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Susanna Horn

Sustainability Strategies for Business

An Integrated Approach with a Life Cycle Perspective

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ABSTRACT

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Sustainability and especially climate change as a prominent sustainability issue, has initiated a situation, where scientists, economists, investors and politicians participate in a discourse about proposing actions for mitigating the impacts and adapting to new situations. What makes it complex for businesses is that many impacts are fairly indirect and still intangible. Furthermore, the policies are still forming and the markets are not showing clear indications. The business decisions require awareness of the situation and possible consequences of the decision. In case the strategies are informed ones, the risks can be seen as opportunities for businesses to proactively strategize for the future. The research task is to understand the need for sustainability strategies in businesses and to use an integrated approach with a life cycle perspective as a starting point. The integrated approach in this context encompasses both mitigation and adaptation as responses, i.e. reducing impacts and modifying the own business so that it survives in the future. The thesis utilizes three research methods (content analysis, surveys, event methodology) and EU commission reports, surveys, investment announces and historical stock prices as data sources. The Climate and Sustainability SWOTs are named as streamlined tools to systematically approach the future. Their basis is the life cycle framework, which includes the impacts caused upstream in the supply chains, or downstream in the consumer or end-of-life actors. There is a tradeoff between usability and accuracy of the results when using these tools but they can be taken as first-cut approaches to lessen the lack of structure in the assessment. According to the results of this study they are able to generate operative and strategic changes within the life cycles. It is encouraging that the streamlined approach tailored according to the logic of business decision-makers is able to find the acceptance and understanding of that vital group. In fact, awareness to climate change, or any sustainability issue, is an important trigger for business action and so far greatly undervalued. Keeping in mind that the LCA community is faced with fears of having its methods understood only by a subset of professionals, the tools need to become accessible for wider audiences. Furthermore, the regulatory framework is undergoing changes. Only by considering the future's regulatory framework, will the company maintain its license to operate. Finally, the investors are expecting actions by the companies in order to ensure future operations.

Keywords: life cycle perspective, climate, sustainability, strategy

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During the process of writing the thesis, academically, I have been enthusiastic about many different things and changing topics every so many months. Some topics became irrelevant, some uninteresting, some were forgotten, or some research questions could not be answered, and some required moving to developing countries, which was physically too challenging keeping in mind that my son was a small baby at the time. So what you are holding in your hands is the result of an almost naive interest to many different things. But looking at it from the bright side, is it not something we need: a holistic approach integrating different viewpoints to reach a more sustainable future. It may sound like a cliché, but it is something I have truly learnt during this research.

I would never have been able to finish this dissertation without the guidance of my supervisor, Professor Hanna-Leena Pesonen. It is with the warmest gratitude that I thank her for the ideas, cooperation, patience, efforts to put focus into my work, but also the friendship that has evolved during the years.

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Susanna Horn

ABBREVIATIONS

AGGG	Advisory Group on Greenhouse Gases
AR4	Fourth Assessment Report
CDP	Carbon Disclosure Project
CO_2	Carbon dioxide (GHG)
CO	Carbon monoxide (GHG)
DSM	Demand side management
EC	European Commission
EEA	European Environment Agency
EE-IOA	Environmentally Extended Input Output Analysis
EU	European Union
EU-ETS	European Union's Emission Trading System
FAR	First Assessment Report
GHG	Greenhouse gas
GRI	Global Reporting Initiative
ICSU	International Council of Scientific Unions
IIGCC	Institutional Investors Group on Climate Change
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization of Standardization
LCA	Life cycle assessment
LCC	Life cycle costing
LCM	Life cycle management
LCSA	Life cycle sustainability assessment
CH_4	Methane
N_2O	Nitrous oxide (GHG)
O_3	Ozone (GHG)
OECD	Organisation for Economic Co-operation and Development
SAR	Second Assessment Report
S-LCA	Social life cycle assessment
SME	Small and medium-sized enterprises
SWOT	Analysis tool for Strengths, Weaknesses, Opportunities, Threats
TAR	Third Assessment Report
UN	United Nations
UNEP	United Nations Environment Program
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
WMO	World Meteorological Organization

FIGURES

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1 INTRODUCTION

> "Don't think of climate change as an environmental issue; think of it as a market issue. In fact, you can remain completely agnostic about the science of climate change, but still recognize its importance as a business issue" (Hoffman & Woody, 2008)

1.1 Background of sustainability, environmental and climate-related issues

Sustainability issues have become increasingly important at all levels of modern society. Even though our generation is considered wealthier and healthier than our predecessors and economic growth has raised many people from poverty, the natural environment is facing serious threats caused by human beings and the wealth among nations is distributed more unevenly than ever before. The paradox is that our livelihoods are reliant on the natural and sociocultural environment and its viability. Ultimately, if we choose to exploit more of our natural and social resources at a growing pace, there are no longer the premises to generate the same type of economic activity and wealth.

With regard to the environmental aspect of sustainability, climate change has become the most prevalent topic. And even though it has been noted that sustainability should not be reduced to mere carbon accounting, climate change serves as the most prominent and well-controllable basis for discussing the regulatory and physical changes businesses are currently facing[1]. There have been other widely discussed topics as well that have provoked criticism about neglecting environmental responsibility (e.g., the use of pesticides, ozone depletion, loss of biodiversity) but the Revelle and Keeling's discovery of carbon dioxide (CO_2) accumulation in the atmosphere in 1957 has been increasingly significant, gaining interest from academia, policy-makers and industry ever since. Sir Nicholas Stern (2008) distinguished four reasons why greenhouse gas

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[1] The interrelationship between sustainability, environmental sustainability and climate change is discussed in more detail in section 2.3 and Chapter 5.

(GHG)[2] emissions are different from other environmental externalities and should receive appropriate consideration: the global impacts, the long-term scope of the effects, the uncertainty of the scientific models and finally, the irreversibility of the effects. In effect, climate change is posing a severe risk to modern society with unforeseen environmental, social and economic consequences (disaster risk, implications for environmental quality and natural resources, global and aggregate impacts, meeting development goals, etc., as listed in IPCC, 2007). In a 2007 report, the Intergovernmental Panel for Climate Change (IPCC), which includes more than 1300 scientists that provide comprehensive scientific, technical, and socioeconomic assessments related to climate change, forecasts a temperature rise of 2°C by the end of the century if the present amount of GHGs is emitted and postulates this risk being largely due to human activities.

The risks associated with climate change will vary over time as well as with the ability of different societal and environmental systems to mitigate or adapt to change (IPCC, 2007), but they include such severe issues as water scarcity, droughts, floods, famine, storms, hurricanes, typhoons, abrupt changes in weather, the rise of the sea level, a loss of land area, extinction, wildfires, and heat waves. These are all emphasized through feedback loops, which mean that higher temperatures cause plants to soak up less carbon from the atmosphere and permafrost thaws releasing methane (CH_4), amplifying warming by additional 1°C–2°C. Further disasters can be initiated by irreversible system feedbacks and impacts associated with the collapse of thermohaline circulation, the melting of the Greenland ice sheet (Gregory et al., 2004), or other singular events (Alley et al., 2003)

The problems surrounding sustainability and more specifically around climate change are everything but unambiguous and a situation has developed where natural scientists, economists, investors, social scientists and politicians have all been participating in a societal discourse about the risks, proposing actions both to *mitigate* the impacts and to *adapt* to the new situation (two fundamental societal response options for climate change). Even though mitigation has received greater attention than adaptation, both scientifically and from a policy-perspective, both responses can be regarded as complementary and mutually reinforcing, rather than as substitutes for each other (Füssel, 2007).

1.2 Regulatory issues related to climate change

The policy development related to climate change, which is currently one of the most prominent sustainability issues being discussed and the reason why specific focus is taken on that issue (Schaltegger & Csutora, 2012), has been strong and volatile. The disconnection between mainstream economic targets and

[2] The main GHG are CO_2, CH_4, N_2O HFCs, PFCs and SF_6, which are covered by the Kyoto Protocol.

those of environmental scientists offers one arena of debate: Should society strive for ever-increasing economic growth, which exhausts our natural resources, or should it prioritize our environment and the sustainable use of it? The policies set the framework for the operative environment: What are the legal limits and the general strategies of human society?

As mentioned, there are two widely discussed policy responses to climate change: mitigation and adaptation. Mitigation implies strategies, mainly drawing on climate policy, to reduce GHG emissions. Adaptation denotes the actions that are taken to reduce the risk and vulnerability to climate impacts or actions to take advantage of the potential impacts.

In relation to mitigation, there is an ongoing debate over the implementation of international emission reduction targets. Policy-makers face uncertainty in developing this new framework and, depending on the nation, there are differing approaches and reduction targets. Some have ambitious goals (e.g., European Union, Iceland, Norway, Switzerland) and others have rather conservative ones (e.g., the United States of America, Canada and many of the Non-Annex I[3] countries which are benefitting from not having binding limits yet). In adaptation there are no binding attempts yet in the international policy framework, but many governments are already preparing for the likely impacts of climate change through adaptation plans.

1.3 Sustainability and climate change transferred to the corporate world

Mitigation and adaptation to all kinds of changes in the operating environment can be considered in the private sector as well and an integrated approach should be applied. Businesses face a range of risks due to sustainability challenges, environmental issues and climate change, and these risks shape the environment in which companies operate. Having more complex economic processes and a global economy with longer transportation routes and more refined materials requires the scope of companies' analyses to be wider. These economic analyses should emphasize the risk and uncertainty, ethics and economics as well as notions of responsibilities and rights (Stern, 2008). However, we are currently in a situation where the risks are accepted by companies only partially and the implementation of risk management actions is still failing (Agrawala, 2011).

Many companies might be aware of sustainability issues and climate change but still struggle with how to manage it. In effect, companies have the choice of acting on a continuum of reactive to proactive stance in planning their strategies for the future (Clarkson, 1995). Pressures are arising from society,

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[3] Non-Annex I countries are mostly developing countries, with no binding emission reductions. The countries included in Annex I include all the OECD countries and economies in transition. Non-Annex I countries are by default all other countries.

consumers, policy-makers, competitors and investors to change their environmental performance. If pressures are seen as merely cost-generating, companies will at minimum respond to changing regulations. However, the pressures could be regarded as opportunities to proactively strategize for the future and could lead the way to a low-carbon society. How quickly a business wants to make the transition and develop a long-term strategy based on a smaller environmental burden instead of short-term quarterly strategies, is ultimately up to the business itself. The policies are still forming, the markets are not yet showing clear indications, so which risks a business is able to carry is individual (Hoffman & Woody, 2008).

1.4 Corporate world aided by life cycle methods

Businesses must be able to find ways to consider and analyze how their activities affect the climate, the environment and the society. Furthermore, it is not only businesses' activities that cause impacts. Impacts can also come from upstream in their supply chains, or from downstream on the consumer side or end-of-life patterns. For climate change in particular, what makes it complex for companies is that many impacts are fairly indirect and still intangible. For that reason, the life cycle perspective is a reasonable and valuable starting point, because it ties together the upstream and downstream processes. The life cycle perspective has been used for decades in various forms, and for several years it has been used for regulations as well. Life cycle assessment (LCA) is a common method for considering full life cycles and it has been standardized by the International Organization for Standardization (ISO) as the compilation and evaluation of inputs, outputs and potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006)[4]. It is clear, however that industry is not aware of the method, its assumptions and the possibilities it offers to generate changes. Instead, they often associate it with increasing costs. (Rebitzer & Schäfer, 2009) LCA scientists are developing the method to cover all interactions between life cycle emissions and impacts on the environment, including temporal issues, complex health issues, market impacts, and uncertainty modeling, often neglecting the fact that these developments only make the method diverge from the priorities of business decision-makers because it becomes too difficult to understand. In the end, this complicates the aim of LCA, which is to optimize the industrial processes within the life cycle of a product system so that it generates less environmental impact. If the gap between industry and LCA scientists becomes too wide, there is little point in carrying out a full-scale LCA if no changes can be materialized.

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[4] In addition to LCA, other life cycle methods are life cycle costing (LCC), social life cycle assessment (S-LCA) and life cycle sustainability assessment (LCSA, which embraces LCA, LCC and S-LCA). However, these are not as widely used in this context as LCA is and will be further discussed in Chapter 5.

There is a branch of scientists concerned with raising awareness, especially within industry, of life cycle based methods, and with making their results easier to communicate to all relevant stakeholders (e.g., Klöpffer, 2008; Finkbeiner et al., 2010; Valdivia et al., 2011; Jørgensen et al., 2009; Rebitzer & Schäfer, 2009). The added value of an LCA, or any life cycle based method, is interesting to the business community for four business reasons: (1) The energy and material usage of processes is reduced, which reduces costs directly. (2) This reduction in usage leads to a more environmentally friendly product, fulfilling the demands of increasingly environmentally conscious consumers. (3) For listed companies, their stock price can be theoretically calculated by discounting all future net cash flows. If future costs are reduced, as in (1) and income increased, as in (2), it would lead to a higher net cash flow and thus to a higher market value. (4) The policies will force and incentivize companies to start including life cycle methods, or any methods leading to environmentally positive changes.

So why is it, that LCA practitioners are still facing barriers in integrating the methods into standard business decision-making? Are they watching the world from their ivory tower and producing complicated analyses, which no decision-maker can use? As Rebitzer & Schäfer (2009) stated in their epilogue for a special issue on LCA in aluminum applications: "The LCA community needs to learn the language of the receiver." In the LCA community, this issue is seen as a pivotal problem of the entire field. Furthermore, LCA practitioners working in the private sector face the threat of becoming marginalized, with no real objective apart from producing an LCA. This might be sufficient for companies to feed into disclosure mechanisms such as the Global Reporting Initiative (GRI) or Carbon Disclosure Project (CDP) and to announce it in their sustainability reports. However, re-entering the discussion already raised by Pesonen in 2005: Could management tools be mobilized to complement the life cycle methodologies and the accounting and analysis of material and energy flows in order to control, reduce, or prevent the sustainability impacts of a defined life cycle?

1.5 Structure of the thesis

In research as complex as the underlying one, it becomes important to carefully review the structure of the report and accentuate those parts, that are important for the storyline and understanding it as a whole. Figure 1 presents the framework of the report.

The report of the research consists of six chapters. Chapter 1 introduces the current societal problems in terms of sustainability and in particular its environmental perspective. In this regard, climate change is specifically considered to be the fundamental sustainability problem of our time (Schaltegger & Csutora, 2012; IPCC, 2007; Stern, 2007). Thus, it drives the storyline of this report. Nevertheless, climate change, and even environmental problems in general, are not the only issues related to sustainability. When applicable and pos-

sible, wider sustainability implications are discussed, even though issues such as social problems are left out of the scope of this study. Chapter 1 highlights the usefulness of the life cycle perspective (LCA, LCC and S-LCA) as the focal point of the entire thesis. Such perspective includes both downstream and upstream processes; detects climate change as well as other environmental impacts, social impacts and economic impacts; and introduces strategic options for companies for mitigation and adaptation.

Chapter 2 explains the motivation behind the research and the academic literature gap as well as the main research questions. Furthermore, the methodological choices of each article are also explained.

Chapters 3–5 introduce the study's key topics as well as the relevant theoretical frameworks that are employed and combined. Chapter 3 sketches the landscape businesses are faced with today. It establishes climate change as the fundamental environmental and sustainability problem of current times. Figure 1 shows how, from a business point of view, changes are forced on the operating environment in two ways. The first way is from the physical environment, as seen in Figure 1 in the top left corner. This includes climate change in particular, which is why the phenomenon is used as a leading storyline in this study. The second way is from the regulatory environment, as seen in Figure 1 in the top right corner. Again, climate change is causing significant changes in the regulatory environment as well, which is why this study focuses on climate and energy policies.

After the operating landscape has been described from a physical and regulatory perspective, Chapter 4 brings the focus to the private sector and what it can do to tackle these problems (Fig. 1, lower half). From an adaptive point of view, Chapter 4 leads the report to climate strategies as a relevant branch for businesses. Furthermore, it introduces market and investor impacts (to climate but also to other environmental issues), which are particularly relevant for larger companies having reporting duties also to their external stakeholders.

Chapter 5 provides a discussion of the origin of life cycle methodologies and why they are relevant to the scope of this study. First, the chapter summarizes the logic behind the levels of sustainability, environmental and climate issues dealt with in the study and shows that they are not isolated or contradictory, but rather they are nested within each other. Second, it describes these methodologies as tools for companies to embrace these issues from a strategic point of view. These tools are further characterized as being full-scale assessments or streamlined, lighter versions of assessments, in which it is left up to companies themselves to assess the trade-off between the accuracy and usability of the results.

Chapters 6 and 7 tie together and report the major findings of the separate studies of the thesis. Chapter 6 discusses the first set of findings on the evolution of the EU's climate and energy policies. It is seen that these are mainly treated in an integrated manner within the EU. The second set of findings arises from the tools used to adapt to the changes. In these findings, climate and sus-

tainability tools are discussed and evaluated for how they generate changes within a network (downstream and upstream) or at organizational levels (i.e., strategic or operative). The third set of findings arises from the analysis of whether or not these changes can be traced further to investor choices. In other words, the analysis attempts to determine if certain kinds of activities (in this case environmental investments) are rewarded by the investment community

Chapter 7 summarizes the main results of the study, outlines theoretical contributions and discusses the practical implications of the results for various actors. The conclusion presents possibilities for future studies in the area of sustainability.

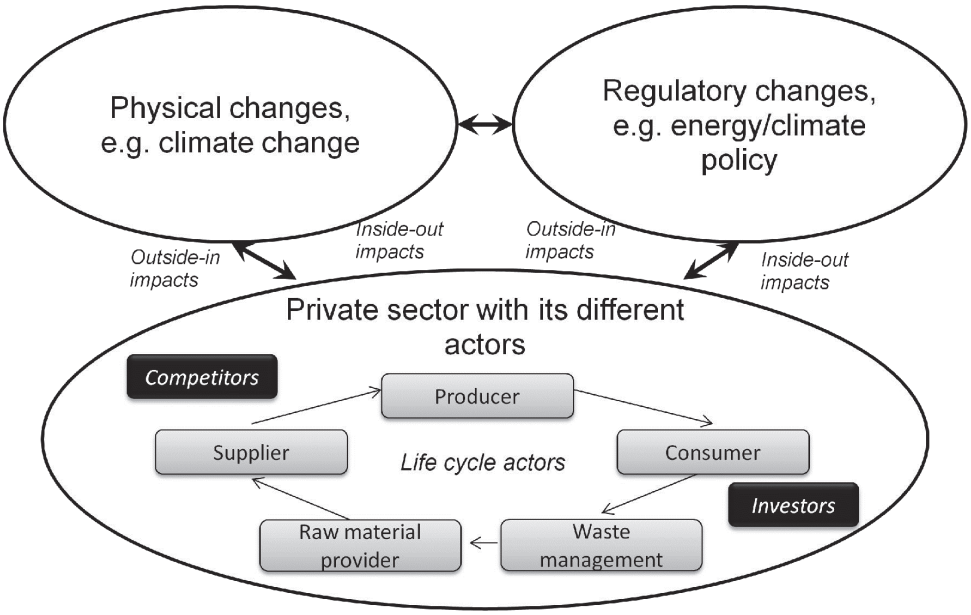

FIGURE 1 Research framework

2 RESEARCH MOTIVATION, METHODOLOGY AND DESIGN OF THE STUDY

This chapter describes the motivation behind the study and which research questions were chosen to be approached in this context. Furthermore, the chapter describes how the chosen set of articles relates to each of the research questions and which methodologies are used to answer these questions.

2.1 Motivation

2.1.1 Private sector responses to climate change

In the last few decades, international organizations such as IPCC, the Organization for Economic Co-operation and Development (OECD), the United Nations (UN), the United Nations Development Program (UNDP) and the United Nations Environment Program (UNEP), as well as numerous governmental organizations have initiated large-scale programs to mitigate current and future environmental challenges and adapt to them, especially those related to climate change. Additionally, assessments of the costs and benefits of adaptation have been initiated (Agrawala & Fankhauser, 2008; Parry et al., 2009; Stern, 2006; World Bank, 2006; UNDP, 2007). In parallel, the academic interest in the planning, financing and implementation of adaptation to climate change from the public sector's perspective has grown (e.g., Urwin & Jordan, 2008; Füssel, 2007; Adger et al., 2005), with some of the focus on developing countries (e.g., Schmidt et al., 2008; Adger et al., 2003; Paavola & Adger, 2006) or other specific regions (Ruth & Lin, 2006). The private sector has been studied primarily as a source of funding (Ayers, 2009; Bouwer & Aerts, 2006). However, little attention has been paid to how it is responding to the risks and opportunities of climate change and wider sustainability issues.

There is a contribution to be made in understanding the private sector's motives to mitigate and adapt and how these can be accomplished. These can

have a powerful impact on the success of international and national climate strategies. Thus it is important to understand the business dynamics in order to facilitate the policy development, recognize possible barriers for an effective policy framework and identify the tools to encourage their engagement (Agrawala et al., 2011).

Companies are aware that some changes are likely to occur with an impact on the operational environment of making business both in operational and strategic terms. The impacts depend largely on the sector, value chain or the geographic region and can be negative for some or positive for. It is apparent that being aware of and anticipating the effects of climate change and other sustainability threats as well as communicating these activities to the public (consumers and investors) becomes more important for companies to uphold their business and seek further strategic opportunities. Moreover, since the emissions of many businesses depend greatly on the sector, the product-specific life cycle perspective is a plausible premise for assessing their climate, environmental and sustainability impacts.

2.1.2 Life cycle perspective

There is academic interest in life cycle methods (assessment methods for the entire life cycle of a product or service to determine environmental, social, economic or sustainability impacts) and their streamlined applications. In terms of streamlined tools, the contribution becomes apparent when reading the current statements of academics. Bala et al. (2010), Hochschorner and Finnveden (2003), Liedtke et al. (2010), McAloone and Bey (2009), Schulz et al. (2012) and Valdivia et al. (2011) all agree on the fact that even though LCAs are valuable assessment tools, in some cases, they cannot be used due to a lack of time or other resources. This has fostered the recent emergence of a branch proposing indicatory management tools with more relaxed data-quality standards that identify sustainability impacts without being cost or time intensive. Furthermore, Rebitzer and Schäfer (2009) published the results of an industry-specific survey that demonstrated that LCAs as a methodological framework is only understood by little more than a quarter of the respondents and that knowledge about LCAs and what they can do is not yet part of mainstream thinking. Nevertheless, LCAs are widely cited as background data in regulatory documents and have been used to assess the potential of alternatives to reduce GHG emissions (Wardenaar et al., 2012). Environmental labeling, public procurement standards, biofuels standards and more all use the life cycle perspective as an assessment approach, but if we consider the level of understanding and the arbitrariness of the method, is the use justifiable? It is in the interest of the LCA community to encourage a discourse with policy and industry decision-makers to enable the use of life cycle methods in the future. Researchers need to understand how well life cycle results are understood in real-life decision-making, what brings them closer to real application, how life cycle thinking can be carried over to strategic choices in business and how to make real changes toward a more sustainable course of action (Finkbeiner et al., 2010).

A further branch focuses on sustainability modeling from a life cycle perspective, also known as life cycle sustainability assessment (LCSA). Climate change is currently one of the most threatening global problems. Nevertheless, reducing environmental impact assessments to carbon footprints reduces the scope too much (Finkbeiner, 2009). There are other important environmental and social impacts present as well. If trade-offs need to be made, such as between child labor and climate change impacts, it should be at least an educated decision. Therefore the holistic approach of sustainability is valuable and Klöpffer has initiated the discussion of how to carry out a full sustainability assessment (Klöpffer, 2006; 2008; Klöpffer & Renner, 2008). Furthermore, as Klöpffer and Ciroth (2011) predict, "the further development of LCSA will mainly depend on the improvement of the [individual] life cycle methods" underlining that all pillars of sustainable development are relevant to the final framework. A recent report by the Life Cycle Initiative introduced the framework of an LCSA (Valdivia et al., 2011).

2.2 Research problem

To understand the complex interplay between businesses, policy, environmental problems and assessment tools, I start this study by describing the current setting and operational environment businesses face, highlighted by current climate change efforts. In an attempt to gain a better understanding of private sector activities, my analysis considers the principal risks that businesses are likely to face due to climate change and takes a detailed look at the investor perspective. Finally, I examine the methods businesses can use to address these risks and how to benefit from them.

My research task is to understand the need for climate strategies in businesses and to use an integrated approach with a life cycle perspective as a starting point for the strategies. In this context the *integrated approach* encompasses mitigation and adaptation as responses to climate change, that is, reducing GHG emissions, while also modifying one's own business so that it survives in the future framework. Furthermore, the *life cycle perspective* is applicable in the sense that a product-specific assessment is practical for businesses.

This assessment addresses the following questions:

- How has the regulatory framework around climate change and energy issues evolved from 1997 to 2007 in the EU? (Article I)
- How can life cycle tools be applied to private sector sustainability (climate) strategies?
    - Are these tools effective? (Articles II and III)
    - How do they initiate actions in businesses? (Articles II, III)
- Are there market-based incentives for private companies' climate-friendly and environmentally friendly investments? (Article IV)

These questions are approached by first describing businesses' operational environment in terms of physical changes (see Figure 1, top left corner), with climate change being the most prevalent environmental challenge. The anticipated changes due to climate change as well as the changes which have already occurred on Earth have a drastic impact on many levels – primarily on resource availability but also on logistics, demand structures, regulatory designs, and geographical distribution, to name a few. Due to the socio-economic perspective of my research, the natural changes will not be researched further in any of the articles.

However, the regulatory changes (see Figure 1, top right corner) to mitigate and adapt to climate change are discussed and studied in Article I (Horn & Korsunova, 2011). As with the physical changes, for businesses the main impact of the regulatory perspective is caused by new climate policies. The policy framework has been studied due to data availability mostly from the EU perspective. The EU is developing its climate and energy policy with an integrated approach and in 2007 introduced the EU's climate and energy package. I analyze the pathway to this extensive policy, how the EU has initiated the discussions and what the important trends prior to the policy over a 10-year period before the package was introduced (1997–2007). It sets predictable demands for efficient technologies and liberal markets and within this framework, climate change policies are widely nested in energy-related policies or other environmental legislation. For businesses, it is important to stay informed about, even have an impact on, the policies that define the leeway within which companies can operate. The synopsis includes a background of the evolution of the climate-related international framework.

The next step is to bring these issues into the context of the private sector (Figure 1, lower half). In articles II and III topics such as business strategies in climate change and sustainability at large, their impact on overall activities and the awareness of the continuing changes among business decision-makers are discussed as drivers for responsible businesses. These articles emphasize testing the ability of the life cycle perspective to help companies tackle either climate change or sustainability problems. These problems are integrated through tools such as the Sustainability SWOT[5] and the Climate SWOT, which use climate change or sustainability strategies as well as awareness building as a backbone and allow an operationalization of the concept of sustainability, be it an environmental one or a holistic one (the latter includes social and economic sustainability as well). Both of these tools are analyzed with surveys in Article II and Article III. The tools also integrate the activities of actors in the value chains and competitive advantages over their competitors within the assessment framework. Life cycle management (LCM), as a management approach, is applied in these tools, which means that management is able to use life cycle thinking in its operation.

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5 SWOT is an analysis tool encompassing strengths, weaknesses, opportunities and threats

An additional branch of quantitative studies is introduced in Article IV, since it clearly represents an additional driver for businesses to act responsibly – namely the stock market reaction to responsible vs. irresponsible business decisions. I examine this issue more closely with panel data from large Finnish pulp and paper companies as well as energy companies over a 10-year period (Article IV). This quantitative analysis is then applied to the regulatory framework and the instability the recent evolution of policies has in fact generated – the impact of which can be detected also in investors' choices.

2.3 Concepts and definitions relevant for the study

The concept of sustainability is discussed in detail in section 3.2.6. However, it is important to understand the connections between sustainability, environmental sustainability and climate change. Sustainability and its operational principle, the triple bottom line, include the perspectives of environmental, social and economic sustainability. Thus, environmental sustainability is one part of sustainability at large. Environmental sustainability, on the other hand, consists of many different environmental impact categories, out of which climate change is one (other ones being eutrophication, acidification, biodiversity, ozone depletion, ecotoxicity, land use, etc.). This means that assessments of sustainability, environmental impacts and climate change are largely complementary: climate change is an indicator of environmental sustainability, which again is an indicator of sustainability at large (Figure 2.). Nevertheless, when studying the sustainability of a system, it should be accepted that it is most often not enough to restrict the assessment to a mere carbon footprint (i.e., climate change assessment), even though the current emphasis is on carbon footprinting and climate change. The problems arising from reducing the scope too much is discussed in section 3.2.5. This study focuses on climate change, especially with regards to the regulatory system and business adaptation strategies, but it makes an effort to apply the issues as often as possible to sustainability at large. Social issues, as well as other environmental impact categories apart from climate change, are therefore left outside the main scope of this study.

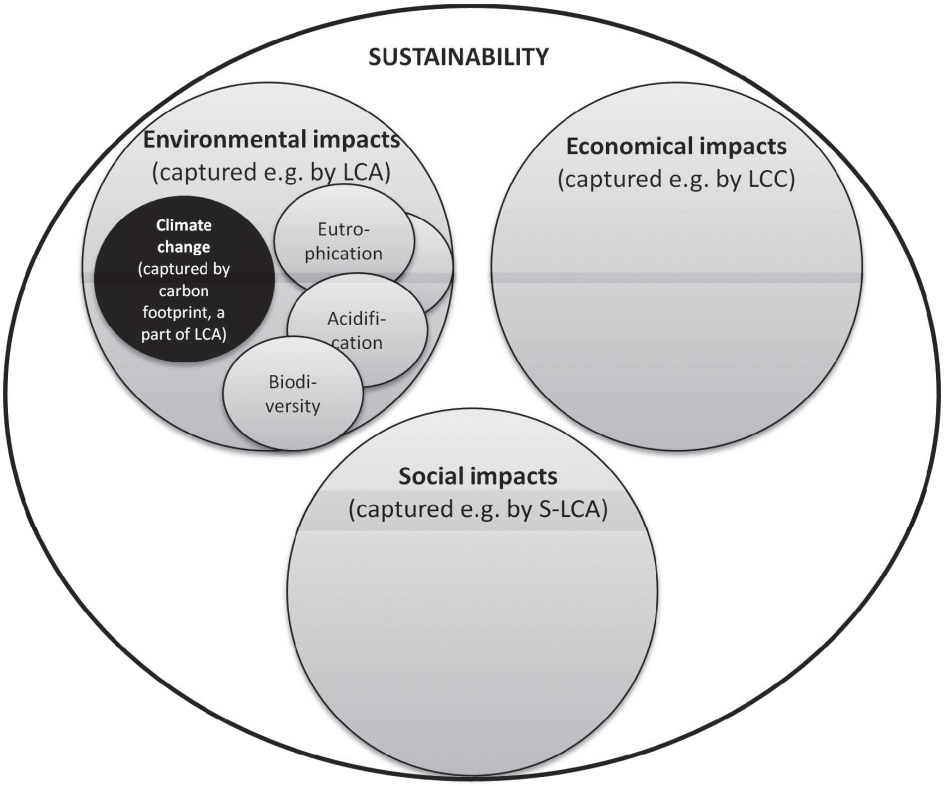

FIGURE 2 The relationship between sustainability, environmental sustainability and climate change

For the purpose of this study, the private sector is defined as privately owned or controlled organizations. Within the private sector there is a wide range of possible business structures, ranging from small and medium-sized enterprises (SMEs) to multi-national corporations. The private sector structures consist of supply chains and other life cycle actors during the life cycle of a product system. Investors are mostly part of this sector.

In the context of climate change risks (and opportunities) for businesses, it is important to understand and distinguish the two societal responses to climate change – adaptation and mitigation – first on a general level and later on a specific level in the context of business, as discussed in section 4.1.1. Broadly speaking, adaptation means dealing with the consequences of climate change. Adaptation to climate change has been defined by several governmental organizations (e.g., Canada, UK, USA, EU, EEA, Australia), by international organizations (e.g., IPCC, UNFCCC, UNDP, UNEP and OECD) as well as academia (e.g., Adger et al., 2005, Nitkin et al., 2009) from different perspectives and there is no clear consensus. However, if we disregard deeper semantic constructions, climate change adaptation is as an adjustment process to cope with climate stimuli or damages which have already occurred or are expected to result from climate change. In short, adaptation comprises the activities taken to reduce the risk or

take advantage of the opportunities of climate change. According to the European Environment Agency (EEA), this would include different activities, such as technological solutions, ecosystem-based options, policy measures and managerial solutions, which would ensure ecosystem resilience and adaptive capacity in general (EEA, 2012).

Mitigation is often mentioned in the context of adaptation. It refers to the human interventions to reduce the release of GHGs or enhance their removal from the atmosphere, therefore avoiding any further change in the climate (IPCC, 2009). There are certain interrelationships between adaptation and mitigation actions. Adaptation and mitigation can have consequences for each other and the processes involving them can also have trade-offs or synergies. The IPCC stated that "effective climate policy aimed at reducing the risks of climate change to natural and human systems involves a portfolio of diverse adaptation and mitigation actions" (IPCC, 2007). Creating synergies between both actions is the ultimate aim. However, because these actions are often taken on different policy levels (IPCC, 2007) it can be difficult to coordinate them effectively.

Hertin et al. (2003), Berkhout et al. (2006) and Agrawala and Fankhauser (2008) assume that climate change is only one driver among many for future industry changes, including technological and commercial innovation, changing regulations, and at root, shifting consumer expectations. Inevitably, humans are crucial factors due to their consumption patterns and psychological processes, and questions regarding these patterns and processes should be incorporated into the analysis: Why do people want to consume more? Why is "sufficient" not enough, but instead they want to have more things that consume more materials and energy? Is there a correlation between consumption and happiness? There is a branch of cross-disciplinary studies that discusses consumption's role in society and sufficiency in consumption (Durning, 1991; Hofstetter et al., 2006; Jackson, 2005; Max-Neef, 1991; Sanne, 2002; Young & Figge, 2004; Princen, 2005). Nevertheless, even though the psychological role is accepted as crucial, it is outside the boundaries of this study.

2.4 Research design and methods

Modern scientists, working with technological and highly specialized themes, are seldom aware or interested in the work of philosophers (Thornton, 2012). However, whether or not we are aware of it or not, we all have our philosophies (Popper, 1972) and our philosophies can and will have a great impact upon our actions. Therefore it makes sense to take a short look at the philosophy which has led – quite unconsciously, I must admit – to this study. When philosophical literature is used in research, it is advised to first consider the philosophical aspects and then proceed with the actual research (e.g., Eriksson & Kovalainen, 2008).

2.4.1 Epistemology, ontology and methodology

The scientific paradigm within which to conduct this research is realism: The identification of the structures of the world and, in terms of (expected) concrete and tangible environmental impacts, there is an observable world independent of human consciousness (Eriksson & Kovalainen, 2008). The scientific proof of certain environmental impacts, in particular climate change, is mostly objective (but still imperfectly apprehensible) in nature, implying that it is not dependent on the individual, social constructs or any other subjective issues and that it can be assessed by quantitative means. All human processes are faced with the same realities from environmental degradation (e.g., changing climate, acid rain, pollution) so the reality is "real" but only imperfectly and probabilistically apprehensible (Healy & Perry, 2000). Crossing the line to phenomenology, it is also interesting to examine how these companies and their boards see the phenomenon, the company-specific perspective and interpretation as well as gain insight into the company's motivations and actions towards environmental issues such as climate change. Some parts of the study (Article V) approach positivism, in the sense that the choice of data and its analysis are value-free and the data do not change because they are being observed and assessed by chiefly quantitative means (Healy & Perry, 2000).

