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"If you think that you are too small to be able to make a difference, try sleeping with a mosquito in your room… and you will see which of the two prevents the other from sleeping."

The Dalai Lama

ABSTRACT

Ilpo Penttinen
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Climate change, smelting glaciers, lack of fresh water, polluted soil and energy consumption are major issues of our time. These phenomena are often considered to be related to industrial activities and their ecological consequences. Sustainable development has become a widely quoted policy in this context as it combines social, economic and environmental/ecological development. Economic and ecological efficiency, eco-efficiency, has a key role in sustainable development. Small and medium size enterprises (SMEs) play an increasingly important role in economic growth, employment and local development. Several methods for adopting eco-efficiency, as well as various models for evaluating eco-efficiency in enterprises, have been developed. Common frameworks to differentiate these methods and thus promote the use of them in SMEs have so far been modest.

The aim of this dissertation is to increase knowledge on the applicability and adoption of eco-efficiency into strategic and operational management of industrial SMEs. The focus is on the role of eco-efficiency in strategic and operational management, adoption of managerial methods, and use of methods for adopting eco-efficiency, use of methods for evaluating eco-efficiency and on the role of material flow management as a link to eco-efficiency in industrial SMEs. The research methodology chosen is action research, and the research methods are case studies and a survey.

The main outcomes of the research are summarised as follows:

- a recommendation for common frameworks to help in adopting sustainability and eco-efficiency in strategic and operational management
- a recommendation for common frameworks to recognize a suitable method for adopting as well as for evaluating eco-efficiency. The frameworks will help enterprises to manage the adoption of eco-efficiency and to demonstrate and communicate eco-efficient improvements both internally and externally
- descriptions and recommendations for some common methods for adopting eco-efficiency
- descriptions and recommendations for some common methods for evaluating eco-efficiency
- use of material flow management as a link to eco-efficiency in SMEs

This study gives new empirical knowledge on the adoption of eco-efficiency and the factors behind the adoption decisions.

Keywords: Sustainable development, eco-efficiency, economical efficiency, ecological efficiency, evaluating, material flow management, decision-making, strategic management and operational management, small and medium size enterprises.

TIIVISTELMÄ

Ilpo Penttinen
Adoption of Eco-Efficiency in Strategic and Operational Management of Industrial Small and Medium Size Enterprises (Eko-tehokkuuden liittäminen strategiseen ja operatiiviseen johtamiseen tuotannollisissa Pk-yrityksissä) / Ilpo Penttinen. - Turku: Turun ammattikorkeakoulu, 2010. - 179 s., 15 liites. - (Turun ammattikorkeakoulun tutkimuksia 33, ISSN 1457-7917).
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Ilmastonmuutos, jäätiköiden sulaminen, makean veden puute, saastunut maaperä ja lisääntyvä energiankulutus ovat aikamme esillä olevia asioita. Nämä ilmiöt on usein yhdistetty teolliseen toimintaan ja sen ekologisiin seurauksiin. Kestävä kehitys on noussut tässä yhteydessä laajalti sovelletuksi toimintaperiaatteeksi, sillä se yhdistää sosiaalisen, taloudellisen ja ekologisen kehityksen. Ekotehokkuudella, eli taloudellisella ja ekologisella tehokkuudella, on keskeinen asema kestävän kehityksen käsitteessä. Pienillä ja keskisuurilla yrityksillä, Pk-yrityksillä, on merkittävä ja yhä kasvava rooli taloudellisessa kasvussa, työllisyyskysymyksissä sekä paikalliskehityksessä. Täten niillä on merkittävä rooli myös kestävän kehityksen edistämisessä. Kestävän kehityksen edistämiseksi on kehitetty useita menetelmiä ekotehokkuuden liittämiseksi yritysten toimintaan sekä sen arvioimiseksi. Yleisiä malleja näiden menetelmien erottamiseksi toisistaan ja niiden soveltamisessa käytäntöön ei kuitenkaan juuri ole ollut.

