be characterised as examples of a growing reflexivity of governance (Voß/Kemp 2006). Given the context of reflexive governance it is also the role of government that has to change insofar as it is rather supposed to provide the appropriate framework conditions for discursive practices than to determine a process's outcome from a top-down perspective. Participation and participation techniques play a dominant role in this new mode of governance. There are considerable challenges for LCA and participation. Participative tools and approaches like consumer conferences, focus groups, future conferences, televoting, mediations, citizen conferences (cp. Abels/Mölders 2007) have seldom been linked with LCA-tools.

▪ **“Institutionalisation of reflexivity processes”**

Reflexivity is not a self-organising process. What might be needed is its strengthening by institutionalised views and incorporated competencies (cf. for a more elaborated discussion (Section 3.4).

▪ **“Deliberation as an element for legitimisation of results”**

The aforementioned aspects are intended to broaden and deepen debates and to strengthen discussions. In general, quickness of decision processes will be slowed, but the extended deliberation would foster the new governance approach. “Deliberation serves both to improve problem-solving capabilities and possibly provide some degree of democratic legitimisation” (Scott/Trubek 2002: 8).

Policy making could be rationalised applying LCT and LCA-tools, but the rationalisation we think is feasible is primarily a process-oriented one. As in the case of Technology Assessment (TA) (see Box IV), learning is an important issue and the whole process of sustainability and governance should be organised in a way that different forms and types of learning are possible; contributing to a dynamisation of processes (Zieschank 2002, Grunwald 2007). New governance means for LCT and LCA-tools (see also Huppel 2007a) – among others –

- to ask and agree the appropriate questions, perhaps also diverging ones between actors;
- to clarify the scope of information needed and in this context also to clarify the sustainability approach used as the reference basis;
- to agree the diverse levels of aggregations and weightings between actors;
- to organise discussions of results of application of LCA-tools and to strengthening participations of actors
- to institutionalise LCT and concerned actors;
- to accept deliberation.

3.2 Possible Levels of Analysis: The Biofuels Case

In the discussions on biofuels there are several overlapping or competing goals, including environmental goals like reduction of climate changing emissions, energy supply diversification, and a rise in rural income. Focussing on the environmental part of the discussion, distinct levels of analysis may be discerned, related to the empirical mechanisms taken into account, and the accompanying modelling choices being made.

The *simplest type* is the technology oriented models which catch the main technologies and the main emissions, assumedly, CO₂. A survey paper on ethanol from corn was published in Science (Farrell et al. 2006), which indicated a range of limited positive or negative effect on CO₂ emissions, depending on feedstock and technology applied. As methods are ad hoc, there

is not much reflection let alone reasoned choices. The *second level* is dedicated LCA studies, focused at technological relations in the life cycle. A good example is the survey study on different biomass types and different processing types by (Zah et al. 2007). A *third level* of sophistication are studies going more explicitly into the methods choices in LCA. It then turns out that for a specific technology like second generation biofuels, the outcomes are similar to the Science outcomes in the sense that some outcomes are positive and negative. But now with opposing outcomes depend on methods choices, especially the allocation methods, and on assumptions regarding N₂O emissions, a potent climate gas (Luo submitted)

A *fourth level* includes specific market mechanisms. In the discussion, several options have come up. Due to the partial nature of such market analysis, somewhat arbitrary choices are unavoidable. For example, recent developments in policies for biofuel have been supported by official impact assessments (Commission of the European Communities 2006a; Commission of the European Communities 2007b). Partial economic models for the European energy market (PRIMES, GREEN-X) have been used in these impact assessments, showing substantial reductions in European emissions in climate gases.

However, the large scale policies for bio-ethanol of the US and Europe seem to have led to consequences which hardly have been covered in such studies. The additional demand for corn for ethanol, for example, has shifted land use towards corn production on a large scale, reducing the amounts of other staple foods produced. A price rise in all staple grains has been a consequence, with poor populations in cities in developing countries suffering most. The empirical analysis is still that of specific markets, but now at a global scale level. This may be seen as a *fifth level* of analysis.

Sixth, the rising prices of staple products have induced large scale development of tropical agriculture, for biomass-for-energy production. These shifts can be measured and predicted based on partial modelling of the land markets involved, markets which are not well regulated in many developing countries. Adding this level of analysis starts to give insight in broader ecological consequences, as due to the biofuel policies and the technologies favoured by these policies. This analysis is still partial however.

So, *seventh*, also for other products for which prices have risen there is an induced land use shifts also leading to serious loss of nature area. This leads to a full land use view, reckoning with the strong non-linearities resulting from the given total of land we have on earth. The environmental effect mechanisms covered now also can become more encompassing and hence realistic. In wet peaty soils like in main parts of Borneo, the land use shifts induced create very extensive long lasting emissions of CO₂. Indonesia now is the third largest emitter of CO₂ in the world, probably negating the limited CO₂ reductions due to the extra supply of biofuels. For second and third generation biofuels these negative effects might be more limited.

If we now expand from the partial market analysis to a full analysis of the economic activities, specifying the changes of induced by the biodiesel en bio-ethanol production, a broader and again more realistic picture emerges, as the *eighth level* of analysis, using input-output analysis as a framework and possibly adding specific dynamic economic mechanisms. Behind these economic mechanisms, there is the broader social aspects, covering cultural and institutional mechanisms, and the policy adjustment mechanisms which may be set in motion.

Let us assign the *ninth level* to cultural and institutional mechanism, which include feedback loops like the easier use of energy when it has become “green”, the new ways of opening up nature areas to make them economically more valuable, and the generation of knowledge for improved primary production and further processing steps in the use of biomass.

Finally, *at place ten*, political feedback mechanisms, as autopoiesis, are present at all levels in the societies involved. Nature conservation in set-aside lands in Europe, losing out fast, is starting to be organised now in different directions. The centre of Borneo has been declared a protected nature area by the Indonesian government. But also, governments of India and China have put restrictions on food exports so as to protect their citizens against price rises on the global food markets, leading to still higher price rises in other countries.

Getting the analysis framed in the right way is one element broadening and deepening life cycle analysis. Getting results which are relevant and interpretable is a second challenge. Starting point for choices on how deep to go relate to the questions at hand. It might be that in restricted choice domains, like optimising second generation biofuels from corn stover, the analysis could be much simplified. However, this is not sure at all and deserves further investigation. In general, the simplification option holds if one option is better than other options in all respects. Do such situations really exist?

3.3 Stocktaking of selected EU policies

Given the high expectations of knowledge based LCT/LCA approaches, how does it look like in reality? The life cycle perspective in policy-making is – in principle – an accepted approach, at least rhetorically. However, in the real world Lee/Xu (2005) observe a generally lagging behind. Could we share this observation? To which degree does policy adopt the life-cycle concept in reality?

We want to analyse this considering two different levels of stocktaking *European* policies, namely on the level of some selected programmes and on the level of some selected tools and instruments. Due to budgetary constraints, we restrict this analysis to two programmes, namely:

- a) Integrated Product Policy, Sustainable Consumption and Production Patterns (SCP) linked with Sustainable Industrial Policy, and
- b) Innovation Policy.

Besides them, we consider two tools and instrumental approaches, namely:

- c) the Energy Star, and the
- d) EuP Directive.

We base our assessment on four criteria:

- “New” governance:
Has the approach / tool supported the shift from government to governance? This criterion looks for the role that science-based tools play in policy making in regulative structures which changed its policy form (Mayntz 1995) where “non-state, private corporate actors participate in the formulation and implementation of public policy” (Rhodes 1997); we are interested if LCT and LCA-tools are used as supportive approaches in this context.
- Relevance of Life-Cycle Thinking (LCT):
Has LCT become (internally) institutionalised within policy? That means that we are interested to learn if and how LCT is embedded in and integrated within public authorities, e.g. by creation of new institutions or rearrangement of institutional settings.
Does LCT provide an (internal) input for policy making? That means that we look for the relevance and application of LCT for policy making along a policy cycle.
- Relevance of LCA-tools:
Does policy ask for and use LCA-tools for policy making? This criterion is focussed

towards the “transmission” of LCT into concrete analytical tools of the LCA-family (independent of the specific chosen tool). We are interested to judge if policy has asked for the application of LCA-tools and is applying them.

▪ Diffusion of LCT & LCA-tools:

Does policy stimulate the (external) institutionalisation and adoption of LCT & LCA-tools especially within business? This criterion looks for the dissemination of both LCT and LCA-tools outside public institutions, namely especially within business and industry. We look for the support of policy to diffuse and apply these approaches.

These four criteria are relevant for the context of our analysis. We do not assess the impacts of these programmes and tools. Neither an intensive assessment nor an in-depth summative evaluation has been carried out in this context.

3.3.1 IPP/SCP in the EU

Integrated Product Policy (IPP) is an area of concern of EU policies⁴. Key policy papers published by the Commission are a Green Paper (Commission of the European Communities 2001) and a Communication (Commission of the European Communities 2003). The Communication is based on five key principles, among them LCT. It mentions two approaches: first the establishment of the framework conditions for continuous environmental improvement; and second the development of a focus on particular products. It envisages preparation of a progress report until end of 2007.

Nowadays, IPP is embedded in the broader focus of SCP⁵, an issue which is linked to the UN summits of 1992 and 2002. The Commission announced several times that it would publish an action plan for SCP which is now foreseen for second half of 2008. For the preparation of this plan, the Commission organised a public consultation process and merged SCP with Sustainable Industrial Policy, an area which is also of top priority for the Commission⁶. The consultation paper (Commission of the European Communities 2007a) encompasses five different key challenges: leveraging innovation, better products, leaner and cleaner production, smarter consumption and global markets.

Table 2 Characterisation and assessment of IPP/SCP

Criterion	Overall assessment	Remarks
“New” governance	☺	<ul style="list-style-type: none"> ▪ Policy approaches are based on incentives and informative tools; traditional regulative approaches are not top priority. ▪ The support of networks has been announced to stimulate innovation (COM 2007a, 4). ▪ Two exemplary IPP pilot projects of the Commission have been carried out to gain experience with co-operative approaches to improve the eco-efficiency of products by business and policy. ▪ A formal and an informal IPP network have been created to co-operate with and consult stakeholders, academia and others.
Relevance of	☺	<ul style="list-style-type: none"> ▪ LCT is mentioned several times (e.g. COM 2003, 4) and

⁴ See for an exhaustive overview Rubik/Scheer (2005, 8ff.), Béyodan et al. (2005). See also EU webpage: <http://ec.europa.eu/environment/ipp/home.htm>.