I adopt Sala et al.'s (2012) view of sustainability science:

> A solution-oriented discipline that studies the complex relationship between nature and humankind, conciliating the scientific and social reference paradigms which are mutually influenced and covering multiple temporal and spatial scales. The discipline implies a holistic approach, able to capitalize and integrate sectorial knowledge as well as a variety of epistemic and normative stances and methodologies towards the definition of solutions.

In line with this view of sustainability science, the ontological, epistemological and methodological aspects are interlinked. Furthermore, Sala et al. formulate the following definition in the context of sustainability science but well transferable to this study:

> Sustainability science does not aim to define a single and unique truth but to gain comprehensive and robust knowledge capable of addressing and solving complex and societally relevant problems, taking into consideration the whole range of values, perspectives and interests from all actors that have a legitimate interest in the problem solution.

2.4.2 Data collection and analysis

In realism, commonly accepted methodologies are case studies and convergent interviewing. Triangulation and interpretation by qualitative and some quantitative methods are accepted. There is a distinct tradition of research methods that advocates the use of multiple methods, usually described as convergent methodology, multimethod, or triangulation (Jick, 1979). Triangulation allows the use of multiple methods, data sources, observers or theories to examine the same phenomenon (Denzin, 1978; Jick, 1979). The concept can be traced back to

Campbell and Fiske (1959), who developed the idea of "multiple operationism," arguing that more than one method should be used in the validation process. Another early reference to triangulation was in relation to the idea of "unobtrusive method" proposed by Webb et al. (1966), who suggested that the uncertainty of an interpretation is reduced if the results have been confirmed by several independent measurement processes. Even though triangulation is often used in the context of qualitative research (Flick, 2011), it has also been discussed in the debate about the relationship between qualitative and quantitative research (Jick, 1983). Denzin (1978) distinguished four forms of triangulation: (1) triangulation of data combining different data sources and at different times; (2) investigator triangulation, using different observers; (3) triangulation of theories, approaching data with multiple theoretical perspectives and hypotheses; and (4) methodological triangulation, in which the "within-method" triangulation uses multiple techniques within a given method (e.g., multiple scales) and "between-method" triangulation involves contrasting research methods, such as questionnaires and observation. Triangulation has been applied in the study as part of articles II-IV because the phenomenon being studied consisted mainly of the business responses and their impacts on climate change and other sustainability problems. These four use multiple methods (qualitative and quantitative), data sources (interviews, surveys and statistical data), as well as theories (network theories, strategy-based theories, asset pricing theories, etc). As the first article's function is mainly on providing and overview, it should not be regarded as part of the triangulation and investigation of the same business phenomenon.

This thesis utilizes four different research methods from the quantitative as well as from the qualitative research approaches.

TABLE 1. Outline of each article's goal, approach, data collection, analysis method, sample size

Article	**Goal**	**Approach**	**Data collection**	**Data analysis**	**Sample size**
I	Understanding policy background	Semi-quantitative	COM-documents	Content	57 COM-documents
II	Studying the usability of Climate SWOT and generated changes	Qualitative/ quantitative	Survey	Statistical and thematic	36
III	Studying the use of Sustainability SWOT and generated changes during the life cycle	Qualitative/ quantitative	Survey	Statistical and thematic	29
IV	Analyzing the influence of environmental investments on market value	Quantitative	Stock rates, press releases	Event study methodology	Stock prices (6 companies) 1.1.2003 – 15.5.2012

I have approached the role of the regulatory framework in light of the EU policies, which give guidance to more specific national legislation within the area. Due to the lack of resources and the rigor of our approach, it would have been

difficult to answer this question on a global level. Nevertheless, the EU policies are also crucial on an international scale and can be used as indications for the global progress. Because official policies are not formulated yearly, it is impossible to find a dataset extensive enough from completed and published policies which would reveal the entire nature and trends of energy issues in the EU. Nevertheless, directives require the commission reports (COM documents), in which the proposals for action are comprehensively discussed. Thus, in Article I the data was collected from theseCOM documents, in which all proposals for action are comprehensively discussed. They can be found in the EUR-Lex database for preparatory acts (EUROPA. Eur-Lex: Access to European Union Law). Altogether, 57 documents, ranging from 2 to 103 pages, were analyzed. The concern with climate change was first manifested in the White Paper on Energy Policy for the EU in 1995. Ever since, it has been handled in an integrated manner with energy issues, which is the reason for gathering the data primarily from energy policies. In addition, searching only for climate-related documents only would have resulted in only 14 documents for the first nine years and 10 documents for the last three years, a result which is by itself of course interesting, but content-wise would only allow a very thin analysis, especially of the first years.

A content analysis method was applied, which is a semi-quantitative method and appropriate for analyzing policies (Silverman, 1985). This method allows content to be revealed from a source of communication and to compare it across many texts (Neuman, 1994). It was used in an inductive manner, which enables documents to be processed and analyzed systematically and objectively, while deriving the concepts from the data itself (Krippendorff, 2004; Kyngäs & Vanhanen, 1999). According to Sayre (2001), allowing categories to emerge naturally from texts provides a richer and more detailed understanding of the content. To create a visual aid for the analysis and results, separate tree diagrams were constructed for each of the four major themes. The number of diagrams equals the number of years during which a particular theme was most actively discussed in the EU energy policy documents (an example of the coding process can be found in Article I, Appendix 2).

The data for Article II was collected in the form of two surveys. The questionnaires (detailed questionnaires in Article II) were sent to two focus groups. The first focus group carried out an analysis with the Climate SWOT tool and the second focus group used the results in decision-making. The first group consisted of 24 master students, which all had used the tool for analysis in cooperation with the second focus group. The second focus group consisted of business and regulatory decision-makers from Finland, Sweden, Germany, Lithuania, Latvia, Estonia and Russia participating in the EU-funded Baltic Climate project from fields such as public transport, bioenergy and energy efficiency, tourism, port operations, agriculture, forestry and wooden construction. The tool needed to be accepted by the users, easy to use and provide practical results. For this reason it was decided that both target groups were appropriate. The survey given to the first group (May 2011), the users of the tool, consisted

of 35 questions about the usability of the Climate SWOT, specifically related to each assessment phase. The participants answered 16 questions in a Likert-scale format (a five-point scale indicating level of agreement), 18 open-ended questions and one yes/no question. Although the sample size was small (n = 24), a narrow statistical analysis was carried out, mainly by calculating average levels of agreement and by testing the impact of background variables through cross-tabulation and the Kruskal-Wallis test. The qualitative open-ended questions were analyzed for general opinions or possible alterations of the tool by coding the data into negative and positive feedback. Further details were discovered by grouping the results into themes consisting of what kind of issues could be analyzed by whom and how and by which stakeholders (internal or external) these results could be used. The second survey (September 2011) was carried out after the second group, the users of the results, had had six months' time to familiarize themselves with the compiled Climate SWOTs and related strategies. The questions were about how useful the results were, if there were any surprising results and if the Climate SWOT had led to concrete changes. This survey was shorter, composed of 10 questions, out of which one was in a Likert-scale format (1–5 grading), six were yes/no, two were open-ended and one was a multiple response. The closed-ended questions were complemented by a comment field. The analysis of this was carried out in the same way as it was for the first survey and both sets of results were combined. The focus of the research is therefore the evaluation of the tool as it is perceived by the users.

The data for Article III was collected in the form of a survey (detailed questionnaire in Article III) in December 2011 from a focus group that used the Sustainability SWOT tool in analysis as well as the results in decision-making. The survey consisted of seven main questions, out of which two aimed at eliciting background data (size of the organization and sector). Of the others, the most extensive question (with eight sub-questions) asked if actual changes had occurred as a result of using the tool (e.g., concrete investments, strategic redefinition, PR, policy making). In addition to binary yes/no answers, the respondents were able to detail them in an additional comments section. The other questions included a general assessment of the tool, its target audience (multiple response) as well as its novelty value, each of which was complemented by additional comment fields. Even though the sample size was small, a narrow statistical analysis was conducted. This included the calculation of averages and testing if the background data had any impact on the willingness to execute changes (e.g., if certain sized companies are more willing to invest in personnel or if certain sectors are unable to make any changes). The comments were analyzed further by a content analysis to understand the implemented changes.

The final method was a quantitative assessment in the form of an event study (e.g., Hamilton, 1995; Klassen & McLaughlin, 1996; Gupta & Goldar, 2005). The data consisted of stock prices of the Finnish forest industry cluster including pulp and paper producers (Stora Enso, UPM Kymmene, Metsä Board), one paper machine manufacturer (Metso), and two energy suppliers (Fortum, Neste Oil) from January 1, 2003, to May 15, 2012. The events consisted

of investment announcements of either (1) direct environmental investments, e.g. environmentally sound products or processes; (2) indirect environmental investments, in which the environment is mentioned, but not the primary target; (3) non-environmental investment, including all other investments in which the environment is not mentioned. Returns are calculated for a period of one, two, and three days after the event as logarithmic returns and the focus was on the impact of the direct environmental investments in comparison to all other investments. The volatility of the stock return induced by the event was considered separately.

3 OPERATIONAL FRAMEWORK FOR BUSINESS: THE PHYSICAL SCIENCE AND POLICY CONTEXT OF CLIMATE CHANGE ISSUES

This chapter sketches the current operating environment for companies and its origins. Climate change is the focus because it is considered to be one, if not the most fundamental, of the six major sustainability problems, the other of which are deforestation, loss of biodiversity, population growth, poverty, scarcity of drinking water (Schaltegger & Csutora, 2012; IPCC, 2007; Stern, 2007). Companies face changes either in the physical environment (discussed in section 3.2) or in the regulatory environment (section 3.3), both of which are altering the environment in the coming years for firms in areas such as insurance, agriculture, fishing, forestry, real estate and tourism. This chapter describes the situation as it is seen by businesses today. It does not take a stand yet on what they can actively do to adapt to the situation or how to mitigate the impacts. The chapter concludes by putting climate change into perspective with sustainability and life cycle considerations.

In general, human systems are vulnerable in three ways in the context of climate change (IPCC, 2001; IPCC, 2007). First, the economic sector is affected by changes in the productive capacity or market demand for certain goods or services. The importance of this impact depends on the range of economic alternatives. Rural settlements can depend on one resource only, whereas urban settlements have more alternatives available. Furthermore, the adaptive capacity of the settlement depends on socioeconomic factors (wealth, human capital, institutional capability of the settlement). Second, human systems are affected by the impact on physical infrastructures. The concentration of population means higher numbers of persons and physical capital are at risk, although economies of scale can assure some level of well-managed transition. Smaller settlements (including villages and small urban centers) and many larger urban centers in developing countries often have less wealth, political power, and institutional capacity to reduce risks in this way. Third, human systems may be affected by the direct effects of weather and extreme events (IPCC, 2001; 2007).

Climate change also affects businesses. Discussed from a practical business point of view, the chain includes interdependencies between three points that are important within the scope of this research (see Picture 1). The first is the changing physical environment. This is manifested in, for example, the changes in freshwater resources, ecosystems and coastal systems. These types of changes can be substantively different for developed, industrialized countries versus less developed countries and regions (see IPCC, 2007). Second, these changes and the anticipation of further changes has implications on the policy framework on an international, EU-level, national and regional scale. Together, the physical and the policy changes alter the resources and the markets of the future. Finally, the business environment will face a drastically different environment. In the long term, the mitigation and adaptation plans prepare them to face the foreseen physical changes, despite how likely or unlikely they may be at this point (Hoffman & Woody, 2008). The impact of climate change will alter the business environment for all competitors. Further, in case competitors decide to make changes in their product selection, strategies or processes, then this changes the competitive dynamics and the markets. Nevertheless, certain companies, industries and sectors will be affected more than others, because the implications of addressing climate change are not uniform and the burden will not fall evenly (Hoffman & Woody, 2008). [6]

3.1 Typologies of climate risks (and opportunities)

The chain including the physical and policy-level changes and how they affect the business environment can also be set against the exposure to different levels of climate risk (or opportunity), that is, exposure to a situation that produces changes due to climate change and its consequences.

The main risk categories include regulatory risk and physical risk, which are both industry specific, and business risk. The latter is a company-specific risk and includes legal, reputational and competitive risk (Labatt & White, 2007; Wellington & Sauer, 2005). Other partially overlapping, but more specific risk categories can be found in the supply chain risk as well as in product and technology risk (Lash & Wellington, 2007). UNEP (2006) discusses the risks from the classical six-point risk analysis perspective that banks use to review credit proposals: market, operational, reputational, counterparty, political/legal and business risk, which are mainly included in the aforementioned categories. Market risk and counterparty risk address the issue from a slightly different angle. The market risk addresses the volatility of the market value of basic materials—the more volatile the markets are, the riskier the situation is. It can be argued that this is already included in the business risk, product risk (i.e.,

[6] The fourth interdependency is with social systems, which are vulnerable to direct climate impacts, but also indirect impacts, because populations' needs, structures, migration patterns, livelihoods, ethnic conflicts, recreational patterns and health care challenges are expected to change.

product demand) and supply chain risk. The counterparty risk represents the sector-specific risks, especially targeted to the financial sector. In banking, this might be client default during a drought. In insurance it could be moral hazard (inattention to risk), anti-selection (selective purchasing by high-risk clientele), or the failure of a reinsurer (UNEP, 2006). However, Kolk and Pinkse (2004), among others, view the issue not only from the risk perspective, but see many of the categories mentioned below as opportunities.

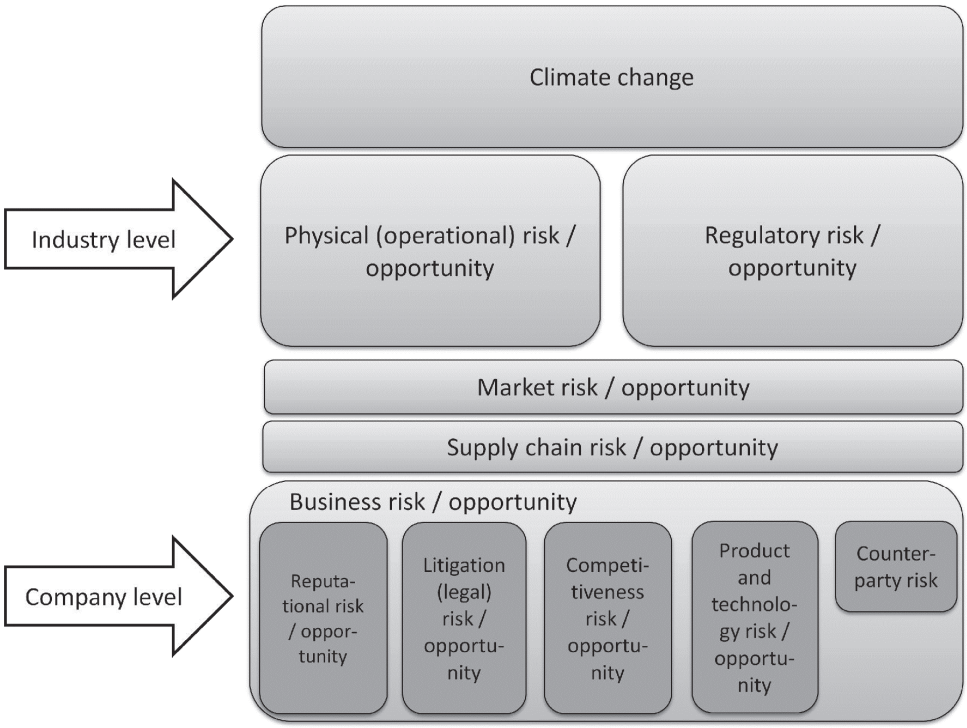

FIGURE 3 Typology of climate risks and opportunities (collected from Agrawala et al., 2011; Ceres, 2007, Labatt & White, 2007; Lash & Wellington, 2007; Kolk & Pinkse, 2004; Jones & Levy, 2007; Wellington & Sauer, 2005; UNEP, 2006)

Physical risk is the most obvious and direct area of impact. It arises from businesses being at risk from the physical impacts of extreme events and gradual climate change. In fact, the year 2011 set records for economic losses and insured losses caused by natural catastrophes in all types of events (geophysical, meteorological, hydrological and climatological events). Extreme weather events accounted for 90% of the disasters in terms of number of events and 8 of the 10 most costly, resulting in overall losses of more than $148 billion (Höppe & Löw, 2012).

Regulatory risk can take the form of emission regulation or regulation of manufacturing processes. In terms of climate change, the regulatory risk is the company's record of compliance, with respect to carbon policies likely to affect its financial performance (Labatt & White, 2007). As a way to illuminate the ex-

posure to carbon policies, the value chain can be divided into three parts, each manifesting a level of exposure. The first level arises from the company's own operations; the second is defined by indirect emissions from the supply chain, especially energy; and the third is described by emissions linked to the use of a company's goods and services. Whether government regulation is viewed as a business risk or opportunity strongly depends on the type of industry. According to a survey by Kolk & Pinkse (2004), the most notable industries that perceive regulation as a risk are oil and gas, mining, metals and utilities. In contrast, the financial sector views government regulation as an opportunity through facilitating customers in emission trading or financing offset projects.

Market risk (UNEP, 2006) arises from the market price volatility of basic materials important for a business. Extreme events or economic disasters make markets more volatile. Changes in consumer habits and demand that accompany changing weather patterns also affect profitability.

Supply chain risk, that is, the vulnerability of the suppliers, arises from pitfalls in the supply chain. Companies evaluate the risks not only for themselves, but also for their supply chain due to potentially higher component and energy costs as suppliers pass along increasing carbon-related costs (Lash & Wellington, 2007). The geographical distribution of the supplier network should be evaluated, since the suppliers are increasingly located far away and they often operate in different regulatory structures.

Business risks, which are company-specific, can arise from legal, reputational, competitive, product and technological as well as counterparty risks. *Legal risks* arise when litigation is brought against companies that contribute to climate change and emit above a legally binding limits. Legal risks are significant, and according to a survey made in the US (Lawyers of Civil Justice, 2010), overall litigation costs are estimated to continue to rise in the future and are consuming an increasing percentage of corporate revenue.

Reputational risks occur when companies act irresponsibly and face consumer or shareholder protests. This is especially important in sectors where brand loyalty has a large impact, such as the automobile sector. However, the reputational issues can also be regarded as an opportunity if a company is able to act in an exceptional manner. This can have important benefits with a variety of constituencies, including investors who consider environmental strategies in making investments; voters who influence future policy; communities who influence a company's ability to expand or build new facilities; employees who work for a company; activists who decide to protest a company's operations; and consumers who purchase a company's products or services. Gaining reputational advantage from climate change is difficult though, given the public's uncertain thinking on the issue (Hoffmann, 2005).

Competitive risks involve the position of the company against its competitors. Depending on the sector, geographical area, political framework and other operative characteristics, some companies will be better off in comparison to others.

Product and technology risk are mostly process related, in case novel products or technologies prove to be failures or processes rely on conservative, inefficient technologies. However, there are significant opportunities as well in fields such as bioenergy, steel manufacturing and plastics.

Counterparty risk arises from a client, or supplier, defaulting due to climate-related impacts (UNEP, 2006). Like supply chain risk, it involves the supply chain network's vulnerability and failure to act or transact as agreed. The counterparty risk, also known as default risk, is used in finance for failure of the parties of a contract to fulfill contractual obligations. Essentially it could also be seen as part of supply chain risk.

3.2 Climate change and the physical environment

3.2.1 Background of climate change

Climate change is mainly caused by society's increasing use of energy for transport, heating, industry and agriculture. If the energy is produced from fossil fuels, it will impact the atmosphere's composition in terms of GHG content and carbon cycle disturbances and cause the temperatures on Earth to rise. Other important contributors to the increase of GHGs in the atmosphere are deforestation, land use, land cover changes, urbanization and an increase in impermeable surface. The greenhouse effect, that is, climate change, is caused by changes in the atmospheric level of GHGs and aerosols, solar radiation and land surface properties, which all alter the energy balance of the climate system. These changes are expressed in terms of radiative forcing, used to compare how a range of human and natural factors drive warming or cooling influences on global climate (Easterling et al., 2000; Walther et al., 2002; Parmesan & Yohe, 2004), as published by the IPCC in their latest (fourth) assessment report in 2007 (AR4).

Forecasts suggest that the changes in the atmospheric composition will cause the sea-levels to rise; reduce biodiversity on Earth; melt the ice caps; reduce crop yields in many areas; increase and intensify extreme weather events such as floods, droughts, storms and heat waves; upheave the ocean circulation with an effect on salinity and water temperature; increase the occurrence of tropical diseases such as malaria; affect crop yield; shift the distributions and abundances of species; end traditional life styles; and cause famines and changes in power consumption and production. Some radical changes include modification of the Gulf Stream, which would result in an abrupt climate change occurring in Europe (AR4).

Since the publication of the AR4, several studies have been in line or even worsened their estimates of the magnitude of climate change and its impacts. Just to mention a few significant research results, Merrifield et al. (2009) and Schaeffer et al. (2012) have found indications that persistent sea-level rise is consistent with or above the IPCC's estimates. Sallenger et al. (2012) found that

sea level rise is not constant everywhere, but is higher in so-called hotspots, such as the east coast of the US, and sea level rise is superimposed on storm surge and wave run-up. This will increase the vulnerability of coastal cities to flooding, and beaches and wetlands to deterioration. Wang and Overland (2009) found indications that sea ice in the Arctic is rapidly decreasing, a finding that has been further strengthened by NASA (2012), which reveals a new consequence of the Arctic's warming climate and provides an important clue to understanding the impacts of a changing climate and environment on the Arctic Ocean and its ecology. Screen et al.'s (2012) results indicate that the Arctic is a main driver in global warming and that the climate is warming faster in the Arctic than elsewhere. The Arctic troposphere has warmed at all heights, but most strongly near the surface and sea ice loss and local sea surface temperature changes are central to near-surface Arctic warming. Geoengineering methods cause abrupt climate changes and do not mitigate the direct effects of CO_2 increase (Robock et al., 2008). The irreversibility of climate change has been studied by Solomon et al. (2009) and the results show that climate change is largely irreversible for 1,000 years after emissions stop.

LCA depicts climate change as one of the environmental impact categories. In fact, LCAs are currently often reduced to mere carbon footprints, that is, estimations of the climate change potentials of a product system measured in CO_2 equivalents. However, they neglect all other environmental impacts that could be estimated with the LCA (e.g., eutrophication, acidification, biodiversity). Nevertheless, an advantage of using the LCA in estimating the carbon emissions of a product system is that it takes into account upstream and downstream processes and thus avoids, for instance, double-counting. The method will be discussed more thoroughly in Chapter 5.

3.2.2 History of climate change science

Even though the AR4, which gave ground-breaking results about the connection of anthropogenic GHG emissions and the climate's warming, was not published until 2007, the scientific knowledge of the greenhouse effect as a phenomenon is not new. In the 1820s, Joseph Fourier (1768–1830) observed that the atmosphere warms the earth's surface not only by letting through high energy solar heat, but also by trapping part of the longer-wave radiation that bounces back from its surface, similarly to how a greenhouse works. Three decades later, John Tyndall (1861) identified the types of gases responsible for the trapping, the most important one being water vapor, but also CO_2 and low levels of CH_4, nitrous oxide (N_2O) and ozone (O_3) add to the effect. At the end of the 19th century, Svante Arrhenius (1896) proposed a theory, according to which the greenhouse effect is strengthened by human activities. He gave calculations of the possible effects of doubling GHGs due to the Industrial Revolution and proposed a 5–6°Celsius increase of the Earth's average temperature (Lampinen, 2012; Stern, 2008; Agrawala, 1998).

Alas, many scientists considered anthropogenic GHG emissions as meaningless until the 1950s[7], at which point several scientists published similar findings indicating the possibility of human-induced climate change. The most important of these was Revelle and Suess's study in 1957. They presented a theory that the oceans were able to absorb CO_2 so slowly that the molecules causing the emissions will have a lifetime of approximately 100 years. There were already a few indications of a new wave of research results before Revelle's study was published, thanks to the development of infrared spectroscopy technology, which allowed absorption measurement of different IR frequencies by a sample positioned in the path of an IR beam (Lampinen, 2012). The measuring technology of CO_2 contents had improved to the point that the measurements in 1960 could reliably show the anthropogenic emissions to have increased the atmosphere's CO_2 levels.

3.2.3 Climate change skeptics

Even though significant scientific agreement exists about climate change and that the central role human activities play in it, there still exist climate change skeptics who remain unconvinced about the phenomenon and its reasons. Since the publication of the IPCC report in 2007, most of this skeptical discussion, especially in scientific forums, has decreased. However, lobbyists and other advocates have kept the debate alive and recent research confirms that skepticism and uncertainty about climate change, especially within the general public, is still in existence (Eurobarometer, 2009; Leiserowitz et al., 2010; Poortinga et al. 2011; UK Department for Transport, 2011). The reasons for the continued skepticism can be found in the public relations activities of small climate contrarian groups, such as the Heartland Institute, who published leaked e-mails written by IPCC scientists (Taylor, 2011). Especially in the United States industry-funded organizations similar to the Heartland Institute are active. These include Frontiers of Freedom, the Science and Environmental Policy Project, and the Global Climate Coalition, which have managed to have an impact on the political level by, for example, undermining the Kyoto Protocol (Rahmstorf, 2004). In Europe a similar attempt has been made in form of the European Science and Environment Forum, but the impact on policy has been much less. Other reasons for public skepticism of climate change arise from errors made in glacial melting forecasts in the FAR of the IPCC (Berkhout, 2010), as well as the recent relatively cold winter temperatures (Poortinga et al., 2011). Other common arguments among climate contrarians come from various sources: Temperature measurements are inaccurate due to urbanization around the weather stations, warming the temperature only around those stations; satellite measurements are incorrect; atmospheric CO_2 is released from the ocean by natural processes

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7 The CO_2 emissions were not believed to affect the climate because (1) the small amount in the atmosphere in comparison to water vapor which was known to prevent heat radiation (IR radiation) in the same wavelength, and (2) it was known that the oceans contained 50 times as much CO_2 and it was believed that they would absorb the additional CO_2.

and is not human induced; the response of the climate system is weaker to CO_2 emission increase than assumed; changes of solar activity are responsible for climatic warming; the warmer climate is in fact a desired development for agriculture. All of these arguments have been contradicted by climate scientists.

Within the scientific research community, even though the science behind climate change is robust and widely accepted, it is important to be aware of the different forms of skepticism against it. Rahmstorf (2004) makes a useful distinction between trend skeptics, who deny there is an increase in global temperatures; attribution skeptics, who accept that the world's climate may be changing but do not think that it is caused by human activity; and impact skeptics, who agree that the world's climate is changing as a result of human activity but do not think it will lead to negative impacts, with some even seeing the change as beneficial. Likewise, a typology has been developed to distinguish between different attitudinal terms such as skepticism, which is the rejection of the mainstream climate change science; uncertainty, which is a lower subjective sense of climate change and its human-induced impacts; and ambivalence, which is used to describe contradictory evaluations someone holds on a particular issue (Poortinga et al., 2011). Whitmarsh (2011) surveyed the public's beliefs in the UK regarding climate change and found that it is mostly political affiliation as well as environmental values that determine which of the attitudes individuals hold.

3.2.4 Emission scenarios as a strategic aid

In order to better manage the complexity related to climate change and understand the wide-ranging interactions between the climate system, ecosystems, human activities and conditions, uncertainty and risk, scenario modeling is applied. Scenarios can be used for a wide array of disciplines and phenomena. Their use originated in military planning and war game simulations (Brown, 1968). In the context of climate change, scenarios provide assumptions about the future emission of GHGs and descriptions of how the climate will change in the future (Moss et al., 2010). These are based on, among others, socioeconomic, technological, environmental and political conditions, including population increase, globalization, energy use and what the response of the Earth's climate system will be. The goal of a scenario is not to predict the future, but to assist in the assessment of impacts, adaptation and mitigation (IPCC, 2000); to produce awareness of complexities; and to help reach robust decisions in technological, economical, consumptive, and policy issues that are applicable in a wide range of possible futures (Moss et al., 2010; Schwartz, 1996). Currently the most widely used climate scenarios are the IPCC scenarios that describe consistently the relationships between emission driving forces and their evolution and add context for the scenario quantification (IPCC, 2007). The latest scenarios are known as the SRES scenarios (IPCC, 2000).

Scenario techniques are used in strategic business planning as well. One of the basic functions of scenario use, in addition to crisis management, natural sciences (climate change), public policy planning, professional futurist institutes

and educational purposes (or R&D), is in fact long-term business planning (Bradfield et al., 2005). For instance, Royal Dutch Shell has been a pioneering company in using scenarios strategically by adopting scenario planning as a permanent strategy in 1973 (van Vuuren, 2010; Bradfield et al., 2005). Bradfield et al. (2005) distinguish two types scenario work: a once-only problem solving procedure and an ongoing process aimed at longer term strategies, opening up an organizational mind, or achieving closure in certain decisions. These types of work have four purpose areas: in the once-only procedure (1) making sense and (2) developing strategy, and in the ongoing process (3) anticipation and (4) adaptive organizational learning.

Scenarios are also used in the context of LCAs to deal with system instability and complexity. They are descriptions of a possible future situation relevant for a specific LCA application, based on specific assumptions about the future and sometimes also presentations of the development from the present to the future (Pesonen, 1999). The practical application of this method is to anticipate future products and product properties, processes, technologies, consumer behavior or even societies, with related opportunities and threats. The scenario techniques comprise exploratory techniques, which combine analytical and creative techniques, and normative techniques, which start with a desired future and move forwards in time recognizing the steps required to reach the desired future. For organizations, so-called what if-scenarios can be used on an operational level with simple processes and exact information about the effects of different decisions. On the other hand, cornerstone scenarios are applied on a strategic level of an organization. This entails a rather unfamiliar research area with complex systems to analyze. Additional information is often needed, since the scenario-building process is much more imaginary and innovative. On a time scale, cornerstone scenarios have a much longer time perspective than the what-if-scenarios. (Pesonen, 1999)

3.2.5 Physical climate risks across sectors and value chains

Businesses face specific challenges from climate change depending on the industry in which they function. Some sectors are much more vulnerable to physical changes than others. For instance, insurance, agriculture, fisheries, forestry, real estate, and tourism industries face severe direct physical threats, but climate change can also affect sectors such as oil and gas through higher insurance premiums paid (Agrawala et al., 2011). Some sectors might still be relatively immune to climate change, assuming that the economy is still functional. In fact, the size of the economy can be a crucial factor when determining the economic impacts of climate change. A larger nation has a larger capacity to bear the impacts. Also, the economic value of highly vulnerable locations is most likely below less vulnerable locations (IPCC, 2007). Furthermore, the physical risks that companies face due to climate change might either be direct or indirect, or abrupt or incremental, which makes it difficult to define the absolute level of risks. A systematic approach promotes the consideration of more risks than just the obvious ones. Examples of different kinds of risks, be they direct or

indirect, are illustrated in Table 2: Physical risks for infrastructure, regulatory or litigation risks, risks that affect the demand for products, risks in the supply chain and logistics, reputational risks, counterparty risks, or social risks, (collected from Agrawala et al., 2011; Ceres, 2012; IPCC, 2007; Labatt & White, 2007; meant not to be an exhaustive listing of all risks). Agrawala et al. (2011) use a broad sectorial breakdown between the goods and service sectors, since the service sector is much less exposed to, say, logistics or supply chain risks and the goods sector typically has additional concerns to those in the service sector. The IPCC (2007) has categorized the climate impacts into built environment (construction, civil engineering), infrastructure industries (energy, water, telecommunications, transport), natural resource intensive industries (pulp and paper, food processing, etc.) as well as services such as trade, retail and commercial services, tourism and insurance.

Furthermore, sector-specific analyses have been made for sectors such as tourism (Belle & Bramwell, 2005; Ceron & Dubois, 2005; Hamilton et al., 2005; Moreno & Becken, 2009; Simpson et al., 2008), agriculture (Howden et al., 2007), fisheries (OECD, 2011), transport (Jaroszweski et al., 2010), financial and insurance sector (UNEP, 2006; Botzen et al., 2010; Swiss Re, 2004), health (Costello et al., 2009), forestry (Broadmedow, 2005; Petit, et al., 2005), residential housing (Isaac & van Vuuren, 2009) and water (Kundzewicz et al., 2012).

TABLE 2. Industry-specific risks, collected and modified from Agrawala, 2011; Ceres, 2012; IPCC, 2007; Labatt & White, 2007.

		Physical	Regulatory/ litigation risk	Market risk	Supply chain risk	Reputational risk	Counterparty risk	Social risks
Goods producing sectors	**Agriculture and mining businesses**	• Resource extraction limited by sea level rise and water availability • Direct risks from flooding, water scarcity, drought • Shifts in seasons • Increased saline intrusion • Changes in pest & disease distribution and prevalence • Loss of biodiversity • Thawing permafrost and land ice • Increased wildfires • Changing regional pattern of production • Damage to infrastructure and facilities		• Changes in quality, quantity and type of agricultural products • Changing lifestyles influencing demand	• Disruptions to farmers and labor force • Higher costs of input resources • Higher decommissioning costs • Altered access to mining deposits and coastal facilities • Supply chain shifts and disruption • Risks to transport corridors and hubs from where raw materials are processed and exported	• Damaged corporate reputation	• Commodity price volatility	• Water conflicts with communities
	Apparel	• Direct risks from changing weather patterns (droughts, floods, storms) to operations		• Shifting consumer preferences (e.g., less reliable seasonal cycles and temperatures)	• Fluctuating availability, quality, cost of agricultural raw materials • Operation disruptions at manufacturing facilities • Constrained exploration, processing, refining, site rehabilitation • Disruptions in supply chain network (e.g. transport, warehouses, stores)			

	Oil and gas	• Increased intensity and duration of extreme weather events • Rising sea level, higher storm surges, increased coastal erosion • Land and sea ice melting and permafrost thawing • Damage to infrastructure and facilities (structural integrity)	• Policy movements towards renewable energy • Rising standards of service	• Changing demand due to renewable energy	• Altered access to fossil fuel reserves • Disruption of transport and distribution systems	• Damaged corporate reputation		• Risks to worker health & safety • Constrained production of water-intensive fossil resources (oil sands) • Water conflicts with communities & other users
Goods and services providing sectors	**Retailers and distributors**				• Interruption, inefficiency, delays in supply chain • Water scarcity •Increased fuel prices • Extreme weather damages during transportation	•Product quality decrease affecting reputation & consumer satisfaction		
	Transportation	• Extreme weather causing delays, supply disruptions, losses of goods • Access to transport routes affected by flooding • Permafrost thawing, mass movements • Subsidence due to drought • Structural integrity of infrastructure	• Rising standards of service					
	Utilities	• Increased intensity & duration of extreme weather events • Rising sea level • Business interruption due to extreme weather, water scarcity, water supply variability, precipitation patterns • Damage to infrastructure and facilities (structural integrity)	• Increasing pressure to conserve water in water scarce areas • Rising standards of service	• Demand effects due to temperature changes • Changing seasonal/peak power demand during extreme conditions	• Reduced output due to water scarcity in hydropower (or thermal plant cooling systems, e.g. nuclear power plants) • Disruptions of supply due to flooding or extreme events • Electricity losses in transmission and distribution systems due to heat load			• Risks to worker health & safety

Services providing sectors	**Financial businesses**	• Virtually all physical effects, including hurricanes and storms, wildfires, floods, droughts, sealevel rise, thawing permafrost, and increased exposure to diseases		• Increased claims, losses, liabilities • Reduced availability and affordability of some types of insurance • Need for new products to address physical climate risks			• Risks in investments in areas with climate vulnerabilities • Increased risk of customer default • Difficulty pricing physical perils	
	Information businesses	• Disruptions of operations due to extreme weather events • Structural integrity of infrastructures			• Difficulties in transportation			
	Real estate businesses	• Delays and disruptions in construction projects • Damage to buildings and drainage problems • Structural integrity • Temperature changes increase cooling loads	• Changes in building and design requirements	• Changing consumer awareness and preferences	• Energy costs • External fabric of buildings • Service infrastructure		• Loss of value due to climate change impacts	
	Tourism	• Increased weather extremes and variability • Increased frequency and severity of floods and storms • Rising temperatures, droughts • Rising sea level and coastal erosion • Increased wildfires • Changes in precipitation patterns and snow reliability • Altered tourist seasons • Damage to infrastructure and facilities		• Tourism industry infrastructure altered • Tourism demand structure • Decreased attractiveness of destinations	• Loss of ski trails, coral reefs, and other natural tourism attractions • Disruptions of transportation (e.g. flights and cruises)			• Conflicts with communities over coastal and other development

3.2.6 Expanding the scope to sustainability

Having focused on climate change as an example of environmental harm caused by humans, it is worth to extending our perspective to sustainability as a whole. There is a branch of researchers (e.g., Finkelbeiner, 2009; Schmidt, 2009) who argue that reducing the question of our society's future to mere carbon accounting neglects other aspects important for society's future. As mentioned, LCAs commonly reduce the scope of environmental impacts to focus only on some impacts, such as climate change potential. Perhaps climate change is in fact merely a modern paradigm, attracting a large troop of scientists due to its high public profile, and it is quicker and easier to focus on one part of the system. In addition to scientists, politicians, NGOs and the media are intrigued by the theme. However, climate change just adds to the list of stressors that challenge our ability to achieve ecological balance and reach other economic and social objectives that define sustainable development.