Tämän väitöstyön tavoitteena on lisätä tietämystä ekotehokkuutta edistävien menetelmien käyttökelpoisuudesta ja käytäntöön soveltamisesta tuotannollisten Pk-yritysten strategiseen ja operatiiviseen johtamiseen. Tarkastelun kohteena on ekotehokkuuden merkitys strategisessa ja operatiivisessa johtamisessa, ekotehokkuutta edistävien menetelmien käyttöönotto sekä tuotannollisten Pk-yritysten materiaalivirtojen hallinta mahdollisena ensiaskeleena ekotehokkuudelle. Tutkimusmetodologina on toimintatapatutkimus ja tutkimusmenetelminä käytetään tapaustutkimusta ja kyselytutkimusta.

Tutkimuksen saavutukset voidaan kiteyttää seuraavasti:

- mallit joiden avulla voidaan edistää kestävän kehityksen ja ekotehokkuuden liittämistä strategiseen ja operatiiviseen johtamiseen
- mallit ekotehokkuutta edistävien menetelmien sekä ekotehokkuuden arviointiin tarkoitettujen menetelmien valitsemiseksi ja soveltamiseksi
- eräiden yleisesti käytettyjen ekotehokkuutta edistävien menetelmien kuvaukset ja suositukset
- eräiden yleisesti käytettyjen ekotehokkuuden arviointiin tarkoitettujen menetelmien kuvaukset ja suositukset
- materiaalivirtojen hallinnan merkitys ekotehokkuuden edistämisessä

Tämä tutkimus tuo uutta empiiristä tietoa ekotehokkuutta edistävien menetelmien käytöstä sekä niiden soveltamisesta.

Avainsanat: Kestävä kehitys, ekotehokkuus, taloudellinen tehokkuus, ekologinen tehokkuus, materiaalivirtojen hallinta, päätöksenteko, strateginen johtaminen ja operatiivinen johtaminen, Pk-yritykset.

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Most of all I am grateful to my wife and my sons for their patience and understanding. It was not easy to combine work, writing my thesis and notifying my family. Without their support and encouraging this thesis would not have been completed.

Naantali 5.10.2020
Ilpo Penttinen

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1 INTRODUCTION

The author has used contents of this work in some conference articles. The author has written them all by himself and other authors mentioned in the articles have only commented these articles. These articles are mentioned in the reference list by the name Penttinen and Penttinen et al.

Sustainable Development (SD) has mostly been defined as balancing the fulfilment of human needs with the protection of the natural environment so that these needs can be met not only in the present, but also in the future. World Commission on Environment and Development (WCED) and United Nations (UN) define Sustainable Development as being such development that today's needs will be met without compromising the of future generations needs (World Commission on Environment and Development 1987, United Nations 1987). This definition was also used by the Bruntland Commission, formally the World Commission on Environment and Development (WCED), convened by the United Nations in 1983. The commission was created to address growing concern about the accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development. In establishing the commission, the UN General Assembly recognized that environmental problems are global in nature and it was determined that it is in the common interest of all nations to establish policies for sustainable development (United Nations 1987). The UN definition has become the most widely used definition for sustainable development.

The field of sustainable development can be conceptually divided into three general dimensions: social development, economic development and environmental development. Eco-efficiency has a central part in sustainable development and it covers two (economic and environmental) of the three dimensions of sustainable development. The term of eco-efficiency is defined by the World Business Council for Sustainable Development (WBCSD) (2000,p.4) as follows: "*Eco-efficiency is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life,*

while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the Earth's estimated carrying capacity". Eco-efficiency is a widely spread term used in many situations when considering environmental and economical questions, from policy making to everyday practices in business world.

SMEs play an increasingly important role because of their contribution to economic growth, social cohesion, employment and local development. For example, in OECD economies, SMEs account for over 95% of enterprises and nearly 70% of employment. SMEs are a major source of technological innovation and new products, and they play an essential role as subcontractors in the downsizing, privatisation and restructuring of large companies. SMEs have a particularly important role in developing countries where poverty is most severe. SMEs are meeting an increasing challenge to take responsibility for their environmental and social behaviour and in promoting sustainable development.

SMEs also generate a large share of new workplaces and they are described to have a particularly important role in developing countries where poverty is most severe. (OECD 2004). SMEs are meeting an increasing challenge of taking responsibility for their environmental and social behaviour and in promoting sustainable development. This present study focuses on eco-efficiency in the practices of industrial SMEs.