⁵ See EU webpage : http://ec.europa.eu/environment/eussd/escp_en.htm.

⁶ See EU webpage : http://ec.europa.eu/enterprise/environment/sip_en.htm.

Criterion	Overall assessment	Remarks
LCT		<p>considered as one core principle of IPP and SCP.</p> <ul style="list-style-type: none"> ▪ The Commission is building up a European platform on LCA at its JRC at Ispra (see http://lca.jrc.ec.europa.eu/). ▪ In the consultation paper (COM 2007a), the consumption phase as one part of a product's life cycle seems to be not intensively developed.
Relevance of LCA-tools	☹	<ul style="list-style-type: none"> ▪ The European platform on LCA supports European Commission with advice with regard to LCA. ▪ Other initiatives are scarce.
Diffusion of LCT & LCA-tools	☺	<ul style="list-style-type: none"> ▪ The Commission is continuously promoting the application of LCT (see COM 2007a, COM 2003 10ff.). ▪ LCA is explicitly dealt with within the 7th Research Framework Programme with the intention to continue and intensify efforts in the area of LCT/LCA ▪ Within the EU's Environmental Technologies Action Plan (ETAP)⁷ performance targets play a key role and they are linked to some life-cycle related approaches and tools like eco-labelling, IPP and EuP. ▪ One core area of concern is strengthening eco-design. The EuP approach is intended to be transmitted to non-energy using products (COM 2007a, 9).

We conclude that overall LCT and LCA-tools play a promising role in this programme area. LCT is strongly embedded on the programmatic level and it plays an important and crucial role in the diffusion of LCT and LCA-tools within business and academia. What is still a deficit is the minor importance of the consumption phase within policy and LCT.

3.3.2 Innovation Policy in the EU

The official European Union's Innovation Policy is mainly based on the documents "More Research and Innovation - Investing for Growth and Employment: A Common Approach" (Commission of the European Communities 2005b), "Putting knowledge into practice: A broad-based innovation strategy for the EU" (Commission of the European Communities 2006c), "An innovation-friendly, modern Europe" (Commission of the European Communities 2006b) and the Aho group report "Creating an Innovative Europe" (Aho 2006). The mentioned documents focus on the whole range of areas relevant for future innovations, such as research and development, knowledge, qualification, financing and building of clusters and networks.

The document "Putting knowledge into practice" defines ten priority actions defining a roadmap for the EU and its member states for the next ten years. The Lisbon Strategy from 2005 defines the overarching framework of these reports. Since the priority action fields in the documents basically apply to all ecological problematic areas, the link to environmental themes and environmental innovation can be expected to be very strong in general.

Table 3 Characterisation and Assessment of the EU Innovation Policy

⁷ See EU webpage: http://ec.europa.eu/environment/etap/policy_en.htm.

Criterion	Overall assessment	Remarks
“New” governance	☺	<ul style="list-style-type: none"> ▪ The policy framework foresees to support public-private networks, to enhance cooperation between business and policy, and to help create economic clusters ▪ Different policy instruments are to be combined ▪ Interlinkages with other policy initiatives (ETAP)
Relevance of LCT	☹	<ul style="list-style-type: none"> ▪ Consumer behaviour is not systematically addressed ▪ The policy framework intends to strengthen the role of Green Public Procurement, but apart from that shows only a rather superficial commitment to LCT in environmental and economic terms ▪ There are only few and weak references to environmental aspects in most of the policy papers
Relevance of LCA-tools	☹	<ul style="list-style-type: none"> ▪ No direct reference to LCA-tools (however, this is based on findings from strategy papers only which have to be made more concrete in single initiatives)
Diffusion of LCT & LCA-tools	☹	<ul style="list-style-type: none"> ▪ Strong reference to FP7 where core principles of the innovation strategy are taken up ▪ Commitment to eco-innovation and eco-efficiency

It can be concluded that the role of environmental criteria for innovation, and especially the importance of life-cycle data can still be strengthened considerably in the European Union’s innovation policy. The overall importance of life-cycle thinking in the criteria for (environmental) innovation is low and superficial. In selected cases like in the guidelines for green public procurement, which form part of the innovation strategy, there is explicit reference to life-cycle criteria and the consideration of life-cycle thinking. The consideration of the consumption phase in innovation policy in general also risks to be underemphasised. This phase of the life cycle remains to be analysed in further detail.

3.3.3 Energy Star

Informative tools informing and instructing consumers are an important approach of IPP and SCP. There are different tools applied in this context (see Rubik/Frankl 2005 for an overview). For the product group of office equipment, end of 2001, the Commission has agreed an energy label for office equipment (Regulation 2422/2001) which co-operates with the US Energy Star programme⁸. The regulation is based on an agreement between the government of the United States of America and the European Community. This agreement was renewed end of 2006 and is valid for five years, i.e. until end of 2011.

The Energy Star is a voluntary environmental label, identifying appliances that meet certain standards regarding energy efficiency. In the United States, it is applicable to a series of different product groups like air conditioners, lighting, home sealing, office equipment⁹. Within the European Union, it is restricted to office equipment.

Table 4 Characterisation and assessment of the Energy Star

⁸ See <http://www.eu-energystar.org/>.

⁹ See for an overview <http://www.energystar.gov/>.

Criterion	Overall assessment	Remarks
“New” governance	☺	<ul style="list-style-type: none"> The Energy Star is a voluntary tool leaving decision power to manufacturers and consumers to apply and/or consider it.
Relevance of LCT	☹	<ul style="list-style-type: none"> LCT is integrated for the whole life cycle of office equipment; however it deals only with energy consumption and does not consider other environmental features.
Relevance of LCA-tools	☹	<ul style="list-style-type: none"> LCA-tools are not relevant in the context of the energy star.
Diffusion of LCT & LCA-tools	☹	<ul style="list-style-type: none"> The diffusion of LCT and LCA-tools is not supported by the Energy Star due to its single-issue character.

We conclude that the “Energy Star” is an important tool of European energy and environmental policies. It is an instructing and informing voluntary approach and herewith an example for a “new” governance approach allocating decision power to market forces. It considers the energy consumption along the whole life cycle, but linkage with the other important tool, namely the energy label is missing. The energy label as mandatory approach is focussed on energy, too, but has taken other environmental features into consideration.

3.3.4 Energy using Products (EuP)

In 2005, the European Council and the European Parliament adopted a Commission proposal for a Directive on establishing a framework for setting eco-design requirements for all energy using products (EuPs), except for means of transport for persons and goods (Commission of the European Communities 2005a)¹⁰. The framework Directive does not introduce directly binding requirements for specific products, but rather defines conditions and criteria for setting requirements regarding environmentally relevant product characteristics. It will be followed by implementing measures which will establish the eco-design requirements and contain legal obligations for manufacturers. The requirements cover generic (e.g., use of raw materials, information for users, disassembly and recycling) and specific requirements (e.g., limit value for electricity consumption in use and in standby modes). With respect to the implementation measures, which will be adopted by a stakeholder consultation process, the Directive gives priority to self-regulatory activities by industry – although regulatory measures can be taken as well.

At present, 19 preparatory studies are underway or partly completed, formulating recommendations whether and which eco-design requirements should be set for a particular product group¹¹. The preparatory studies provide information for the next phases which are impact assessment, involvement of the Consultation Forum¹², and possible draft implementing measures. The transposition of EuP framework Directive by Member States has been scheduled for August 2007. Adoption of first implementing measures for some product groups is expected to start in 2008.

¹⁰ See also http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm (accessed June 25, 2008).

¹¹ Product groups covered are, for instance, boilers and water heaters, PCs and computer monitors, residential room conditioning appliances, refrigerators and freezers, dish washers and washing machines, and domestic lighting.

¹² The Consultation Forum encompasses representatives from industry, including SMEs and craft industry, trade unions, traders, retailers, importers, environmental protection groups and consumer organisations. It had its constitutive meeting in June 2007.

Table 5 Characterisation and assessment of EuP

Criterion	Overall assessment	Remarks
“New” governance	☺	<ul style="list-style-type: none"> ▪ The EuP Directive and the concrete implementation measures involve a Consultation Forum of stakeholders intended to exchange opinions and improve insights (Art. 18). ▪ The EuP Directive mentions the equivalence of mandatory implementation measures and voluntary agreements (Art. 15 & 17). Self regulation is here an alternative to regulation. ▪ Four different types of declaration of conformity are accepted which could be chosen by the manufacturer (Art. 9)
Relevance of LCT	☺	<ul style="list-style-type: none"> ▪ The EuP Directive considers nearly the whole life cycle of energy-using products, except of material extraction.
Relevance of LCA-tools	☺	<ul style="list-style-type: none"> ▪ An LCA-tool has been elaborated a methodological report for the preparation of the concrete product related studies (http://ec.europa.eu/enterprise/eco_design/finalreport1.pdf). ▪ The 19 preparatory studies are applying the elaborated method.
Diffusion of LCT & LCA-tools	☺	<ul style="list-style-type: none"> ▪ LCT is stimulated by the focus of EuP. ▪ Business could elaborate LCA-studies and deliver their results as inputs to the preparation and discussion of the preparatory studies. ▪ Business could declare conformity of their products by environmental profiles based on LCA-tools.

We conclude that on a conceptual level the EuP Directive is a very appropriate example of the relevance and application of LCT and LCA-tools. The crucial challenge is the environmentally-related quality level and qualitative ambitions of the product-group specific implementation measures.

3.4 Reflexivity and institutionalisation

Reflexivity is a general request – reflexive governance is considered as a key element for sustainable development¹³. Institutional reforms have been discussed and a series of proposals have been delivered, e.g. by Minsch et al. (1998), and this is an area of considerable attention. As mentioned before, LCA is not a stand alone tool. Other tools have been elaborated contributing to an improvement of rationality within decision-making process, like Technology Assessment (TA) (see *Box IV*), Impact Assessment (see *Box III*) or Environmental Impact Assessment (EIA). They came up in the last four decades and it would be interesting to study their institutionalisation.¹⁴ TA for example has been taken up as core area by new parliamentary committees, institutionalised parliamentary scientific consultancies, scientific TA-communities, research institutes dealing with TA etc. (see Hüttner 2002; Schmittel 1994). This case delivers some interesting insights concerning retrospective and prospective assessments and the contribution to sustainability, governance and policies¹⁵.