The principle of sustainability was formulated originally in the context of forest management (i.e., silviculture) during the 18th century in Saxony (nowadays part of Germany), due to the mining industry's extensive use of wood. J. L. Carlowitz, the superintendent of the Saxon silver mines in the early 18th century and the founder of this principle of practice, developed the idea of balancing the annual wood use with the growth and became a pioneer of the concept's operationalization. He also recognized the economic and social implications of his idea (Sieferle, 2007; Klöpffer, 2003).

The modern paradigm of sustainability was used for the first time in 1980 by the World Conservation Strategy (IUCN et al., 1980), but was formally introduced in 1987 by the World Commission on Environment and Development (WCED, 1987) and thus became renowned in the global political agenda linking environmental protection with political development. Furthermore, the United Nations declared sustainability as the guiding principle for the 21st century at the World conference in Rio de Janeiro in 1992 (UNEP, 1992). After this the scope has broadened and the usage has become random at times, but nevertheless the basic idea behind sustainability and sustainable development remains clear and acceptable: meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.

There is a high moral claim in this principle—and a lack of guidance in how to reach it (Klöpffer, 2003). Yet, even though the scope has broadened, the elements in designing a sustainable future in any of these understandings are the identification of what to develop and what to sustain, and characterizing the links between these. The future contexts for these links should be envisioned (NRC, 1999). As Sala et al. (2012) state,

> Sustainability science is an emerging discipline, applicative and solution-oriented […]. The challenges of the discipline are not only related to better identifying the problems affecting sustainability but to the actual transition towards solutions adopting an integrated, comprehensive and participatory approach.

Furthermore, the concept of sustainability has to be made more operationally suitable (Swarr et al., 2011). The standard model, which is well accepted by industry and often called the triple bottom line (UNEP, 2007; Elkington, 1997), is the three pillar interpretation of sustainability. It includes three perspectives of sustainability: environmental, societal and economic. In a broader context, the institutional aspect is also included in the framework for sustainable development (UN, 1992; Valentin & Spangenberg, 2000) and cultural, inter-and intra-generational, geographical, procedural and interspecies equity aspects complement the social aspects (Munasinghe, 1993; Haughton, 1999). The term is in fact highly dependent on the context in which it is used.

Since 2002, when the concept of sustainability was reconfirmed in Johannesburg in 2002 (UNEP, 2002), the life cycle aspect has been added to the concept: Products and services are analyzed during their entire life cycle, from raw materials extraction to end-of-life processes (recycling, landfill, etc.). Furthermore, LCM was launched as a management approach, which means that management should use life cycle thinking in their operations. Sustainability was becoming more operational on a company level, in contrast to before when it was most of all discussed on a national or international level (Jørgensen, 2007). LCM by definition (UNEP, 2007) is "the application of life cycle thinking to modern business practice, with the aim to manage the total life cycle of an organization's products and services towards more sustainable consumption and production" and most of all, "LCM is about systematic integration product sustainability e.g. in company strategy and planning, product design and development, purchasing decisions and communication programs."

3.3 Climate-related policy framework

3.3.1 Background of climate policies

In addition to the changing physical environment, there needs to be a working policy framework in which all actors operate. Climate and climate change have distinct features, which lead to a vulnerable future and un-sustainability, unless restrictions are set according to which economic operators can emit GHGs. Climate is characterized as a public good, that is, those who fail to pay for it cannot be excluded from its benefits and one person's enjoyment of the climate does not diminish the capacity of others to enjoy it too. Markets do not reflect the consequences of different consumption and investment choices, thus climate change is referred to as the "greatest market failure" (Stern, 2006) and can be regarded as a result of the externality associated with GHG emissions. As long as there are no legal or economic incentives why fossil fuel use should be reduced, new energy sources will not have real markets. Intuitively, the most powerful way would be to legally force businesses and people to stop emitting GHGs. However, in modern society, a dictatorial approach to climate change will not work and political structures do not allow decision-making in an auto-

cratic manner. Therefore, a global policy framework that encourages each party to willingly reduce emissions and endorse sustainable practices needs to be built.

Building a working framework, however, is complex. The interplay between different sectors is impossible to foresee, demand structures can be arbitrary and the behavior of individuals cannot be forecasted. Certain GHG stabilization policies can reduce the emissions from one sector, but increase the emissions from another. On a global scale, one complication is caused by the developing country dilemma. Taking its starting point from development studies, Schmidt et al. (2008) propose sector-specific energy-intensity benchmarks (by independent experts) to be the basis of establishing a framework and initially be voluntary for developing nations. The study indicated that the approach improves the likelihood of atmospheric concentrations of CO_2 being stabilized at 450 ppm by the end of the century.

In general, building a credible and workable policy is an iterative process known as a policy cycle, with evaluations feeding in knowledge at different points in the cycle. Policies, unlike many specific and focused programs, are in fact cyclical and repetitive (Crabbé & Leroy, 2008). Theoretically, the background factors behind the climate policy cycle consist of a wider societal discussion induced by climate and other environmental factors, global politics and economic development, which lead to a societal structural change and changes in emissions, vulnerability and adaptive capacity. These issues lead to agreed climate change commitments, objectives specified in policy documents, concrete actions and finally monitoring. (Hilden, 2011)

Climate policies embrace a variety of different measures, either to encourage the reduction of GHG emissions, the use of clean technologies through incentives (e.g., subsidies for investments or tax credits for R&D), or, to penalize GHG emissions through disincentives (e.g., taxes). The creation of a functioning emission trading system as well as ensuring viable markets for environmentally sound technologies is also a form of policy intervention toward a carbon-free economy (Fischer & Newell, 2008).

The institutional architecture for climate change, energy and sustainable development covers a wide range of different entities and processes, conventions and declarations (IPCC, 2007). Especially in climate change and energy policies there is little point in handling them separately from each other. From a broader perspective, policies for sustainable development can also be coupled with these. This entire bundle can be seen as a meta-policy covering a wide range of social activities. To succeed, they must deal with drivers of climate change and not merely focus on specific pressures such as GHG emissions or immediate adaptation measures (Hilden, 2011).

3.3.2 Climate policies history internationally and European-wide

The United Nations Framework Convention on Climate Change (UNFCCC) is paving the way for climate change actions and its Kyoto Protocol sets binding commitments. Other major declarations in climate change are the Millennium

Development Goals, the World Summit on Sustainable Development and its Johannesburg Plan for Implementation and the UN Commission on Sustainable Development. All of these have broad and important connections to climate change in the context of sustainable development, energy and poverty eradication (IPCC, 2007). Other international institutions important for sustainable development and climate change are the OECD, International Energy Agency (IEA), G8 Roundtable of Climate Change, World Bank and World Trade Organization (WTO).

The history of climate negotiations started with the First World Climate Conference in 1979. The conference, organized by UNEP and the World Meteorological Organization (WMO), provided an international forum devoted exclusively to climate change. This scientific gathering recognized climate change and initiated further research on the phenomenon. No direct policy action resulted, but a statement was given for the world's governments to "foresee and prevent potential man-made changes in climate that might be adverse to the well-being of humanity" (UNEP & UNFCCC, 2002). The conference led to the establishment of the World Climate Program under the joint responsibility of the WMO, UNEP, and the International Council of Scientific Unions (ICSU) (WMO website). A series of workshops organized under the auspices of the WMO, UNEP and ICSU followed, with the purpose of better understanding the problem and to raising international concern about the issue (UNEP & UNFCCC, 2002). In 1985, a consensus was reached that "in the first half of the next century a rise of global mean temperature would occur which is greater than any in man's history" (Agrawala, 1998). This was a milestone in climate policy history and since then climate change has interested the media and thus a much wider audience.

In 1986, the WMO, UNEP and ICSU formed the Advisory Group on Greenhouse Gases (AGGG) to review studies related to GHGs and assess the GHG concentrations (Potter, 1986). However, the advisory group was described as having "no money and no muscle" (Bolin, 1997, as cited in Agrawala, 1997) and the Intergovernmental Panel for Climate Change (IPCC) was founded by WMO and UNEP to have a body directly under the control of governments. The AGGG and IPCC did overlap for a few years until the AGGG ended its activities in 1990, but the IPCC clearly overtook the policy role from the beginning. The panel was given a mandate to assess the state of existing knowledge about the climate system and climate change; the environmental, economic, and social impacts of climate change; and the possible response strategies.

The IPCC released its First Assessment Report (FAR) in 1990. Approved after a thorough peer review process, the FAR confirmed the scientific evidence for climate change, according to which humanity's influence on the global climate was stronger than ever before. It also concluded that GHG emissions should be reduced by more than 60% in order to stabilize their impacts. This received the interest of policymakers, the media and the public and provided the basis for negotiations on a climate change convention. In 1992, the UNFCCC was signed by 154 states. It entered into force in 1994 (UNEP & UNFCCC, 2002).

The key objectives of the convention are to reduce emissions from economic activity at a level that would prevent harm to the climate system and to lessen the impact of unavoidable climatic changes. However, the UNFCCC did not include any binding commitments and the "safe level" for reducing emissions was interpreted by different nations in various ways.

Consequently, the Kyoto Protocol was formulated in 1997 by the UNFCCC countries to include binding commitments for industrialized countries (Annex I countries, responsible for 64% of the 1990 GHG emissions) to reduce GHG emissions. It entered into force in 2005, when 191 countries had ratified the Protocol. These ratifiers included almost all of the UNFCCC signatories. As of 2013 the only countries who have not yet ratified the protocol are the USA, Afghanistan and Canada, which withdrew its ratification in 2012. The binding level to which the ratifiers are committed to reduce their GHG emissions is 5.2% compared to 1990 levels during 2008–2012 (the EU has committed itself to 8% emission reduction compared to the 1990 baseline in 2008–2012). These binding commitments do not yet include commitments for developing countries (non-Annex I countries), which has provoked some dissatisfaction among the signatories, especially the USA. If China, Brazil and India are not included in the solution, many US decision-makers believe that efforts by the developed world could be eclipsed and become futile (Hoffmann, 2005).

Following the FAR, so far also the Second Assessment Report (SAR) (1995), Third Assessment Report (TAR) (2001) and AR4 (2007) have been published, and the Fifth Assessment Report is being finalized for publication in 2013.

After the UNFCCC was signed, national climate policies started to emerge around the world. Depending on the country, the negotiation processes might vary significantly, but nevertheless, the national practices should be in line with the international treaties. Climate policies evolve in an unstable and rapidly changing policy environment, and the frequent revisions of national climate policies in all countries attest to this turbulence (Hilden, 2011).

The EU has a strong impact on the national climate-related legislation of its member states. The European Coal and Steel Community and the European Atomic Energy Community were pre-stages of forming a common EU energy policy. However, the current EU energy policy only started to take shape in 1973, during the first oil crisis (EUROPA. Gateway to the European Union, 2007). In fact, the concern with climate change was first manifested in the White Paper on Energy Policy for the EU in 1995. In addition, the development of the EU's common energy policy (a set of guidelines enforced through directives, regulations and national legislation) is also a result of growing global concerns about the whole range of political and economic issues related to the energy sector (Kaivo-oja & Luukkanen, 2004) and its effects on climate change.

In the EU, climate and energy issues have been bound together explicitly through the current climate and energy package, the so-called "20-20-20" targets. It requires that by the year 2020 the EU will reduce GHG emissions to at least 20% below 1990 levels, increase renewable energy use to at least 20% of energy consumption and reduce primary energy use by 20% to be achieved by

improving energy efficiency. In January 2008, the EC proposed binding legislation to implement the 20-20-20 targets. This was agreed by the European Parliament and Council in December 2008 and became law in June 2009. It essentially includes four different issues: the revision and strengthening of the EU's Emission Trading System (EU ETS), an Effort Sharing Decision governing emissions from sectors not covered by the EU ETS, binding national targets for renewable energy which collectively will lift the average renewable share across the EU to 20% by 2020 and a legal framework to promote the development and safe use of carbon capture and storage. It is clear that the demanding goals require much joint effort and collaboration between the member states of the EU but throughout the years there have been numerous contradictions and clashes related to the role of the EU and its member states (Kaivo-oja & Luukkanen, 2004). The dynamics of the discussions and goals raised in previous EU energy policies are important to be able to better reflect on energy challenges in the EU today. In fact, such processes as widespread deregulation and liberalization of the energy markets and pursuit of sustainable development goals have significantly changed European energy markets (Salmela & Varho, 2006). The trends revealed in the energy policies also shed light on changes in the European markets and lay a basis for understanding the new developments made possible in competitive markets, such as emission trading.

It is not only the case that the international treaties lay the grounds for EU to act on those. Rather, it is a two-way interaction and it is relevant also to understand that the decisions made in the EU will also have an effect globally. EU member states have been key figures in discussing global treaties for combating climate change and in addition to minimizing its own GHG emissions it has also taken serious steps in lowering the emissions of developing or emerging economies through efforts such as EU ETS.

Within the EU, several policy activities are linked with the LCA (e.g., Integrated Product Policy, Thematic Strategies on Waste Prevention and Recycling, Sustainable Use of Natural Resources) and rely on LCA results for assessing the environmental impacts and making decisions. The European Commission has concluded that LCAs provide the best framework for assessing the potential environmental impacts of products currently available. Nevertheless, there are some occasions where by following these results, it could be seen that the European policy has been misguided and based on flawed LCA results (e-g-, the policy for biofuels and waste management) and the need for more consistent data and consensus LCA methodologies becomes clear (ANEC, 2012; Lazarevic, et al., 2012; OECD, 2007). It is acknowledged that using LCA tools should only support decisions, rather than used as a decision-making tool. For this, the European Commission's Joint Research Centre has developed the environmental footprinting methodology for products and organizations, which is largely based on the LCA and is currently awaiting a pilot phase to ensure the consideration of businesses' feedback.

3.3.3 Climate policies and the private sector

Until the late 1990s, climate-related policies were generally opposed and seen as a negative influence on business (Kolk & Pinkse, 2005). Given the developments in the policy framework in recent years, private companies now face practical reasons to become familiar with the policies, including GHG reduction targets, the compliance of countries such as China, India and Brazil, the real effects of the Kyoto Protocol on their operations, emission trading schemes, the possibility of new global treaties and more (Marcus et al, 2011). Companies can, in fact, turn these into competitive advantages.

Clearly, the regulatory framework of climate change is complex and emerging on many levels. When assessing the effect international, regional, national or even sub-national policies can have on private sector activities, it is important to realize the importance of a robust, credible and transparent policy framework on private sector activities, investments and viability. For example, feed-in tariffs and subsidies can be used directly in investment viability calculations as positive cash flow and therefore make the result of calculations more favorable for investing. Guellec and van Pottelsberghe de la Potterie (2003) studied the impact of government funding on business-financed activities with results arising from a large panel of data that direct funding as well as tax incentives are more effective when they are stable over time and that firms do not invest in additional R&D if they are uncertain of the durability of the government support. If an environment with stable investment subsidies, tax reliefs and feed-in tariffs is not achieved, it is in the worst case scenario, with the public sector left to make these investments due to the fact that regular investment calculations, such as net present value, internal rate of return or payback period calculations cannot be made (Marcus et al, 2011). The EU has the advantage of strong leadership in these matters, with policy mechanisms ranging from market-based solutions to regulatory ones.

The interventions have made the investment sector interested in joining the policy discussion. For example, in the EU, the Institutional Investors Group on Climate Change (IIGCC) has produced several policy statements to enhance the discussion between political decision-makers and have a "collective influence to engage in dialogues" (IIGCC, 2012 website). These include EU ETS, CH_4 emissions in the oil and gas sector, green bonds, energy efficiency and more. However, these efforts have also failed to provide an adequate price signal for carbon and support schemes for renewable energy (Ceres, 2010). Other significant joint initiatives are CDP, which focuses on carbon emission disclosure, and UNEP Finance Initiative, which focuses on identifying, promoting, and realizing the best environmental and sustainability practices in financial institution operations.

Sullivan (2011) surveyed climate and environmental policy requirements of the private sector about the uncertainty related to the policy framework and to help policymakers better understand the factors that investors consider in their decisions. Again, the results indicated that primary needs are the existence

and reliability of effective policies with clear and concrete reduction targets, enforceable mechanisms as well as timelines. The incentives should encourage investments into riskier renewable energy, low-carbon projects and also large-scale projects. The transparency, duration, prospective perspective, market-based mechanisms as well as a rules-based international climate change regime are critically important to send the appropriate signals to global capital markets and increase commitment and confidence.

4 THE PRIVATE SECTOR'S INTEGRATED APPROACH TOWARDS CLIMATE CHANGE MITIGATION AND ADAPTATION

This chapter views companies not as passive bystanders, but as active players in adapting to and mitigating the changing physical and regulatory environment. It covers both mitigation and adaptation in an integrated way but acknowledges adaptation as a particularly important issue to ensure the organization's response to the risks and opportunities of climate change. The chapter takes an overall view on the approaches companies can take at the strategic level. There is also an examination of issues such as awareness, the often-neglected trigger for taking action and disclosure that brings these actions to the visibility of further stakeholder groups. Regarding disclosure, one stakeholder group is looked at in particular, namely the investors. Especially larger companies consider investor relations closely on a strategic level, because investors' decisions have a direct impact on the market value of the company.

As opposed to the pure natural science basis of climate change, in the last 10 years, the scientific community's interest in researching the corporate response to climate change has increased (e.g., Dunn, 2002; Halady & Rao, 2010; Hoffman, 2002; Jones & Levy, 2007; Jeswani et al., 2008; Kolk & Pinkse, 2004; Lash & Wellington, 2007; Nitkin et al., 2009; Sprengel & Bush, 2011). Furthermore, especially due to the demand of business managers and investors, a need has arisen to systematically approach the complex uncertainty related to climate change from a business perspective. Businesses have sought ways to mitigate their climate impacts, as well as adapt to the changes in terms of minimizing the risks associated with climate change or even to capitalize on them. Though they might be opportunistic in their adaptation strategies, the results for the environment can be favorable, presuming the regulatory framework is built efficiently. Self-interest is indeed a sufficient incentive for economic actors to undertake mitigation and adaptation measures. According to a survey (Hoffman, 2006), the three primary reasons for companies to take action against climate

change are to increase profits, to anticipate and influence government regulation and to enhance corporate reputation.

At this point in the study's storyline, I examine the multifaceted relationship between physical climate change, regulatory context and business actions. They all impact each other and have the potential to amplify or mitigate climate effects. The industry's carbon emissions have initiated anthropogenic climate change. Anthropogenic climate change, on the other hand, disturbs modern society and changes the environment in an unforeseeable manner. This again makes it necessary to have the policy context to prevent emissions and enable society to adapt to the impacts. Furthermore, governments have started to look to the private sector to enhance their ability to mitigate (Agrawala, 2008) and businesses have to start adapting to the changing environment and changing policies so that they are able to function in the future.

Currently there is a range of business and market responses emerging to address global warming or other environmental harms and to reduce emissions either in their own processes or by responding through the use of market mechanisms (Kolk & Pinkse, 2005). The way this is done depends on several different issues: on the industry and markets the firm is active in, the country and regulative framework, the size of the firm, its adaptive capacity, the chosen strategic pathway, risk-bearing capacity and more. All of these will make an impact on the company and its product-specific (i.e., life cycle-specific) integrated strategy.

4.1 Climate change approaches in business

4.1.1 Mitigation and adaptation measures and awareness raising

Societies, ecosystems, organizations, political bodies and individuals have adjusted, that is, adapted, either consciously or unconsciously their behavior in response to past changes, climatic or otherwise, and many are now contemplating the altered climatic conditions of the future (Adger et al., 2005). Especially in terms of adaptation, according to Nitkin et al. (2009), the main focus in recent literature has been on sector-specific or regional adaptation strategies (e.g., Ribeiro et al., 2009; Juhola & Westerhoff, 2011; Juhola et al., 2012; Hallegatte & Corfee-Morlot, 2011; Smith & Hopkins, 2010), wider policy-level adaptation possibilities (Adger et al., 2005; Westerhoff et al., 2011) or theoretical frameworks (Smit et al., 2000). By definition, these are much wider in perspective than business adaptation.

In the previous sections I explained what kind of risks climate change poses to different sectors and value chains. The extent to which potential vulnerabilities are likely to motivate mitigation and adaptation in the private sector is not only dependent on the geographic location but also on the sector and its flexibility. Those sectors with longer-lived infrastructure requiring higher investments, such as utilities, are not as flexible adapters as sectors with low investments (and despite having weather-dependent resources as in agriculture).

So it becomes the technological or economic resources of the specific business that determines whether or not it is capable of adapting. Furthermore, even if the financial resources and experience with risk management are higher (e.g., in utilities), the social acceptance of climate-change investments, implying higher energy prices, could be limited (IPCC, 2007).

Firms' responses to pressures from climate change are in many ways similar to the actions they take in response to conventional market, technological or regulatory changes (Berkhout et al., 2006). Climate risk management can be integrated into overall business strategy and operations where it is regarded as one issue among many that demand attention, as long as it is supported by investors and shareholders (IPCC, 2007). In fact, adaptation measures often cannot be isolated from other decisions, making an isolated analysis of adaptation difficult. This is especially true if there are simultaneous social or economic events requiring changes (Adger et al., 2005).

Due to the increasing interest in climate change adaptation, the need to categorize adaptation measures and attributes has emerged. Categorization can refer either to the motivation for adaptation, the initiator of activities, the timing of adaptation measures, or the degree of spontaneity. Furthermore, adaptations can take technological, economic, legal or institutional forms (Smit et al., 2000). Many of these adaptations represent incremental adjustments to current business activities (Berkhout et al., 2006). According to Smit et al. (1999), there are several bases for characterizing adaptation to climate change, differentiated by the purposefulness (autonomous vs. planned, spontaneous vs. purposeful, automatic vs. intentional, natural vs. policy, passive vs. active), by the timing (anticipatory vs. responsive, proactive vs. reactive, ex ante vs. ex post), by the temporal scope (short-term vs. long-term, tactical vs. strategic, instantaneous vs. cumulative), by the spatial scope (localized vs. widespread), by the function or effects (retreat, accommodate, protect, prevent, tolerate, spread, change, restore), by the form (structural, legal, institutional, regulatory, financial, technological) or by the performance (cost, effectiveness, efficiency, implementability, equity). An abbreviated version of this, as presented by Levina and Tirpak (2006), is a widely used six-level typology which includes anticipatory adaptation (before impacts are tangible, also known as proactive adaptation), autonomous adaptation (or spontaneous adaptation, not a conscious response to climate change, rather triggered by ecological, market or welfare changes)[8], planned adaptation (result of a deliberate policy decision, based on awareness that conditions have or will change), private adaptation (initiated and implemented by individuals, households or private companies, usually out of rational self-interest), public adaptation (initiated by governments for collective needs) and reactive adaptation (after impacts have been observed). All of these types can generate short-

[8] Organizations rarely adapt autonomously, since their adaptive behavior is influenced by policy and market conditions, and draws on resources external to the organization (Berkhout et al., 2006). Furthermore, autonomous adaptation is unlikely to be optimal because of uncertainty, imperfect information or financial constraints. This means adaptation efforts cannot be left entirely to individuals or businesses (EU White Paper on Adaptation, 2009).

or long-term benefits. It should not be forgotten that they are not necessarily all environmentally positive changes such as, for example, the demand for air-conditioning in buildings (Adger et al., 2005).

Awareness of climate change is a factor that has so far has been greatly undervalued in terms of its effect on mitigation and adaptation. Scholars from different fields of science are well-informed of the status of climate change, its potential physical, political, social and economic impacts, but since climate change is a global problem in which the stressors are mainly industry (and consumers), it is important to be sure that the wider public and industry are aware of what climate change is and how it can be mitigated and adapted to.

In order to get companies to act and start preparing action plans for climate change adaptation and implementing them, they need to be aware of the phenomenon and its drastic implications. There is a high level of awareness among companies of the risks associated with climate change, but not all companies perceive *their* businesses as being vulnerable to them. Furthermore, companies tend to focus more on risks from extreme events than on those from gradual changes (Agrawala et al., 2011). Looking at the issue from the perspective of the investment community, a survey conducted by Ceres (2010) indicated that the increase of awareness of asset owners has had a positive impact on their practices if they, for example, raise the awareness through asking climate change-related questions from investment managers.

An awareness of climate change is an important prerequisite for climate information to be incorporated into decision-making (Westerhoff & Juhola, 2010). The progress proposed by Tang et al. (2009) in the context of land-use planning can also be applied in the field of business: to enhance preparedness for the possible adverse impacts of climate change, decision-makers should recognize three components to address climate change: awareness, analysis and action. The awareness is the primary initiator, which further leads to actual analyses or actions.

Identically, Agrawala's (2011) three-tier adaptation framework takes its starting point from the acknowledgement of climate change as a business risk. Being aware of the risk (Tier 1: Risk awareness) allows the risk to be assessed in a more structured way and identification of the actual climate risks, as discussed in section 3.1. Only by having assessed the actual risks to which one's own business is vulnerable to, can that business enable a consideration of potential adaptation options (Tier 2: Risk assessment). The final part of the framework (Tier 3: Risk management) includes the development, implementation and monitoring of an adaptation strategy.

A similar approach, but from an organizational learning perspective, is formulated by Berkhout et al. (2006) on the basis of an empirical study, in which issues of perception, interpretation, problem-solving and decision-making were central in determining whether and how adaptation among social agents takes place. The awareness raising level is seen by Berkhout et al. as an external signal, which in climate change is challenging, due to the fact that climate change stimuli are not always directly experienced by the organization. The risk as-

sessment was formulated as an interpretation of the signals and knowledge articulation in the form of a strategy. The risk management phase was articulated by Berkhout et al. as a feedback mechanism, which based on the empirical data was rather weak due to the slow materialization of climate impacts.

4.2 Business strategies for climate change

At present, even though the physical changes are slow, business decision-makers need to act in terms of their strategic planning, since the framework, markets and competitors are already changing (Hoffmann & Woody, 2008). The regulatory, social and economic effects of climate change are so tangible that they should be approached with strategic tools (Porter & Reinhardt, 2007) and currently there are not many of these tools. As regulations change and become stricter, they will alter the business landscape through taxes, standards and government expenditure. Energy prices will increase, which is a threat to some and an opportunity for others. The investment community will also have new preferences. These changes will present the strategic decision-makers with questions of what action is needed, how vulnerable their businesses are, what the markets of the future will look like, what the opportunities are and how competitors will act (Hoffmann & Woody, 2008) .

There have been some practical approaches to develop climate-related strategies for a given company – be they large, medium-sized, small or micro (Ceres, 2006; Hoffman & Woody, 2008) and scientific discussion about strategies for climate change. As Kolk and Pinkse (2004) suggest, "most companies focus on internally oriented measures that improve the energy efficiency of their business processes." They further state that "a growing number are exploring possibilities to integrate the supply chain in its climate strategy and develop new (energy-efficient) products," and this binds the strategic level considerations to a product-specific life-cycle perspective (presented in section 5).

According to a typology developed by Porter and Reinhard (2007) that is well suited for the strategic approach to climate change, GHG emissions are known as "inside-out" impacts. Porter discussed the framework already in 2006 with Kramer in the context of corporate social responsibility but it was not until the next year that he linked it with climate change strategy. In Porter and Reinhard's proposal, the idea was to establish a firm's approach to climate change and assess the strategic opportunity through having two opposite perspectives on the interlinkages of business and climate change: The inside-out perspective allows business leaders to look at a company's impacts on climate and the idea is to include the firm's entire value chain and its emissions impact, direct or indirect. The emissions are then proportioned to the value chain. Once managers understand the overall carbon exposure and the emissions impact of specific activities in the value chain, they can devise an action plan to address them.

The other perspective looks at how climate change affects people, species, and plants in a variety of complex ways, most notably via water in some shape

or form, including storms, floods, droughts and sea-level rise. These changes will potentially transform the physical and human geography of the planet, affecting where and how we live our lives, involving however considerable uncertainty (Stern, 2008). Following Porter and Reinhard's typology, these can be called "outside-in" impacts, those effects that the changing climate (both physical and regulatory changes) has on the activities of the company.

Companies that successfully deal with climate change must have comprehensive climate change strategies, with the following key elements (collected from Ceres, 2006; Hoffmann & Woody, 2008): assessment of financial connections between climate change, businesses and markets; development and implementation of plans to manage climate risks and vulnerability to peers, reduce carbon footprint and seize new market opportunities; disclosing climate strategies; influencing the policy-development process. A competitive strategy involves the consideration of key factors determining the limits of what a company can successfully accomplish (Porter, 1980). It is essential to contrast its strengths and weaknesses against competitors and in the context of climate change also against physical, technological and regulatory changes in the surroundings.

Furthermore, integrating climate activities (or sustainability activities at large) can create value for the company. The value of sustainability can be materialized in various ways: regulatory compliance, risk management, operational efficiency, image improvement, source of market growth, innovations leading to redirection of existing business concepts, staff motivation (Pesonen, 2007) and an increase of the firm's market capitalization (for references see section 4.4).

4.2.1 Classification of climate change adaptation types

A recurrent theme in the context of this study is regulatory uncertainty. It has an impact on many issues in the private sector and it is unfortunate that high regulatory uncertainty exists and that strategic decisions still have to be made. Managers can make relatively good strategic choices based on what they perceive to be the most probable regulatory framework for the future, based on their intuition and experience. Nevertheless, given that the uncertainty of the regulatory environment is likely to persist, managers need a systematic tool for coping (Marcus et al, 2011; Marcus, 2009). Marcus et al. (2011) introduced a tool for differentiating the pathways for future activities in different regulatory surroundings. Depending on the level of regulatory certainty, he differentiates the pathways for the best ways to cope with the regulations (betting on the most probable outcome, choosing a robust strategy regardless of regulatory changes, delay decisions, commit with fallbacks, shape the future). Similar typologies or characterizations have been introduced by other scholars earlier. Carroll (1979) discussed CSR responsiveness as being on a continuum, with one end being "do nothing" and the other end being "do much." His continuum was based on the categorizations of Wilson (1975), McAdam (1973) and Davis (1960), who in previous works had all found out that in terms of corporate social responsive-

ness, the companies were located somewhere between these two extremes. In fact, Ian Wilson originally formulated the widely used RDAP scale (which at that time was not called so) that rates companies as either reactive, defensive, accommodative or proactive. In 1988 Clarkson named the scale RDAP scale. Based on the RDAP scale, the defensive, opportunistic/hesitant and offensive stances have been used since the mid-1990s in climate change strategies (Kolk, 2000, as cited in Kolk & Pinkse, 2004). Levy and Kolk (2002) have further classified corporate climate change strategies into a matrix form, with companies on the x-axis being either cooperative or uncooperative and on the y-axis being either assertive or unassertive. This enables a categorization of companies into four categories: resistant, proactive, avoidant or compliant.

Further typologies have been used in the literature to classify their strategies in terms of environmental issues at a large, not restricted to climate change. Some of these can be traced to the original RDAP scale and they are either on a continuum, typology or a combination of both (this influences their applicability). Kolk and Mauser (2002) have made a thorough assessment of the developed categories up until 2000 and developed a list of 50 models of how corporate responses to environmental management are characterized, which presented the key studies and scholars researching classifications. One of the most important ones, and the most widely referred to typology, was presented by Hart (1995), who found several strategic characteristics by using a resource-based view of the firm[9] and empirical data from Belgium. The data resulted in three strategic categories of the environmental management of a firm. The first was pollution prevention (subdivided into two categories, either control or prevention) with a great amount of so-called low-hanging fruit to be achieved. The second was product stewardship, entailing the entire life cycle of a product system which would at best lead to redesign. The third category was sustainable development, including reducing the impacts of the firm and the value chain as well as the impacts on the severe problems in developing countries. Other similar typologies have been presented by Aragón-Correa (1998), Hart (1995), Roome (1992), Sharma (2000) and Sharma and Vredenburg (1998). Tilley (1999) specifically addresses small firms and their environmental strategies by dividing them into resistant, reactive, proactive or sustainable firms.

Buysse and Verbeke (2003) have developed Hart's distinction of corporate environmental efforts by dividing them into five categories: (1) investment into green technology, (2) investments into employee environmental training, (3) investments into organizational competencies in environmental management, (4) investments into formal management systems and (5) efforts to reconfigure the strategic planning process with a focus on environmental issues. In Buysse and Verbeke's (2003) categorization the lowest level indicates that the environ-

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9 The resource-based view was originally built by Wernerfelt (1984), Dierickx and Cool (1989), and Prahalad and Hamel (1990). Barney (1986) noted that by nurturing internal competencies and applying them to an appropriate external environment, a firm can develop a viable strategy. Thus, for a firm's resource to become valuable, it must allow the firm to "exploit opportunities or neutralize threats" in the firm's environment (Barney, 1991).

mental strategies start from investments into a company's own operations and factories and their direct (environmental) impacts. Using Hart's terminology, pollution prevention, be it the end-of-pipe control or the lessening of the emissions, are part of what is occurring in the company's own part of the life cycle. The next step covers the entire value chain or life cycle of products, raising the environmental strategies to a higher level.