1.1 Background of the Research

Climate change is one of the greatest environmental, social and economic threats facing the planet. Climate change results in worldwide impacts ranging from affecting agriculture further endangering food security, sea-level rise, increasing intensity of natural disasters, species extinction to the spread of vector-borne diseases. This became clear e.g. in the United Nations Climate Change Conference in Bali culminating in the adoption of the Bali roadmap representing various tracks that are essential to achieving a secure climate future.

Humanity is no longer living in balance with nature's capacity. This growing pressure on ecosystems is causing habitat destruction, degradation and permanent loss of productivity. It is also threatening both biodiversity and human well-being. The global audit of natural ecosystems revealed a decrease of about 31 percent in the earth's natural resources between 1970 and 2003. Forests had lost 12 percent of their biological resources in these thirty-three years and marine ecosystems had lost 27 percent. One billion hectares of land that used to be suitable for cultivation can no longer be cultivated because of the large quantities of pesticides that have been poured into the soil. Humanity's demand on the biosphere (biologically productive land and sea) required to provide all the resources we use and to absorb our waste, was calculated to be 14,1 billion global hectares. In 2003 the total supply of productive area (bio capacity) was calculated to be 11,2 billion global hectares. The use of natural resources has exceeded the earth's biological capacities by 25 percent on global scale. (WWF 2006).

The total of the world's energy consumption is calculated to be almost 60 percent higher in 2030, and the amount of carbon-dioxide (CO_2) generated will be 60 percent higher than now (International Energy Agency, IEA, 2004). Global warming, mostly agreed to be caused by the carbon-dioxide emissions and other greenhouse gases, is one of the most discussed anthropogenic effects. The majority of climatology experts recall for actions to mitigate climate exchange (Westkämper et al. 2001) and water supply challenges are becoming reality for communities around the world (Miller 2006). The current economic system and related values are mentioned to arise global ecological and social conflicts and this is mentioned to result in the need for sustainable development (Zabel 2005). These consequences of human activities are strengthening the role of sustainable development phenomenon.

1.2 Sustainable Development and Eco-Efficiency

Sustainable development consists of three dimensions which are social, economic, and environmental dimensions (Linnanen et al. 1997, Welford 2000, Vanhala et al. 2002). Sustainable development covers development in all of these dimensions. Development is a described to be a process of social change, not only a set of policies and programs instituted for some specific results. This development process has been going on for the whole human history. This development has increased in speed and intensity during the last five centuries and during the last five decades there has been noticed a big increase in acceleration (International Commission on Peace and Food 1994). *"Development can be broadly described to have upward ascending movement with greater levels of energy, efficiency, quality, productivity, complexity, comprehension, creativity, enjoyment and accomplishment"* (Jacobs et al. 1999, p.152). The term social development means in this case qualitative changes in the structure and functioning of society which can help society to better realize its aims and objectives.

Economic development has been under intensive research for a long time, and it is not the main scope of this study. Nevertheless, it is appropriate to mention some definitions for economic development as it is the other fundamental part of eco-efficiency. Economic development can be seen as a complex multi-dimensional concept involving improvements of human well-being. Economic development is described to be a process for creating wealth by mobilizing human, financial, capital, physical and natural resources to generate goods and services for the markets (American Economic Development Council, AEDC 1984). It is development of economic wealth of countries or regions as well as well-being of their inhabitants. It also stresses, that legal and institutional adjustments are made to give possibilities for innovation and investments to develop the efficient production and distribution system for goods and services. Economic development means sustainable increase in living standards including increased income per capita, better education and better health. It refers to improvements in many different indicators, such as literacy rates and life expectancy. AEDC points out that natural resources should also be noticed.

Economic development can be described as a process for raising the level of prosperity and material in a society by increasing the productivity and efficiency of its economy. In less industrialized regions, this process is believed to be achieved by an increase in industrial production and a relative decrease in the importance of agricultural production. The aim of economically efficient production is to minimize the ratio of inputs to outputs. Production is considered economically efficient when goods are produced with minimum costs and resources. (Spero et al. 1999).