The institutionalisation of reflexivity could also be linked with institutions or institutional/organisational measures which take care for introducing aspects which might represent an independent "logic". Their increasing importance could also be considered as an intermediary strategy between self regulation and hierarchical regulation¹⁶. Some interesting examples will be presented for further discussion, how to establish a creative and structured way of self reflexivity about content, surrounding field and processes of LCT:

Independent institutions

- **European Central Bank (ECB):** The ECB is an institution and has to guarantee price stability within the European Union. The ECB is an independent body which could not be influenced by the European institutions like Council, Commission or Parliament. Its independency could be regarded as an example that such an institution could be prudent enough to organise internally reflexivity.
- **Ombudsman:** An ombudsman is an official person, often appointed by the government or by parliament, who is charged with representing the interests of the public by investigating and addressing complaints reported by individual citizens. The major advantage of an ombudsman is that he or she examines complaints from the outside of the offending state institution, thus avoiding the conflicts of interest inherent in self-policing. However, the ombudsman system relies heavily on the selection of an appropriate individual for the office, and on the cooperation of at least someone from within the apparatus of the state. The origin of ombudsmen is Scandinavia where several ombudsmen have been appointed.
- **Stiftung Warentest:** The Stiftung Warentest (foundation for comparative product testing) is an independent consumer information centre which has been established after years of discussion as a foundation by decree of the German Federal government. Its intention is to intervene in the structural information asymmetry between suppliers and consumers and to strengthen the position of the latter by publication of independent information, for example.

¹³ See for example the comprehensive anthology edited by Voß et al. (2006).

¹⁴ An international research project (EVIA) funded by the European Union has recently come up with a number of empirical findings on this topic, see for example (Jacob et al. 2008).

¹⁵ It is quite interesting to observe that the network TA organises a conference "Technology Governance. Der Beitrag der Technikfolgenabschätzung" [Technology Governance. The contribution of Technology Assessment] June 4-6, 2008, in Vienna/Austria (see: <http://www.oew.ac.at/ita/ta08nta3/topic.htm>, accessed January 10, 2008).

¹⁶ See also Minsch et al. (1998: 99ff.) and Kiwit/Voigt (1995) for the categorisation of institutions.

- **Certification:** Certification refers to the confirmation of certain characteristics of an object, product, person, or organisation. This confirmation is often, but not always, provided by some form of external review, education, or assessment. One of the most common types of certification in modern society is professional certification, where a person is certified as being able to competently complete a job or task, usually by the passing of an examination. Another type of certification is product certification confirming that a product fulfills specific requirements.
- **Accreditation:** Accreditation is a process in which competency, authority, or credibility of an organisation is certified. Organisations that certify third parties against official standards are themselves formally accredited by the appropriate bodies; hence they are sometimes known as "accredited certification bodies". The accreditation process ensures that their certification practices are acceptable, typically meaning that they are competent to test and certify third parties, behave ethically, and deliver certified quality. One example of accreditation is the accreditation of testing laboratories and certification

Box IV: Experiences from Technology Assessment (TA)

The use of LCA has considerably developed in the past decades. The LCA method is more and more considered part of a family of methods to assess the sustainability impacts also of future technologies (cf. European Commission 2007). However, by extending the use of LCA to the assessment of prospective technologies, the method at the same time exposes itself to additional types of uncertainties and appreciations of values that were not part of the LCA methodology before. It is therefore necessary to closely follow practices in other prospective assessment methods and their inherent problems at this point in research. In the case of Technology Assessment (TA) Grunwald (2007a) identifies four different issues of uncertainty in the analysis:

- **inseparability issue:** the co-evolution of technology and society leads to an inadequacy of closed models
- **incompleteness issue:** prioritisation of a multitude of sustainability aspects along the whole life cycle that can only be assessed in parts
- **incommensurability issue:** the measuring of sustainability effects relies on quantitative approaches the usefulness of which is in many cases limited
- **prediction issue:** future developments influence the life cycle data and thus create even more uncertainties

An elaboration of these problems creates a universe of contested and unknown "futures" prospective LCA is also forced to deal with. One example concerns the prognoses about energy use in the 1960s not taking fully into account the possibility of complete dematerialisation (Grunwald 2007b). There is still no consensus about how a distinction between "knowing" and "supposing" can be made in the case of controversial futures. TA has responded to this challenge by working with scenarios instead of clear cut prognoses. However, in the case of knowledge for policy-making this does not solve the question which future is supposed to be the basis for decision-making.

Against this background Grunwald (2007a) proposes a threefold reflexivity for sustainability governance:

- taking into account meta-knowledge on the premises, limitations and normative grounds of prospective sustainability assessments
- designing governance for sustainability in a way that learning during the process is possible to the largest possible extent: what strategies exist to deal with a lack of knowledge, what provisions of reflexivity and participation are incorporated in the underlying governance paradigm?
- keeping in mind the limitations of quantitative approaches: main issues are the problem of „futures“ and the incommensurability issue

specialists that are permitted to issue official certificates of compliance with established standards.

However, when promoting the institutionalisation of reflexivity care must be taken not to over-formalise the process. The more independent an institution becomes, the more it risks to become detached from practical issues such as requirements for implementation. Therefore, to institutionalise reflexivity the independence of institutions must not be regarded as the ultimate goal but the right balance needs to be found.

Dependent institutions acting on request or on contract

- **Evaluation regimes:** Some regulative acts prescribe a periodical evaluation study carried through to consider experiences with the regulation's impacts. European examples are the EU eco-label and the EU EMAS-schemes; for both instruments evaluation reports have been foreseen which should collect empirical evidence on successes and failures of these tools (see IEFE et al. 2006). Suchlike studies are intended to reflect the status of the challenge and to look for weaknesses and paths to reduce them.
- **Meta analyses:** Meta-analyses combine the results of several studies that address a particular challenge and intend to explain the variety of results (Eisend 2004). They are carried out either on behalf of a client or without specific contract.
- **Reviews:** Reviews are an established approach of scientific quality control. Within LCA, the ISO 14040 standard has arranged three different types of critical review processes which are intended to improve the quality of LCA-studies, namely an internal expert review, an external expert review and a review by interested parties. The decision on the need for a critical review is up to the customer of an LCA-study. Especially the review by interested party is an interesting example to organise discussions and to start some reflexivity.
- **Scientific Technology Options Assessment (STOA):** STOA is an official organ of the European Parliament. Its work is carried out together with external experts, which can be research institutes, universities, laboratories, consultancies or individual researchers contracted. The STOA Bureau runs the activities of STOA and prepares the Panel meetings. A panel is politically responsible for STOA's work which is composed of members of the European Parliament nominated by EU Parliament's Committees.
- **European platform on LCA of the Joint Research Centre:** The LCA platform has been arranged as project by the European Commission settled for the period 2005-2008; its main tasks are to support life-cycle thinking in the development of goods and services and to support life-cycle thinking in a broad range of policies. The platform is financially dependent from the Commission and intended to support European policy making.
- **High-level group (HLG):** HLG are groups established, e.g., within the European Commission, to consider specific interesting challenges. An example is the High Level Group on Competitiveness, Energy and the Environment, which was set-up by the Commission on the basis of its Communication on Industrial Policy 2005¹⁷. The Group has a mandate for two years. The meetings of the HLG, whose members are taking part on a personal basis, will be prepared by a group consisting of sherpas nominated by each member of the HLG. It will receive input from four ad-hoc working groups dealing with topics like the electricity and gas market or the EU Emissions Trading Scheme.

This enumeration could be continued. It shows that a number of interesting institutional settings have been launched, some of them could act independently whereas others are

¹⁷ See EU webpage: http://ec.europa.eu/enterprise/environment/hlg/hlg_en.htm (accessed January 10, 2008).

dependent on specific mandates, either single contracts or single mandates. We believe that a couple of them provide some opportunities to be transferred in the context of LCT and LCA-tools and to strengthen reflexivity of LCA-tools, therefore we recommend to examine the experiences of these approaches and to look for the transferability of “best” practises to LCT and LCA-tools.

Nevertheless, we want to add some tentative thoughts; these thoughts are intended to improve the first stages of the policy cycle and the applications of LCT and LCA-tools:

- An *ombudsman* could be appointed who is related to the commissioning of LCA-tools and acts as a reviewer of the awarding authorities. The intention is to consider the chosen level of detail, the question considered etc., that means to give independent hints beyond the shadow of hierarchies.
- *Participatory approaches* might be suitable to discuss different interests and values and to try to look for consensus. They could be connected to the work of the ombudsman.
- Disputed areas of public concerns need to be examined from a meta-level to understand hypotheses, assumptions, interests and values by *meta-analyses*.
- Ad-hoc groups like *high-level groups* or “*group des sages*” which are appointed from case to case might be an interesting supplement, however their mandate and infrastructural setting must be sufficient to secure an appropriate role.
- *Learning in loops* should be a general attitude of the commissioning institutions and the intended audience.

These thoughts and their relevance resp. appropriateness depend on the functional requirements of types of LCA-tools’ applications. Huppel (2007a) distinguished between five types of applications which are related to the degree of simplicity/complexity of cases.

4. LCA and self-regulation

In the previous chapters, we elaborated the changing facets of governance: new governance is based on changing actor constellations between public and private actors and on an increasing use of “new”, often less hierarchical instruments in political steering. This chapter deals with this topic and look for the relationship between new governance and business (*section 4.1*), presents some empirical evidence for drivers for LCA (*section 4.2*) and looks for chain management and organisational aspects (*section 4.3*).

4.1 New governance and business

As mentioned above, governmental measures and activities are limited; we think that there are some *structural* and *inherent* limitations of traditional regulatory policy approaches to intervene and regulate business-internal processes and decisions:

- The complexity of environmental externalities is characterised by a huge amount of different substances which increase continuously and which are combined to form an exploding amount of interactions (Minsch 1998).
- There is a systematic problem causing insufficient knowledge of allocation calculations and decisions of microeconomic actors. The state can neither theoretically nor empirically provide the necessary information of microeconomic actors (Wegner 1995).
- Given the hypothetical assumption that information would be available to the state, there would immediately arise an information overload which could not be dealt with.