In contrast to the resource-based view and the idea of competitive advantage arising from internal organizational processes, that is, optimal resource use, minimizing environmental impacts and thus striving for sustainability, Porter maintains the view of a firm positioning itself in comparison to its rivals through low costs or through product differentiation (Orsato, 2006). In fact, on a time-scale, it can be seen that the resource-based view of the firm grew out of frustration with the unrealistic assumption that a firm's success is wholly determined by its external environment.

Orsato later suggested a classification combining these two schools of competitive advantage: Porter's positioning school and Hart's resource-based view. Orsato's matrix-form classification of competitive environmental strategies relied on competitive advantage (Porter), whether or not it was low-cost or differentiation. On the other hand it also differentiated the competitive focus into organizational processes or products and services. This resulted in four generic types of companies or strategies: eco-efficiency, beyond-compliance leadership, eco-branding and environmental cost leadership.

Berkhout et al. (2006) studied the issue empirically through case studies and recognized patterns within the housing and water companies in the assessment of vulnerability and adaptation options. They distinguished four factors which shaped the organizations' adaptation strategies: (1) The company's core competencies suggested the most likely adaptation measures being close to the current practices and knowledge base. (2) The company's core business and its vulnerability influence the involvement in adaptation measures. (3) The dynamic capabilities, that is, the ability to modify organizational routines, affect the timing of adaptation activities. (4) The organizational culture, that is, how conservative the company is, determined how cautiously a firm responds to the risks posed by climate change. Furthermore, Berkhout et al. (2006) also identified four alternative adaptation strategies for all firms, more along the lines of the RDAP scale than for example the resource-based categorization or Buysse and Verbeke's investment-based distinction. These categories, out of which the firms could fall into several (i.e., deploy a range of strategies in different departments), are (1) wait and see (deferral and skepticism), (2) risk assessment and options appraisal (preparation for adaptation), (3) bearing and managing risks (possibly also opportunities) and (4) sharing and shifting risks (externalizing risks through insurance and collaboration). However, whether or not the chosen strategies have been appropriate is difficult to measure since the climatic conditions are changing rather slowly, giving slow feedback into the decision-making process (Berkhout et al., 2006).

Additionally, there is a useful distinction of the types of capabilities enabling businesses to better adapt to climate change drawing on the theory of organizational learning , used for example by Berkhout et al. (2006) and Zollo and Winter (2002): the distinction between operational capabilities and dynamic capabilities. Operational capabilities, or routines, enable a business to carry out routine business activities and dynamic capabilities are those capabilities that enable a company to adapt its operational routines by, for example, integrating, building and reconfiguring internal and external competencies and routines. Zollo and Winter (2002) defined dynamic capabilities as systematically generating and modifying routines in pursuit of improved effectiveness. In terms of climate change, where the stability of the environment is questionable, organizations are pressured to make greater investments to explore and discover new ways of doing things, whereas in stable environments organizations focus on efficiency gains through improvements of operating routines (March, 1991; Benner & Tushman, 2003).

Clearly the need to classify companies and strategies according to their environmental responsiveness indicates that there are numerous approaches companies choose either consciously or unconsciously and either explicitly or as part of a general strategy. The private sector has a tremendous impact on the current situation in terms of emissions, environmental impacts and adaptation options. And in spite of differences in terminology, typologies or continuums for corporate environmental strategies, it is generally accepted that there are companies with reactive strategies that merely aim to meet legal requirements and implement pollution controls, to more proactive strategies that consist of voluntary practices for reducing energy, waste and pollution which require an innovative attitude to processes, processes and entire organizational cultures, including an awareness of the entire life cycle of the systems.

4.3 Disclosure of climate-related information

The communication of environmental risks and complexities, especially scientific information on climate change, to non-specialists is a major challenge for climate scientists (Pidgeon & Fischhoff, 2011). Apart from the scientific basis of climate change, the firm-specific perspective requires deeper understanding, namely, the communication of climate-related issues faced by the firm to stakeholders. This can include information related to climate change important for the business operations and profit-making ability but difficult to communicate for stakeholders, such as risks and uncertainties in the coming years, economic or social consequences, strategic preparedness for these consequences, adaptation actions including investment choices, risk management issues, sector-specific vulnerability, etc.

Whether or not a business has compiled a strategy for overcoming the risks and capitalizing on them has a direct effect on its turnover in the future. This, in turn, is vital for investors to understand, since a firm's present value

can be regarded as the discounted value of its future net cash flows. However, at current, it is still difficult for firms to disclose these strategic efforts. Although there are many guidelines for climate communication, there is little empirical evidence of the efficacy of these efforts. As a baseline, the communication of climate change and its business implications should take an integrated approach as it involves complex and uncertain interactions of many processes (Pidgeon & Fischhoff, 2011) as well as many stakeholder groups as an audience.

Kolk et al. (2008) examined the historical development of corporate reporting mechanisms for GHG emissions and state that "the institutionalization of carbon disclosure is a political project because it entails a change in the structures of corporate governance in a way that shifts attention toward environmental objectives and enhances the legitimacy and engagement of environmental NGOs in governance processes." Further, they suggest that even though carbon disclosure is theoretically seen as a win-win situation, the management and shareholders might still be against it, reasons for this being the loss of autonomy, additional costs or emission-reducing pressures. The findings of Kolk et al. (2008) reveal that even though the institutionalization of disclosure mechanisms for companies has been successful and received publicity and support, the comprehensibility of the individual carbon disclosures has remained questionable. The call for stricter carbon disclosure with clear guidelines is still existent, as is the need for an external verification.

Nevertheless, investors are able to source a varied amount of research for understanding environmental issues and their impact on investment (Ceres, 2010). Companies publish environmental reports which address the most important environmental issues as perceived by the company and how they are able to cope with these issues. However, they are not always objective by nature and can reflect merely the competence of the staff preparing the report—not the actual activities against environmental impacts or adaptation strategies. Additionally, there are also research reports compiled by expert organizations or ratings based on these reports and analyses. According to a survey by Ceres (2010), the majority of investors utilize advisory-generated research material such as broker reports or in-house bespoke research. These are disseminated among investors using various methods such as inclusion in a proprietary database and internal communications such as reports, websites, newsletters and presentations.

Disclosure is ultimately named as a part of an efficient climate strategy (Ceres, 2006; Hoffman & Woody, 2008). It involves reputational risks and opportunities and is a strategic decision if and to what extent the disclosure is done. Hoffman and Woody note that in case a firm decides to disclose through public means, it should be on a sound basis, since the activities will then be open for scrutiny. There are several mechanisms through which companies can disclose their climate-related risks and opportunities: the CDP, the INCR as well as the GRI with its broader focus, and in the US, the Securities Filings. Companies can use the voluntary disclosure mechanisms to provide information about themselves, mainly for reputational reasons. The information

provided can then be used by investors or other analysts for their investment or analysis purposes. Additionally, authorities can ensure that the disclosure adheres to the disclosure mechanism. Commonly, elements of disclosure include information about emissions level, regulatory risk, physical risks and a strategic analysis of climate risk or emissions management (Global Framework for Climate Risk Disclosure, 2006).

In order to increase the ability to generating an understandable communication of climate change, Filho et al. (2009) propose cost-efficient and, above all, integrated solutions to communicating issues relating to climate change. Some elements raise awareness of climate change and hence allow it to be communicated more efficiently. These include stakeholder engagement, a combination of technical expertise and communication approaches and the need to identify and promote solutions. Larger companies often use the above mentioned disclosure mechanisms (e.g., CDP and GRI), but SMEs seldom participate in these. For SMEs, the disclosure is a voluntary exercise depending on the passion of managers, shareholders or customer requirements and the uptake of sustainability reporting by small and medium-sized enterprises remains fairly low compared to large companies (GRI, 2011).

4.4 Market-based drivers

The dilemma so far in the financial markets has been managers' pressure for short-term profits while sustainable development and climate change mitigation or adaptation requires long-term actions (Marcus et al., 2011). However, in the context of climate change, little attention has been paid to examining markets and how they can incentivize mitigation and adaptation actions. After all, economic agents need to be encouraged (Agrawala, 2008).

The new markets and the anticipation of new legislation are slowly initiating investors in the asset markets to make a shift toward a low-carbon economy. This makes the issue interesting from a pure market economy perspective. Significant opportunities for investors in areas such as cleaner and renewable energy, energy efficiency and de-carbonization will yield substantial economic benefits (UNEP, 2011). For investor reactions and market issues, large-scale asset managers need to make informed choices in how to invest funds. They must weigh many the aspects of their investment choices and start to include environmental and social factors in their choices. Large-scale borrowers, who need to draw money from the financial markets, cannot risk a low rating.

The same idea has been formulated by the US, European and Australian investor networks about climate change in the 2011 Global Investor Statement (IIGCC, 2011):

> Climate change presents major long-term risks to the global economy and to the assets in which we invest. At the same time, well designed and effectively implemented long-term climate change and clean energy policy […] will not only present significant opportunities for investors in areas such as cleaner and renewable energy, en-

> ergy efficiency and decarbonisation, but will also yield substantial economic benefits including creating new jobs and businesses, stimulating technological innovation, and providing a robust foundation for economic recovery and sustainable long-term economic growth.

This statement is not to be taken for granted or regarded as trivial. It represents much more than just progress on climate issues or sustainability issues in general, nor is it merely welcome value-added benefits or a way to green-wash businesses. It is a huge advancement toward receiving the interest of large-scale investments. This statement is backed with nearly 20 trillion euro, which makes it a serious issue for consideration in the global asset markets.

This makes it plausible to discuss the climate or environmental strategies of a company from a value creation perspective and to introduce the recently developed branch of empirical research studying the relationship between environmental performance and corporate value. A growing body of research shows that strong environmental performance has a positive effect on corporate value, commonly measured as stock value (Klassen & McLaughlin, 1996; Gupta & Goldar, 2005) and conversely even more so, in the case of very weak environmental performance (Lanoie et al., 1998; Yamashita et al., 1999).

However, the impact of a company's environmental activities on its market value has not been demonstrated unambiguously. The ideal situation for sustainability is that environmental activities reduce a company's operating costs as well as increase its valuation on the market. Ideally, investors in the financial markets would look at long-term gains in terms of how the markets are evolving and of how the company is adapting to the changing markets. Essentially there is some visible public interest to change the markets toward a direction which encourages sustainable products, clean processes, recycling loops and clean energy, all of which are at best encouraged by public policy. Some of these issues also have a direct impact on the future cash flow of a company, because they reduce operating costs (e.g., less energy consumption) and increase sales (e.g., increase in demand for new innovative products). After all, according to financial theory, investors maximize expected utility, which in turn is a function of discounted net cash flows. So if an investor sees the discounted net cash flows increase, the asset is inherently valued more. This can be achieved through an increase in efficiency of the production process or employee motivation, eliminating costly materials, reducing unnecessary packaging, simplification of design, innovation and consumer focus methods such as ecolabeling (Porter & Van der Linde, 1995; Allen et al., 2007; Bagnolli & Watts, 2003).

However, Henderson (2001, 2009) formulates a contradicting opinion about the effect environmental and social activities have on a company's net cash flows. He sees these activities as inherently increasing costs, impairing performance, over-regulating the framework and reducing profit-making ability.

The discrepancy of opinions can stem from the markets being not fully efficient and having imperfect information. In the context of climate change, markets indeed fail to reflect the true price of, for example, energy, land use, innovation and emissions, largely due to the special features of climate change. It is

a phenomenon that is global in its causes and consequences and the impacts are persistent and develop over time. GHG emissions, once they have been emitted to the atmosphere, stay there for hundreds of years. This condition means that standard modeling with defined discount factors is very impractical to make, if not impossible. Small changes in, for example, the discount factor, make relatively large changes to the result. Additionally, the uncertainties related to this modeling, are considerable. If modeling the future is done for hundreds of years, the size, type and timing of potential impacts is extremely uncertain, as are the costs of combating climate change. Even with extensive sensitivity analyses the financial analysis becomes very impractical. But these impacts are relevant for the future and have a significant effect on the global economy, which makes ignorance of these issues highly controversial.

In addition to corporate responses to climate change, private investment has a critical role in addressing the risks and opportunities posed by climate change. At present this is widely recognized by different regional and international investor coalitions in Europe, the USA and in the Pacific region in order to increase the awareness of climate related issues in asset owners and asset managers and increase transparency. A survey by Mercer (2010) sent to large investor bases shows that more than 10% of global investment managers have begun to integrate environmental and social issues into their investment process and climate change issues were viewed as a material investment risk/opportunity by the majority of investors who responded.

Problems still remain, however. These include (1) how to integrate the issues in the investment decisions, (2) what kind of data to use and (3) are the data credible (annual reports, industry publications, broker and independent research reports, informal conversations with corporate stakeholders, etc.), (4) how to translate climate change data into investment decisions, (5) how long are policies robust for (e.g., the price of carbon), (6) lack of confidence in the materiality of climate change (e.g., longer term nature of climate change impacts) and (7) lack of experience in interpreting and analyzing data (Mercer, 2010).

4.4.1 Methods for calculating the impact of environmental or climate actions on corporate value

There are four main approaches to test the impact of corporate environmental actions quantitatively: event study methodology, regression analysis on firm value, regression analysis on stock returns, and portfolio performance evaluation. The first method approaches the problem by using relatively short timespans ("event windows") and testing the immediate stock market reaction within this time (Ziegler et al., 2008; Guenster et al., 2006; Wagner & Wehrmeyer, 2002). It can be applied in studies where there is a specific date (event) for an environmental activity, for example the announcing of a large investment (Halme & Niskanen 2001), the release of Toxic Release Inventory data in the USA (Hamilton, 1995; Khanna et al., 1998) or corporate environmental standards (Klassen & McLaughlin, 1996), press releases of environmental valuation

(Konar & Cohen, 1997; Karpoff et al., 1999), third party rating (Gupta & Goldar, 2005; Dasgupta et al., 2004) or ISO certification (Paulraj & de Jong, 2011). Within the event window (1–10 days), it is possible to calculate the abnormal returns after an event by modeling expected returns with the capital asset pricing model and compare these with the actual returns.

There are also contradicting results. Gilley et al. (2000), for example, did not find any stock market reaction to environmental initiatives published in media. However, when the events were divided into initiatives to improve organizational processes and initiatives for improving the firm's products, they found a significant positive reaction to product-driven initiatives but none for the process-driven cases. In context of life cycle methodologies, it can be hypothesized that especially the process-driven changes result from life cycle assessments in its traditional application ways. However, product-driven changes can also ultimately result from using these methods if used on a strategic level and in product design. Nevertheless, the visibility of these changes is different. Without considerable media or marketing efforts, process-driven changes are unlikely to be included in the public's assessment. On the other hand, the introduction of new products or major changes to existing ones are relatively high-profile events and can be used by investors in their purchasing decisions.

Nevertheless, we can conclude that there is a clear immediate stock price reduction following negative corporate environmental news and a weaker positive reaction following positive news (Hamilton, 1995; Klassen & McLaughlin, 1996; Konar & Cohen, 1997; Gilley et al., 2000; Gupta & Goldar, 2005, Dasgupta et al., 2001). If there is an immediate stock price reaction, it can be only temporary, because event methodology cannot show a longer term reaction. In addition, it is not clear whether the price reaction, if there is any, is caused by a change in expected cash flows, change in risk level, or by change in demand by non-value sensitive green investors.

The regression analysis approach relates to the impact of environmental or social variables or ratings to stock return or other value variable in a time series data (e.g., Brammer et al., 2006; Ziegler et al., 2008). Henriques and Sadorsky (2010) estimated in panel data the impact of energy price risk on stock returns and measured environmental sustainability by a private rating agency, and found that increased environmental rating decreased corporate energy price risk. Konar and Cohen (2001), Barth and McNichols (1994) and King and Lenox (2001) focused on the impact of CSR or environmental performance on the market value of a company, usually measured by Tobin's Q. Additionally, the portfolio approach is widely applied to other SRI topics, but only in a few cases to environmental performance and issues (Derwall et al., 2005; Cohen et al., 1997).

All these used metrics would justify the inclusion of environmental issues also from a pure economic sense, or at least generate interest in researching the issue further (some studies do also show a reversed effect, which would indicate that investors see the environmentally beneficial actions as only cost-generating). Because it is becoming more common to rate companies according to their environmental actions and against their peers (e.g., CDP, Risk Metrics

ratings, GRI, Innovest Strategic advisors' ecoefficiency score, Sarasin & Cie rating, EIRIS rating), it makes sense, from a marketing perspective, to initiate activities for environmental improvements.

5 LIFE CYCLE METHODS AS A WAY TO DEAL WITH CLIMATE CHALLENGES

Having described the climate change and sustainability setting for companies as well as companies' role in facing the issues, in this chapter the focus is on actual tools these companies can use to tackle issues such as climate change, or even sustainability impacts at large. Life cycle methodologies can be useful for companies due to their holistic view that ties together the upstream and downstream impacts. In other words, these methodologies can help, for example, with generating changes on different organizational levels, with communicating to regulators and with disclosure for other stakeholders. In addition to the accurate but resource-consuming LCAs, the chapter discusses the potential of less accurate but more usable streamlined life cycle based tools.

5.1 Background to life cycle methods

The current definition of life cycle thinking links the economic, social and environmental dimensions of a product system (goods or services) throughout its entire life cycle. Life cycle thinking is essential to sustainable development and makes the rather abstract concept of sustainability operational (Hunkeler & Rebitzer, 2005; Klöpffer, 2003). The life cycle framework is one of the most well-known basis point for quantitative, sometimes qualitative, environmental assessments of product systems. The life cycle aspect has been included in the general guideline of sustainability since Johannesburg 2002 (UNEP, 2002). As a response to governments' calls for a life cycle economy in the Malmö Declaration (2000), UNEP and the Society for Environmental Toxicology and Chemistry (SETAC) launched an International Life Cycle Partnership, known as the Life Cycle Initiative, to enable users around the world to put life cycle thinking into practice. The launch of the Life Cycle Initiative in 2002 further emphasized the importance of the life cycle approach (Solgaard & de Leeuw, 2002) but also promoted the adoption of a life cycle approach that reflects the global relevance

and impacts a developing countries has for a global economy (Klöpffer, 2003; Töpfer, 2002).

Life cycle methodologies can be seen to date back to *The Limits to Growth*, a report to the Club of Rome and in the energy crises of the 1970s, which showed that the global economic system is in fact vulnerable (Hunt et al., 1996; Oberbacher et al., 1996; Boustead, 1996) and these life cycle methodologies were mainly focused on the environmental perspective. Currently, development is strong in the methodological refinement of individual tools as well as in developing an overarching, holistic modeling tool for assessing the environmental, economic and social aspects of a given product system. In addition to the environmental impacts (LCA), the Life Cycle Initiative emphasizes that an integrated framework should also include the economic and social impacts of a system, a change which has been discussed since the mid-1990s (Benoit et al., 2010). When these impacts are included, it allows a holistic view of the system with recognition of trade-offs and avoidance of problem-shifting (Klöpffer, 2003). There can be situations where an environmental improvement at one stage may have consequences on social impacts on another part of the life cycle. When making informed choices, the decision-maker should, at least, be *aware* of the implication the choice has. Optimally the choices lessen any negative impacts – be they social, environmental or economical. Nowadays, life cycle approaches vary from qualitative decision support concepts and screening methods to detailed inventory-based LCA, life cycle cost assessments (LCC), or sometimes even social life cycle assessments (S-LCA) (Hunkeler & Rebitzer, 2005).

LCC is the logical counterpart of LCA for the economic assessment of a product system and has been developed actively in recent years (e.g., Swarr et al., 2009). S-LCA is still under development and the guidelines are currently being drafted. Nevertheless, it is clear, that these methods should, if applied in parallel to each other, use the same system boundaries and take into consideration the full system (i.e., from raw material extraction and production to use, recycling and waste disposal or other end-of-life activities, which finally lead back to the raw-material extraction as replacing flows) in order to make holistic decisions and avoid problem-shifting.

LCA is still far from being standard practice. Even though many organizations have implemented life cycle thinking, and especially EU policymakers have adopted LCA as a guiding principle for several directives, the application of LCA is still often limited to singular efforts (Hunkeler & Rebitzer, 2005). However, the concept of LCM is becoming more general in practical approaches. It is a business management approach that can be used by all types of businesses and organizations to improve their products and their sustainability performance within value chains. It was developed to build a business approach to managing the total life cycle of products and services (Remmen et al., 2007) and it can be used to target, organize, analyze and manage product-related information and activities toward continuous improvement during the life cycle (UNEP/SETAC, 2009). This way it fulfills three basic functions: analyze the life cycle, identify the risks and opportunities, and establish systems to manage

these risks and opportunities. The management of environmental impacts can include different types of activities ranging from operative to strategic adjustments. The strategic level requires long-term plans in order to achieve changes. According to Linnanen (1995), LCM consists of three parts highlighting the connection between LCM and strategic planning: (i) integrating environmental issues into decision-making; (ii) optimizing the product system's environmental impact during its life cycle; (iii) creating a new organizational culture supporting decision-making.

Figure 2 visualizes how sustainability, environmental and climate change impacts are linked within this family of methods. The figure shows that assessing sustainability impacts presents the largest scope to be applied. In this case, an organization should assess the environmental impacts, the economic impacts and social impacts. (Note that each can also be assessed individually.) Thus, assessing the environmental impacts (generally known as an LCA) has a more narrow scope. The LCA furthermore can be divided into several different environmental impact categories, one of which is climate change. Thus, assessing only the climate change potential reduces the scope further. Nevertheless, the results of these assessments should be in line with each other, but due to the weighting decisions, they are still subjective and not always unambiguous.

5.2 Life Cycle Assessment (LCA)

Traditionally, LCAs are the backbone of the life cycle methods. To a degree this is still valid. However, the parallel methods of LCC and S-LCA as well as the entire framework of LCSA are becoming more widely discussed and developed.

The first life cycle studies from an environmental perspective (i.e., LCAs) were carried out in the late 1960s and early '70s. The original idea was attributed to the Coca-Cola Company (Hunt & Franklin, 1996; Klöpffer, 2006) for packaging and waste issues. However, the LCA as we know it today was created by SETAC (Klöpffer, 2006). When the oil crises were overcome, the interest in energy conservation and balances declined for a few years. At the end of the 1980s, as Klöpffer (2006) states, there was an "unprecedented and still not fully understood steep increase of the demand for ecobalance studies." In its original form, the methods focused on mass (waste) and energy flows, which in the 1990s were further developed to an evaluation framework in the form of the LCA[10] as an assessment tool for the environmental impacts (energy, resources, emissions,

[10] Previously, the term Life Cycle Analysis was used, but that term is now obsolete for designating the method. It is still used as a synonym for life cycle thinking or other forms not strictly corresponding to the ISO standard (Klöpffer, 2006). Another terminological confusion arises from the terms ecobalance and LCA. By definition, an ecobalance reports the physical flows occurring within a particular organization during a specified period of time, and LCA is a product-specific declaration of its environmental impacts during the entire life cycle. However, ecobalance as a term has been used sometimes, albeit rarely, in context of an LCA.

waste) of a product or service was developed. The methodological development in the area has been strong ever since (Finnveden et al., 2009), starting from pollution prevention and gate-to-gate concepts or single facility perspective and having developed into entire life cycle models (Hunkeler & Rebitzer, 2005). The method, with its current name and structure, was presented for the first time in 1990 even though it had already been used before, both in North America and in Europe. The harmonization efforts led to LCA being standardized under the ISO standard (ISO 14040) in 1997.

According to ISO, the concept of LCA was portrayed as the compilation and evaluation of inputs, outputs and potential environmental impacts of a product system throughout its life cycle (ISO 14040), meaning that each life cycle stage (raw-material extraction, production, transportation, use, end-of-life processes) has to be acknowledged and included in an LCA. The product system (a product or service) is followed from its *cradle*, where raw materials are extracted from natural resources, through production and use to its *grave*, the end-of-life processes (Baumann & Tillman, 2004). The aim is to quantify the environmental impacts that the product system causes in each process. Some more common usages of the LCA methodology include the carbon footprint, which is an LCA for only one environmental impact category (climate change potential). The comprehensive scope of LCA is useful in order to avoid problem-shifting between life cycle phases, regions or environmental problems (Finnveden et al., 2009).

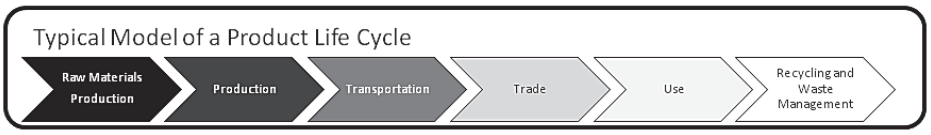

FIGURE 4 Typical model of a product life cycle

All full-scale LCAs contain (1) goal and scope definition, (2) life cycle inventory, (3) life cycle impact assessment, and (4) interpretation and reporting as an iterative process (ISO 14040).

There is some criticism against the LCA method. Even though the results seem unambiguous, there is uncertainty and arbitrariness present (Huijbregts et al., 2001; Geisler et al., 2005; Lloyd & Ries, 2007). Uncertainty can stem from many different sources, such as variable, erroneous, misspecified, incomplete or rounded data, boundary choices, inconsistencies in the goal and scope, allocation principles, time horizon in the impact assessment, and inaccurate implementation of relations in software applications of LCA. (Finnveden et al., 2009).

All of these issues can have a dramatic effect on the end results and depending on the modeler or the purpose, different results can be reached purposefully. Also, LCAs are often static in time, and an LCA done a year ago does not represent the situation currently. Neither is it possible to predict how changes in the product system will affect the future. If a decision is made based on current LCA results, it is characterized by considerable uncertainty at all

stages of the decision-making process. Ecological systems in general are uncertain and the ways our natural environment will change due to climate change, or any environmental problem, are not fully predictable. Sixty years ago, anthropogenic climate change, for example, was not anticipated or seen as a threat.

An LCA can be made to be more dynamic by using a consequential approach. This brings us closer to the next point of criticism—over-complexity. Adding many features, and not only in terms of consequential LCA, to an LCA makes the results more unclear and unsuitable as a basis for decision-making. For example, the modeling of uncertainty—be it for a static system or for the future—involves several methods, such as scenario forecasting, sensitivity analysis, probability analysis, decision trees and Monte Carlo simulation. The great amount of detailed data required to complete a full LCA can discourage some practitioners from using one as a decision-making support tool. However, over-simplification of the processes or the situation is not appropriate either, so the modeler has to make some subjective choices of trade-off in the process of preparing an LCA (Benedetto& Klemes, 2009).

5.3 Environmental life cycle costing and social life cycle assessment as emerging methods

5.3.1 Life cycle costing (LCC)

A way to add a business perspective to LCA is being actively sought. The proposals have included consequential LCA, partially integrating economic considerations in the system delimitation (see the review in Earles & Halog, 2011), hybrid input–output LCA, combining economic input–output tables with considerations of environmental assessment (Suh et al., 2004) as well as LCC, summarizing all direct costs within the lifecycle of a product system (Swarr et al., 2011). There is clearly an interest to find a method to logically combine environmental and economic issues.

Originally, LCC[11] was not developed in an environmental context. The history of LCC dates back further than LCAs, to after the Second World War, as the USA initiated life cycle cost calculation in its public procurement and public defense (Fisher, 1971, as referred to by Swarr et al., 2009; Gluch & Baumann, 2004). LCC in the public sector makes intuitively more sense than in the private sector, because there are certain functions the government needs to offer either for free or for a nominal price (e.g., public health care, recreational areas, parks, road network, defense). In this case, the public sector is in general not interested in the generated income (since it is low or since the service must be provided in

[11] Also known as environmental LCC, full cost accounting, full cost environmental accounting, total cost assessment, total cost accounting, life cycle accounting, full cost pricing, whole life costing. For a detailed account of the variants of LCC tools, see Gluch and Baumann (2004).

any case), but in the cost side, that is, how much the government needs to budget for the function.

LCC in its traditional form yields the present value of all current and future real asset-specific expenditures throughout the product's useful time for any of the actors. It is possible to evaluate the differences and timing of costs because they are all discounted to a base year, similarly as in a traditional net present value calculation. However, the development of the current understanding of environmental LCC, as the counterpart for LCA, has not been unanimous. There have been contradictory opinions mainly in the way the so-called hidden, social or external costs are dealt with. Originally the idea of the environmental LCC was that all external costs (e.g., emissions, environmental harm, social impacts, and other non-monetary damage) are included in the calculation. However, there are several problems with this idea. First, most of these impacts are not transferrable to monetary units and, as Klöpffer (2003) states, "even the attempt to monetarize [these impacts] sounds clearly repulsive—what is the monetary value of a human?" Still, the monetarization is used in some methodologies, such as cost-benefit assessments, because this is often the only measure investors, public or private decision-makers have been interested in.

The Code of Practice (Swarr et al, 2009) formulated the current understanding of environmental LCC in such a way that instead of having to monetarize external impacts, such as pollution, one carries out the LCA and LCC in parallel (and later also an S-LCA), so that the LCC summarizes only all *direct* costs during its entire life cycle from all points of view which are attributable to the product system (Swarr et al., 2011). As in LCA, the attribution to a product system is important for assessment in order to estimate the true costs or true environmental interventions of the product in comparison with another that fulfills the same function or has the same benefit (Klöpffer, 2003).

The parallel LCA and LCC would rectify the problem of double-counting any impacts (having external costs expressed both in monetary units and in environmental units). By using parallel LCA and LCC methods with the same system boundaries and by neglecting all environmental externalities from the LCC would avoid the double-counting the impacts. In some cases, where externalities are foreseen at a high degree of certainty to be internalized in the near future, these can be included also in the LCC, even though they are not yet concrete costs (Klöpffer, 2003; Swarr et al, 2009). The current view of environmental LCC also differs slightly from the traditional version of cost accounting therefore, as it includes less tangible hidden costs (but which are still relevant and real flows), such as waste, recycling and environmental protection costs, which are not always allocated directly to a specific product. These costs can be included in conventional cost accounting in "overhead costs," but commonly they cannot be attributed to a specific product.

The current method differentiates the costs depending on who will carry them (e.g., the manufacturer, consumer, NGO, government), giving different values for each user group. Adding up all costs into one lump sum would not

be logical, since there would be double-counting in terms of, for example, the consumer price, which includes the producer prices.

The phases of carrying out an LCC are more or less the same as in an LCA. An LCC consists of a (1) goal and scope definition, (2) economic life cycle inventory and (3) economic interpretation. The life cycle impact assessment as a phase is redundant, because the data does not refinement. The monetary units are one-dimensional and therefore easy to comprehend.

Typical cost categories during the development phase are research and development, test equipment, wages, design and marketing costs, all covered by the manufacturer (or hidden costs such as consumers school taxes, as well as society's public education buildings, salaries, and investment subsidies). During component and main product manufacture, the manufacturer (including component manufacturers) has costs for materials, energy, capital equipment, operating and maintenance, logistics and salaries. From the consumer's perspective, the initial purchase price is included in this phase. From a wider perspective, the consumer's taxes and health insurance are included along with society's waste and water treatment, health impacts and infrastructure. Looking at the use phase of the product, the manufacturer pays for items such as customer support services and warranties. The consumer can face costs such as energy, maintenance and repair (if not under warranty) and taxes. Society's costs could include waste disposal, health impacts and infrastructure. During the end-of-life phase, the manufacturer may have a take-back program to pay for, and the consumer may have disposal fees and society recovery and disposal and landfill development costs. In fact, the cost categories are very much dependent on the product and what kind of a life cycle consumption process it has. Further typical one-off costs include implementation and acceptance costs, initial training, documentation, facilities, transition costs, changes in business processes, withdrawal from service or disposal. However, more importantly from the life cycle perspective, examples of recurring costs that need to be modeled prior to starting any actual calculations are retraining, operating costs, service charges, contract or supplier management costs, costs caused by changing volumes or other changes, downtime or non-availability costs, maintenance and repair, transportation and handling as well as taxes.

As was the case in LCA, making the LCC dynamic, especially in long-term calculations, is difficult. Comparing the dynamics of LCC and LCA, there is a slight discrepancy in the methods. In common use, an LCA is static or it can include certain dynamic features. However, an LCC, through the use of the discount rate, automatically includes a dynamic feature (in case the product's life cycle is less than two years, the discounting can be neglected, which then results in a static system). But how can these methods be used as exact counterparts? This is confusing for products that have an long life cycle and require maintenance for an extensive period of time, such as cars and trains. To estimate future cash flows, the modeler needs to make uncertain assumptions about issues such as future price levels, inflation, markets, institutional factors and technological advances.

Gluch and Baumann (2004) raised an interesting point by discussing the environmental LCC in context of neoclassical economic theory. They pointed out that certain aspects of the theory, such as the complete information requirement, alternative options, no ownership of natural environment and the unavailability of quantification units, conflict with the characteristics of environmental goods. These are well-known limitations of traditional neoclassical theory but they still explicitly point out the difficulty of using traditional economic tools in decision-making that rely on these assumptions.

5.3.2 Social life cycle assessment (S-LCA)

The development of assessing the social impacts of a product system throughout its lifetime is still in its infancy. The effort to develop a systematic framework was started in 1993 by Fava et al., who proposed a social welfare impact category. A discussion of how these social impacts should be measured followed (Norris, 2003, 2004; Weidema, 2006; Dreyer et al., 2006; Hunkeler, 2006; Hutchins & Sutherland, 2008; Klöpffer & Udo de Haes, 2008; Jørgensen et al., 2008; Nazarkina & Le Bocq, 2006; Grießhammer, 2004; Labuschagne & Brent, 2006). There are several problems that make it difficult to add the social perspective to an LCA: (1) The social problems are highly diverse and are weighted differently by different stakeholder groups; (2) the determination of damage categories, impact categories and indicators for these impacts are challenging; (3) defining the system boundaries is difficult as they should be in line with the LCAs; (4) the questions of whether issues are raised by translating criteria or attributes into impacts has been raised; (5) the subjectivity of the data; (6) the ability to express the results per reference unit; and (7) the need for further case studies, etc.

The Life Cycle Initiative has become active in developing the social assessment methodology and set up a working group for the integration of social criteria in LCA. In 2009, the group published the Guidelines for Social Life Cycle Assessment of products (UNEP, 2009). Based on this, Benoit et al. (2010) published a paper in the International Journal of Life Cycle Assessment, in which S-LCA is described as a systematic process using data on positive and negative social impacts during the life cycle and "allowing identification of key issues, assessing, and telling the story of social conditions in the production, use, and disposal of products". The procedure of carrying out such an assessment starts by defining a goal and scope, similarly as in an LCA. Product system modeling is essentially the same as in an LCA or an LCC, by defining system boundaries and the functions of the system under study with a functional unit to which the study refers. Currently, the need for further development of methodological sheets, including subcategories of impacts as well as inventory indicators, is emphasized to structure the data gathering. The inventory indicators are linked to subcategories, which in turn are grouped into impact categories and stakeholder categories. Impact categories are each related to social themes of interest to stakeholders and decision makers (Benoit et al, 2009). Thus, the S-LCA needs to consider which stakeholder groups the study accounts for (e.g.,

workers, consumers, local community, society, value chain actors, NGOs, public authorities) and in the context of these stakeholders, which subcategories of impact are considered. A comprehensive list of these subcategories of impact is presented by Benoit et al (2009). It includes issues such as child labor, fair salary, working hours (worker); health and safety, feedback mechanism, end-of-life responsibility (consumer); cultural heritage, community engagement, local employment (community); contribution to economic development, corruption, technology development (society); and fair competition, supplier relationships, promoting social responsibility (value chain actors), which relates to broader social themes, such as human rights, work conditions and poverty. Additionally, allocation procedures, assumptions, value choices, limitations, data quality requirements, social acceptability, stakeholder approach, model development and a systematic review process are still called upon.