Ecologically sustainable development is the environmental component in sustainable development. Australia's National Strategy for Ecologically Sustainable Development (NSESD 1992) defines ecologically sustainable development as the use, conservation and enhancement of the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, also in the future, can be increased. It can be achieved through the implementation of the following principles of the Rio Declaration on Environment and Development (United Nations 1992):

- Principle of intergenerational equity (Principle 3): the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- Conservation of biological diversity and ecological integrity should be a fundamental consideration (Principle 7)
- Precautionary principle (Principle 15): if there are threats of serious or irreversible environmental damage, measures to prevent environmental degradation must be taken. Lack of full scientific certainty should not be used as an excuse for postponing these measures.
- Improved valuation, pricing and incentive mechanisms (Principle 16): environmental factors should be included in the valuation of assets and services.

Agenda 21, the global plan of actions to promote sustainable development, from Rio Summit 1992, has been an important milestone for the future of mankind. The action plan encourages the adoption and reporting of best environmental practices (United Nations 1992). "*The European Commission explicitly recognizes the need for sustainable management and protection of our environment and concludes that environmental protection is a "key duty" that we have for future generations"* (Dimas 2005, p.1). Sustainable production (an environmental perspective) can be defined as such production where the throughput of materials and energy is reduced. The target should be to a level where the regenerative and assimilative capacities of environmental sources and sinks can be maintained (Welford et al. 1998). These principles connect industrial enterprises and production to sustainable development.

Eco-efficiency was made public by WBCSD (World Business Council for Sustainable Development) in 1992 and is defined as "*the delivery of competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity"* (UNEP 1998, p.3). Eco-efficiency has widely become accepted as a key strategic theme for global business towards sustainable development (Ehrenfeld 2005). Since 1992, WBCSD has developed and publicized a framework for implementing and evaluating eco-efficiency. Eco-efficiency combines economical and ecological improvements which are essential components for all business. There for it is necessary to increase efficient use of resources and to prevent emissions (Verfaillie et al. 2000).

Eco-efficiency means producing goods and services with less energy and fewer raw materials, which results in less waste, less pollution and less cost (UNCTAD 2001). Schaltegger et al. described the concept of eco-efficiency as the aim of environmentally sound management to increase eco-efficiency by reducing the environmental impact while at the same time increasing the value of an enterprise (Schaltegger et al. 1989). These definitions of eco-efficiency stress that economy and ecology do not exclude each other

but, on the contrary, that a combination represents a benefit both for the enterprises and the society. Eco-efficiency is highly a management philosophy, which encourages business to search for environmental improvements that give parallel economic benefits. It focuses on business opportunities and allows companies to become more environmentally responsible and more profitable (WBCSD 2000). According to these definitions eco-efficiency can be considered as a managerial method. Evaluation of eco-efficiency can be used to measure improvement as well as to report progress towards eco-efficiency in a consistent manner (UNCTAD 2001).

WBCSD has identified seven success factors for business to improve their eco-efficiency:

- Reduce the material intensity of goods and services
- Reduce the energy used in producing of goods and providing services
- Reduce the toxic dispersion
- Enhance material recyclables
- Maximize sustainable use of renewable resources and increase material durability
- Extend the product durability
- Increase the service intensity of goods and services

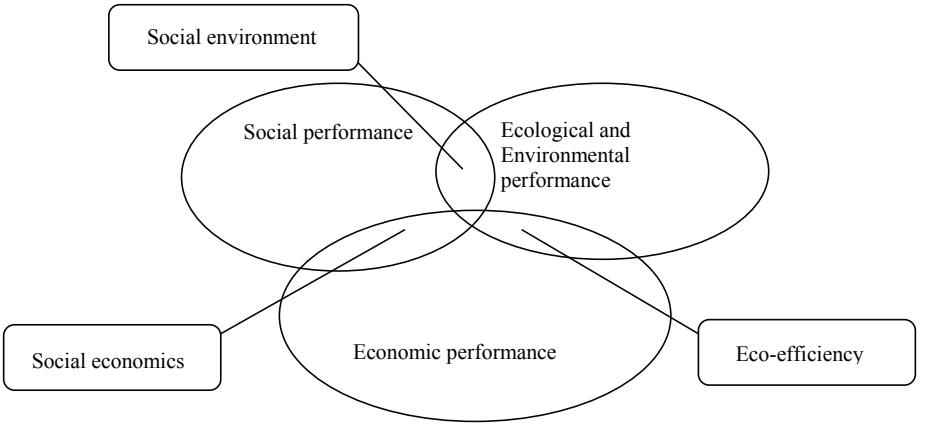


Figure 1 Eco-Efficiency and Eco-Performance (Modified from Hua 2005)