- Transmission of information from business to policy will not occur due to secrecy.

Therefore, a certain trust in self-regulation capacities and in own activities of economic actors is a key element of new governance. Self regulation means that manufacturers take up the challenge of producing environmentally (more) reliable products and services and contribute their bits on a path towards sustainability. New governance offers a new scope for business – with all the challenging potentials, opportunities and risks. Which role does LCA play in this context? Are there any possibilities to support business' acceptance of its new role?

Self regulation needs knowledge, and in this context LCA-tools are supposed to contribute. Research and development of ISO-LCA concentrated on methodological improvements and the proliferation of data. This is based on the belief that LCA-tools increase rational decisions within business and contribute to develop cleaner products (cp. Remmen 2007). A series of guidelines and material has been prepared to stimulate companies on their paths towards eco-design¹⁸. However, it has also been stressed that a *comprehensive* approach is necessary. An orientation towards the pure improvement of the knowledge basis is not sufficient: Remmen (2007) hinted at the insufficient attention to organisational aspects and the role of management. Therefore, Life Cycle Management (LCM) should receive more attention. LCM is defined as "...the application of life cycle thinking to modern business practice, with the aim to manage the total life cycle of an organization's products and services towards more sustainable consumption and production. LCM is about systematic integration product sustainability e.g. in company strategy and planning, product design and development, purchasing decisions and communication programs" (Jensen/Remmen 2006, p. 10).

LCM and the taking up of these opportunities by business and by its corporate commitment are influenced by a number of factors in- and outside of business. One key factor is business-internal organisation which we discuss in *section 4.3.1*. Another factor is the appropriateness and application of a series of supporting activities of organisations both on international¹⁹ and national levels supporting development and dissemination of life-cycle management within business. But also market requirements from public, commercial and private customers could contribute. Their demands can signal some market requirements towards producers and ask for some information on the environmental features of products traded on markets. Here, the whole range of product-related information tools receives some importance. Eco-labels and Environmental Product Declarations (EPD) as tools linking the bridge between suppliers and customers are of importance (see Rubik/Frankl 2005); a specific type of labelling is the BASF developed method and label to indicate environmental leadership (cf. Saling 2007).

With regard to policy analysis and the focus on changing modes of environmental governance, this raises the question of what possibilities there are for policy to instigate and further the application of LCT/LCA-tools in companies and herewith stimulate the self-reflecting and self-organising potentials of business. As elaborated in *section 3.2*, our stocktaking of EU policies reveals that policy is dealing with this subject and tries to stimulate endogenous efforts within business. We observe that most of the present research concentrates on the macro-economic level and its implications for policy-making. Micro-economic dynamic considerations about interaction between policy activities and business product development (and the applied approaches) are scarce (cf. Kautto 2006). Therefore, research should try to investigate effects of certain policies on the adoption of LCT/LCA-tools in companies.

¹⁸ See for example Tischner et al. (2000) or Waage (2007).

¹⁹ For example the World Business Council for Sustainable Development (WBCSD) or UNEP's & SETAC's Life cycle Initiative.

4.2 Empirical Evidence: Drivers for LCA²⁰

Business uses and applies LCA-tools within its core activities. That seems to be a good message. In this section, we will look on some empirical evidences of application patterns of LCA-tools within business. We refer to some selected results of studies and report which investigated these patterns in some states like Austria (Seebacher et al.: 2003), Germany (Wagner/Schaltegger: 2001; Konrad: 2002), Sweden (Beckmann/Baumann: 1998), different European states (Verschoor/Reijnders: 1999; Hanssen: 1999; Baumast: 2000; Frankl/Rubik: 2000; Ansems et al.: 2005; Neumann: 2007), and on an intercontinental (EU-Japan-USA) level (Gutowski et al.: 2003).

- *Establishment of LCA-tools*

Life-cycle assessment is one important tool to consider environmental challenges within business, but it is the child of a broader family. Qualitative, qualitative-quantitative and pure quantitative tools are applied. Results from Frankl/Rubik (2000), Konrad (2002) and Neumann (2007) show that the most regularly used tools are environmental indicators, risk assessment, checklists and simple LCA. Companies prefer easy to use and simplified forms of LCA-tools, and, with the exception of environmental indicators, qualitative cost-related tools are not frequently applied.

A broader overview on the application frequency of LCA within business has been presented in the context of the (former) European Business Environmental Barometer (EBEB), but of which the results are more than seven years old; they show a modest application frequency of LCA in industry. Ansems et al. (2005: 110) conclude that SMEs hardly use LCA-tools.

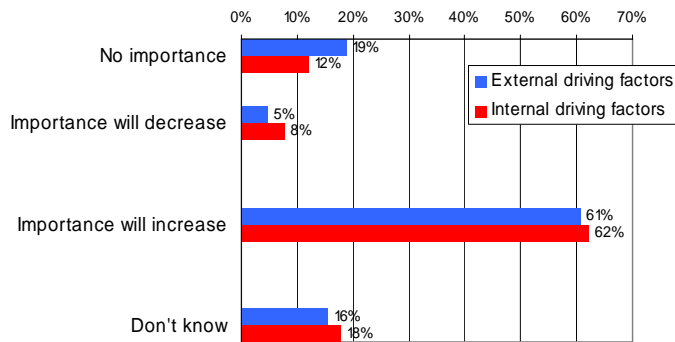
The majority of companies think that the application frequency will increase – independent of the concrete LCA-tools they apply.

- *Drivers*

Different impulses to start LCA-related activities exist. A clear separation of business internal drivers (like product-related environmental challenges, anticipated environmental advantages, anticipated image advantages) and external (like market/customer demands, environmental legislation, collaborative studies with industrial associations, public environmental discussions) drivers is neither possible nor reasonable. Based on her survey, Neumann (2007, 74) came recently to the conclusion, that the importance of both types of drivers will increase in the future (see *Figure 1*). Environmental challenges, public environmental pressures, market requests from customers and the check of challenges due to future environmental legislation are considered as main drivers.

Figure 1 Future importance of aggregated external and internal driving factors

²⁰ Another working package of the CALCAS project, namely WP6, is dealing with the analysis of user needs. See the website of CALCAS for more information.



Source: Neumann: 2007: 74²¹

▪ *Role of policy and role of different instrumental approaches*

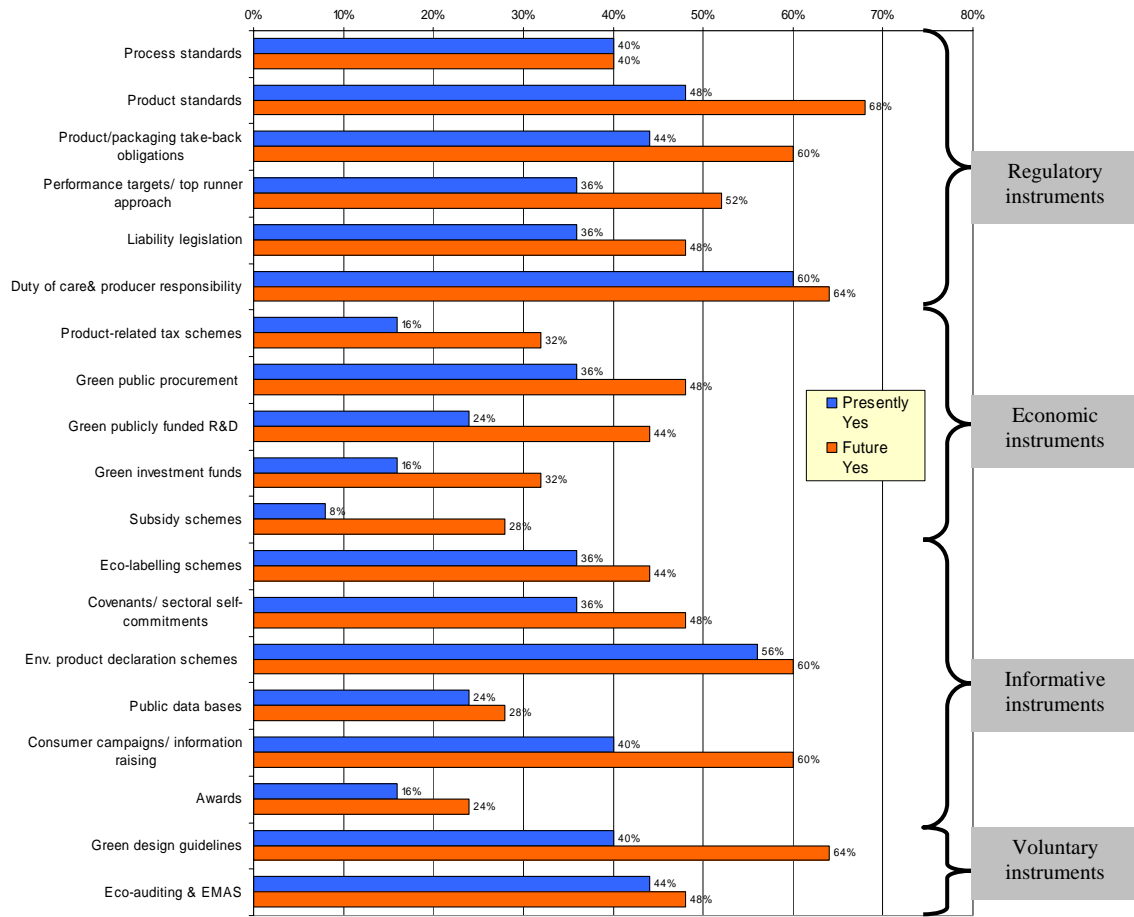
Policy is *one* important driver to apply LCA-tools, but not the exhaustive one. As mentioned, the assessment of compliance with future legislation is considered by business as an important driver to apply LCA-tools, only a small share of companies is directly urged by public demands to start these activities.

However, this does indicate neither the relationship with specific policy “styles” nor with specific instrumental approaches. Some – small – empirical evidence refers to this challenge: Neumann (2007, 74ff.) analysed the question how different policy actions would affect the application of LCA-tools presently and in the future (see *Figure 2*). Presently as well as in the future, regulatory and voluntary instruments affect businesses most: presently 44% of the companies feel affected by regulatory instruments and 42% by voluntary instruments. In the future 55% respectively 56% expect these instrument categories to affect the application of life-cycle approaches in their companies. The largest increase is projected for economic instruments. While presently 20% of the companies are affected by measures of this policy class, in the future the share will rise to 37%. However, compared to the other instrument categories, the influence of economic instruments is relatively low.