It seems that the S-LCA methodology receives heavy criticism for three reasons: (1) The LCA concept is not suitable for measuring social aspects, but rather a site-specific perspective would be more appropriate; (2) lack of data from the use phase; (3) even though the methodology has been widely discussed during the last 15 years, there is still a very limited number of studies that look into the complete life cycle for social issues. (To my knowledge there is only one, Ciroth and Franze, 2011.) It remains to be seen whether or not the S-LCA method will be able to overcome these problems and become a practical tool for modeling the social impacts of a product system throughout its life cycle.

5.4 Life cycle sustainability assessment (LCSA)

The use of an LCA, LCC or S-LCA alone as a decision-making basis for sustainability in a strategic sense is insufficient. To achieve sustainability in business or any other activities, all three requirements (environmental, economic and social sustainability) must be met. Even though, from a pure opportunistic business perspective, one might assume that fulfilling economic sustainability (i.e., making a profit) is sufficient for trading, in the previous sections of this study we have shown that even from a business perspective there are future regulatory changes anticipated due to the changes in the environment. If a business is not able to accommodate these changes, it cannot operate in the future. Thus, business should fulfill the environmental and social sustainability requirements as well, which in the future will be, at least to some level, internalized in the regulatory environment.

The first time the three dimensions of sustainability—economic, environmental and social—were applied from a life cycle perspective was in product line analysis (Ökoinstitut, 1987). Curiously enough, this was the same year as the Brundtland report was published, so it has remained uncertain, who had an

impact on whom, or were they produced independently[12]. Essentially, product line analysis was an LCA with an impact assessment with the three dimensions, which represents an operationalization of the concept of sustainability. However, the formulation of a code of practice took until 2011 to be drafted (Valdivia et al. 2011). To date, standardization has not been carried out. Prior to the code of practice, critics said that despite the variety of environmental impacts being produced, sustainability assessments were often reduced to an LCA, or even a mere carbon footprint calculation (Finkbeiner, 2009). The reason may not lie only in the lack of relevant data, but also in the lack of a unanimous perspective and goal. But currently the LCA community has identified that not only LCAs, but rather a full life cycle sustainability assessment is an important part of decision-making. Over the years, the discussion has evolved from a pure methodological development of LCA and case studies to a more holistic approach in increasing awareness of false optimization and wrong choices, such as the burden shifting within or between each domain (environment, economy and society) or to the future. Klöpffer has initiated the discussion on the options of how to formulate the procedure to carry out a full sustainability assessment (Klöpffer 2006, 2008; Klöpffer & Renner, 2008). Furthermore, as Klöpffer and Ciroth (2011) predict, "the further development of LCSA [life cycle sustainability assessment] will mainly depend on the improvement of the [individual] life cycle methods," a statement which underline the fact that all pillars of sustainable development are relevant to the final framework. As an intermediate conclusion, a recent report by the Life Cycle Initiative introduced the framework of a life cycle sustainability assessment (Valdivia et al., 2011).

The current understanding of LCSA is formulated as such (Finkbeiner et al., 2008, 2010; Klöpffer 2003, 2008; Klöpffer & Renner, 2008):

LCSA = LCA & LCC & S-LCA

The results for an LCSA calculation cannot be reduced to one quantitative measure, but rather the results of an LCA, LCC and S-LCA are viewed separately to allow the visibility of trade-offs. There is no consensus about the relative weight of these aspects (nations with different development levels also weigh these aspects differently), so for decision-making a one-dimensional result cannot be envisioned (Klöpffer, 2003).

There is a second approach to sustainability modeling developed by Guinée et al. (2010), which goes under the name life cycle sustainability analysis. It takes the modeling a step further from product-based assessment. The life cycle sustainability analysis broadens the analysis to a meso-level in terms of sectorial modeling and allows sectorial environmental impacts (environmentally extended input output analysis, EE-IOA) as well as economic impacts (input–output analysis or partial equilibrium models) to be included in the assessment. Furthermore, economy-wide assessments can be carried out by modeling envi-

12 According to a personal statement of Walter Klöpffer both the product line analysis drafters and the working group of the Brundtland report have claimed the application to be their own handwriting.

ronmental impacts (EE-IOA) and economic impacts (multi-region IOA or general equilibrium models). Social impacts of the meso- or economy-wide level have not been addressed yet in Guinée et al.'s framework. Furthermore, Guinée et al.'s framework is not as widely used as a systematic modeling approach as Klöpffer's and Valdivia et al.'s.

Currently there is an ongoing attempt to standardize the LCSA. An additional possibility has been introduced by Jørgensen in the SETAC LCA case study conference (see Cinelli et al., 2013), who had the idea that, instead of the three separate pillars of sustainability in the formulation, an LCSA would consist of a modified LCA and a modified SLCA, changed in such a manner that both would include some economic factors (e.g., the same amount of capital to be maintained and poverty to be alleviated). Klöpffer, even though fully behind his original proposal, has additionally stated in the same conference that other possibilities might include adding social and economic impacts to a standard LCA framework as new impact categories. However, this would require the ISO standard to be changed. Other options include the LCSA constituting of an eco-efficiency score added to an SLCA or an LCA added to a socio-economic analysis, as proposed by parties such as the Institute for Energy and Environmental Research (IFEU).

Traverso et al. (2012) published the first implementation of a sustainability assessment of PV modules with a new methodological development in the form of a Life Cycle Sustainability Dashboard, which allows an easy-to-understand visualization of the LCSA results and a direct comparison of different product systems. Currently there are attempts to further implement the framework, but peer-reviewed publications are not available yet. (Conference papers from Bozhilova-Kisheva et al., 2012, and Lehmann et al., 2012, present indicatory results).

LCSAs essentially require multidisciplinary knowledge bases, incorporating natural sciences, business and economics as well as social and medical sciences. The decisions based on these multidisciplinary assessments and the fact that they involve shared resources and broad constituencies, means that group decision processes are often necessary. This may have some advantages over individual processes. In particular, more perspectives may be proposed for consideration, the probability of benefiting from the presence of natural systematic thinkers is higher, and groups often learn to rely on more deliberative, well-informed members (Kiker, 2005).

5.5 Call for streamlined methods

Even though a thorough assessment framework with individual methods has already been proposed and is in the process of being further developed, there are still numerous areas in need of development in order to advance the implementation of LCSA tools. Even though more research has been undertaken to develop and systematize the individual methods within the framework—

namely LCA, LCC and S-LCA—less attention has been given to understanding the overall management tools of the framework and how these can contribute to the assessment. The management tools could be mobilized to complement the life cycle methodologies and the accounting and analysis of material flows in order to control, reduce or prevent the sustainability impacts of a defined life cycle (Pesonen, 2005). Klöpffer (2003) discussed that ultimately what is needed are simple-to-use methods giving reliable results that are relevant for the businesses and that would be able to operationalize the principles of sustainability, that is, the triple bottom line. As the area of simplifying is still in its infancy, no general methods are recommended at present (Rebitzer et al., 2004).

Moreover, for practical decision-making in early phases, there is a demand for less complicated, more widely utilizable tools in situations in which preliminary analyses need to be made or in which less-than-perfect results can still be considered better than no results at all. A systematic methodology to combine quantitative and qualitative inputs of risk, cost, benefit, and stakeholder views and values to rank project alternatives, has yet to be fully developed for environmental decision making. As a result, decision makers are prevented from identifying all plausible alternatives and from making full use of all available and necessary information in choosing between alternatives. When facing complex and multifaceted problems, people are intuitively trying to reduce the problem to a more manageable form, which in the process of simplifying might lose important information. This underlines the need of a *systematic* approach for making informed, thoughtful choices in a complex decision-making environment involving value trade-offs and uncertainty (Kiker et al., 2005).

Rebitzer and Schäfer (2009) published the results of an industry-specific survey that demonstrated that LCA as a methodological framework is understood by little more than a quarter of the respondents and that knowledge about LCA and what it can do is not yet part of mainstream thinking. Jørgensen et al. (2009) studied the industry's ability and willingness to devote efforts in the context of S-LCA. These studies indicate that the LCA community should encourage a discourse with industry decision-makers to enable the use of life cycle methods and its results in the future. The scholars need to understand how well life cycle results are understood in real-life decision making, how they are brought closer to real application and how the life cycle thinking can be carried over to strategic choices in businesses and real changes toward a more sustainable course of actions (Finkbeiner et al. 2010).

There are three basic levels of LCA (Wenzel, 1998):

- a full-scale LCA, quantitative and including new data inventory;
- a screening LCA, quantitative using readily available data or semi-quantitative;
- a matrix LCA, qualitative or semi-quantitative.

As mentioned previously, a full-scale LCA can be time and resource intensive, which leads to the outcome that they are not always the primary or best action of a company. In fact, the inherent complexity of carrying out a full LCA can be hypothesized to stand in the way of a widespread application in the industry and policy-making sectors (Bala et al., 2010). Furthermore, the results of a full LCA can be very complex and difficult to understand for decision-makers either in the industry or in the public sector.

Both screening and matrix LCAs from Wenzel's division are streamlined approaches. A screening LCA uses mainly quantitative data from ready-made databases so that no new inventory calculations are made. Qualitative matrix approaches and the use of energy demand as a screening indicator are the most widely applied screening approaches. Matrix methods are especially preferable if detailed LCAs of similar product systems exist, from which conclusions can be derived based on the identification of differences to a well-known system. Energy demand can be useful, because energy-related data are readily available for many single processes as well as in aggregated forms, and several environmentally important impacts are strongly linked to energy generation and consumption processes (Rebitzer et al., 2004). In general, streamlined life cycle approaches can be qualitative, quantitative or semi-quantitative. A large number of simplified LCA methods have been developed (see Baumann & Tillman, 2004 or Pesonen, 2007). Complementing these systematic methodological options, also the experience of the LCA practitioner is an invaluable asset for providing screening insights and recommendations. However, even if sufficient know-how and experience for a product group is available, it is difficult to predetermine the important unit processes and environmental issues without the risk of neglecting relevant hot spots or trade-offs. (Rebitzer et al., 2004)

Rebitzer and Hunkeler (2002) proposed criteria for a simplified system:

- Relevance: Compatibility to the decision to be supported by the LCA;
- Validity: The simplified LCA should give the same ranking/insights for a given study as a detailed LCA, though lower resolution is acceptable;
- Compatibility with computational procedures: Only if a method can be implemented in software algorithms, is it possible to integrate the procedure into existing databases;
- Reproducibility: A method should be designed so that different practitioners arrive at the same ranking results;
- Transparency: In order to be credible and to identify improvement potentials, a method should be transparent.

Additionally a simplified assessment should pass a reliability check in the form of a sensitivity analysis after the simplification procedure. The procedure is a dynamic method, where the different steps interact, and the results of one step might lead to an adapted repetition of another (Rebitzer et al., 2004).

Currently some streamlined methods for a full sustainability assessment have also been developed. The fields of application for simplified life-cycle-

based methods are, for example, product development and procurement, more specifically in planning, conceptual design, embodiment design as well as detail design (Baumann & Tillman, 2004). Many of these methods are developed for a specific group of products and are not well-documented (Hochschorner & Finnveden, 2003). Some previously used methods for streamlined sustainability assessment are life cycle influences matrices, software tools, LCA-derived proxies, rules of thumb, hot spot analysis, combination tools, LCA as a creativity tool as well as life cycle thinking, environmental sustainability assessment tool and sustainability matrices. A number of life cycle approaches exist, both analytical and creative, for all stages of product development (Pesonen, 2007; Baumann & Tillman, 2004). However, the majority of these approaches do not assess full sustainability. Instead, they remain in the field of environmental impacts.

In the literature it is not the ultimate ambition that the streamlined approaches fully substitute a full-scale assessment such as LCA. It is not either the ambition to produce material for external communication (McAloone & Bey, 2009). Rather, their goal is to illustrate how individually adapted simplified models can be useful in providing a reliable, quantitative measure of environmental impact, which may just be what is in order for the purposes of imminent political and economic decisions (Bala et al., 2010). And even with these limitations, these simplified methods give a quick overview of a product's environmental profile (McAloone & Bey, 2009). Additionally in the corporate context a step-by-step approach has been proposed (Liedtke et al., 2010) in which a streamlined analysis, with any of its methods available, is carried out. After this, the second and third steps, which would be carried out for a viable selection resulting from a streamlined analysis, could either be a material input per service unit (MIPS) or a full-scale LCA including, as the assessment becomes more detailed, other core indicators as in the streamlined first-cut assessment and more exact differentiation. Environmental life cycle considerations are probably best supported by a well-balanced combination of a few approaches (Baumann & Tillman, 2004).

When life cycle methods, particularly LCA, are used to support decisions, uncertainty is again an important issue to be incorporated into the assessment. Keeping in mind that a streamlined LCA can increase the uncertainty of the sources, it would be appropriate to try to deal with this issue. In particular, if a streamlined approach produces quantitative results—such as for software-based applications—the results can at first seem very certain. Nevertheless, if only looking at the results, it is often overlooked that the actual process behind them is not very transparent. An approach is required which manages uncertainty of all types and does so with transparency, fairness and competence.

However, the more tangible and ambitious the measures resulting from streamlined tools are, the more significant is the trade-off between the accuracy and usability of these tools. It is a strategic choice to decide whether to make a first-cut assessment with a streamlined tool and then continue the exercise by carrying out full-scale LCAs on chosen product systems or impact categories to

get more accurate and reliable results. The other option would be to merely carry out the streamlined exercise. However this option does not necessarily provide information about specific process optimization, but rather increases awareness, gives an overview, highlights the supply chain, enables future-oriented rough guidelines, or communicates the results of more detailed assessments. Furthermore, for quick responses and imminent decisions, full-scale LCAs cannot be carried due to time pressure, but streamlined, less-accurate versions could be applied at minimum. In some cases streamlined assessments can provide results that are complementary to a quantitative LCA (Hochschorner & Finnveden, 2003). Nevertheless, in streamlined assessments the results will always rely on the expertise, size and inputs of the panel. Their results will be subject to the risk of obtaining results that are different from full LCAs (Hunt et al., 1998). Therefore the results will not be accurate, nor should they be used for ranking. Furthermore, the results should be communicated in a manner that highlights the level of accuracy. In effect, the companies should be informed about these trade-offs, and decide case-by-case whether or not to apply a streamlined study. And if they do apply one, they should use it either as a pre-study to a full-scale LCA, as a parallel assessment, providing complementary results to an full-scale LCA or as a quick and cost-efficient way to approach and generate awareness of particular impacts.

5.6 Climate SWOT and Sustainability SWOT

Both the Climate SWOT and Sustainability SWOT are used in this study as examples of streamlined life cycle methodologies. They are analytical tools combining two well-known methods: the basic SWOT tool developed in the 1960s (e.g., Ansoff, 1965) and LCA, which emerged roughly at the same time (Pesonen, 1999), with the core idea of integrating life cycle considerations with strategic business planning. As a tool for decision-making, these tools foster learning and cooperation. The Climate SWOT as well as the Sustainability SWOT can be constructed independently by companies, or formed as a cooperative effort among business and climate experts, thus engaging stakeholders in an integrated way. Using these tools can be a powerful learning experience increasing awareness of the complexity of climate and sustainability issues. They can be further used as a starting point for a more comprehensive environmental management system, or they can be parallel tools for complementing other assessment methods. Nevertheless, the same criticism that was discussed in the last paragraph of section 5.5 needs to be considered in the context of these two methods as well. The trade-off between the accuracy and usability of these tools needs to be weighed, especially if either of the tools is used as a stand-alone assessment method.

In the Climate SWOT and the Sustainability SWOT, the following steps are identical and refer to the main product of the company (a physical product or service). The core requirement is that a life cycle can indeed be modeled. If the

company produces more than one product, a separate assessment would be required for each, particularly if their life cycles differ considerably:

1. Identification of product life cycle stages
2. Identification of climate/sustainability impacts (in climate impacts, the outside-in and inside-out impacts should be separately identified and in sustainability impacts all three pillars of sustainability should be considered at this stage)
3. Qualitative or semi-quantitative significance assessment of these impacts
4. Compilation of the Climate / Sustainability SWOT (a visual representation in matrix form of all life cycle stages, their respective impacts and the significance of these impacts)

Results of the Sustainability and Climate SWOT, which consider sustainability or climate impacts of all life cycle stages as well as their significances, can be used subsequently for strategic planning. The format of a SWOT enables a preliminary qualitative sensitivity analysis of the product sustainability by including the potential opportunities and threats. Thus, if using the Sustainability or Climate SWOT for strategy drafting, there can be different strategy options resulting from the initial SWOT matrix. These strategy options are built in such a way that they strengthen the current strengths further and actively build future sources for competitive advantage for all life cycle stages. On the other hand, the current weaknesses should be mitigated and the threats should be actively followed. Adaptation plans should be designed early on in order to implement the required abatement measures. These should be the basis for the final strategy formulation.

For further details and examples on carrying out the Climate SWOT, seeArticle II. For more on carrying out the Sustainability SWOT, see Article III.

6 RESULTS

This chapter ties together and reports the major findings of the separate studies of the thesis (Articles I-IV). In line with the original research questions it gives answers to each individual question through the results from the research articles as well as puts them into the context introduced in the previous sections of the overview document.

6.1 The evolution of the regulatory framework for climate and energy issues in the EU, 1997–2007

The EU policies, as they were analyzed throughout a 10-year period, indicate the regulatory activities within all the member states. The EU member states are playing an important role in discussing global treaties for combating climate change and are reducing their own GHG emissions and taking serious steps in lowering the emissions of developing or emerging economies.

In terms of energy policies in the EU, some clear trends were found. Four major themes emerged from the data, which are related to energy issues and to the integrated climate change approach: energy efficiency, security of supply, liberalization of markets and diversification. Each of these themes was examined more closely and put into context with climate change since all of them have a contribution to its mitigation and adaptation, not only within the EU, but worldwide.

The increasing interest in energy efficiency was the most prominent trend to be found and it was seen as an important method for reducing GHG emissions. At the beginning of the period, this topic included an educational and informative perspective, because the lack of information was seen to be the primary barrier to energy efficiency, in contrast to technical issues. Later the focus was shifted to legislative and framework issues. However, one should keep in mind that along with legislation aimed directly at promoting energy efficiency, there are many other energy-related directives that have direct and

indirect impacts on energy efficiency (e.g., directives in emission trading, renewable energy in electricity production, promotion of biofuels in transportation, air pollutants and the combustion of waste, Soimakallio & Manninen, 2007). However, the influence of these directives on energy efficiency and the integrated view on climate change is not straightforward. The interconnections are in fact very complex and despite the common goal of reducing emissions, energy efficiency is not always necessarily promoted by the interconnected directives—in some cases it is even weakened. It was stated that a great amount of the necessary technical solutions have been found, thus the problem seems to be more on the policy side (i.e., how to generate a demand for them and ease their market entry) or on the diffusion side, which means how to increase the market entry/size.

In the EU, a significant problem in drawing up energy efficiency policy has been to find and develop more sophisticated mechanisms to increase consumers' and companies' interest in energy efficiency solutions, especially in the building and transport sector. The developed incentives have ranged from standards, taxation and feed-in tariffs to state aids and special funds and it has been left mainly up to the member states' which ones they want to use. Demand side management (DSM) has been widely accepted as one of the main tools. It is hoped that this tool will influence the energy consumption by end-users. The focus has been on improving energy efficiency rather than on controlling the overall rise in energy demand and ultimately there has been a clear interest to create market demand for energy efficiency technology. New approaches have been developing to suit the competitive liberalized markets. A clear benefit of the demand-response approach is customers' activation and motivation to take advantage of energy efficiency possibilities. On the other hand, implementation of demand response requires major technological investments because it is based on up-to-date metering and communications equipment.

Security of supply in general is strongly connected to energy efficiency, because the EU's security strategy relies on systematic development of its energy efficiency policy in parallel with the policy for renewable energy. There is a strong connection to climate change concerns, which is reflected in the change of attitude towards environmental issues in general throughout the years, because improving environmental protection and seeking clean energy sources is increasingly seen as a source of security and advantage rather than a nuisance. The interest in renewable energy sources grows, but dependency on gas remains a concern. Overall, security of supply has a strong international dimension and further validates the choice of the EU as an indicator for the global progress. Although in earlier stages the geographical scope was mainly limited to Eastern European and former Soviet countries, it has rather rapidly expanded to include Mediterranean countries, developing countries, as well as Caspian basin countries which act as either producer or as transit countries. This reflects the EU's efforts to improve security of supply through diversified cooperation and reliance on different supplier and transit countries.

Interest has increased in environmental, mainly climate related, problems and a more integrated approach between climate change and energy policies. Previously the attitude towards climate efforts in terms of security of supply was negative, or at least these two things were considered in isolation from each other: "Sustainable development must also consider security of supply" (COM 1998/571) or "Efforts will have to focus on orienting the demand for energy in a way which respects the EU's Kyoto commitments and is mindful of security of supply" (COM 2000/76). However, the negative tone has diminished and the reduction of GHGs has been seen as a complementing part of securing energy supplies. These two things are almost parallels in more recent discussion: The Commission's Green Paper on energy efficiency identifies the following major benefits of efficient use of energy: securing the competitiveness of European industry benefiting from reduced spending on energy, environmental protection due to a reduction of the CO_2 emissions caused by energy use, security of energy supply due to reduction of energy demand and hence reduction of dependency on energy imports (COM 2005/265). In 2007, the viewpoint became even more extensive: "The measures outlined below will not only put the EU on the path to becoming a low carbon knowledge-based energy economy, but will at the same time improve its security of supply and make a progressively more significant contribution to competitiveness" (COM 2007/0001). Here the strategy is clearly outlining these three issues as complementing each other and the general attitude has changed and transformed environmental issues from a drawback to a benefit.

In the context of climate change, renewable energy sources are seen as a solution to improve security of supply in all member states. Renewable energy sources are available and indigenous, so the member states have a domestic supply of them, thus increasing the supply security. The focus on any specific sources has ranged between gas, oil, nuclear and renewable energy, with a clear trend towards promoting the use of renewable sources. Since 1995, renewable energy has been named as a solution for supply security practically every year and since 1996 it has been noted that it is even necessary for securing safe supply of energy.

In terms of market liberalization, the establishment of common technical standards, reliable grids across the borders and thorough infrastructural planning were emphasized until 2004, when the markets were liberalized. This meant that EU's internal gas and electricity markets were set into force so that small business customers could choose from different suppliers, new suppliers were born and more competition developed.

In the context of climate issues, the trends of this topic are important enough that environmental, and especially climate issues, gained interest even before the markets were liberalized. Environmental externalities of a fully liberal market were first discussed in 1998. In 2003, it was noted that high environmental standards need to be introduced before the markets are liberalized. Otherwise the higher competition in the markets may lead to unsustainable activities and hazards due to low investments into environmentally sound technolo-

gies. Especially creating a legal framework for internalizing the externalities of energy production became an issue which needed to be solved, to ensure the promotion of sustainable energy and to monitor the environmental impacts in the future's liberal markets.

There are two main issues discussed in context of diversification in terms of geographical, supplier and source diversification. First, it is strongly coupled with supply security and improvement of import dependency. Second, there are renewable energy and climate change concerns. In source diversification, renewable energy receives the most attention due to climate change concerns, but also due to its domestic and secure availability in all the member states. In terms of climate change concerns, GHG emission levels were noted to decrease through use of renewable energy sources. At the beginning of the study period the positive impact of a diversifying trend of the energy sources has been observed and it was mentioned in the same context with sustainability and the fulfillment of growing energy consumption.

The challenges of the EU's energy policy between 1995 and 2007 remain relatively unchanged with a focus on competitiveness, sustainability and security of supply. The four main themes that emerged from the communications can be perceived as proposed solutions to the above mentioned challenges. Promoting all the most important themes found through the content analysis might contribute effectively to improving competitiveness, sustainability as well as security of supply. This is an indication that even within a lager geographic area such as the EU, finding common ground is possible, even though often difficult and time-consuming. The largest problem therefore is not on the EU level, but rather on the periodical nature of most national approaches as well as the uncertainty of the international scope.

In the context of climate change, two things are clear: An integrated approach to energy issues and especially to climate change is a relevant pathway, and to succeed, climate policies must be overarching and not focus on specific pressures in an isolated manner (Hilden, 2011). The integrated approach should be built into and underlie many of the other policy sectors. Nevertheless, despite the common goal of reducing emissions, climate change adaptation and mitigation are not always promoted by the interconnected directives and it is clear that policy formation is an iterative and cyclical process (Crabbé & Leroy, 2008; Hilden, 2011) requiring scientific data as well as cooperation of the different policy fields, entities, processes, conventions and declarations (IPCC, 2007) so that a common goal could be achieved. Within a large geographical scope, such as the EU for instance, even though common goals have been found, it is difficult to commit to common methods to reach these goals. This difficulty becomes even more apparent when talking about global efforts.

6.2 The usability, effectiveness and action-generating capacity of life cycle tools in the private sector

6.2.1 Overall usability of the streamlined tools

The results of the studies validated that there is a clear need for tools incorporating environmental or sustainability impacts with life cycle perspectives on the strategic level of companies. Being aware and understanding the life cycle of a company's products (or main product) is an issue which has emerged both from the theoretical background as well as from the empirical findings of this study. It is not only the firm's own processes, but also all other upstream and downstream processes in the product's life cycle which add to the environmental burden. The intuitive feeling of many unaware managers is that environmental considerations are both costly as well as annoying. Nevertheless, exploring the issue further might enable managers to find opportunities in these issues both on an operative as well as on a strategic level. Unawareness, it seems, can unnecessarily raise the hurdle to acceptance too high.

The general usability and applicability of the tested streamlined tools were promising. The tools are easy to understand and use and the results are visually easy to communicate. Their systematic procedure and inclusion of several important perspectives were seen as beneficial. However, the collected information often needs to be drastically reduced to maintain a clear visual appearance. In some cases this reduction clarifies the overall view, but in more complex product systems it might reduce the informative value. This conflict highlights the importance of tradeoffs between usability and accuracy both in assessing and presenting the results. Most often it is necessary in terms of informative value and visual appearance, which of course depends on the system, goal and scope. Keeping in mind that the LCA community is faced with the fear of having its methods understood only by a small subset of industry professionals, it is encouraging that the streamlined approach tailored according to the logic of business decision-makers (i.e., the inclusion of the SWOT) is able to find the acceptance and understanding of that vital group. Though they do not follow the strict guidelines of impact assessment, be they environmental, economic or social, these tools are able to communicate the significance of a life cycle perspective to businesses and allow them to take into consideration issues along the value chain. In this sense, they can be seen to increase the understanding of the life cycle perspective.

Any life cycle method has its share of uncertainty. Streamlined tools are able to incorporate this uncertainty into the assessment process through qualitative presentation of the results and through the dynamic features (now vs. the future). An approach that manages uncertainty of all types with transparency and competence is required. In full-scale LCAs, more precise uncertainty methods such as a Monte Carlo simulation can be carried out, but in a streamlined method the inclusion of uncertainty is also simplified. The tool includes future

possible opportunities and threats and takes these into consideration with a differing significance, i.e. how likely they are to occur. The presentation does not restrict itself to only one path, but allows a consideration, on different probability levels, of several views of the future. LCA in its traditional form has been criticized for consuming resources and time, producing outcomes which are subject to high variability, even though they seem very precise (e.g., Bala et al., 2010; Hochschorner & Finnveden, 2003; Valdivia et al., 2011). In the background there is a high amount of assumptions and inaccuracies in data, so the results of an LCA are in fact unrealistic and the application of the results demands a fair command of the method. It might be more appropriate to use a more simplified approach, with the results not being as accurate but rather suggestive.

Using a life cycle assessment method, even if it is a streamlined one, still requires a basic understanding of the life cycle perspective. It would be helpful if first of all the users had brief training about life cycle modeling, including at least the central terminology as well as an introduction to modeling life cycles. Furthermore, the analyst must have enough knowledge of the business in order to make a deep, value-adding analysis and raise awareness. The companies must be bound to the project on a strategic level and give inside information. If the strategic-level managers do not believe in real, long-term effects, there is little sense in carrying it out. Or as Porter and Reinhardt (2007) say: "Companies that persist in treating climate change solely as a corporate social responsibility issue, rather than a business problem, will risk the greatest consequences."

The general perception amongst the respondents was that several issues in general could be analyzed with the tool: strategic opportunities, product life cycles, regional issues, industry-specific issues, and innovation. According to the respondents, the potential target audiences were mostly public sector decision-makers or business managers. However, other target groups were found, such as the media, environmental agencies, scientists, investors, consultants and society at large. The uses of this kind of a tool could result mainly in technological investments or changes, which would make it helpful for companies to carry out an exercise as such prior to technological changes. Additional uses of objectives were named for which the tool might be effective, ranging from setting action plans, to giving structure to climate analysis, and ultimately also to building up awareness, with a slight emphasis on adaptation activities.

In terms of raising awareness, which is a significant behavioral trigger (Halady & Rao, 2009), the tools were perceived by the respondents to offer companies a concrete way with which to become aware of sustainability impacts or climate change, in order to relate their activities to the environmental threats and incorporate their opportunities and threats into long-term strategic planning. The tools are seen as particularly helpful, even surprising, in understanding and being aware of implementation possibilities, stakeholder involvement and the usefulness of the life cycle perspective in this context. Also, the final model underlines the importance of the policy-level framework by including regional aspects in the study, emphasizing the linkage to public policy implications and lessons for business policy (Bradford & Fraser, 2008).

The difference between the Climate SWOT and the Sustainability SWOT is in the more restricted focus of the Climate SWOT on climate-related impacts. In this perspective many of the respondents were missing a more holistic view of sustainability (e.g., in terms of social, health or cultural impacts). Thus, there is a decision the user has to make. Either use the Climate SWOT and concentrate primarily on the climate issues and strategies related to those, or opt for the Sustainability SWOT, which allows for a more holistic view. Naturally, as these tools are first-cut approaches, both can be carried out in parallel, especially in cases where the company has a high level of carbon emissions.

6.2.2 Effectiveness of the streamlined tools

Both of the suggested assessment frameworks (Climate SWOT and Sustainability SWOT) were seen to lead to actual changes within the participating companies as well as among the other life cycle actors. This acceptance validates the effectiveness of the tools. If the tools can initiate changes which in turn lessen a company's climate, environmental, or sustainability impacts, then they can be seen as effective. A significant finding is also the fact that in many processes there are adjustment possibilities. Even by using a quick streamlined method like the Sustainability SWOT, business decision-makers are able to detect points to be optimized if sustainability and life cycle perspective are considered.

Even though the tool was originally not meant to be an exhaustive tool for decision-making, it is remarkable how many changes have been initiated. Conceptual changes, such as awareness-raising, were also considered as actual changes. In addition to these, some more concrete as well as more strategic and operative changes were initiated by carrying out a streamlined exercise with relevant stakeholders. The changes were observed to be mainly the following: investments in technology (energy efficiency, energy-saving devices, process changes), investments in human capital (dedicated personnel), new innovative product development, and redefinition of corporate strategy (environmental/climate strategy), introduction of a quality and management system. The intangible changes were mainly described as raising general awareness. The Sustainability SWOT survey additionally confirmed supply chain changes, user communication and public decision-making, which were not asked in the context of the Climate SWOT, as well as changes for improving social impacts (safety investments, toxic substances substitution). Furthermore, those respondents, who had replied that no changes had been generated in any of the cases, specified that either the results were not detailed enough or that no changes yet had occurred, but might in the future. Taking into consideration that the focus group was mainly mid-level or senior management, it is striking to discover that the mere awareness of the system's life cycle is able to provide new information to this level of employees. This indicates that prior to using the tool the focus group had been rather ignorant about life cycle impacts. Unfortunately, it is impossible to assess how many projects have indeed been initiated. (Several projects, for example, might be in product development.)

When talking about the life cycle perspective, it is important to take a look at the processes outside the primary organization carrying out the assessment. There are significant changes to be made along the life cycle in other organizations and these can be systematically approached with a classification based on the LCM target group division by Pesonen (2007), which is based on the IMP Group classification of network groups (1997). Within partnerships or networks of actors, which is the second target group as a multiorganizational target group, (the first one is the organization itself), there are both strategic and operative changes. Focusing more on sustainable or responsible suppliers as well as demanding certain issues (recycled materials, product quality) and auditing the suppliers have become recognized outcomes of the process. The compilation of lists of requirements or instructions for procurement, which can be openly communicated to the partners or to the network, makes the business-to-business activities between companies more transparent, fairer, and certainly more motivating for suppliers to view their own operations. In terms of strategy, the use of a standardized disclosure mechanism has been initiated in one organization, which ultimately leads to the inclusion of the end users as a target group.

An increasing amount of initiatives toward consumers (the second target group) were undertaken, primarily through marketing efforts, certification, or other communications. On a strategic level, the changes were both in communication (sustainability disclosure and marketing mechanisms) and more sustainable product development, in which customer orientation stretched into strategic product concept development. On an operative level, the customer' perspective was included through increasing the energy and water-use efficiency of the product systems.

Some of the strategic level changes which were reported, for example the development of local strategies, highlight once again the connection between policy-level decisions and private businesses. Smaller companies often had an implicit view that they are inherently unable to participate at the policy-making level. However, participation at a regional level and in a focused manner, or through a coalition of businesses, might be effective and appropriate (Hoffman & Woody, 2008). However, as discussed in the previous sections, the regulatory framework needs to be built efficiently and robustly so that private businesses are able to anticipate a steady framework and carry out investments both for mitigation and adaptation based on that (Marcus et al., 2011). Furthermore, the focus group detailed that the stakeholder group's active participation should be emphasized more in order to create positive changes along the entire life cycle, which would indicate a necessity for a development of a holistic approach to the entire value chain. This also relates to the avoidance of the misfit between the information that is provided and the information that is required (Hallegate, 2009; Westerhoff & Juhola, 2010).

An important change process on a conceptual level was awareness building. The process of using life cycle data in strategic decision-making commonly follows an initial awakening process of overcoming the ignorance. In practice,

this means that a person, or a strategic group within a company, becomes aware of the entire supply chain and its sustainability implications and then is able to disseminate the information or requirements further. Awareness of sustainability issues and their consequences are factors which have been greatly undervalued to date. According to Halady and Rao (2010), it has been found that awareness of certain environmental or sustainability issues does lead to significant behavioral change among managers in the industry, alleviating potential and existing threats. Paradoxically, taking climate change as an example, Agrawala et al. (2011) reported that there is a high level of awareness among companies about the significant risks associated with climate change, but not all companies perceive their businesses to be vulnerable to them or to other gradual changes, let alone find opportunities through mitigation and adaptation measures. Therefore, the disconnection lies in an unawareness of the implications of environmental phenomena on a company-wide level. The major contribution of the tool's usage is an increase in awareness.