Eco-efficiency can be described as a sum of economic performance and environmental performance. Efficiency means the state or quality of being efficient which means competency in performance (Webster's Encyclopedic Unabridged Dictionary 1994). Efficiency can be understood as the extent to which outputs are maximized for a given level of inputs, or inputs minimized for a given level of outputs. Effectiveness means adequateness to accomplish a purpose, meaning producing the intended or respected result (Webster's Encyclopedic Unabridged Dictionary 1994). Effectiveness means the extent to which program outcomes are able to achieve program objectives.

Performance in this context means the manner in which, or the efficiency with which something reacts or fulfils the intended purpose (Webster's Encyclopedic Unabridged Dictionary 1994). Performance describes business activity and means fulfilment of an obligation or a promise compared to the results of an organisation or investment over a given period of time.

1.3 Strategic Management and Decision-Making

There is a clear connection between environmental issues and strategic management. According to Michael Porter (1991a) strategy means that a company takes into account its business environment in order to maintain a dynamic balance. Countries worldwide have formulated laws to limit companies from polluting. The ecological dimension of sustainable development has become an important part of the global business environment, and thus the natural environment should be a strengthening theme in strategic management (Figure 2). Strategic environmental management in an organization entails the organization's commitment and the setting of the organization's environmental targets. Operational management includes all the practical issues, which are needed to reach the environmental targets of the organisation as presented in Figure 2. Taking the environment into account in decision-making as a permanent part of doing business is obvious. Reasons for this can be e.g. customer demand, public opinion, environmental advocacy groups,

environmental laws and regulations, liabilities, resources, supply chain demands etc. An enterprise management and leadership strategy can be the key tool for considering the relations between an organisation and the environment. A company who is promoting sustainability has to find a balance between environmental excellence and business competitiveness. Eco-efficiency has widely become accepted as an important strategic theme for global business towards sustainable development (Ehrenfeld 2005).

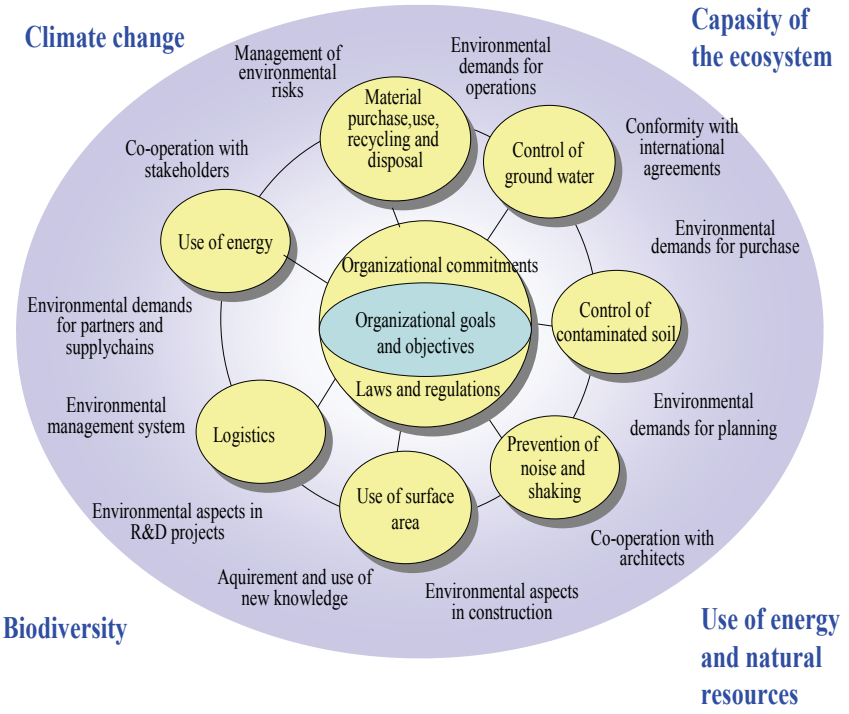


Figure 2 Strategic and operative environmental management (Pohjola 2005)