Figure 2 Present and future affection of business by policy actions (Neumann: 2007, 77)²²

²¹ Question: *How do you anticipate the future importance of the internal and external driving factors?* The answers are relative shares in % of all given answers.

²² Question: *Do the following policy actions affect the application of product assessment tools within your company presently or in the future?* The answers indicated are relative shares in % of yes-answers, n=25, one answer per company for each present and future policy action possible).



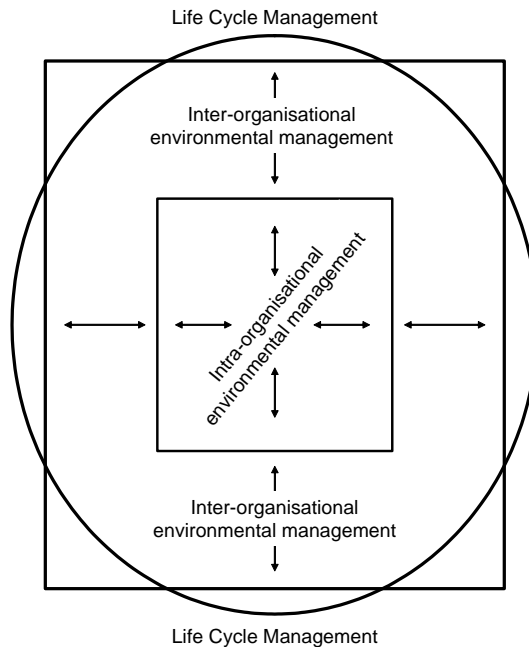
4.3 Chain management and organisational aspects of LCT and LCA-tools

Despite the fact that in general life-cycle thinking, LCA-tools and life-cycle management in companies have gained importance in the past decades, the life-cycle concept still has to travel a long way until it can be considered universally accepted and a tool applied by routine within business, i.e. before LCT becomes fully institutionalised. In order to make LCA a tool for the implementation of truly sustainable systems, it cannot be regarded in isolation from its socio-economic environment. Progressing from Life-Cycle Analysis to Life-Cycle Management transgresses the traditional quantitative boundaries of LCA, and it transgresses traditional intra-organisational boundaries. A strictly rational perspective would imply that once firms obtain the right tools to assess the life-cycle impacts of their products, they will develop cleaner products (Remmen 2007). In the same light it could be assumed that once consumers know about the detrimental environmental effects of their behaviour, they will change their consumption patterns. These assumptions, however, fall far short from the empirically observable reality with a dramatic lack of sustainable consumption and production patterns worldwide. What does this mean for the integration of organisational theory, sociological constraints and actor constellations into decision-making with LCA?

It has been stated that the key for the adoption of environmental considerations in product design relies on the management of organisational change (Lenox et al. 1996; Lenox et al. 2000). The following chapter attempts to continue the discussion from the preceding chapter by adding some theoretical considerations about obstacles, opportunities and trends of the application of LCT in organisations. The term “organisation” will thereby be analysed on two

dimensions (see *Figure 3*): as a background for LCT application within the firm (here: intra-organisational environmental management), but also describing the organisational aspects of the entire product chain (here: inter-organisational environmental management).

Figure 3 The organisation's position in life-cycle management



4.3.1 Intra- organisational aspects of life-cycle management

Material flows cannot be regarded as a separate domain from organisational theory (Frankl/Rubik 2000; Baumann 2007). However, organisational theory and environmental management often tend to be considered apart from material flows. Against this backdrop, the life-cycle concept faces a number of obstacles for its successful intra-organisational implementation. First, life-cycle thinking challenges the traditional idea of organisational theory that organisation is a process taking place within one company, and that the company can control what happens in its relationships and procurement relations at best with first tier suppliers: While the organisational horizon tends to end at the factory gate, life-cycle thinking is based on cradle-to-grave thinking. This product-based or chain-based approach of LCA is in contrast to the rather site-specific and firm-specific paradigm of organisational thinking. Kogg (2003; cf. also Baumann 2007), e.g., reports on the case of a Swedish textile company which succeeded in greening its product chain by comprehensively rearranging it, assisting local farmers in geographically distant production locations, and helping to build up certification bodies. During a reorganisation process lasting up to ten years, the focal company *Verner Frang* played the role of a very active “steward” for the application of the life-cycle concept, thus considerably extending its traditional organisational role. The company sought cooperation with local Peruvian partners for whom its orders were important enough to motivate the extra efforts for environmental improvements, and who would assist the farmers to start growing organic cotton which they had not done before. However, the company was also prepared to pay a substantive premium in order to convince especially the producers in the wet processing stage,. For these companies Verner Frang did not constitute a major customer, and it did not represent more than 5 % of the total turnover of these suppliers (Kogg 2003: 60). Since Verner Frang decided to comply with the criteria of the Nordic Swan the companies in the wet processing stage had to obey ambitious targets in criteria like levels

of chemical oxygen demand and pH in waste-water effluent, or limitations concerning the chemical content in finished textile products.

A further aspect regarding the mixed picture of LCT institutionalisation concerns the general position of environmental and life-cycle management within a company's corporate social responsibility (CSR) policies. If LCM in environmental terms is regarded as one element among others in CSR, it risks to lose ground against social issues often dominating the CSR debate. Therefore, despite the fact that life-cycle thinking may have become an "institutional logic", it also has to be underlined that first "LCA is not as yet a routine, everyday practice throughout industries – and some authors doubt whether it will become that in the future" (Heiskanen 2002), and second that the empirically observable institutionalisation of this logic shows a large difference between different cases. Regarding the application of life-cycle thinking in the entire product chain, general patterns are as hard to find as in the case of sector studies. Statistical material is scarce and empirical research has so far been insufficient for comprehensive generalisations (see *Section 4.2*). In general it can be stated that life-cycle thinking, if applied in organisations, has mostly been a case for product design and corporate communication.

Baumann (2007) notes as an example the Finnish beverage industry where life-cycle management was only accidentally applied. Accordingly we observe that the implementation of the life-cycle concept differs not only sector-wise, but also between similar companies, and even within the same organisation there is often no uniform understanding of what life-cycle thinking might stand for. It is difficult to generalise about the implementation of life-cycle thinking and life-cycle management on sector level – a fact that has also been highlighted by Frankl and Rubik (2000).

In order to make the life-cycle concept travel among different organisations, different actors like consultants, champions of the life-cycle concept as well as imitators of certain role models will play a dominant role (Frankl/Rubik 2000; Baumann 2007). As a result, Baumann (2007) underlines that a further institutionalisation of the life-cycle concept in organisations must rely on a reformulation of the life-cycle idea as well as on measures to ease the concept's travelling. Concerning the former, she proposes a combination of "types of analysis" with "ideas of action". The presentation of the idea is crucial, assigning a special role for life-cycle champions. Accordingly, these life-cycle champions will have to be supported (by policy), and capacity-building for champions needs to be strengthened. It has to be understood that life-cycle management is not a technical, but an organisational problem and could only gain a momentum if institutionalised and applied by routine. Communication between experts and users of life-cycle methods also has to be strengthened.

4.3.2 Inter-organisational aspects of life-cycle management

With reference to Heiskanen (2002) it has already been noted that life-cycle thinking/LCA should not merely be considered a management tool, but an "emerging institutional logic". This hints first of all at the central role of products as sources of environmental problems, but also at the fact that companies have to become aware they are finally responsible for a number of environmental impacts outside their realms and along the entire product chain. In this light Heiskanen argues that life-cycle thinking can be seen as part of a counter-tendency to what Beck has coined "organised irresponsibility" (Beck 1995). However, as soon as organisational issues and the optimisation of life cycles or entire product systems begin to play a central role, the crucial questions to be asked become how and by whom such systems might be designed.

The inclusion of organisational thinking into the application theory of LCA has stimulated research to combine the quantitative assessment of material flows with sociological aspects,

particularly actor analysis (cf. Binder et al. 2004; cf. Korhonen 2007). Binder (2007) states that

[b]y linking the key agents to the material flows, we are able to determine both the stakeholders' impact on these issues and the areas of conflict or disagreement. Based on this information, an effective consensus building process can be started where strategies can be discussed and their implication for the material flows can be estimated. Once the relevant structural elements are known, the constraints implementing these measures can be identified and overcome. Graphic representation permits abstraction and, thus, provides a neutral foundation for a potential consensus process.

Following these basic considerations, it can be said that LCA needs to be analysed in a wider context of organisational and socio-economic aspects along the entire supply chain. If changes in the supply chain are to be induced, it ultimately has to be kept in mind that LCA is not a *communication tool per se*, and other tools are necessary to establish cooperation in and along the organisation. There are a number of different communication tools for the exchange of life-cycle information between producers, customers and other stakeholders, and more and more companies are making use of them²³. The issues at stake are co-operation along the supply-chain, business-to-business relations, drivers for the adoption of change in the supply chain, but also the importance of power (a)symmetries in the chain. A study by Green and Foster (2005) has highlighted the importance of a “central structuring role and qualitative asymmetric power” in a re-orientation of the product’s life cycle towards sustainability. E.g., in their case of frozen peas in the UK this role could only be attributed to one major player in the supply chain, being Unilever with its enormous purchasing power and possibilities to influence its partners. Following a similar logic, but with a different conclusion, Jensen and Remmen add a “soft” element to the organisation of LCM in the supply chain by underlining that the product chain can effectively be defined as *supply chain + value chain + collaboration* (Jensen/Remmen 2006: 17)²⁴. The same idea is being presented by Hamner (2006) who argues that green corporate purchasing alone is not sufficient to install real environmental supply chain management within the firm:

Suppliers can produce „greener products“ without necessarily becoming green themselves [...] The German ban on textiles dyed with azotropic dyes has caused thousands of textile producers to change their dyestuffs to more ‘friendly’ types but has generally not caused them to reduce pollution or improve their environmental management practices, yet this is what is necessary for a sustainable supply chain (Hamner 2006: 27).