6.3 Market-based incentives for climate and environmentally friendly investments

The results of the empirical testing of whether or not listed companies have, as indicated in previous studies, stock market based incentives for carrying out environmentally friendly investments are surprising. According to data gathered from the Finnish pulp and paper and energy cluster, investors seem to be indifferent about the announced environmental quality of investments. There is some evidence, not conclusive, that in the case of green investments there may even be a tendency for a share price decrease. Even though it has been explicitly formulated among investor groups that the investment community should encourage climate and environmentally friendly behavior, the actual decisions made by investors do not reflect this. This can be for several reasons. First, the focus of the study was on a conservative branch of the Finnish economy. As a rigid field of business, the investors might penalize any investment into new technologies or products as risky. Since the old ones are still operable, there is no need to deviate from business as usual. Furthermore, due to the renewable resource which it uses as its main resource, the pulp and paper business might be seen as already inherently sustainable and in an obscure way it would be needless to invest into any additional environmentally friendly processes or projects. Paradoxically, the pulp and paper as well as energy business in Finland at current is in a highly volatile operating environment. The demand for traditional pulp products is constantly decreasing, the operating costs are increasing, local raw materials are finite, and global competitors especially from Asian countries are catching up quickly. So the branch finds itself in a situation where changes need to be made on a structural level in order to survive. Perhaps the second finding of the study, that the environmentally friendly invest-

ments actually decrease the volatility of the share price, indicates that the investor community was already expecting changes such as these. A change in the share price might have occurred at another point in time, not within the time frame of the event windows.

The results can also be hypothesized to indicate lack of a robust regulatory framework in terms of the environment. Even though it is clear that investors can have a critical role in addressing environmental issues, there are still practical constraints in integrating these into rational investment decisions. The regulatory framework behind different environmental issues is highly complex, volatile and still emerging on many levels. If a stable regulatory framework with reliable assumptions for legislation, subsidies, taxes, penalties and emission limits is not in place, investment decisions can be difficult to make (see also Marcus et al., 2011, and Sullivan, 2011). The incentives ideally encourage investments into riskier renewable energy, low-carbon projects and other environmental projects. Perhaps due to the current lack of regulatory stability and guidance, investors are inclined not to reward risky environmentally friendly investments. Moreover, our results can be seen in the light of Sullivan and Gouldson's (2011) study in which the environmental policy requirements of investors were studied to better understand their decision making process. Sullivan and Gouldson's results indicated that the current environmental reporting mechanisms are, in fact, not sufficient for the needs of investors. The information released by companies to be used by investors should be further harmonized in a manner that would make the environmental choices transparent and comparable between companies.

7 CONCLUSIONS

This chapter is dedicated to summarizing the main findings, stating the main contribution of the thesis to the relevant academic literatures, clarifying the limitations of the research, stating the main implications for managers and policy-makers as well as pointing out directions for future research.

The main research objective of this thesis is to understand the need for sustainability, environmental and climate strategies in businesses and to use an integrated approach with a life cycle perspective as a starting point. Companies are currently facing pressures from several directions – pressures which will only grow in the future. The storyline of the thesis follows a pathway of describing what companies are being faced with in terms of physical as well as regulatory changes and then describing the companies as active participants in this change. Investors are regarded as a further important stakeholder group. After the companies have been accepted as active players, the focus turns to actual tools with which they can engage either climate change as the fundamental sustainability problem of our time, or sustainability from a holistic view, depending on the scope. The focus of these tools is the life cycle perspective, in which the company is able to substantiate the otherwise fairly indirect impacts.

7.1 Main research findings

One of the most interesting issues discussed in this study has been the practical motives and tools for companies to start integrating responsible actions to their business activities. So far, companies have often had barriers – internal or external, financial or cognitive – to integrate sustainability, environmental issues or climate change in their strategic decisions or investment plans. Nevertheless, there are several underlying reasons why companies could benefit from further considering them.

First of all, the regulatory framework will change and, in light of the trends of the European integrated policies, they will most probably not become

less stringent. Only by considering the future's regulatory framework and adapting to it, will the company maintain its license to operate.

Second, the integration of life cycle considerations, where energy and material flows as well as emission flows can be traced, will help especially energy intensive companies and their supply chains to detect hotspots in which energy consumption and other environmental impacts can be reduced. This will lead to concrete monetary savings in future cash flows (in e.g. energy, material, abatement costs) for the company.

Third, the investor community is already expecting certain changes and investments by the companies in order to ensure cash flows in the future. This expectation presents a motive for larger companies in particular to reduce their environmental footprint and present this to stakeholders.

As a result, it becomes apparent that companies are motivated to include sustainability, environmental targets and climate issues in their strategic decision-making. In the scope of this study it was found that in particular the use of streamlined tools enable the inclusion of sustainability issues in corporate decision-making, and furthermore proves to be a valuable initiator of changes in an organization.

Let's take a closer look at each of the above mentioned issues. First, the challenges of the EU's energy policy between 1995 and 2007 have crystallized from more fragmented focus areas to three areas: sustainability, competitiveness and security of supply. What is interesting is that during this period the EU has come to the conclusion that none of these issues should be tackled in an isolated way, but rather in cooperation. This underlines the fact that competitiveness and sustainability are not counter-forces but complementary. Promoting all the most important themes found through the content analysis (i.e., energy efficiency, market liberalization, security of supply, diversification) contribute effectively to improving competitiveness, sustainability and security of supply. In addition to having detected the complementarity of competitiveness and sustainability, the findings indicate that even within a larger geographic area such as the EU, finding common ground is possible, although often difficult and time-consuming. In contrast to the conservative way of seeing climate (or sustainability) issues as a negative influence on business (Kolk & Pinkse, 2005), businesses could in fact take advantage of the regulatory changes in this context. The largest problem therefore is not on the EU level and its climate targets, but rather in the periodical nature of most national approaches (Crabbé & Leroy, 2008) as well as the uncertainty of the international scope (Sullivan, 2011; Marcus et al., 2011). This is reflected in the investor expectations and reactions.

Second, assessing the companies' ability to use the life cycle perspective to tackle the changing framework confirmed that there is a clear need for tools incorporating climate or sustainability impacts on the strategic level of companies and furthermore integrate life cycle considerations in their activities. This is in line with wider academic literature (Klöpffer, 2003; Kiker et al., 2005; Bala et al., 2010; McAloone & Bey, 2009; Liedtke et al., 2010; Hochschorner & Finnveden, 2003; Valdivia et al., 2011) and with Rebitzer and Schäfer (2009), who

found that at present more complex assessments, such as an LCA, are not understood by industry (Rebitzer & Schäfer, 2009) and in fact, the inherent complexity of an LCA can be seen to prevent the wider application of the method (Bala et al., 2010).

The results have indicated that awareness of climate change, or any sustainability issue for that matter, is an important trigger for business action and should be inspected more closely. Personal values of the organization, which are the motivation behind any new strategy, must include an understanding of climate change and reflect a deep consensus about the change. Our results are, in that sense, very similar to Halady and Rao (2010), who in the context of climate change found that awareness of the phenomenon does lead to significant behavioral change among managers in the industry, alleviating the potential and existing threats of climate change. Both the Climate SWOT as well as the Sustainability SWOT were helpful, even surprising, in understanding, being aware of and taking into consideration the life cycle perspective and the respective impacts. Moreover, they helped to make concrete changes and improvements in the organizations. Even a simple exercise raises awareness of life cycle impacts as well as climate change and sustainability, which further initiates changes to move to a more sustainable direction. The goal is to illustrate how individually adapted simplified models can be useful in providing a reliable, quantitative measure of impacts, which may be what is needed for imminent decisions (Bala et al., 2010). Nevertheless, neither tool is an exhaustive approach. The results they produce are not considered to be overarching strategies to overcome climate or sustainability challenges, but they can be taken as first-cut approaches (Baumann & Tillman, 2004) to lessen the lack of structure in analysis methods. Based on these, more detailed analyses can be carried out to get more extensive knowledge about certain hotspots.

Furthermore, it is not only the industry, which should be well aware of the method. Life cycle considerations are integrated into many of our policies, especially on the EU level. This integration requires that the method gains wider understanding among policy-makers and other stakeholders. The use of the simplified tools of the research necessitates stakeholder involvement to create positive changes along the entire life cycle. It is in contrast to a more restricted (e.g., one-company) perspective, because the use of the tool enables a cooperative stance between stakeholders to set joint goals as well as to identify and establish appropriate levels of involvement (e.g., Gadde et al., 2003).

Finally, the reactions of the Finnish investment community show a neutral to negative impact of environmentally friendly investments on the stock price, unlike e.g. Klassen and McLaughlin (1996) and Gupta and Goldar (2005), who found that the environmental performance has a positive effect on corporate value. However, the underlying study's stock reaction is not unambiguously negative, which is why result cannot either be seen as similar to Henderson (2001, 2009), according to whom environmental investments are mostly seen to increase costs and reduce profit-making ability. Rather, this result can be taken as an indication that the markets have been expecting the environmental in-

vestments that the companies have made and do not show an unexpectedly high or low interest in the stock after an investment has been announced. In essence this is an encouraging trend in the markets. Due to the chosen data set (press releases) this relates partially to the comprehensibility of the individual disclosures which has remained questionable (as discussed in Kolk et al., 2008). However, a more critical look at especially the negative stock impacts can indicate that the markets currently are not functioning as needed. There is a disconnection between the policy targets and the investment community's actions. This disconnection can be due to the ongoing development of the decision-makers mind- and goal-setting and the fact that these policies are not fully mature yet (Marcus et al., 2011). As Article I presented, the EU policies, even though they are crystallizing, are still in a phase of formation. This is materialized in the policies' instability, which further results in the investor's negative and partially contrary reactions to companies' responsible investments. In light of these results, we can ask, as suggested also by Sullivan (2011) if a more radical approach to responsible investment and corporate environmental responsibility is needed in order to deliver the goals of sustainable development.

7.2 The main implications for managers and policymakers

The studies underline the importance of the policy-level framework and especially the linkage between public policy formation and business decision-making. The regulatory framework needs to motivate investments both for mitigation and adaptation (Marcus et al., 2011). International treaties provide a common framework for most countries to reduce GHG emissions, but governments can utilize many different ways to regulate business impact on the climate and the environment. From the perspective of the policy-maker, harmonizing national approaches, reducing uncertainty and volatility as well as reducing the bureaucracy are overarching goals on a global scale. Furthermore, for a robust, integrated regulatory framework to ensure a climate-resilient and equitable future, the public sector needs to ensure stability for longer than just parliamentary terms. Sustainability and climate change efforts cannot be regarded in isolation but must be made more effective by linking them with broader sustainable development efforts (Munasinghe & Swart, 2005). These issues enable the construction of an environment to encourage innovation in decision-making tools, strategies, and mechanisms as well as to mainstream corporate or sectorial climate and environmental strategies.

In business responses, one must keep in mind, that the processes, goals and entire purpose of the private sector are inherently different from the public sector. The rational self-interest of businesses is a major driver of strategic climate actions. It is crucial to understand the private sector's role in climate change, its impacts and mitigation potential as well as adaptation possibilities. The risks posed by climate change may significantly harm business operations, competitiveness, and profits unless they are addressed. Additionally, the com-

petitive pressures caused by other companies further emphasize the need for change. However, as Kolk and Pinkse (2004), among others, have stated, the issue should not only be seen from the risk perspective. Many threats caused by climate change can be seen as opportunities as well.

The managerial level of larger companies, even if they possess knowledge about sustainability, environmental and climate issues, can feel restricted because they need to show shareholders profits and often environmental investments are seen primarily as costs that do not entail any benefits. These do not as such receive the acceptance of the owners. The private sector should be given an incentive from the stock markets, namely, that environmental, and especially climate-related actions are in fact appreciated by the investors. In addition to the difficulty firms have in disclosing their climate efforts, it is difficult for investors, regulators and other stakeholders trying to find information about a company's preparedness for the future. An easy presentation format, such as the streamlined tools discussed in this study, might have a role to play in communicating the sustainability and climate impacts and strategies to these larger audiences. For large and small companies, the life cycle perspective is a valuable starting point, since it ties together the upstream and downstream processes. As a result, the managerial level can feel itself equipped with these easy-to-use tools, which are not too costly and still allow the company to integrate sustainability or climate change throughout the entire value chain in their strategies.

7.3 Limitations of the study

This summary, as well as the individual articles, were prepared with every effort to be as thorough as possible in order to ensure high-quality research. In an article-based thesis each of the articles has undergone a peer review during the publication process, which in a way ensures a certain qualitative level of the content. However, there are some limitations to the thesis as a whole as well as some shortages specific to each article, due to different reasons.

As a whole, the writing process of the thesis has not followed a strict research proposal, schedule or progress. Rather, the three main themes of the articles (policy framework, life cycle methods, and stock reactions) present my own areas of interest and have emerged autonomously. Therefore, even though they represent a larger entity, some minor issues might not be in line with each other (e.g., environmental issues, climate issues, sustainability issues; large companies vs. small companies; EU focus and international focus). Nevertheless, I feel that they pursue the same overall theme and that the context is similar enough that in fact they can be discussed together. A further limitation of the study relates to the comprehensiveness of the data acquisition. The response rate, both in the surveys as well as the interviews, was not as high as hoped for. This is a problem in many studies: How to receive the desired amount of potential respondents in order to be able to carry out a decent analysis with the underlying methodologies? The last of the studies, using stock exchange data that is public-

ly available, did not encounter this problem. There were, however, problems in finding enough information about the events discussed used in it.

7.4 Directions for future research

The findings of this study suggest that it is indeed relevant to examine the private sector's role in mitigating and adapting to different levels of sustainability impacts as well as regarding the life cycle perspective as a valuable tool for these actions. However, during the research new directions of study emerged.

For the streamlined tools discussed in the research report, the trade-off between accuracy and usability was found to be a significant factor to be studied. After all, the life cycle based tools, be they streamlined or full-scale, both have significant negative and positive attributes. A closer look to reveal the situations in which decision-makers need quick responses, those situations in which they can cope with less accurate results, and those in which streamlined tools are definitely not recommended would be valuable. What would be the role of these tools in this context? Furthermore, are there any sectorial differences in the application of these tools? As section 3.2.5 details, sectors face different threats – should the tools to tackle the threats be modified accordingly? In practice, answering these types of questions would help the further implementation and recommendation of the tool, as it is clear that it is not always the best available option.

In addition to this practical avenue of further research, an ethical question emerged regarding decision-making based on increased awareness, decision-making when facing trade-offs and decision-making in light of unreliable results: What is the process and how is this process guided by different with ambiguous results? The question could be asked in the public sector as well as in the private sector. The moral philosophy, but also the moral hazard, would serve as good starting points for further research. In this respect, the streamlined tools as well as the full-scale LCAs can be accused of allowing a moral hazard, because both are largely dependent on the ethics and objectives of the panels or assessors. A streamlined tool communicates the subjective ideas of the panel as results, and a full-scale LCA envelops the researcher's subjective choices into seemingly unbiased results. It is impossible to say without a doubt which one is better, but further studying the roots, the morally hazardous situations as well as the decision-making process would allow a discussion about companies' and regulators' role in climate change and wider sustainability efforts.

Companies' internal decision-making (as well as assessors, decision-making for that matter) is certainly interesting, but also investor decision-making clearly deserves more research. What are the attributes in environmental investments that trigger more interest from investors? Can the companies' disclosures be modified to accentuate the factors that investors value? It is clear that companies have different methods of disclosure and different values that

they communicate to investors. However, investors still, at least theoretically, should react to increased future net cash flows in such a way that they value the stock at a higher price. Then what is the reason that the environmental investments, which in fact can increase cash flows by saving energy and materials, do not increase the stock price? Is it the manner in which the companies communicate these investments and their consequences, or is it the instability of the regulatory framework? Or, perhaps it is the assumption of the investors that these investments are necessary anyway and do not deserve further attention? Furthermore, if the market does not seem to reward responsible and environmentally friendly investments, could there be a role to play for instruments such as LCA and streamlined LCA tools in assessing systems and in disclosing relevant information to investors?

TIIVISTELMÄ

Kestävä kehitys on tärkeä tutkimuskohde nyky-yhteiskunnassa. Erityisesti kysymys ilmastonmuutoksesta yhdistää niin tiedeyhteisön kuin sijoittajat, yrittäjät ja poliittiset päätöksentekijät. Ilmastonmuutoksen riskien tiedostaminen ja ilmiötä lieventävät toimenpiteet ja muutokseen sopeutuminen ovat keskeisiä teemoja, joista näillä foorumeilla keskustellaan.

Kestävän kehityksen vaatimukset ja ilmastonmuutos asettavat lukuisia riskejä yrityksille – mutta myös mahdollisuuksia. Vaikka ilmastonmuutoksen vaikutukset luontoon ovat vielä epäsuoria ja immateriaalisia, on yritysten toimintaympäristö jo muuttumassa sääntelyn takia. Ongelmallinen tilanne on siksi, että linjaukset erityisesti ilmastonmuutoksen suhteen ovat vielä epävakaita ja toimintasuunnitelmia päivitetään kansainvälisellä, EU-, kansallisella ja alueellisella tasolla jatkuvasti. Tässä hämmentävässä tilanteessa yritysten pitäisi pystyä toimimaan, luomaan pitkäjänteisiä strategioita ja varmistamaan toimintakykynsä myös tulevaisuudessa. Yrityskohtaisesti riskinsietokyky ja muutosketteryys vaihtelevat ja siksi yritysten on pystyttävä peilaamaan omaa toimintaansa ympäristömuutoksiin ja luotava omat toimintamallinsa. Jos yritys pystyy tekemään kauaskantoisia päätöksiä, voidaan riskit nähdä myös mahdollisuutena. Muokkaamalla strategiaansa pystyy yritys ennakoimaan tilannetta ja parantamaan näin kilpailukykyään myös tulevaisuudessa.

Yritysten on löydettävä konkreettisia ja systemaattisia menetelmiä toimintansa arvioimiseksi pystyäkseen aidosti sisällyttämään ympäristövaatimukset ja ilmastonmuutoksen paineet yrityksen toimintaan. Tulevat toimintasuunnitelmat eivät saa jäädä pelkiksi visioiksi. Yritysten pitää pystyä arvioimaan oman toimintansa vaikutus ympäristöön, mutta myös muuttuvan ympäristön vaikutus omaan toimintaansa. Yritysten näkökulmasta tuotekohtainen näkökulma on usein looginen. Tuotekohtaisen arvioinnin lähtökohta on elinkaariperspektiivi, joka tarkoittaa, että tuotteita ja niiden vaikutuksia seurataan koko elinkaaren ajan. Elinkaari pitää sisällään raaka-aineiden hankinnan, tuotannon eri vaiheet, kuljetusprosessit, käytön ajan sekä käytöstä poiston variaatiot. Menetelmät, joita elinkaariarviointiin käytetään, ovat elinkaariarviointi (life cycle assessment, LCA), sosiaalinen elinkaariarviointi (social life cycle assessment, S-LCA), elinkaarikustannusten arviointi (life cycle costing, LCC) sekä näiden yhdistelmä tai kevennetty versio. Näiden menetelmien käyttö mahdollistaa arvoketjujen kaikkien vaiheiden sisällyttämisen analyysiin, jolloin vältetään väärän optimoinnin vaara.

Tämän tutkimuksen tarkoitus on ymmärtää kestävyyteen perustuvien liiketoimintastrategioiden tarve sekä käyttää integroitua lähestymistapaa näiden strategioiden muotoiluun. Integroitu lähestymistapa tässä yhteydessä tarkoittaa, että tarkastellaan sekä yrityksen vaikutuksia ympäristöön että myös ympäristön vaikutuksia yritykseen. Näin minimoidaan omat haittavaikutukset ympäristöön, mutta samalla yritetään sopeutua toimintaympäristössä tapahtuviin muutoksiin. Tutkimus hyödyntää kolmea eri tutkimusmenetelmää (sisällön analyysiä, teema-analyysiä sekä event study menetelmää). Aineistona käytetään

EU:n komission COM-dokumentteja, kyselytutkimuksia, kuuden metsäklusteriin kuuluvan yrityksen pörssitiedotteita sekä näiden yritysten pörssikursseja.

Ilmasto-SWOT ja Kestävyys-SWOT ovat tässä tutkimuksessa käytettyjä niin kutsuttuja kevennettyjä versioita täysimittaisista ympäristövaikutusten tai kestävyyden arviointimenetelmistä ja niillä yritykset pystyvät aloittamaan systemaattisen vastuullisuusstrategiaprosessin pienilläkin resursseilla ja suunnittelemaan tulevaisuuttaan ja kestävyyttään tulevaisuuden muuttuvassa ympäristössä. Tutkimuksessa osoitettiin, että nämä työvälineet tehostavat yrityksen päätöksentekoa ja muutoksia organisaatiossa. Menetelmien keveys ja ketteryys kuitenkin tarkoittaa, että joudutaan hyväksymään epätarkemmat tulokset ja sen takia kumpaakaan menetelmää ei voi sanoa tyhjentäväksi tai itsenäiseksi työkaluksi täydellisen strategian luomisessa. Niitä voidaan siitä huolimatta pitää alustavina lähestymistapoina ja niiden avulla voidaan yrittää jäsentää analyysia. Tämä tutkimus osoittaa, että kevennetytkin elinkaarimenetelmät pystyvät saamaan aikaan sekä operatiivisia että strategisia muutoksia kaikissa elinkaaren vaiheissa ja ne voivat olla hyödyllisiä arvioitaessa yrityksen suhdetta kestävään kehitykseen, ympäristöasioihin ja ilmastonmuutokseen. Lisäksi energia- ja materiaalivirtojen sekä tuotannon aiheuttamien päästöjen selvittäminen edistää yrityksen ja koko sen tuotantoketjun kulutuksen vähentämistä. Kevennetyt menetelmät auttavat esimerkiksi välittömässä päätöksenteossa, jos aikaa, rahaa tai muita resursseja ei ole täsmällisemmän analyysin tekoon ja myös osoittamaan tarkemman analyysin suunnan. Kevennetty elinkaarianalyysi edellyttää yhteistyötä kaikkien tuotteen arvoketjuun kuuluvien kanssa, jotta koko elinkaareen vaikuttavat seikat voidaan optimoida. Työkalujen käyttö mahdollistaa yhteisen pyrkimyksen elinkaaren analysointiin, jolloin voidaan asettaa yhteisiä tavoitteita ja niiden pohjalta toimijat voivat yhteisesti määritellä kullekin sopivimman osallistumisen tason.

Tällä hetkellä elinkaarimallintamisen vaarana on eristäytyminen käytännön sovellutuksista menetelmän kompleksisuuden takia. Siksi elinkaarimallintamisen asiantuntijoiden on yritettävä tehdä menetelmistä helpommin lähestyttäviä ja käyttökelpoisempia laajemmalle yleisölle. Varteenotettava objektiryhmä ovat strategiset päätöksentekijät. Tutkimuksen apuna käytetyt kevennetyt työkalut, jotka on räätälöity yritysten päätöstentekijöiden tarpeita varten, ovatkin löytäneet juuri sen tärkeän ryhmän ymmärryksen ja hyväksynnän. Elinkaarimenetelmien kehittäjillä on mahdollisuus rohkaista vuoropuhelua poliittisten ja yritysten päätöksentekijöiden välillä niin, että elinkaarimenetelmät tulisivat osaksi yhteistä työkaluvalikoimaa. Yritysten johtajat hyötyisivät siitä, että ymmärtäisivät tutkijoiden tekemiä elinkaarikartoituksia ja niiden linkityksen liikeelämän tuloksellisuuteen. Lisäksi tutkijat hyötyisivät siitä, että ymmärtäisivät paremmin menetelmien käytännön soveltamisen, miten tulokset voidaan aidosti hyödyntää strategisessa päätöksenteossa ja miten niiden avulla saadaan aikaan aitoja muutoksia kestävämmän tulevaisuuden puolesta.

Ilmastonmuutoksen, kuten muidenkin kestävään kehitykseen vaikuttavien seikkojen tiedostaminen on tärkeä, vaikkakin vielä aliarvostettu edellytys yritysmaailmassa selviytymiseen. Tutkimuksen tulosten mukaan riskien ja

mahdollisuuksien tiedostaminen jopa kevennetyn analyysin seurauksena saa aikaan yllättävän paljon konkreettisia muutoksia koko elinkaaren aikana.

Tutkimuksessa tuli lisäksi esille tämänhetkisen regulatiivisen ympäristön epävakaisuus. Yhdistyvän Euroopan lainsäädäntö kehittyy ja uusia vaatimuksia tulee esille. Yritysten olisi pystyttävä ennakoimaan regulatiiviset muutokset pitkän aikavälin suunnittelussaan sekä rakennettava riskienhallintaansa ja kartoitettava tulevaisuuden todennäköisimmät toimintaympäristöt sen pohjalta. Yritykset pystyvät ylläpitämään (sosiaalisen) toimilupansa vain ottamalla huomioon tulevaisuuden muutokset. Kuten tutkimuksessa on osoitettu, elinkaaren aikaisten vaikutusten optimointi tuottaa etuja erityisesti siksi, että yrityksellä on valmius ennakoida tulevaisuuden lainsäädäntöä sekä vastata kuluttajien arvopohjan muuttumiseen. Niiden on myös pystyttävä ottamaan huomioon sijoittajien luoma paine. Erityisesti pörssissä noteeratuilta yrityksiltä odotetaan itsestäänselvyytenä tiettyjä ympäristömyönteisiä investointeja. Sijoittajille vastuullinen toiminta tarkoittaa sitä, että se mahdollistaa yrityksen toiminnan tulevaisuudessa ja voi parhaimmillaan lisätä tulevaisuuden nettokassavirtoja, joihin osakkeen arvoa peilataan. Yrityksen kannattaa ottaa nämä seikat huomioon strategisessa päätöksenteossa.

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ORIGINAL PAPERS

I

TRENDS IN EU ENERGY POLICY 1995-2007

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Chapter 4
Trends in EU Energy Policy 1995–2007

Susanna Horn and Angelina Korsunova

Keywords European Union • Energy policy • Liberalization of markets • Security of supply • Diversification • Energy efficiency

Introduction

Today, climate change and a significant increase in energy consumption are considered to be the two greatest global challenges facing the energy world (e.g., Hasselmann et al. 2003: 1923; IPCC 2007; Kara 2007: 5; Karl and Trenberth 2003: 1719). In addition to the scientific community having a common understanding about these two issues relating to each other, the political decision makers also need to acknowledge it and start building a framework around it – with the same long-term targets. On the EU-level, climate change concerns were already manifested in the White Paper on Energy Policy for the European Union in 1995. The development of the EU's common energy policy is also the result of growing global concerns regarding a wide range of related political and economic issues (Kaivo-oja and Luukkanen 2004: 1511). The purpose here is to examine the development of EU energy policies during the period between 1995 and 2007, through an inductive content analysis of selected preparatory acts.

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Background to EU Energy Policy

The EU has agreed upon a very challenging target to reduce total primary energy consumption by 20% by the year 2020 (European Commission 2011). Clearly, such a demanding goal requires great cooperation and collaboration between the EU Member States. Not surprisingly, the development of a common energy policy for the EU that emphasizes interconnections for more effective goal achievement is on the agenda once again (European Union 2008). Despite the strategies and programmes already implemented in 1995, the accelerating energy demand remains a serious problem with regard to reaching the established reduction target.

Nevertheless, processes such as widespread deregulation, the liberalization of energy markets and the pursuit of sustainable development goals have already transformed European energy markets (Balmaceda 2002: 15; Salmela and Varho 2006: 3669). The more long-term trends revealed in the energy policies also shed light on changes in the European markets and lay the groundwork for understanding new developments that arise in competitive markets, such as emission trading, demand response and ESCOs (energy saving companies).

Also, when discussing EU energy policies, it is important to understand their effect globally. EU Member States have assumed an active role in discussions regarding global treaties for combating climate change in the UN-led process. In addition to minimizing their own greenhouse gas (GHG) emissions, Member States have also taken serious steps in lowering the emissions of developing or emerging economies through the implementation of the EU GHG emission trading system. Thus, the policies the EU sets for itself are also crucial on an international scale.

Political decision making seldom follows a rational process, which makes the already turbulent research topic of climate change even more difficult to grasp (Mallon 2006: 2). The far-reaching effects of climate change together with the short-term and unpredictable decision making on an international, EU, as well as national levels are a demanding combination. In order to let new clean technologies diffuse and climate markets to function in a frictionless manner, the political and operational environment has to be stable and therefore less risky. Large-scale investments have a lifetime of decades, and in order to calculate the viability, some assumptions of future political framework need to be made, in terms of tax rates and reliefs, subsidies, feed-in tariffs, etc. In case reliable assumptions cannot be made, the investment eagerness decreases due to high regulative risk (Labatt and White 2007: 13). This is the reason why a stable and foreseeable environment is a necessity for letting climate change mitigation to have its best results and in order to make this happen, it is important to be aware of the past trends in political decision making.

A crucial issue in the success of the policies is the specificity of their objectives (Mallon 2006: 15). In terms of EU policies, it is clear that in the beginning of setting a common energy policy, Member States may have differing methods or motivations for these policies. However, hopes are high that along the better establishment of the EU and longer cooperation within the Member States, the objectives would be harmonized. Therefore, it could be suggested, that the more the Member States

are being engaged in discussion about the target setting, the more unified they will get about these targets and the better the outcomes will be.

According to the glossary of the official online gateway to the European Union, the aim of current European energy policy is to develop a low energy economy, which is safer, more sustainable and more competitive (European Union 2008). The energy policy includes a set of guidelines that is enforced through directives, regulations and national legislation, but it is limited by EU treaties and inadequacies within the global market. The European Coal and Steel Community (ECSC) as well as the European Atomic Energy Community (EURATOM) can be considered crucial to the pre-stages of forming a common EU energy policy. However, the current EU energy policy, which focuses largely on limited energy supplies, did not begin to form until the first oil crisis in 1973 (European Union 2008). In addition, all throughout the years, there have been numerous contradictions and clashes related to the role of the EU and the Member States in preparing and implementing the energy policy (Kaivo-oja and Luukkanen 2004). Previously, security of supply had been central to national policies, but with the creation of EU's single market, the focus seems to have shifted to the common policy as the most effective way to tackle energy challenges that are shared by all Member States.

Overall, the aim here is to contribute to the understanding of developments in EU energy policy during 1995–2007, through examination of the process of its integration, its challenge areas, as well as success and failure areas based on the temporal dynamics of focus points and recurring issues within Commission communication documents. The examination of these issues will be elaborated upon by means of inductive content analysis. In the discussion, the important trends in EU energy policy are summarized, while reflecting on historical and political settings that have influenced the evolvement of the trends.

Method and Data

Analyzing policies essentially entails the analysis of policy texts. Content analysis is an accepted method of textual investigation (Silverman 1985: 149) that reveals the content in a source of communication and allows comparison across many texts (Neuman 1994: 262). In order to obtain sufficient temporal insight into the dynamics of EU energy policy trends, a time interval of at least 10 years was decided upon. Initial investigation into energy policies revealed that the issue of climate change was first conspicuously manifested as a concern on an EU level in the White Paper on Energy Policy for the European Union in 1995. The White Paper generated several strategies and programmes for the energy field and it was considered an important benchmark in the development of EU-level energy policies and trends. Thus, the year 1995 was chosen as the starting point for the analysis, while 2007 was used as the end point, resulting in a 12-year time interval. The end point year corresponded to the year when the analysis was conducted.

The purpose of the analysis is to identify trends emerging from the EU energy policy documents between 1995 and 2007 and note any changes in the trends. Thus, it fit the purpose to use the inductive mode of content analysis, which allows for the processing and analyzing of documents systematically and objectively, while deriving concepts from the data itself (Krippendorff 2004: 36; Kyngäs and Vanhanen 1999: 5–7). According to Sayre (2001), allowing the categories to emerge naturally from the text provides a richer and more detailed understanding of them.

Adams et al. (2007) raise the issue of reliability for situations where the dominant themes are categorized as a result of reading the texts, as opposed to having pre-existing categories derived from a theory. They assert that the best way to ensure reliability is by having more than one person read the texts and draw up the categories independently. The final classifications should be based on a comparison of the different data sets and ultimately, the selection of categories that were identified by all readers. Thus, the reliability of content analysis here was ensured through the described procedure and the co-operation of two researchers.

Since official policies are not formulated yearly, it is impossible to conjure a dataset from the published policies extensive enough to reveal the entire nature and trends or all energy issues in the EU. Nevertheless, all directives set in force in the EU, also energy-related, require Commission reports, in which the proposals for action are comprehensively discussed. These are published as Commission communications (COM documents)[1] and can be found as such in the EUR-Lex database for preparatory acts (European Union 2007). They include Commission legislative proposals, Council common positions, legislative and budgetary resolutions and initiatives of the European Parliament, as well as opinions of the European Economic and Social Committee and of the Committee of the Regions. So this means that the preparatory acts should include the documentation related to a common EU energy policy. The use of exclusive COM documents narrowed the scope of the research, but at the same time helped to keep the data load manageable and homogenous. In other words, the research could also be defined as a study of policy trends, as communicated by the Commission to any interested parties.

Results

The actual search was conducted on January 25th, using “energy” as a keyword. This resulted in a total of 132 hits. However, only documents published between 1995 and 2007 were accepted for analysis. Thus, the material used for analysis consisted of 57 COM documents to the Council and other institutions, centering on the subject of energy. A complete listing of analyzed COM documents is available

[1] Proposed legislation and other Commission communications to the Council and/or the other institutions, and their preparatory papers. Commission documents for the other institutions (legislative proposals, communications, reports, etc.). (EUROPA: Gateway to the European Union).

Table 4.1 The number of analyzed COM documents in the studied period of 1995–2007

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Number of COM documents	7	4	4	5	1	3	8	6	5	3	2	8	1

in Appendix 1. Table 4.1 demonstrates the number of documents for each year of the studied time interval.

As previously mentioned, the initial reading and categorization of COM documents, as well as subsequent readings, coding, analysis and interpretation of results, were performed by the combined effort of two researchers in order to ensure reliability of the method. To create a visual aid for the analysis and results, separate tree diagrams were constructed for each of four major themes, where the number of diagrams equals the number of years during which a particular theme was most actively discussed in the EU energy policy documents. An example of a tree diagram is provided in Appendix 2. After the initial reading, four major themes emerged from the data: energy efficiency, security of supply, liberalization of markets and diversification.

After subsequent readings, each theme was examined more closely. A total of 17 sub-categories emerged that appeared to be more or less the same across the four themes (Table 4.2). Later, several topics were identified within each sub-category. By analyzing these topics, the transformations, changes and dynamics within the major energy policy themes could be identified and summarized.

Energy Efficiency

Content-wise energy efficiency received the most attention. Several issues came up repeatedly, with some shifts in focus, during the period between 1995 and 2007. The central topics under discussion in setting a well-designed policy for energy efficiency are public education and promotion. This has been pursued through various programmes throughout the years (there have been EU-funded programmes to promote energy efficiency during the entire period) but it seems to have lost momentum since 2002. Between 1995 and 2002, when a lack of information was identified to be the first barrier in achieving energy efficiency, this campaign has been included in documents every year (except in 2001, when there was no major communication on policy issues whatsoever). After 2002, the focus has shifted towards legislative and framework issues. Even the interest in those seems to be diminishing and the trend towards greater energy efficiency continues to weaken.