Seuring presents an interesting overview about the interlinkages between different concepts of environmental management, including LCA/LCM (Seuring 2004). He analyses four holistic concepts (integrated chain management, environmental supply chain management, life-cycle management and industrial ecology) on three levels: management philosophy or mission level, strategic level, and the operational level. In comparison to the other concepts, the link to political strategies is therefore most explicitly set up in integrated chain management. In terms of stakeholder engagement, it is however not only the legal system, but the wider societal system that has to be taken into account. The extent to which companies react to political incentives along their supply chains and causalities in this regard are still open to further investigation.

²³ Prominent examples are the ECO-VAS system developed by Toyota based on life-cycle data, or the π -standard for household appliances (cf. for a compilation of several examples Jensen/Remmen 2006); another example is the European platform on LCA of the Joint Research Centre. Also Environmental Product Declarations (EPDs) could be mentioned.

²⁴ cf. the works by Reinier de Man on the issue of material flow management, further literature references in Rubik (2002)

Against this background and the introduction of the company's societal environment we distinguish four relevant stakeholder groups that could also play a stronger role in the adoption of organisational life-cycle thinking (cf. Henriques/Sadorsky 1999):

- regulatory stakeholders, who have the power to regulate themselves or who can exert power on political actors to regulate, like legislating bodies or lobbying organisations
- organisational stakeholder (customers, suppliers, employees, shareholders)
- community groups (environmental organisations and those that can mobilise the public against a company)
- media

As has been depicted in *Section 4.2*, companies perceive that legislation is being of rising importance as a driver for the application of life-cycle thinking. It could be shown what specific policy measures seem capable to induce the application of LCA-tools in business.

From a broader systems, organisational or governance perspective the analysis should, however, be enlarged to the incentive structures along the entire supply chain, taking into account the variety stakeholders mentioned above. The underlying logic builds on an actor-centred approach to the discussion about new environmental governance. It is assumed that the increasing complexity of regulatory issues as well as the globalisation of product chains set clear limits for the nation state's steering capacity. Thus, the state depends on the willingness of private actors to provide critical information for sustainable policy formulation like emission data, marginal abatement costs or technological options, and on their willingness to take regulatory action themselves (De Bruijn/Norberg-Bohm 2005). In regulatory strategies explicitly taking into account second and third-order effects in the supply chain (i.e. effects taking place on second or third tier level, but which can still be linked to measures taken by the focal company), the role of non-state actors changes from a pure regulatee to a virtually co-regulating actor. Slater (1997) labels the free market a mechanism encouraged by the state to allow it to manage "at a distance" a complex process it cannot directly govern. This fact seems to be especially virulent for policies that try to influence eco-design of products, where "the number of enterprises that systematically apply eco-design strategies is still very limited, even in countries that have a strong environmental product policy" (Dalhammar 2007: 102). Against this background it can be presumed that regulatory strategies should aim at a strengthening of third actors *within* the chain, for example companies that are able to exert strong economic pressure on their suppliers, but also investors and financial institutions that pursuing an ambitiously ecological portfolio. However, while for example Dalhammar puts strong emphasis on regulatory intervention and product standards for influencing product design – thereby keeping in mind the necessity of a broader policy mix (Jänicke et al. 2000) – he does not explicitly take into account the role of third actors in regulatory measures.

As a theoretical exercise, *Table 6* attempts to give an overview about how several policy measures might enhance the capacities of selected stakeholders in the supply chain to exert environmental pressure on manufacturers (cf. Gunningham et al. 1998; Hutter 2006; cf. Vagt 2007a). As relevant stakeholders in the supply chain and in the environment of manufacturing companies we choose

- a) institutional investors
- b) financial institutions
- c) industrial companies
- d) insurance companies

- e) environmental consultants
- f) and civil society stakeholders.

Taking the necessity to go beyond single instrument use as a starting point, the list encompasses the whole range of environmental policy instruments, including command-and-control, market-based, voluntary as well as informative instruments. It will be subject to further research whether especially the latter can indeed be an effective element in the toolkit of new environmental governance. In theory, there is no doubt that, e.g., a high flow of information in the supply chain is a prerequisite for life-cycle management. Thus measures like the Toxic Release Inventory in the United States (Graham/Miller 2005), the Indonesian *Program for Pollution Control, Evaluation and Rating* (PROPER) (Blackmann et al. 2000), or the *GreenWatch-Programme* in China (Wang et al. 2004) appear to be suitable approaches to evoke ecological effects along the supply chain. Policies aiming at the mandatory provision of upstream information in the entire product chain risk however to cause conflicts with trade-related issues. This is also why the EuP directive has chosen a rather cautious approach in this regard by explicitly leaving out the phase of material *extraction* and referring to the life cycle's initial stage as material *use* (cf. for a detailed analysis Dalhammar 2007).

Table 6 Policy measures and potential effects on Green Supply Chain Management

	Institutional Investors	Financial Institutions	Industrial Companies	Insurance Companies	Environmental Consultants	Civil Society Stakeholders
Measures directly affecting the target group	<ul style="list-style-type: none"> - Assistance in the development of sustainability performance measures 	---	<ul style="list-style-type: none"> - Ecological public innovation initiatives - Green public procurement 	<ul style="list-style-type: none"> - High standards as well as long-term orientation and predictability of regulation, making it possible for insurers to orientate along easily calculable risks 	---	<ul style="list-style-type: none"> - Financial Incentives for NGOs - Legal Possibilities for NGOs / organisations to issue collective claims - Incorporation in coregulatory arrangements
Measures enhancing stakeholder groups' capacities to monitor and regulate	<ul style="list-style-type: none"> - Disclosure Requirements for Companies - „Community-Right-to-Know“-legislation 	<ul style="list-style-type: none"> - Strict liability legislation - Regular reporting obligations for companies about their environmental performance 	<ul style="list-style-type: none"> - Ecological product labelling schemes covering aspects up and downstream of the supply chain - Producer Responsibility along a product's life cycle - Resource Taxation close to the source - Product and Process standards (requirements for eco-design) - Strict liability legislation 	<ul style="list-style-type: none"> - Mandatory insurance for licensing 	<ul style="list-style-type: none"> - Subsidies, tax exemptions, easier licensing, preferences in criteria for public procurement in case of regulatory environmental audits. - Incorporation of independent environmental auditing in coregulatory arrangements - Enact strong liability schemes that moves investors to rely on consultants' work 	<ul style="list-style-type: none"> - Disclosure Requirements for Companies - „Community-Right-to-Know“-legislation

Source: (Vagt 2007a)

5. Conclusions: Challenges and recommendations for LCA from a governance perspective

With this paper we have tried to link discussions about new environmental governance with the ongoing efforts to “broaden” and “deepen” the current ISO-LCA framework. Judging from the background of political sciences, we began by sketching general characteristics, shortcomings and challenges for concepts of environmental governance. These were discussed against the background of the ongoing debates about the state’s abilities to remain its steering powers in modern societal contexts. Given the increased call for legitimization of hierarchical policies and the integration of participatory elements in political decision-making, these discussions are linked to one crucial element of modern environmental governance: the importance to create and supply a sufficient **knowledge base** for state and non-state actors.

While this new role of knowledge and accordingly also science in modern environmental governance paves the way for a wider use of LCA and related methods, a different comprehension of application of LCT and LCA-tools is required. Generally speaking, “new” LCA is, among other things, identified here as having to rely on principles such as openness and learning instead of “closed” and final results, a clarification of scope and hidden normative values, a new understanding of how underlying questions need to be framed, a design of process learning in the largest possible extent, and a proactive acceptance of necessary but also problematic quantifications. In a nutshell: in the context of new environmental governance the process of gathering knowledge is more important than the aggregation of different types of data. According to the structure of this paper, these requirements and research needs for new LCA can be concretised under two subheadings: the implications for LCA in policy-making and the requirements for research on LCA regarding its role for self-regulatory processes of business.

5.1 LCA and Policy

In *Section 3.3* on the role of LCA/LCT in European policies it was shown that political strategies do not often build on the use of life-cycle methods and considerations. However, research in this area still needs to be strengthened considerably. The stocktaking of policies should be enlarged in two ways. On the one hand, core areas of European policies like CAP, trade policy or structural fund have not been considered here. It will be an interesting challenge to analyse to which degree LCT has indeed “arrived” within these policies, either to inform the implementation or as a mean for self regulation of the target groups. On the other hand, the stocktaking should be enlarged to policies of EU Member States to detect best practices and derive recommendations for the European level. Furthermore, the overall relevance of LCT and LCA-tools can still be strengthened in the areas of the examples presented, and further research should use this analysis as a starting point when formulating ideas to strengthen the application of LCA/LCT in the observed policy areas.

The strengthening of LCA/LCT has been connected with a call for their institutionalisation in the political system. There is both a need to express the political will to use LCA/LCT as well as a need to provide technical support in terms of data, methods, and quality assurance. This raises the question of how this institutionalisation should be organised. Should existing institutions (e.g., Eurostat, JRC, EEA) be further strengthened, or should new institutions (e.g., an ombudsman for LCA, a European organisation like the German Stiftung Warentest) be created? This paper has argued that especially the external logic of, e.g., an independent ombudsman could help to overcome shortcomings of participatory assessment procedures. It also has to be considered which part of the assessment procedure should be institutionalised in what way. This implies not to mix the dimensions of a) framing the problem and b) ensuring an adequate level of quality control of the results. In general, strong policy incentives are

needed for the institutionalisation of LCA. Since such ideas of institutionalisation have not been sufficiently covered by existing research yet, it is recommended to intensify research on the applicability of these issues.

We have argued in this paper that one key element for the construction of “new” governance contexts includes the reflexivity of decision-making contexts. However, since reflexivity bears the risks of infinite decision-making processes and therefore continuous constraints for legitimation, reflexivity must be embedded in a clear time-schedule and decision-path to avoid undecided situations. In any case, reflexive governance should be designed as a participatory process, providing a new arena for the application of LCA and other knowledge-generating tools. Despite the fact that participatory elements are included in the ISO framework, participation techniques and their link with LCA-tools are still not very well developed. This can be considered a major shortcoming of present LCA because participation might help to overcome problems of hidden normative values within LCA and increase the results’ robustness as well as their acceptability within the political discourse. However, participatory elements need educational backup, and the question how the general awareness of the importance of LCA within European policies can be raised must be further analysed. This includes learning from other (environmental) fields, like the increasing public awareness of issues like climate change, which was inter alia successfully promoted by the work of the IPCC.