Achieving proper legislation for energy efficiency has still managed to spark some interest, between 1995 and 2006. However, there has been little or no written documentation about EU energy efficiency in 1999, 2000, 2001, 2003, 2005, 2006 or the beginning of 2007. Therefore, our data suggests that the bulk of all legislative

Table 4.2 Categories identified from COM document readings 1995–2007

Sub-categories	Brief explanation
1. Actors	Refers to the roles of various actors in the energy market (e.g., consumers, energy utilities)
2. Area specific	References to different geographical regions
3. Economical	Refers to all positive and negative financial flows and viability issues in the Member States
4. Environment	Includes direct and indirect influences on the environment
5. Diversification	Refers to the role of the diversification theme on its own and in the context of three other major themes
6. Energy efficiency	Refers to the role of the energy efficiency theme on its own and in the context of three other major themes
7. EU strategy, focus areas	Identifies key/focus areas in EU strategy (e.g., CO_2 reduction goals)
8. International issues	Issues that emphasize the need for international solution, focus and cooperation
9. Liberalization	Refers to the role of the liberalization theme on its own and in the context of three other major themes
10. Markets	All references to processes and changes taking place in energy markets (e.g., integration, structural changes)
11. Mechanisms/Instruments	Implementation tools for different themes (e.g., tendering procedures for increased security of supply)
12. Member States	Reference to the role, plans, implementation histories, etc. of EU Member States
13. Policy issues	Includes all issues that require policy-level implementation outlines (e.g., EU-wide educational initiatives)
14. Problems	General problems within the energy field in the EU (e.g., rising electricity demand)
15. Security of supply	Refers to the role of security of supply theme on its own and in the context of three other major themes
16. Specific sources/sectors	Refers to issues within specific sectors, like transport, or energy sources, such as biofuels
17. Technical	Includes specific technical problems, challenges or improvements (e.g., storage of liquefied natural gas)

actions concerning directly the energy efficiency issue have occurred in between 1995–1998 and 2004. However, alongside legislation, there are many other energy-related directives that have had direct and indirect impacts on energy efficiency. Soimakallio and Manninen (2007) observe that the directives having been addressed include: emission trading; renewable energy in electricity production; the promotion of biofuels in transportation; air pollutants and the combustion of waste. However, they also note that the influence of these directives on energy efficiency is not straightforward. The interconnections are, in fact, very complex and despite the common goal of reducing emissions, energy efficiency is not necessarily promoted by the interconnected directives. In some cases, they even weaken the arguments for energy efficiency.

In the EU, an obstacle in achieving an energy efficiency policy has been to find and develop more sophisticated mechanisms to increase consumers' and companies'

interest in energy efficient solutions. The developed incentives have ranged from standards, taxation and feed-in tariffs to state aids and special funds. Each EU Member State has been given the freedom to choose which incentives they wished to use.

In addition to the aforementioned mechanisms, demand side management (DSM) has been widely accepted as an important tool in increasing energy efficiency. The aim is to influence energy consumption by end users, for example, through government programmes, so that demand and supply would move closer to the given optimum. The focus has been more on improving energy efficiency than on controlling the overall rise in the demand for energy. As a result, there has been a clear interest to create a market demand for energy-efficient technology. In fact, two main goals of DSM are load shaping (e.g., decrease in daily or seasonal load variations) and load leveling (e.g., decreasing energy consumption – saving). However, as noted above, DSM is mostly a prerogative of governmental interventions. New approaches are being developed to suit the competitive liberalized markets. For example, demand response can be used in competitive electricity markets to get demand-side or end-use customers involved in setting prices and clearing the market (Helynen et al. 2007: 86). Demand response is based on real-time prices and customers' active response to them, which may be expressed through a shift in consumption depending on the time of day or through the reduction of total or peak demand, via energy efficiency measures. Customers should also have the opportunity to sell back their load to the market. Benefits of the demand response approach include customer activation and the motivation to take advantage of energy efficient possibilities. On the other hand, the implementation of demand response requires major technological investments, as it is based on up-to-date metering and communications equipment, such as automatic meter reading systems.

International issues have been discussed from several different angles. Some areas, rather randomly picked, such as Eastern Europe, China, former Soviet areas, South America, developing countries in general, etc., have been mentioned individually and projects or investment activities have been started to help the energy efficiency promotion in those areas. An interesting shift, probably due to the growing concern about climate change, has been the shift from local problems to global ones. It can be noticed that especially developing countries have recently received more attention than ever before, as they are perceived to be the ones most heavily impacted, but simultaneously also having most to catch up in terms of technical solutions in energy efficiency. Also, prior to the EU enlargement process in 2004, there was a perceived need to urgently assist the new member states towards meeting adequate levels of energy efficiency.

Concern over the environment has been a central theme behind discussions regarding energy efficiency throughout the entire study period. In particular, Eastern Europe's poor energy efficiency has been associated with some of the environmental degradation within that region. Also, electricity generation has focused around the promotion of cleaner as well as more efficient technologies, due to current environmental concerns, especially climate change challenges. Meeting Kyoto Protocol commitments has become a pivotal part of energy discussions since 1998. Currently, there is much discussion about how to proceed from the Kyoto Protocol and whether

it is an effective way to deal with the GHG emissions. For example, the outcomes of Copenhagen climate negotiations 2010 are very controversial: even though a political agreement for a two-degree warming limit was set, achieving a comprehensive working agreement through a pledge-and-review system will take at least 2 years or longer. Moreover, the targets currently pledged by EU are very modest when compared to what science recommends, as seen against the 2007 baseline (Tangen 2010).

The data suggests that technical issues no longer play a central role in increasing energy efficiency. Many necessary technical solutions have been implemented, and therefore the problem seems to fall on either the policy side (i.e. how to generate a demand for them and ease their market entry) or on the diffusion side (i.e. how to increase the market entry/size). The documentation from 1995 to 2007 suggests that the focus has shifted from finding technical solutions to finding the necessary policy tools, which would best spur the technologies. On the technical side, the most discussed themes have been: the standardization needs of technological equipment (1996); the potential or opportunities for improving energy efficiency that have not been fully realized (1995, 2004), improving IT applications and infrastructural problems (1998) and the broadening of technical education (1998).

Security of Supply

Security of supply, as a second main theme, focuses on the international dimensions of energy policy to an even greater degree than the other themes. An international perspective arises in nearly every document where security of supply is mentioned but from various viewpoints. In the beginning of the study period, the focus was on Eastern European and former Soviet countries (Russia, Commonwealth of Independent States, the Balkans, Turkey, etc.), but it rapidly spread to the Mediterranean countries as well as all third party countries in general (developing nations, "Northern Dimension" and Caspian Basin countries) since they fall under the umbrella of either producer or transit countries. Dialogue and cooperation with these third-party countries have been considered valuable throughout the entire period.

In terms of setting policies for security of supply in the EU, there has been an ongoing discussion regarding setting special policy objectives. Generally speaking, since 2001, there has been an increased interest in environmental (particularly climate related) problems. Attitudes towards the Kyoto Protocol in terms of security of supply were predominantly negative, as the two issues were considered independent from one another. This can be seen in the following quotes from the COM documents: "sustainable development must also consider security of supply" (1998) or "efforts will have to focus on orienting the demand for energy in a way which respects the EU's Kyoto commitments and is mindful of security of supply" (2001). However, negative attitudes have significantly diminished, and since 2006 and 2007, the Kyoto Protocol and the reduction of greenhouse gases have been seen as a complementing part of securing energy supplies. These two run almost parallel to each

other in more recent discussion, which can also be seen in the following quotes from the COM documents: "improve security of clean energy supplies" (2006) or "The Commission's Green Paper on energy efficiency identifies the following major benefits of efficient use of energy: securing the competitiveness of European industry benefiting from reduced spending on energy, environmental protection due to a reduction of the carbon dioxide emissions caused by energy use, security of energy supply due to reduction of energy demand and hence reduction of dependency on energy imports" (2006). In 2007, the viewpoint becomes even more extensive, which becomes evident from the following quote of a COM document published that year: "EU [will be put] on the path to becoming a low carbon knowledge-based energy economy, but will at the same time improve its security of supply and make a progressively more significant contribution to competitiveness." The strategy clearly outlines how these three issues complement each other. EU-level documentation has acknowledged the important notion and in doing so, transformed environmental issues from being perceived as drawbacks to benefits.

The key concerns, which were identified in the COM documents, are manifold. The most common issues, until 2003, were technical problems related to network and capacity building. It has been a difficult and expensive task to secure energy supplies for the entire community, without overloading some bottleneck areas within the network and reaching all remote or otherwise special regions difficult to reach. Since the internal markets began to operate effectively, much of the discussion concerning technical problems ceased. Apparently, the majority of the network was built in time for market liberalization.

The insecurity of energy supplies, resulting from geopolitical uncertainties, was another issue that came up rather often. Such issues have been discussed regularly (1995, 1997, 2002, 2003, 2006), where, for example, the 9/11 bombings, the Iraq war and other similar conflicts have increased the pressure to pinpoint the effects of political risks on supply security both in producer as well as in transit countries.

Renewable energy sources were seen as a solution to improve security of supply in all EU Member States. The focus in the COM documents regarding renewable energy corresponds more or less with finding benefits that link environmental concerns with security of supply (see above). Renewable energy sources are available and indigenous, so Member States have domestic supply of them, thus increasing the supply security. The focus has shifted between gas, oil, nuclear and renewable energy, with a clear trend towards promoting the use of renewable energy sources. Renewable energy has been considered a solution for supply security nearly every year since 1995, and since 1996, it has even been considered necessary for securing the safe supply of energy.

On the other hand, fossil fuels, hydrogen and nuclear energy sources have been receiving mixed responses. Although natural gas was accepted as an energy source, it was described as problematic ever since 1995. Its future demand and utilization would certainly require a reassessment due to the import dependency of gas. Nevertheless, throughout the study period, natural gas has remained a necessary, although problematic, part of the energy mix. On the other hand, it has been used to campaign the reduction of fossil fuel use. In 1997, a consensus within the EU was

reached to keep only a minimum stock of fossil fuels within the region, in order to secure some level of energy supply. This consensus has remained unchallenged throughout the study period and the emphasis on climate change has only reaffirmed the goal of minimizing fossil fuel use. An interesting approach taken in 1998 was to include energy saving as a so-called energy source, since it was basically considered to be additional energy that aided the security of supply. There are growing concerns within the EU that safety standards relating to nuclear energy be met, for instance due to the threat posed by aging nuclear plants.

Liberalization of Markets

The third set of results arises from the liberalization of energy markets. Market barriers and a lack of transparency between market actors have been noted to be the largest obstacles to achieving a fully liberal and operational market. The documents published during and prior to 2003 have focused on providing a detailed timetable to liberalization as well as searching for specific mechanisms for aiding the liberalization. Following 2004, after the markets were liberalized, the documents focused on external issues and decreased rapidly in quantity.

Formulating policies has been a central issue in all of the documents – mainly the development of a working framework for the internal energy market in the EU, which include objective setting and the formulation of necessary ground rules and legislation. Understanding how the market works and assessing and monitoring its functionality have been key issues while preparing for a common energy market. Another key issue has been the competition on the market, once it was working. The concerns focused on how a healthy competition could be established in the market, should it be regulated in any way and whether it is worth to remove all barriers, so that all the players would have equal access to the market.

The reasons and objectives behind market liberalization seem to have changed slightly during the years. In 1995, the COM documents stressed security of supply, the desire to increase the competitive edge of individual companies through removing barriers inhibiting new energy suppliers' market entry (as a response to increased global competition), as well as reducing energy prices. But gradually – starting from 2001 – the focus shifted to creating the largest internal energy market in the world, which would increase the EU's competitiveness amongst international players.

Environmental issues gained interest even before the markets were liberalized. Environmental externalities (higher competition may lead to unsustainable activities and hazards due to not investing into environmentally sound technologies) of a fully liberal market were first discussed in 1998. In 2003, it was determined that high environmental standards needed to be introduced before the market was liberalized. It became a priority to create a legal framework for internalizing the externalities of energy production, meaning that the producers would bear the costs of causing environmental harm. A legal framework would ensure the promotion of sustainable energy and monitor environmental impacts in the future liberal markets.

Between 1996 and 2003, technical issues related to liberalizing EU energy markets have been important. Production and distribution issues, as well as the technical standardization of equipment and facilities (also related to environmental standards), have required attention. Building an extensive enough electricity network to ensure a truly EU-wide common internal market, overcoming bottleneck and remote area provision problems, has also been a topic of interest. Before 1996, grids had not been developed to reach over all borders and bottlenecks, due to which additional capacity was seen necessary to be built to these grids. All in all, the infrastructural planning needed careful planning on an EU level, before the actual internal network could begin functioning. These technical discussions ended with the introduction of the internal market in 2004.

In 2004, the EU's internal gas and electricity markets became fully operational and suddenly small business customers could choose from different suppliers. This essentially meant that new suppliers were born and more competition developed.

After the internal gas and electricity markets became functional, all COM documents subsequent to 2003[2] have focused on external issues, such as the growing role of Russia in the internal energy market. All EU documentation concerning internal energy markets has considerably decreased in quantity after 2003. The reason was rather self-evident. Market liberalization for all consumers was dependent on each Member State, so essentially, only national documentation and proposals were required. The entire legal framework required for achieving liberal markets was founded on a national level.

However, since monitoring and assessing the functionality of the markets had previously been a top priority, additional communication concerning those phases, even after 2004, might be expected. In 2006, there has been some discussion regarding international issues and the possibility of granting Russia a stronger presence in the EU internal energy market. Some communication has also related to the markets, more specifically to internal market principles. None of these topics necessarily relate to any direct monitoring or discussion concerning the assessment of the energy market.

As previously noted, Russia's role in the EU's energy market has grown considerably towards the end of the study period. In the early phases of planning the general appearance and framework of the internal market, communication regarding international issues generally referred to countries outside of the EU as "third countries." However, since 2003 and around the time of EU enlargement, the topic of international issues needed to be readdressed. A number of former Soviet states, which were referred to as "third countries" in previous documents, were now a part of the EU. Upon closer examination, it appeared that most of the issues outside the EU concerned Russia. Russia's role, either as a transit or as a producer country, gained a special focus within the EU.

[2] All necessary legislative proposals, plans and other communication were prepared by 2003, even though the internal markets started functioning only after 2004.

Diversification

The final results section concerns geographical, supplier and fuel diversification targets. Diversification was a major concern in the beginning of the study period, and between the years 1995 and 2002, it was discussed thoroughly in a number of documents and in conjunction with numerous sub-topics. Towards the end of the study period, diversification received less attention. It was mentioned in documents throughout 2003–2007 but in limited amounts, and in conjunction with the previously mentioned topics. No new, ground-breaking ideas, measures or targets have been introduced after 2003.

Policy issues related to reaching diversification targets have been discussed thoroughly during the entire period. The main objective for any new diversification policy was security of supply. Supply security has been mentioned on several occasions (1995–1997, 2003–2006) but the environment and sustainable growth of the economy have been targeted as special objectives. In recent years, policies have been also focused on improving political dialogue and developing international issues related to the diversification of fuel sources, as well as expanding the geographical scope of energy supply.

International issues have gained significant interest. This has ranged from cooperation between producer and transit countries (since 1997) and amongst developing and transition countries (since 2002) to cooperation within the Member States (e.g., Austria and Slovenia, Nordic and Baltic States and countries around the North Sea).

Focus on specific sources, such as increasing the use of renewable energy, has also been a main objective of recent policy making in the EU. The attitudes expressed around this issue were similar to those concerning security of supply. Renewable energy was certainly receiving more attention, due to its domestic and secure availability in all the Member States. It has been discussed since the beginning of the study period. In terms of diversification, only renewable energy sources have been mentioned repeatedly. Few references have been made to include more nuclear energy (1995), improved gas networks (1997, 2001) and even a new oil terminal (2003) in the diversification strategies but the prominent focus nevertheless remained in renewable sources of energy (mentioned in 1995, 1996, 1997, 1998, 2001, 2002, 2006 and 2007).

Import dependency, due to a lack of indigenous, traditional energy sources, has been identified as an acute problem in the EU (as noted in the section concerning supply security). Diversification has been seen as a viable strategy to secure the supply of energy. It has appeared as a subject in 1995, 1996 and 2002 and oddly enough, thereafter, import dependency as a concern had not appeared, at least in direct connection with diversification plans. Thus, it was already more or less clear that import dependency was the underlying problem.

Technical problems have arisen surprisingly little in connection with diversification. Diversification, as such, did not require specific technologies. Nevertheless, the energy sources, to which the diversification aimed, might have required new innovations (e.g., adjusting production to local conditions, technically improving

networks, extracting sources in different geographic locations, decentralization technologies, etc.). In the middle of the study period (2002–2003), technical problems relating to network building or capacity problems were addressed, but otherwise, it appeared that they have either assumed radically new technologies, were not relevant or they have been addressed in connection with other issues. In fact, it seemed that the obstacles were more policy related, rather than of technical nature.

The effects on the society or the economy have been briefly discussed in 1995 and 1997 in conjunction with employment effects or possible problems with consumption growth and supply increases but otherwise policy, international and other abovementioned issues have superseded them.

Emission levels have decreased through the use of renewable energy sources. The positive impacts of alternate energy sources have been observed as early as 1995 and have been mentioned within the same context as sustainability, for instance. Also, growing energy requirements could possibly be fulfilled by more diverse energy sources, especially renewable ones, which are more environmentally friendly. Environmental issues and emission levels as factors determining energy policy were mentioned again in 1997 and 2005.

Mechanisms for promoting diversification have varied during the studied time period, but none have succeeded in promoting any significant interest. In 1995, the instruments used were sector specific and not very homogenous. In 1998, direct financial support was promoted, and in 2002, closer to the introduction of internal energy markets, market-based instruments, healthy competition and long-term contracts were seen as priority in increasing diversification. In addition to promoting fuel diversity, these mechanisms also serve to increase the geographical diversity of energy sources.

Discussion

The conclusions of this study are categorized into four main sections, in a matter similar to the data-based results. Political interest in *energy efficiency* has witnessed a decreasing trend, both in terms of information distribution, as well as in the number of legislative proposals. Although it may be labeled as controversial, the path to increasing energy efficiency needs to focus more on policy-level changes and less on technical innovations. Several mechanisms have been tested in the quest to improve energy efficiency, but there was no mutual understanding between the Member States as to which one was the most effective. The chosen mechanisms should not only increase energy efficiency in the Member States, but their benefits should extend into developing countries as well. Sector-wise, interest in the building and transport sector has shown the greatest growth during the study period.

Generally, *security of supply* was strongly correlated with energy efficiency, since the EU's security strategy relied on the systematic development of its energy efficiency policy, which, in turn, paralleled the policy for renewable energy. This is reflected in the change of attitude towards environmental issues in general.

Throughout the years, improving environmental protection and seeking clean energy sources had increasingly been viewed as a source of security and an advantage, rather than a nuisance. The interest in renewable energy sources continued to grow, while dependency on gas remained a concern.

Overall, a strong international dimension characterized the focus points of EU energy policy within the area of security of supply between 1995 and 2007. Although the geographical scope in the early stages of the energy policy documents being studied was mainly limited to Eastern European and former Soviet countries, it rather rapidly expanded to include Mediterranean countries, developing countries, as well as Caspian basin countries. This reflects the EU's efforts to improve security of supply through diversified cooperation and reliance on different supplier and transit countries. Although nuclear power was sometimes considered as a solution to reduced GHG emissions and to improved security of supply, the safety concerns connected to the growing number of aging nuclear plants and waste were troublesome.

Evidently, the *liberalization of markets* theme received more attention between 1995 and 2003, while the amount of documentation decreased thereafter and the focus areas of the theme shifted. Initially, the discussion centered on setting an adequate policy to establish and support healthy competition in the common liberalized market. The mechanisms, benefits, as well as dangers of the liberalized market were thoroughly examined and reviewed. For example, environmental externalities were a serious concern due to the lack of common stringent environmental standards and the insufficient use of environmentally sound technologies. Thus, the focus has been set on the implementation of common standards and mechanisms for internalizing the externalities, making the producers carry the costs of causing harm to the environment.

In addition, the establishment of common technical standards and reliable grids across the borders, besides the general infrastructural planning, were emphasized up until 2004. It was interesting that while the initial reason behind liberalization was mostly the reduction of energy prices, the main endeavor had later been transformed into the formidable goal of creating the largest internal energy market in the world in order to increase the EU's competitiveness with other global contenders. In addition, the international dimension of the discussion within the COM documents often centered on the ever-increasing role of Russia in the EU's internal energy market.

There were two main issues related to the context of *diversification*. Firstly, it was strongly coupled with supply security and improvement of import dependency. The second issue concerned renewable energy and diversifying in its direction. Interest in renewable energy sources had been growing increasingly. In regards to other trends, a new focus aimed at increasing diversification in developing countries had emerged. Both renewable energy targets and development issues went hand in hand with growing concerns regarding climate change and obligations to cut CO_2 emissions. However, the extent to which diversification has been discussed has weakened towards 2007. Nevertheless, the actual aims (renewable energy, security of supply, development aid) have not lost their relevance. They were merely not discussed in this context.

Conclusions

Overall, the challenges facing EU's energy policy between 1995 and 2007 remained relatively unchanged. The number of focus areas, however, has been reduced from six to three main sectors. In 1995, the six focus areas of the energy policies were: (1) market integration, (2) deregulation, (3) economic and social cohesion, (4) sustainable development, (5) environmental protection and (6) security of supply. By 2007, the main challenges were reduced to (1) competitiveness, (2) sustainability and (3) security of supply. Each of these later challenges included one or more of the previous ones, which would indicate that discussing the problems in this kind of policy formation process helped to clarify the most important problems even to the decision makers themselves and to present them to the public in a clearer way.

Obviously, the economic (competitiveness), environmental (sustainability) and technical (security of supply) aspects have been separated from each other and these three topics have crystallized during the 12 years of policy formation to be the next generation's challenges. Although they have been viewed as separate issues, the Communications still stress the need for cooperation among all fields in order to improve any one single issue. Promoting the most pertinent themes of energy efficiency, market liberalization, security of supply and diversification might effectively contribute to improving competitiveness, sustainability and security of supply within the European Union's energy market, thus presenting a solution to the current main challenges.

Appendix 1

COM documents related to energy policy of the European Union in the studied period 1995–2007 (Based on search through EUR-Lex database)

1995	COM 127	A memorandum on the activities of the European Atomic Energy Community relevant to the objectives of Articles III and IV of the Treaty on the Non-Proliferation of nuclear weapons
	COM 171	The conclusion of an agreement for peaceful nuclear cooperation between the European Atomic Energy Community (EURATOM) and the Government of the United States of America
	COM 197	Multiannual programme to promote international cooperation in the energy sector – SYNERGY programme
	COM 225	The promotion of energy efficiency in the European Union (SAVE II Programme)
	COM 391	The repeal of several community legislative texts in the field of energy policy
	COM 440	The conclusion by the European Communities of the Energy Charter Treaty and of the Energy Charter Protocol on energy efficiency and related environmental aspects
	COM 682	White Paper – an energy policy for the European Union

(continued)

(continued)

1996	COM 149	The Euro-Mediterranean partnership in the energy sector
	COM 308	Europe-Asia Co-operation strategy for Energy
	COM 320	The repeal of several Community legislative texts in the field of energy policy
	COM 576	Energy for the future: Renewable sources of energy – Green paper for a Community Strategy
1997	COM 125	The external dimension of trans-European energy networks
	COM 167	An overall view of energy policy and actions
	COM 196	The energy dimension of climate change
	COM 599	Energy for the future: renewable sources of energy – White paper for a community strategy and action plan
1998	COM 244	Financial assistance by the European Communities to the energy sector from 1995 to 1997
	COM 246	Energy efficiency in the European Community – towards a strategy for the rational use of energy
	COM 267	The position to be adopted by the European Community within the Energy Charter Conference and the International Conference of the Signatories of the Energy Charter Treaty, on the amendment to the trade-related provisions of the Energy Charter Treaty and its provisional application
	COM 458	Progress report on the multiannual programme for the promotion of energy efficiency in the Community – SAVE II
	COM 571	Strengthening environmental integration within Community energy policy
1999	COM 548	Strengthening the Northern dimension of European energy policy
2000	COM 117 (COD)	The procurement procedures of entities operating in the water, energy, transport and postal services sectors
	COM 247	Action Plan to improve energy efficiency in the European Community
		Communication from the Commission to the European Parliament pursuant to the third indent of Article 251, 2 of the EC Treaty concerning the common Position of the Council on the adoption of a European Parliament and Council Directive on Energy Efficiency Requirements for Ballasts for Fluorescent Lighting
2001	COM 69	The implementation of the Community Strategy and Action Plan on Renewable Energy Sources (1998–2000)
	COM 98 (COD)	Common position of the Council on the adoption of a Directive of the European Parliament and the Council on the energy performance of buildings
		Communication from the Commission on adoption of a Regulation of the European Parliament and of the Council on a Community Energy Efficiency Labelling Programme for Office and Communication Technology Equipment
	COM 125	Completing the internal energy market
	COM 126	Enhancing Euro-Mediterranean cooperation on transport and energy
	COM 311 (COD)	The guidelines for trans-European energy networks
	COM 506	Pursuant to the second subparagraph of Article 251 (2) of the EC Treaty concerning the common position of the Council on the adoption of a Directive of the European Parliament and the Council on the promotion of electricity from renewable energy sources
	COM 775	European energy infrastructure

(continued)

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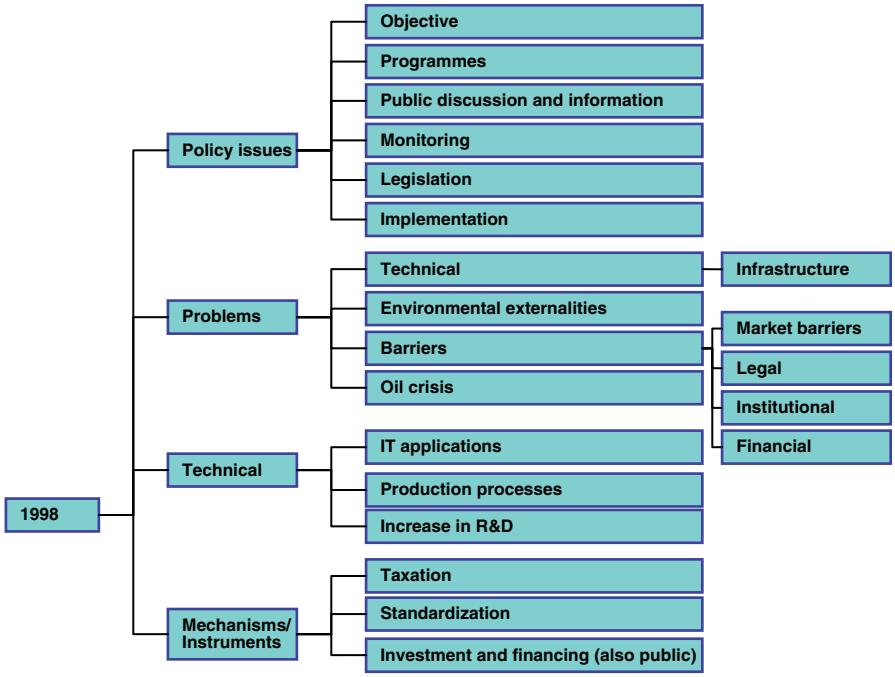
2002	COM 82 (COD)	A multiannual programme for action in the field of energy: "Intelligent Energy – Europe" programme (2003–2006)
	COM 185 (COD)	The promotion of cogeneration based on a useful heat demand in the internal energy market
	COM 321	Final report on the Green Paper "Towards a European strategy for the security of energy supply"
	COM 408	Energy cooperation with the developing countries
	COM 448	Comments of the Commission on the conclusions of the Mid-term Assessment of the Energy Framework Programme (1998–2002)
	COM 488	The internal market in energy: Coordinated measures on the security of energy supply
2003		Communication from the Commission concerning the conclusion of an Agreement for Co-operation in the Peaceful Uses of Nuclear Energy between the European Atomic Energy Community (EURATOM) and the Cabinet of Ministers of Ukraine
	COM 164	The consequences of the war in Iraq for energy and transport
	COM 215	State of progress of the negotiations concerning the ITER international nuclear fusion energy research project
	COM 262	The development of energy policy for the enlarged European Union, its neighbors and partner countries
	COM 743	Energy Infrastructure and Security of Supply
2004	COM 366	The share of renewable energy in the EU
	COM 711	The future development of the EU Energy Initiative and the modalities for the establishment of an energy facility for ACP countries
	COM 777	The Energy Dialogue between the European Union and the Russian Federation between 2000 and 2004
2005	COM 222	The negotiation of the accession of the European Atomic Energy Community (Euratom) to an international Framework Agreement among the Members of the Generation IV International Forum in the field of nuclear-related research
	COM 627	The support of electricity from renewable energy sources
2006	COM 20	External Action: Thematic programme for environment and sustainable management of natural resources including energy
	COM 121	Enhancing the status of the European Atomic Energy Community at the International Atomic Energy Agency
	COM 357	Comments of the Commission on the conclusions and recommendations of the Mid-term Evaluation of the "Intelligent Energy – Europe" programme (2003–2006)
	COM 545	Action Plan for Energy Efficiency: Realizing the Potential
	COM 583	Mobilizing public and private finance towards global access to climate-friendly, affordable and secure energy services: The Global Energy Efficiency and Renewable Energy Fund
	COM 590	External energy relations – from principles to action
	COM 848	Renewable Energy Road Map: Renewable energies in the 21st century: building a more sustainable future
2007	COM 1	An energy policy for Europe

Appendix 2

An example of tree diagram for one of the major themes (*energy efficiency*) constructed as a result of the analysis of COM documents related to energy policy in the studied period of 1995–2007.



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III

EVALUATING THE SUSTAINABILITY SWOT AS A STREAMLINED TOOL FOR LIFE CYCLE SUSTAINABILITY ASSESSMENT

by

Hanna-Leena Pesonen & Susanna Horn, 2013

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Evaluating the Sustainability SWOT as a streamlined tool for life cycle sustainability assessment

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Abstract
Purpose From a management perspective, there are two main issues in the life cycle sustainability assessment framework which require further work: (1) the approaches to quicken the resource-consuming inventory and assessment process and (2) the easy-to-understand communication of the results. This study aims at contributing to these needs for quicker and cost-efficient ways to draft strategies that include the life cycle perspective and encompasses all three dimensions of sustainability in an easily communicable way. The focus of the study is on a streamlined, rapid assessment the tool proposed by Pesonen (2007) called the Sustainability SWOT (Strengths, Weaknesses, Opportunities, Threats) and on the empirical testing of whether or not it is understood in the corporate world and if it leads to concrete changes in either strategic- or operative-level activities.
Methods The data for the research were empirically collected from a survey targeted to representatives of organizations having used the Sustainability SWOT within the last 5 years. The primary findings, i.e., the generated changes or improvements, were reflected in the various levels of cooperation in a network (along the value chain, in end users, in the institutional framework).
Results and discussion The results of the analyses of both the usability of the Sustainability SWOT in business as well as the suggested assessment framework leading to any actual changes were promising. It is encouraging that the streamlined approach tailored according to the logic of business decision-makers (i.e., inclusion of the SWOT) is able to find the acceptance and understanding of that vital group. Remarkably, many changes were initiated—not only at an operative level but also at a strategic level and in the entire value chain—by carrying out an exercise such as the Sustainability SWOT.
Conclusions The Sustainability SWOT has proven to be usable and able to generate changes and improvements along the value chain and, in some cases, in the institutional context as well.

Keywords Life cycle perspective · Streamlined assessment · Sustainability · SWOT

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1 Introduction

The life cycle assessment (LCA) community has identified that not only LCAs, but rather also a life cycle-based full sustainability assessment should be an important part of decision-making. Over the years, the discussion has evolved from a pure methodological development of LCA and case studies to a more holistic approach in increasing awareness of false optimization and wrong choices, like the burden shifting within or between each domain (environment, economy, and society) or to the future. Klöpffer has initiated the discussion on the options of how to formulate the procedure to carry out a full sustainability assessment (Klöpffer 2006, 2008; Klöpffer and Renner 2008). Furthermore, as Klöpffer and Ciroth (2011) forecast, "the further development of LCSA [life cycle sustainability assessment] will mainly depend on the improvement of the [individual] life cycle methods," which underlines the fact that all of the pillars of sustainable development are relevant to the final framework. As an intermediate conclusion, a recent report by the Life Cycle Initiative introduced the framework of a life cycle sustainability assessment (LCSA) (Valdivia et al. 2011).

Nevertheless, even though a thorough assessment framework with individual methods has already been proposed and is in the process of being further developed, there are still numerous areas in need of development in order to advance the implementation of LCSA tools. Whilst more research has been undertaken to develop and systematize the individual methods within the framework—namely LCA, life cycle costing, and social life cycle assessment (S-LCA)—less attention thus far has been given to understanding overall management tools of the framework and how these can make a valuable contribution to the assessment. The management tools could in fact be mobilized to complement the life cycle-based methodologies and the accounting and analysis of material flows in order to control, reduce, or prevent the sustainability impacts of a defined life cycle (Pesonen 2005).

By reading current statements from scholars trying to develop the three-pillar interpretation of sustainability from a life cycle perspective, it is noticeable that from a management perspective, there are two main issues which require further work: (1) the streamlined (or "simplified," both of which, in the context of this study and in line with previous studies, are seen as synonymous) approaches to quicken the lengthy and resource-consuming assessment process and (2) the easy-to-understand communication of the results to the stakeholders. For instance, the recently published framework for LCSA demands the "development of more streamlined approaches that analyze the whole picture (instead of looking in high detail only at one aspect)." Klöpffer (2008) also states that "the assessment methods should be simple and not always quantitative.[1]" Finkbeiner et al. (2010) remark additionally that "another challenge is a comprehensive, yet understandable presentation of the results [of an LCSA]." Currently, even though the individual LCSA methods are able to produce a wealth of important information, the entire framework is faced with the challenges of being too difficult to understand and interpret as well as ultimately too difficult to use in decision-making for a non-expert audience. Altogether, this leads to the requirement of having an understandable yet comprehensive presentation technique of LCSA results (Valdivia et al. 2011).

This study aims at contributing to these needs for quicker and cost-efficient ways to make strategic planning that dynamically includes the life cycle perspective and encompasses all three dimensions of sustainability in a visually easily communicable way for all stakeholder groups. The focus of the study is on a streamlined, rapid assessment tool proposed by Pesonen (2007) called the Sustainability SWOT (Strengths, Weaknesses, Opportunities, Threats) and on the empirical testing of whether or not it is understood in the corporate world and if it leads to concrete changes in either strategic- or operative-level activities. The main research questions guide the underlying study: (1) How usable is the Sustainability SWOT in business? (2) Does the suggested assessment framework lead to changes or improvements in life cycle management (LCM)? (3) Does the tool increase understanding of the life cycle perspective?

When structuring the intertextual field around the underlying study, the main contribution is novel approaches to life cycle-based methodologies, which in a way displays progressive coherence around the entire field. Bala et al. (2010), Hochschorner and Finnveden (2003), Liedtke et al. (2010), McAloone and Bey (2009), Schulz et al. (2012) and Valdivia et al. (2011) all agree on the fact that even though LCAs are valuable assessment tools, in some cases, they cannot be used due to lack of time or resources. This has fostered the recent emergence of a branch of studies proposing indicatory management tools with more relaxed data-quality standards that identify sustainability impacts—without being cost or time intensive.

Moreover, for practical decision-making in early phases, there is a demand for less complicated, thus more widely utilizable, tools in situations in which preliminary analyses need to be made or in which less-than-perfect results can still be considered better than no results at all. Rebitzer and Schäfer (2009) published the results of an industry-specific survey, which demonstrated that LCA as a methodological framework is only understood by little more than a quarter of the respondents and that knowledge about LCA and what it can do is not yet part of mainstream thinking. Also, Jørgensen et al. (2009) studied the industry's ability and willingness to devote efforts in the context of S-LCA. As these studies indicate, it is of interest that the LCA community encourages a discourse with industry decision-makers in order to enable the use of life cycle methods and its vital results in the future as well. The scholars need to understand how well life cycle results are understood in real-life decision-making, what effort might bring life cycle methods closer to real application, and how the life cycle-based thinking can be carried over to strategic choices in businesses and real changes towards a more sustainable course of actions (Finkbeiner et al. 2010).

The paper first discusses the need for streamlined approaches in life cycle-based research and presents a review of the approaches that are currently used, displaying in more detail the status of the current discussion and field of contribution. Second, the paper presents the Sustainability SWOT as a possibility to both streamline the assessment and to represent the results in a straightforward manner. Third, the empirical survey data and methods will be presented

[1] In order not to falsify the citation, it should be mentioned that it continues "…this may be true for finding hot spots, but certainly not for decision-making: If different solutions are proposed, quantitative methods are needed." The context, however, is further discussed in later sections.

after which the results of the study will follow. It brings together the empirical material in light of the theoretical framework to highlight which changes at what stage will be generated. The conclusion sums up the findings of the study and highlights the need for more research in this field.

2 Streamlined approaches in LCSA

In terms of already developed streamlined approaches to life cycle-based assessment methodologies, these relate chiefly to assessing the environmental impacts of a given product system, i.e., LCAs. This is why we will focus primarily—but not exclusively—to reporting on the progress in streamlining the LCA method in particular.

There are three basic levels of LCA (Wenzel 1998):

- A full-scale LCA, quantitative and including new data inventory
- A screening LCA, quantitative using readily available data or semiquantitative
- A matrix LCA, qualitative or semiquantitative

As mentioned previously, a *full-scale LCA* can be both time and resource intensive, which leads to the outcome that they are not always the primary or best action of a company trying to develop its processes or products towards a more sustainable direction. In fact, the inherent complexity of carrying out a full LCA can be hypothesized as standing in the way of a widespread application in the industry and policy-making sectors (Bala et al. 2010). Furthermore, the results of a full LCA can be very complex and difficult to understand for decision-makers either in the industry or in the public sector.

Both *screening* and *matrix LCAs* from Wenzel's division are seen as streamlined approaches in terms of this study. A screening LCA uses mainly quantitative data; however, it is available from readymade databases so that no new inventory calculations are made. In general, streamlined life cycle approaches can be qualitative, quantitative, or semiquantitative. A large number of simplified LCA methods have been developed (for a listing, see, e.g., Baumann and Tillman 2004 or Pesonen 2007). Currently, some streamlined methods for a full sustainability assessment have also been developed. The fields of application for simplified life cycle-based methods are, for example, product development and procurement, more specifically in planning, conceptual design, embodiment design as well as detail design (Baumann and Tillman 2004). Many of these methods are developed for a specific group of products and are not well documented (Hochschorner and Finnveden 2003).

In the literature, it is not the ultimate ambition that the streamlined approaches fully substitute a full-scale assessment in the form of an LCA, for example. Neither is it the ambition to produce material for external communication (McAloone and Bey 2009). Rather, their goal is to illustrate how individually adapted simplified models can at times be useful in providing a reliable, quantitative measure of environmental impact, which may just be what is in order for the purposes of imminent political and economic decisions (Bala et al. 2010). And even with these limitations, these simplified methods give a quick overview of a product's environmental profile (McAloone and Bey 2009). In the corporate context, a more agreeable step-by-step approach has been proposed (Liedtke et al. 2010). The ideal progress of such a gradual analysis would start by carrying out a streamlined analysis, with any of its methods available (see list in Section 2.1). After this, the second and third steps, which would be carried out for a viable selection resulting from a streamlined analysis, could either be a material input per service unit (MIPS) or a full-scale LCA including—the more detailed the assessment becomes—other core indicators as in the streamline first-cut assessment and more exact differentiation. Environmental life cycle considerations are probably best supported by a well-balanced combination of a few approaches (Baumann and Tillman 2004).

When life cycle-based methods, particularly LCAs, are used for decision support, uncertainty is an important issue to be taken into consideration (Huijbregts et al. 2001; Geisler et al. 2005; Lloyd and Ries 2007). Uncertainty, especially in an LCA, can stem from many different sources, e.g., variable, erroneous, misspecified, incomplete, or rounded data; boundary choices; inconsistencies in the goal and scope; allocation principles; time horizon in the impact assessment; inaccurate implementation of relations in the software; etc. (Finnveden et al. 2009). As there are obviously many sources of uncertainty in the method, there has arisen a need to systematically incorporate uncertainty into the assessment. Keeping in mind that a streamlined LCA can increase the uncertainty of the sources, it would be appropriate to try to deal with this issue in the streamlined methods as well. In particular, if a streamlined approach produces quantitative results—such as for instance software-based applications—the results can at first seem very certain. Nevertheless, if only looking at the results, it is often overseen that the actual process behind them is not very transparent. An approach is required which manages uncertainty of all types and does so with transparency, fairness, and competence.

2.1 Currently used streamlined approaches

Some previously used methods for streamlined sustainability assessment from a life cycle perspective are qualitative, streamlined, or simplified LCAs in the form of life cycle influence matrices, software tools, LCA-derived proxies, rules of thumb, hot spot analysis, combination tools, LCA as a creativity tool as well as life cycle thinking, Environmental Sustainability Assessment Tool (ESAT), sustainability matrices, etc. From this nonexhaustive list, it becomes apparent that there exist a number of life cycle approaches,

both analytical and creative, for all stages of product development (Pesonen 2007; Baumann and Tillman 2004). However, the majority of these approaches do not assess full sustainability; rather, they remain in the field of environmental impacts. The strengths and weaknesses of these different approaches are presented in Table 1.

2.2 Sustainability SWOT as a streamlined approach

The study's main contribution is the presentation and evaluation of an assessment tool in the form of a Sustainability SWOT (Pesonen 2007). The Sustainability SWOT (Fig. 1) is an analytical tool combining two well-known methods: the basic SWOT tool, a strategic business planning process in matrix form, and LCA, which calculates the environmental impacts of a given product system. It is able to integrate all aspects of sustainability into one assessment matrix efficiently. The Sustainability SWOT can be used as a product-level assessment of an organization's main product or product groups, the core requirement being that a life cycle can indeed be modeled. After having a life cycle at hand, the present and future sustainability impacts (environmental, social, economic) for each life cycle stage will be mapped and complemented with a qualitative valuation of their significance. Visually, the life cycle stages are presented above the SWOT matrix. In the SWOT matrix, the life cycle stages of each impact can be identified through respective symbols or color legends (see Fig. 1). The number of symbols (from one to three) indicates the significance of the impact in question.

The specific features of a Sustainability SWOT include, firstly, the consideration of all three dimensions of sustainability as well as the coverage of the main life cycle stages in one model, as has been suggested in the general framework of LCSA. Additionally, the features of the tool include a qualitative or semiquantitative valuation of the significance level of the found sustainability impacts. The tool is able to communicate the most important factors through the three-level valuation indicator. Moreover, a rough, preliminary qualitative sensitivity analysis is possible in this context by looking at the future changes as the opportunities and threats of the model. Finding the most significant sustainability impacts and sensitizing these can add value in the form of a qualitative sensitivity analysis. This streamlined approach is particularly relevant within the industry and policy-making sectors, in which decisions with potentially large environmental and economic consequences are often made with limited time and financial resources, and in which the decision-making process often cannot wait for the results of full LCAs (Bala et al. 2010). In the case that at least the hot spots can be found in the beginning of the assessment, these can be further emphasized in extended, more detailed analyses.

In practice, the use of the Sustainability SWOT follows a clear structure as follows:

1. Identification of product life cycle stages
2. Identification of sustainability impacts from all three perspectives (environmental, social, economic)
   (a) Now
   (b) In the future—year *X*
3. Significance assessment of the sustainability impacts
4. Compilation of the Sustainability SWOT

Figure 1 exhibits a fictional Sustainability SWOT, which was drafted for biodiesel to depict an example case. On the top of the figure, the life cycle of the product has been visualized from raw material production to the use phase (biodiesel in this case has been expected to have no significant impacts after it has been used). The strengths, weaknesses, opportunities, and threats have been outlined for this hypothetical case in order to visualize how the tool is able to communicate the relevant issues during the life cycle of this product.

As a tool for business decision-making, the Sustainability SWOT fosters learning and cooperation. General experience shows that the assessment of sustainability cannot be treated merely within the community of experts. Rather, in order to attain credibility and effect changes towards sustainability, it is essential to involve an extended community with different perspectives (Elghali et al. 2007). The Sustainability SWOT is ideally formed as a cooperative brainstorming effort by both business and sustainability experts. Drafting a Sustainability SWOT together with sustainability experts can be a powerful learning experience about the complexity of sustainability for the business decision-makers, as it is able to present an overall, though simple, picture of the entire product life cycle summarizing the most important sustainability aspects. Moreover, a SWOT is an easy-to-read and familiar tool for business people. The framework is designed to meet the requirements of the extended peer community with different perspectives by incorporating stakeholder concerns in decision-making, to guide the private sector and include the implications of the wider institutional community as well. However, we must also keep in mind at this point Klöpffer's (2008) writings, in terms that though the streamlined tool can be used to aid decision-making, it should not be used as a comprehensive method, but as a first-cut approach instead.

3 Target groups of LCM

In terms of the generated changes as a result of using the Sustainability SWOT, these can be analyzed in light of the industrial network theory as a possible framework for understanding the extended focus of sustainability management and the need to manage sustainability issues beyond a single organization. A division of possible target groups of life cycle management, based on the industrial network theory, has been suggested by Pesonen (2005) and can be

Table 1 Summary of streamlined approaches for life cycle-based assessments

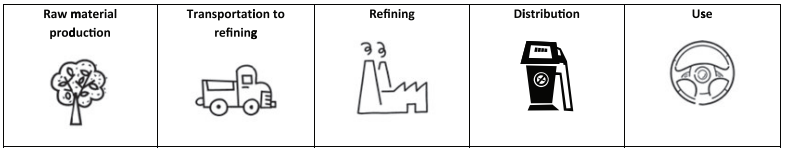
	Description	Sustainability perspectives			Qual./Quant.	Based on case-specific data
		Envir.	Soc.	Econ.		
Hot spot analysis (Wallbaum and Kummer 2006, as cited in Bienge et al. 2010)	Elaboration of the most relevant ssues or phases influencing resource use in the life cycle/value chain	x			Quant.	x
Sustainability hot spot analysis (Bienge et al. 2010)	Elaboration of the most relevant factors or phases influencing resource use, further environmental and social impacts in the life cycle/value chain	x	x	(x)	Qual./quant.	x
Life cycle thinking	Conceptual application of life cycle-based methods	x	(x)	(x)	Qual.	x
Streamlined LCA	Preliminary, shortened LCA either qualitatively or by using readymade databases	x			Qual./quant.	(x)
7-Step approach to environmental improvement through product development (McAloone and Bey 2009)	Systematic and creative 7-step approach to identify the company's potential for creating synergy between environmental improvement and business creation	x	(x)	(x)	Qual.	x
Rules of thumb	Simple design rules based on experience from "ordinary" quantitative LCA studies, which repeatedly reveal the same environmental impact source (e.g., reduced environmental impact in transportation through lower weight)	x			Qual.	
LCA-derived proxies	Simple, easy-to-measure metrics evaluate a product with respect to its critical environmental properties. A well-known proxy is MIPS (Schmidt-Bleek 1994), calculating material weight	x			Quant.	x
Socio-ecological impact matrix, ecomatrix (Belz 2005)	Analytical tool in matrix form exhibits social and ecological problems of a life cycle: on the *x*-axis are the stages of life cycle and different ecological and social dimensions on the *y*-axis	x	x		Qual.	x
MET matrix (Brezet and van Hemel 1997)	Analytical tool in matrix form, covering main life cycle stages on the *x*-axis and main environmental impacts on the *y*-axis (material, energy, toxicity)	x			Qual./quant.	x
MECO matrix (Wenzel 1998)	Analytical tool in matrix form, covering main life cycle stages on the *x*-axis and main inputs and outputs on the *y*-axis (material, energy, chemicals, others)	x			Qual.	x
Software tools	Software packages allowing quick execution of an LCA through built-in large material and databases. Often only cradle-to-gate data.	x			Quant.	
Artificial neural network (ANN) modeling (Park et al. 2001)	"learning by example," used to perform preliminary environmental assessments. Based on what is known from existing products, ANN models are "trained" to model a new product	x			Quant.	
Combination tools (e.g., eco-functional matrix, QFD-LCA)	Combine, e.g., LCA with assessment of other aspects (e.g., technical aspect, cost), without going into too much detail	x	(x)	(x)	Quant.	x
Life cycle design structure matrix (LC-DSM) (Schlüter 2001)	Different life cycle stages are both on the *x*- and *y*-axis and the relations	x			Quant.	x

Table 1 (continued)

	Description	Sustainability perspectives			Qual./Quant.	Based on case-specific data
		Envir.	Soc.	Econ.		
	between all stages are noted in the matrix					
Environmentally responsible product assessment matrix (ERPA) (Graedel and Allenby 1995 as cited by Baumann and Tillman 2004)	Semiquantitative LCA, 5×5 matrix, one dimension is the life cycle stages and the other is environmental concern; total environmental responsibility is the sum of the matrix element values.	x			Semi-quant.	x
ESAT (Schulz et al. 2012)	Software tool using life cycle inventory data for rapid estimation of the environmental and economic performance of different water servicing scenarios which are further prioritized by interactive multicriteria analysis	x		x	Quant.	
Reverse LCA (Graedel 1998, as cited by Baumann and Tillman 2004)	Begins with the ideal environmental impacts of a product and works backward to determine the physical design satisfying them	x			Qual.	x
Carbon footprint e.g., Wiedmann and Minx 2008)	Same system boundaries and FU than LCA, but only one impact category	x			Quant.	x
Simplified GWP algorithm (Bala et al. 2010)	Calculates GWP for the most important phases in the product life cycle	x			Quant.	(x)
Simplified differences modeling (Bala et al. 2010)	Comparing recycling systems, takes into account only the differences that occur in one system vs. the other	x			Quant.	(x)

applied in this context. The target groups are approached in terms of where the visible changes are occurring (Fig. 2). The first level of changes occurs within the organization itself (intraorganizational); thus, the organization is the target group. The second level of changes can be visible in the industrial network, either in the inter- (partnerships) or multiorganizational (networks of organizations) networks. Here, the target groups are, in addition to the organization itself, also its partners within the industrial network, which would stimulate the idea about shared responsibility. In order to be able to control the entire network, the dominant actors of a network have to take responsibility of other network partners, especially their suppliers and subcontractors. Any individual organization in an industrial network has usually limited influence and control over the entire network. For example, when the product reaches the main contractor in the production chain, many of the crucial environmental decisions have already been made earlier in the value chain. An active cooperation with suppliers and subcontractors increases the main contractor's control and information about the whole value chain and reduces the risks associated with the environmental burdens of the products (Pesonen 2005).

The third level of changes would occur in the group of the product's final users, i.e., consumers. The changes are primarily initiated through the promotion of the sales and consumption of sustainable products over conventional products and through supporting the correct use and disposal of the products (e.g., eco-labels, user guidelines, maintenance and repair services connected to the products, product take-back programs, and disposal schemes offered to the consumers). Finally, the highest level of changes will occur in the institutional context, with opportunities to mold the regulative or infrastructural framework. The institutional context of the network, i.e., the last target group, refers to those external institutions, NGOs, or other stakeholders who have an influence on the operation of the network. The goals of life cycle management in transforming the institutional context are either to promote the production, sales, and consumption of sustainable products; to prevent the production, sales, or consumption of competing conventional products by changes in legislation; or to create infrastructure for more sustainable products or service concepts (Pesonen 2005). As Hoffman and Woody (2008) say, "at the highest level you should gain (and maintain) a seat at the table when future regulations are being designed, always keeping in mind that credible action will give you a greater leverage in that process."



Strengths

Environmental

- Renewable raw materials
- GHG neutral fuel
- Decreasing traffic air emissions (NOX, SOX, particles) => city air quality improvement
- Decreasing transportation, if local raw materials used

Social

- Increasing social welfare at rural areas with more employment and business opportunities

Economic

- Higher fuel performance compared to fossil fuels (octane number for ethanol is 108 compared to 90-100 of gasoline)
- Global supply opportunities for raw material producers (e.g. palm oil) => increased economic well-being of raw material producers
- Existing distribution network for liquid traffic fuels (compared to other alternatives to hydrocarbons such as hydrogen gas or other gases)

Weaknesses

Environmental

- Inefficient production technologies and supply chain management => life cycle energy balance of biofuels in some cases negative
- Pre-harvest burning => air pollution

Social

- Supply and availability is still limited, and therefore those with lower income may not have access to alternative fuels => inequality between income classes, when taxation is favoring the use of alternative fuels

Economic

- Guarantee of vehicles doesn't currently cover use of alternative fuels => financial risks for car owners in case of motor breakdowns
- Currently in many cases higher production prices compared to fossil fuels

Fig. 1 Exemplary Sustainability SWOT for biodiesel

4 Data and methods

The data for the research were empirically collected from a survey given in December 2011(see Table 2 for survey questions). The Sustainability SWOT has been used within the last 5 years in a total of 111 organizations. Representatives from all these organizations were approached within the context of this study in order to assess the tool. Only 89 of these 111 representatives received the survey, due to maternity leaves, resignations, etc. The final sample size was 29 (33 % response rate). The survey consisted of seven main questions, out of which two aimed at eliciting background

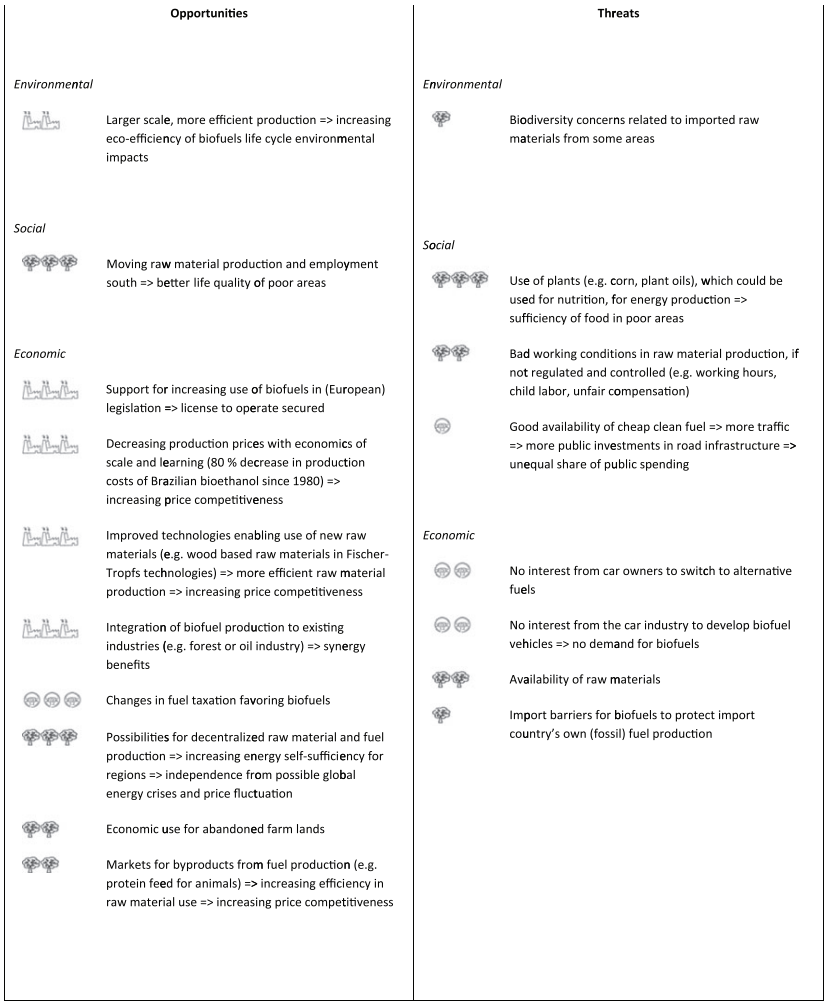


Fig. 1 (continued)

data (size of the organization and sector). The other five questions related to four main themes. The most emphasized question (with eight subquestions) concerned whether or not *actual changes* had occurred as a result of using the Sustainability SWOT in terms of (a) investments in technology or production processes, (b) investments in personnel, (c) investments in product development, (d) redefinition of corporate strategy, (e) changes in the supply chain, (f) new communication to the user base, (g) participation in the policy-making process, or (h) any other changes. In addition to giving a binary yes/no answer, the respondents were able to detail the actual changes in an additional comments section. The other questions related to a *general assessment of the tool* (rated from 4=worst to 10=best), its *target audience* (multiple response) as well as its *novelty value* (yes/no), each of which was complemented by an additional field for writing

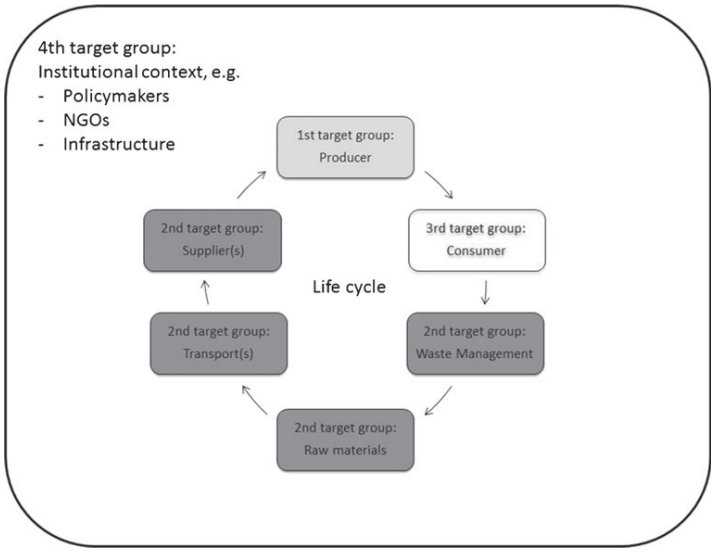


Fig. 2 Target groups of material flow management (modified from Pesonen 2005)

comments. Even though the sample size was small, a narrow statistical analysis was conducted. This included mainly the calculation of means and modes, but also testing if the background data had any impact on the willingness to execute changes as a result of using the Sustainability SWOT (e.g., if certain sized companies are more willing to invest in personnel or if certain sectors are unable to make any changes). The comments were analyzed further by means of content analysis in order to get an idea of the kinds of changes that were implemented.

The focus of the research is to find all concrete improvements or investments that result from using the Sustainability SWOT. The primary findings, i.e., the generated changes or improvements, will be reflected in the various levels of cooperation in a network. This aims at finding out if a model like the Sustainability SWOT can indeed lead to changes along the value chain, in end users or even in the institutional framework. Additionally, the general usability of the tool will be assessed to ascertain whether or not it can be implemented in practice as a streamlined tool for using life cycle-based methods and presenting results in a comprehensible and visually understandable manner.

5 Results and discussion

The first set of results reveals in a rough quantitative manner how the respondents valued the tool and if any concrete changes occur by using the Sustainability SWOT. The average grading of the tool was an 8 on a scale from 4 (worst) to 10 (best), which is encouraging. The quite consistent grading (standard deviation=1) indicated a positive reaction. The tool was able to provide some new information to 45 % of the respondents, with the primary additional value being in the systematic approach of drafting the situation and including more than one angle. Taking into consideration that the focus group was mainly mid- or senior management, it is quite striking to discover that the mere *awareness* of the system's life cycle is able to provide new information to this level of employees. This indicates that prior to using the tool, the focus group has been rather ignorant about life cycle-wide impacts.

Summing up the results of the changes as a result of using the Sustainability SWOT (question 6), 57 % of the respondents made at least one change in their activities (either through technological investments, personnel investments, product development, redefinition of strategy, supply chain changes, user communication, public decision-making, or any other investments or changes). By average, the respondents reported to having made changes in more than three different change categories (note that the “no answers” have been ignored in calculating the averages). Thus, according to the results, changes have occurred in the previously mentioned activities, but based on the data, it is impossible to assess how many projects have indeed been initiated (there might be several projects in, for example, product development).

Table 2 Survey questions and results

Question	Answer
1. What is the number of personnel in your organization?	1–9 (10 %), 10–49 (7 %), 50–249 (21 %), 250 or more (41 %), no answer (21 %)
2. In which sector is your organization active?	Manufacturing (21 %); accommodation and food-service activities (17 %); electricity, gas, steam, and air conditioning supply (10 %); construction (10 %); professional, scientific, and technical activities (7 %); arts, entertainment, and recreation (7 %); other service activities (7 %); public administration and defense; compulsory social security (3 %); wholesale and retail trade, repair of motor vehicles, and motorcycles (3 %); activities of extraterritorial organizations and bodies (3 %); no answer (21 %)
3. Which overall grading (4=worst to 10=best) would you give the Sustainability SWOT?	8
4. Did you learn anything new?	Yes (45 %), no (27 %), not able to say (21 %)
5. What would be the best target audiences?	Entire personnel (48 %), senior management (45 %), customers (41 %), partners (41 %), midmanagement (34 %), investors (17 %) public decision-makers (14 %), entire society (14 %), NGOs (7 %), media (3 %), consultants (3 %)
6. Did the results of the Sustainability SWOT encourage you in the following issues:	
a. …investments in technology or production processes?	Yes (21 %), no (59 %), no answer (20 %)
b. …investments in personnel?	Yes (17 %), no (62 %), no answer (21 %)
c. …new product development?	Yes (21 %), no (55 %), no answer (24 %)
d. …redefinition of corporate strategy?	Yes (28 %), no (52 %), no answer (20 %)
e. …changes in the supply chain?	Yes (14 %), no (55 %), no answer (31 %)
f. …communications to the users?	Yes (21 %), no (45 %), no answer (34 %)
g. …participating in public decision-making?	Yes (14 %), no (59 %), no answer (27 %)
h. …or in any other investments or changes?	Yes (10 %), no (52 %), no answer (38 %)

However, the second and perhaps more revealing set of results arises from a closer look at the magnitude of changes as well as if changes are transferable along the supply chain or to the customer base. These are collected from the additional comment fields of the survey, in which the respondents were asked to detail exactly which changes had been put into effect. They were classified based on the LCM target group division by Pesonen (2007) and further organized based on their level of impact (strategic vs. operative). Readdressing the actual changes occurring as a result of using the Sustainability SWOT, these can be further classified into being either strategic or operative (Table 3).

The most tangible changes occur within the organization itself. The strategic-level changes within the organization had primarily and explicitly an environmental focus (environmental strategy, environmental impact included in the strategy, energy efficiency aims on a strategic level), but some could also be seen as having a sustainability view (sustainability strategy and its introduction to the personnel, redefinition of the entire strategy, general awareness). One of the generated changes was still at a relatively universal level (general awareness); however, all the others were either very specific and tangible, requiring financial inputs, or had an impact on the entire corporate strategy (except for energy efficiency being added as a strategic aim, these strategic changes were not detailed further to indicate the level of impact this kind of tool could have). The most tangible and immediate changes were, e.g., process changes, personnel changes, and introduction of a quality and management system. Looking further to the operative changes, some consequences were detected on the social side as well (safety investments, toxic substances substitution). Naturally, the social problem areas in Finland can be quite different from those in other developed or even developing countries. As 41 % of the respondents were from large enterprises, which could be estimated to have international activities, it would become more of a requirement to also emphasize social assessment in these organizations. Moreover, the increasing level of globalizing supply chains makes it important for the smaller, even micro-level organizations, to include the social aspect in the assessment. This of course still requires work from the social impact assessment methodology and should currently be discussed case by case within the organizations, depending on the actual social impacts they are facing. Further, the intraorganizational, operative changes included in particular energy-saving devices or process efficiency investments, which can be further traced to the economic aspect of sustainability as well, in addition to the environmental sustainability.

However, there are also concrete changes along the value chain. Within partnerships or networks of actors, there are both strategic and operative changes. These cannot necessarily be exclusively categorized into either one, but many

Table 3 Changes within the network target groups

Changes	Network target groups			
	Intraorganizational MFM	Network target groups	Consumers	Institutional context
Strategic-level changes	•Changes in the planning process	•More aggressive focus on responsible suppliers	•The Swan eco-label	•Raising issues in labor market organizations
	•Adding personnel dedicated to environmental strategy	•Creating disclosure profile for communicating for partners, improving transparency in responsible business	•Sustainability fact sheet for customers	•Understanding that policy-level cooperation includes opportunities and risks
	•Introducing sustainability strategy to personnel •Quality and management system	•Focus on cooperation	•Sustainability is highlighted in all communications •New solutions to customer with improved Sustainability SWOTs	
	•General awareness		•User-oriented product concepts	
	•Environmental impacts of the entire life cycle are particularly included in strategic decision-making •Energy efficiency becoming strategic aim in product development •Redefinition of corporate strategy in the entire organization		•Creating disclosure profile for communicating for partners, improving transparency in responsible business	
Operative changes	•Energy-saving devices	•Initiating audits for raw material suppliers	•Improving energy efficiency of the products	
	•Substitution of toxic substances in the production process	•Clear instructions about product quality	•Water use optimization	
	•Safety investments	•Finding practical business concepts with a partner		
	•Efficiency of the processes	•Demanding recycled materials from supplier		
	•Electric motors			
	•Investments in environmentally friendly operations			

of the issues relate to both inter- or multiorganizational target groups. Focusing more on sustainable or responsible suppliers as well as demanding certain issues (recycled materials, product quality) and auditing the suppliers have become recognized outcomes of the process. The compilation of lists of requirements or instructions for procurement, which can be openly communicated to the partners or to the network, makes the business-to-business activities between companies more transparent, fairer, and certainly more motivating for suppliers to view their own operations. In terms of strategy, the use of a standardized disclosure mechanism has been initiated in one organization, which ultimately leads to the inclusion of the end users as a target group. The disclosure mechanism is targeted at both partners and customers to increase transparency in the field of conducting responsible business.

The results of the survey indicated clearly that, in addition to the previously mentioned disclosure mechanism, an increasing amount of initiatives was taken with a focus on the consumers, primarily through marketing efforts, certification, or other communications. On a strategic level, the changes were both in communication (sustainability disclosure and marketing mechanisms) and more sustainable product development, in which customer orientation stretched into strategic product concept development. On an operative level, the customer' perspective was included both through increasing the energy and water-use efficiency of the product systems.

To a lesser extent, some respondents also reported having had an impact on the policy level. It is noteworthy that these companies, who are becoming more active at the policy level, had a personnel total of 50 or above (thus were within the two highest classes regarding number of personnel). Smaller companies often have an implicit view that they are inherently unable to participate at the policy-making level. However, participation at a regional level and in a focused manner, or through a coalition of businesses, might be efficient and appropriate (Hoffman and Woody 2008).

Testing whether the size or sector of the company had any impact on the initiated changes resulted in negative findings. Even though actual statistical testing with a small sample size is discouraged, it becomes evident from cross-tabulating the survey results that there was no significant difference within the different size groups (micro, small, medium, large[2]) in terms of the generated changes. This means that small and larger companies were equally prone to initiate changes as a result of using the Sustainability SWOT.

Additionally, there was no impact from the different sectors in terms of which changes were generated. Ten different sectors were represented in our sample, and it seems that most of them were able to initiate some sort of change (except for "Arts, entertainment and recreation," "Wholesale and retail trade, repair of motor vehicles and motorcycles" as well as "Public administration and defense, compulsory social security," which represented 13 % of the entire sample).

In terms of the audiences of the Sustainability SWOT, the primary group is the personnel of the organization itself, primarily the upper or midmanagement. However, other target groups along the value chain were also named important, for instance, the customers and partners. The target groups of the Sustainability SWOT, as estimated by the respondents, can be separated conveniently within the LCM target group division. The primary target group was indeed the intraorganizational network (in either mid- or senior management, or the entire personnel). However, the industrial network as a target group was also emphasized through partners in general (41 %). An equally important target group was seen to be the end users (41 %).

6 Conclusions

The results of the analyses of both the usability of the Sustainability SWOT in business as well as the suggested assessment framework leading to any actual changes were promising. The tool is easy to use and understand, and the results are visually easy to communicate. Its systematic procedure and inclusion of several important angles were seen as beneficial. Keeping in mind that the LCA community is faced with the fear of having its methods understood only by a small subset of industry professionals, it is encouraging that the streamlined approach tailored according to the logic of business decision-makers (i.e., inclusion of the SWOT) is able to find the acceptance and understanding of that vital group. Though it does not follow the strict guidelines of impact assessment, be they environmental, economic, or social, it is able to communicate the significance of a life cycle perspective to businesses and allow them to take into consideration issues along the value chain. In this sense, the tool can be seen to increase the understanding of the life cycle perspective.

Moreover, the concrete changes not only within the organizations themselves but also along the value chain and within the institutional context signal first of all that based on a streamlined sustainability assessment, there are adjustment possibilities. Even by using a quick streamlined method like the Sustainability SWOT, business decision-makers are able to detect points to be optimized if sustainability and life cycle perspective are regarded. Secondly and more importantly, these findings have indeed led to changes in the case organizations. It is remarkable how many changes have been initiated—not only at an operative level but also at a strategic level—by carrying out an exercise such as the Sustainability SWOT. A question for further management studies remains in describing the process of how the Sustainability SWOT is able to generate changes in the entire value chain.

Any life cycle-based method has its share of uncertainty. The Sustainability SWOT tool is able to incorporate this uncertainty into the assessment process through presentation of the results and through its dynamic features. An approach that manages uncertainty of all types with transparency and competence is required. In full-scale LCAs, more precise uncertainty methods such as a Monte Carlo simulation can be carried out, but in a streamlined method, the inclusion of uncertainty should, in fact, be streamlined. The tool includes future possible opportunities and threats and takes these with a differing significance into consideration, i.e., how likely these are to occur. The presentation does not restrict itself to only one path, but allows a consideration, on different probability levels, of several different views of the future.

In this article, we propose the use of a Sustainability SWOT as a streamlined method for the life cycle sustainability assessment. The call for streamlined methods in the field has been formulated several times by scholars, and the underlying proposal is meant to be one possibility in the approaches. In this paper, we have discussed the usability as well as the capability of a Sustainability SWOT to generate changes towards

[2] Enterprise size according to employee amount defined by the European Commission: micro, <10 employees; small, 10–49 employees; medium, 50–249 employees; large, ≥250 employees.

sustainability not only in the organization itself, but in the entire value chain. The Sustainability SWOT has proven to be usable and able to generate changes and improvements along the value chain and in some cases in the institutional context as well.

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