Additionally, LCA and related tools are perceived largely as a technical effort, while the social framing of problems, the set up of studies and the use of the result is largely ignored. Here again, the link with participatory techniques may overcome this weakness. Several participatory instruments are worth mentioned and compared with procedures within LCA, e.g. methods like participatory scenario building. For the construction of “New LCA” in a context of sustainability governance, the CALCAS project should be further enriched by establishing even tighter links with the results from other EU-funded projects like Sustainability A-Test, MATISSE, or FORESCENE. It will be subject to further investigation what exact procedural aspects of participation might be pursued, and how these processes could be institutionalised.

The paper has furthermore argued that research in LCA must broaden the perspective and look for possible synergies of LCA with other assessment tools like technology assessment (TA) and impact assessment (IA).

Against the background of developing LCA into a veritable sustainability assessment tool including all aspects of sustainability, there has furthermore been a vivid discussion and several applications about the integration of social aspects into the classic LCA methodology in the past years (cf. Dreyer et al. 2006; Griebhammer et al. 2006; cf. Heinrich 2006; Griebhammer et al. 2007). A feasibility study on the integration of social aspects in LCA (Griebhammer et al. 2006) nevertheless highlighted a number of problematic aspects regarding the complexity and categorisation of social indicators, the use of quantitative indicators for social impacts, or the lack of substantive data. The study, however, did not call the general inclusion of social aspects in the LCA methodology into question. These assumptions go in line with results from the PROSA project (Manhart/Griebhammer 2006; Griebhammer et al. 2007). An empirical study on the social impacts of the production of notebooks (Manhart/Griebhammer 2006) confirms some of the methodological caveats currently prevailing for the calculation of social aspects in the product chain:

- the restricted availability of unit process data for product related social life-cycle assessment (SLCA)
- the different perception of social issues by different actors, thus making stakeholder involvement a key issue for SLCA

- the importance of including the degree of actual corporate commitment also for those industries where the distinction between individual brands and products is difficult

In Belgium a governmental label for the social aspects of products and services based on LCA data was introduced in 2003 (Spillemaeckers 2007). The label rules encompass the whole product life cycle back to the resource extraction phase. By obliging applicants to the label to get into contact with all kinds of subcontractors and eventually sign agreements with them, the label bears implications for a lot of organisational aspects in corporate chain management. Spillemaeckers (2007), however, also raises objections against the applicability of environmental LCA to social LCA. In her view, the classic LCA's input-output model of physical flows does not take account processes within the company, whereas "essential social criteria such as wages, working hours and discrimination are characteristic of what happens during the production process and within the organisation itself" (2007: 4). A further distinction between the preconditions for environmental and social LCA concerns the necessity to include geographical aspects into the calculation. Although it can be stated that – not least due to its governmental support – the Belgian label is an important initiative, it also has to be noted that its acceptance in companies is rather weak and that there have been only a few applications so far. This problem can mostly be attributed to a lack of awareness of the label, something the Belgian Government is attempting to overcome via green procurement policies, public campaigning and awareness rising among potential customers.

5.2 LCA and self-regulation

The analysis of drivers for the application of LCA in business (*Section 4.2*) has shown that business receives pressure to apply LCA and LCA-related tools both from internal and external sources. Companies also assume the importance of these drivers will increase in the future. The analysis by Neumann (2007) further revealed that – regarding external policy drivers – product standards, producer responsibility regulation, product declaration schemes, consumer pressure, and green design guidelines are perceived as the strongest drivers for the application of LCA and related tools. However, an in-depth status-quo research with recent empirical evidence on the question of drivers from LCA seems to be missing. One extensive study in this regard has been carried through almost a decade ago (Frankl/Rubik 2000). This underlines the need for a more encompassing research design, including larger, longitudinal data-sets assessed at different points in time to give valid evidence about the actual development of drivers over time.

However, we conclude that research is furthermore lacking on both the intra- as well as the inter-organisational aspects of life-cycle management. With regard to intra-organisational aspects of life-cycle management, there is a lack of research especially with regard to the question of how organisational features interact with LCM. One of the crucial questions here is what effects the level of vertical integration has on the organisation's ability to integrate life-cycle thinking. Is the trend to vertical disintegration and the outsourcing of corporate functions detrimental or beneficial for the adoption of the life-cycle concept? Thus far, conclusive evidence to answer this question has not been presented, and research seems to be restricted to anecdotal examples instead of presenting a coherent theory of LCM and organisation.

Looking at the organisational features of LCM, not only the internal, but also the external selection environment of companies (Nelson/Winter 1982; Metcalfe/Boden 1992) must be considered more thoroughly in further research. As it was shown, there is already a large body of research dealing with issues of environmental or green supply chain management, and several studies deal with a multitude of external pressures (cf. Hall 2000). However, we identified a lack of research on the interplay of specific political initiatives and environmental supply chain management. The empirical part in *Section 4.2* illustrated that policy instruments

differ in their ability to effect the application of LCA in companies. The same applies to the effects of policies on the application of green supply chain management – a fact that has, however, not been subject to sufficient attention in policy and management research yet (cf. Vagt 2007). The acceptance of and the pressure for LCA and related tools must not be analysed disregarding the political environment firms are surrounded with. There are a multitude of possibilities for policies to instigate the dissemination of life-cycle *assessment* by incorporating life-cycle *thinking* into a wider variety of policies, including the integration of environmental and life-cycle concerns into policy areas that are originally not designed to promote the environment. This opens up new opportunities for research on the interrelation between policies and LCA/LCM/LCT, and should become a field of analysis also for governance research.

ANNEX

Inputs of LCA into Politics: The Case of Swedish Waste-Management Policy

Tomas Ekvall, IVL Swedish Environmental Research Institute

Swedish Commission on Packaging

At the end of the 1980s, public opinion in Sweden turned against the increasing quantities of packaging. In response, the Swedish government launched a Commission on Packaging to investigate the possibility to reduce the quantities of packagings and to stimulate recycling of the packaging materials.

The Commission gave the task to the research foundation Chalmers Industriteknik to carry through life-cycle inventory analyses (LCI) to assess the energy requirements and emissions associated with the use, re-use, and recycling of nine different packaging materials. Tillman et al. (1992) compared scenarios with a high degree of re-use or recycling to scenarios with no re-use nor recycling. For combustible materials, incineration with district-heat production was also compared to landfilling.

Recycling and re-use resulted in lower emissions for most materials and most parameters; however, the net emissions of CO₂, SO₂ and particulates were lower in the scenarios with incineration of used wood, corrugated board and starch packagings. This was because the energy recovered at incineration was assumed to replace heat produced from oil. Then incineration of these packagings means that biofuel replaces oil. Net emissions of SO₂ were also reduced in scenarios with incineration of plastic waste (low and high density polyethylene, and polystyrene).

Tillman et al. did not apply impact assessment or weighting across parameters. Their overall conclusions were “that recycling or reuse of packaging materials results in a reduction in energy requirements and emissions, and that the energy content of the non-recovered/re-used proportion of combustible materials should be utilised by means of incineration.”

Tillman et al. also investigated the energy demand and emissions from transport in the different scenarios. They could demonstrate that a high level of recycling not necessarily results in more transports, because primary materials are often transported from far away.

The LCI was published as an attachment to the report from the Swedish Commission on Packaging.

REFORSK

REFORSK was a foundation aiming at stimulating and funding research on waste and waste management. It was initiated by the industry and by local and national authorities. They saw a need to discuss, review and refine the study by Tillman et al. This task was given to Chalmers Industriteknik, Chalmers University of Technology, IVL, and the Federation of Swedish Industries. Most of the authors of the original study were involved also in the new project.

The project was carried through in two phases. The first phase (Baumann et al. 1992) included a review of the original study. This review concluded that the LCI included important uncertainties. The assumption that energy recovered at incineration replaces oil was highlighted as an important assumption that was unfavourable to re-use and recycling.

The first phase also included a life cycle impact assessment (LCIA), including weighting across impact categories, with three parallel methods: the EPS method, the BUWAL approach based on ecological scarcity, and the CML and RIVM impact category approach. All were adapted to Swedish conditions. This impact assessment was carried through for two materials only: aluminium and high density polyethylene (HDPE). All LCIA results indicated that aluminium recycling is environmentally superior to incineration. However, the conclusion for HDPE depended on the choice of LCIA method.

The LCI was expanded and updated in the second phase (Baumann et al. 1993):

- The assumption that energy recovered at incineration replaces oil was complemented with scenarios where waste incineration replaces renewable fuel.
- The new LCI also included scenarios where combustible natural resources (pulpwood and crude oil), which is saved through re-use and recycling of paper, wood and plastics, are extracted and used as fuel.
- Emissions from electricity production were excluded in the original study. Here, they were included and calculated using data on marginal electricity production in coal-power plants.
- The new LCI also included newsprint, besides the packaging materials.

The expanded and updated study also included LCIA, including weighting across impact categories, with the three parallel methods: the EPS method, the ecological scarcity approach, and the impact category approach.

Baumann et al. (1993) concluded that “recycling seems to cause less environmental impact than incineration” in most scenarios. However, with certain combinations of assumptions and LCIA methods, incineration got better results. Important methodological choices included the fuel replaced at waste incineration, the alternative use of pulpwood, and the choice of LCIA method.

Extended producer responsibility and the alternative fuel

In 1994 Sweden introduced extended producer responsibility for

- glass and corrugated-board packagings (SFS 1993),
- newsprint (SFS 1994a),
- packagings of aluminium (excl. beverage cans), paperboard, plastics (excl. PET), and steel (SFS 1994b), and
- car tyres (SFS 1994c).

These ordinances assigned to the producers the responsibility for the waste management. They specified the level of re-use and recycling for each material or product group.

The ordinances fulfilled the requirement in the EU Directive on Packaging (EU 1994) to recover at least 50% and recycle at least 25% of packaging materials. The use of extended producer responsibility as a policy instrument was inspired by the extended producer responsibility in Germany, which was introduced as early as 1991. But the LCA results from the Swedish Commission on Packaging and REFORSK also had a role. The fact that they confirmed the belief that recycling in general reduces environmental impacts, made the ordinances easier to justify and, hence, to implement. The Swedish ordinances also went beyond what was required in the EU Directive, because they included some non-packaging products and because the stipulated recycling rates were higher than required by EU.

In response to the ordinances, the producers established material companies – one for each material and product group – to organise the collection and recycling of the waste. These activities were financed through a fee on each kg of material. The fee made the use of material more expensive, stimulating a reduction in the weight of the packagings. This was also one of the purposes of the ordinances, as explicitly stated in later versions (SFS 1997a).

When the extended producer responsibility had been introduced, several other LCAs were carried through to assess it (e.g., Finnveden et al. 1994a, Granath & Strömdahl 1994, Finnveden et al. 1994b). These studies focussed on the materials for which the environmental benefits of recycling were the least clear: paper and board. The results indicated that total energy demand is reduced through recycling. However, the conclusions on fossil-fuel demand and associated emissions depend on what fuel is assumed to be replaced by waste incineration. To some extent they also depend on what fuel is used, or assumed to be used, in the recycling process (Finnveden & Ekvall 1998).

The extended producer responsibility has repeatedly been challenged in the public debate. Here, the fuel replaced by waste incineration was also a core issue. As recent as February 2003, a group of directors, including a former Director-General of the Swedish Environmental Protection Agency (EPA), argued that the best option is to recover energy from the waste, replacing oil in the district heating systems.

The Swedish EPA also repeatedly evaluated the extended producer responsibility. As an example, Westin (1998) reported to the government that the recycling of packaging is good for the environment and saves energy and other resources. They stated that “manufacture using recycled materials is much less energy intensive than production from new raw materials. The environmental benefits from energy saving far outweigh any losses in connection with increased transport.” In connection to the EPA evaluation, several LCAs were commissioned by different material companies, and also by a municipality. These studies were carefully read and provided important input to the evaluation (Westin 2007).

The extended producer responsibility of packagings was also revised to include beverage cans and PET bottles, to increase the level of recycling, and to give further guidance (SFS 1997a, SFS 2006). The extended producer responsibility was also expanded to include other product groups: cars (SFS 1997b, SFS 2007a), lightbulbs and fluorescent lamps (SFS 2000), other electric and electronic products (SFS 2005), and certain radioactive products (SFS 2007b).

The EPA currently considers expanding the collection of packagings to include other products of similar materials. A purpose of such a change is to adapt the collection system to consumer perceptions, allowing them to deliver other plastic products at the same drop-off point as plastic packagings, etc. Another purpose is to further increase the recycling rate. To confirm that this is still good for the environment, the EPA commissioned a literature survey of LCAs carried through to date from Tyskeng & Finnveden (2007). This survey reached the expected conclusions (Due 2007).

Meanwhile, Swedish waste incineration expanded rapidly because of the introduction of landfill bans for combustible waste (2002) and organic waste (2005). Sahlin et al. (2004) made an inquiry into how this expansion affected the plans for district-heat production. They found that waste replace mainly biofuel in the district-heating systems where waste incineration is expanded. These results spurred questions regarding how the market for biofuel was affected, and for what fuel production would be affected in the end. These questions still lack a final answer. Some researchers (Frees et al. 2005, Gustavsson et al 2006) argue that the marginal fuel in Sweden is fossil fuel because all available biofuel will be used in the effort to reduce climate change. However, the production of biofuel can, to some extent, adapt to changes in demand (Ivarsson 2004). And the emissions of fossil CO₂ in the Nordic countries and the EU are formally decided by political decisions following the Kyoto protocol. This indicates that biofuel is the marginal fuel and that any energy recovered from waste will reduce the production and use of biofuel. This is an ongoing debate, also within the Swedish EPA. It is important for the environmental assessment of waste incineration, but also for a host of other issues.

Cost-benefit analyses, time, and kerbside collection

In the late 1990s, Radetzki (1999) combined LCA results with economic data to a cost-benefit analysis (CBA) of the extended producer responsibility of packagings and newsprint. Similar studies had recently been done in other countries (Leach et al. 1997, Bruvold 1998). These studies all indicated that incineration with energy recovery is a better option than source separation and recycling.

For Leach et al. the conclusion reflected their assumption that energy from waste replaces energy from coal. For Bruvold and Radetzki, the main reason was the time spent by consumers on source separation. Since source separation schemes require the participation of a large share of the population the total time required from households is huge. If this time is associated with a cost in the CBA, as Radetzki and Bruvold argue it should, this cost often dominates the CBA results.

The CBA results highlighted the efforts of consumers in the source separation schemes. It made the need apparent to adapt the collection systems to consumers and their perceptions. Allowing consumers to deliver other products at the same drop-off point as packagings is one such attempt. Other approaches focus on giving clear information and feedback to the households. Still others focus on reducing the time required to participate in the collection schemes.

Most of the time required for source separation is spent on rinsing the packagings and on transporting them to drop-off points. An increase in kerbside collection would be a way to reduce the time and effort required from consumers. The Swedish EPA planned a regulation stipulating that all multistorey buildings should have kerbside collection, and commissioned a literature survey from IVL Swedish Environmental Research Institute to investigate the environmental and economic implications of such a regulation. The survey concluded that it is difficult to say if kerbside collection is better than a system with drop-off points. Kerbside collection reduces the time required from consumers and is likely to increase the collection and recycling of materials. On the other hand, the cost of collection increases dramatically, and the emissions from collection trucks also increases (Ekvall et al. 2006). The weak support for kerbside collection in the survey was unexpected for the EPA. It was the most important reason why they dropped the plans for the regulation on kerbside collection (Due 2007).

Discussion and conclusions

Results from LCAs and CBAs have affected Swedish waste-management policies. Sometimes LCAs reach conclusions that are expected in advance. This was true, for example, for the early studies carried through on behalf of the Swedish Packaging Commission and REFORSK, and for the recent survey by Tyskeng & Finnveden (2007). In such cases, the LCA results do not change the policy decisions but they make it easier to justify these decisions and to implement them.

In some cases, the results are not what the policy-makers expect, and this might directly affect policy-decisions. An example is the literature review on kerbside collection (Ekvall et al. 2006), which made the Swedish EPA change their mind on the planned regulation requiring kerbside collection in all multistorey buildings.

Case studies to assess different technologies and/or systems for waste management have been commissioned not only policy-makers, but also organisations that want to inform or influence policy-makers.

The large number of case studies that have been carried through to date provide a good basis for metastudies, i.e. literature surveys where the systems aspects of waste management are analysed and discussed. They have also given insights into what issues are important in the environmental comparison of waste-management options. As a consequence, much of the debate focus on what fuels are replaced at waste incineration. Early LCAs demonstrated that this is an important issue. On the other hand, little attention has been given, in the informed debate, to the long-distance transports of material collected for recycling. Early LCAs demonstrated that this issue is not very important for the environmental comparison.

Hence, LCA has not only informed decision-makers. It has also assisted the public debate in focussing on the important issues.

While interviewing policy-makers, it became apparent that there is a large difference in the need for detailed information. In some cases, EPA investigators have the time to dig into LCA reports, interpreting them and making up their own mind about the assumptions, methodological choices, results and conclusions. In such cases, the tradition of LCA practitioners to deliver reports with a great deal of information is valuable. The LCA practitioner should not apply weighting across impact categories but leave this part of the interpretation to the EPA.

However, in other cases, the EPA investigators focus on the conclusions presented in the summary. In such cases, they want the conclusions and recommendations to be brief and clear, making it possible to use them, without risk of misinterpretation, in their report to the government. Here, it is essential that the LCA practitioner does all of the interpretation, including assessing the relevance of different scenarios and uncertainties, and also including implicit or explicit weighting across impact categories.

The EPA investigators accept results of an LCA as an indication to the environmentally superior waste-management option. However, they are not accepted as final proof. Investigators at the Swedish EPA are aware of the fact that different LCAs sometimes contradict each other. This is a sound attitude, since the LCA results depend on subjective methodological choices.

In assessments of the environmental impacts of waste management, LCA helps expanding the perspective beyond the waste management system. This is important, since the indirect environmental impacts caused by surrounding systems, such as energy and material production, often override the direct impacts of the waste management system itself. However, the applicability of LCA for waste management planning and policy-making is restricted by certain limitations, some of which are characteristics inherent to LCA

methodology as such, and some of which are relevant specifically in the context of waste management (Ekvall et al. 2007):

- LCA models of waste management often calculate the environmental burdens per kg or tonne of waste generated. It implies that the quantity of waste is unaffected by the management measures investigated. Such models allow for environmental comparisons of different options for dealing with this waste, but not for analyses of changes in the quantities of waste generated.
- Traditional LCA models are also static. In the context of waste management, this implies that they cannot give information about the appropriate time for investments in waste management plants.
- Perhaps more seriously, the system structure and the input data in a traditional LCA both reflect the recent past. This means that, at the best, traditional LCA provides a basis for identifying what waste management strategies are best served to solve the needs of the current society. But waste management plants are large investments that will be used for several decades, and the surrounding society can change significantly during this time. In addition, decision-makers might want information on the long-term sustainability of different technologies, rather than on the environmental performance in the current system.
- Traditional LCA does not differentiate between emissions occurring at different locations. Because of this, the typical LCA model does not give information that is adequate for deciding where a waste-management facility should be sited.
- Pollution involves a very large number of chemical substances. An LCA typically aggregates substances of the same type into sum parameters such as polyaromatic hydrocarbons (PAH), volatile organic compounds (VOC), total organic compounds (TOC), etc. Such aggregate measures reduce the ability of LCA to accurately model actual environmental impacts.
- LCA models are typically linear models of physical flows. This means that typical LCA models cannot be used for identifying optimal reuse and recycling rates.
- Many LCAs use average data to model the systems indirectly affected by the actual system under study. This means that the LCA model is inaccurate in describing how the background systems are affected by changes in the waste management system.
- The results of LCA are limited to environmental impacts, which means LCA provides only part of the necessary basis for a well-informed decision.

Different efforts have been made, and can be made, to improve LCA methodology with regard to these limitations (Ekvall et al. 2007). Other tools are also available that cover issues currently not adequately dealt with in LCA. In some cases, these tools can be integrated into the LCA methodology. To make LCA more relevant for sustainability assessments, for example, it is important to integrate methods for futures studies in the methodology.

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