When considering eco-efficiency as a managerial technology or method, adoption of managerial methods is an important issue in this present study. Rikhardsson et al. (2005) describe that adoption theories can be classified into two main categories. They can be

called 'the efficient choice explanation' and the other one 'the institutional explanation' The efficient choice explanation points out to the efficiency of adopting something that can improve corporate performance in some ways. The focus of institutional explanation is more on sociological and psychological factors that determine the adoption or rejection of innovations and technologies. Institutional theories point out that organizational choices are not always efficient and based purely on efficiency or effectiveness criteria. The use of methodologies and concepts can be explained also by innovation theories (Rogers et al. 1971). The adoption groups can, according to Rogers, be classified as innovators, early adopters, early majority, late majority and laggards (Rogers 1995).

Decision-making has a major role in adopting and incorporating eco-efficiency. Decision-making approaches are available mostly in the process design literature. They are often discussed as part of investment theories and in theories dealing with single goals, like cleaner production, which is one method for implementing eco-efficiency. Decision-making involves the analysis of different alternatives and their consequences, and the subsequent commitment to action, usually in connection with a commitment with resources (Janssen 1992, Kirkwood 1997). Kirkwood describes decision-making as consisting of four stages which are: specifying objectives, developing alternatives, considering how well they meet the objectives set, and then selecting the best available solution (Kirkwood 1997).

In SMEs (small and medium sized enterprises) decision-making is often limited to only one or a few persons. This indicates that individual attitudes, responsibility and behavior towards the environment are important factors in decision-making. These are difficult questions to observe in decision-making. Attempts to understand human behavior have pointed out to be as frustrating as they are challenging (Ajzen 2005, Zabel 2005). So far one of the main drivers, influencing people to behave in an environmentally friendly way, has been environmental legislation. According to the theory of reasoned action, behavioral intentions are explained to be determined by a person's attitude towards the behavior and by his subjective norms. Attitudes are described to be personal in nature and they are determined by the beliefs of the consequences of that kind of behavior (Verplanken and

Aarts 1999, Ajzen 1998, Ajzen 2005). Necessary preconditions for any attitude are claimed to be factual knowledge and environmental values (Ajzen 1998, Kaiser et al. 1999, Barr et al.2005). A person's awareness of environmental problems and his environmental knowledge are very variable because of several reasons, such as education and life experience (Uusitalo 1991, Hines et al. 1987, Finger 1994, Dietz et al. 1998, Olli et al. 2001, Syme et al. 2002)

1.4 Research Problem

The research problem has aroused from the author's background as a teacher, consultant and a project manager within environmental management topics since 1995. There is a wide range of different methods for adopting eco-efficiency, as well as for evaluating eco-efficiency. Often occurring questions are: how do these methods differ from each other, and which of them could be most suitable in my case. Eco-efficiency, as a term, has been relatively unknown among industrial small and medium sized enterprises and common frameworks to differentiate these methods have so far been modest.

The main objective of this present study is to design a framework for increasing understanding on the applicability and adoption of eco-efficiency into strategic and operational management of industrial SMEs. In this present study the focus is on how and why, SMEs adopt or neglect eco-efficiency practises. The practises of material flow management issues are also investigated. The solution for the research problem presented can be reached with more specific research questions. The research questions are the following:

Q1. Can eco-efficiency be considered as a key element in business strategies for SMEs?

Q2. Do SMEs use eco-efficiency methods and models in practise?

Q3. Which factors enable or disable the adoption of methods for eco-efficiency?

Q4. Can material flow management be a link to eco-efficiency?

Q5. Can the developed frameworks help enterprises in adopting eco-efficiency in their strategic and operational management?

The main contribution of this dissertation is in finding out applicable models and methods, which may improve the adoption of eco-efficiency in SMEs at industrial sectors. Motivations and barriers for adopting eco-efficiency to strategic and operational management in SMEs at industrial sectors are discussed.

1.5 Scope and Limitations of the Research

This present study focuses on the challenges of SMEs in adopting eco-efficiency practises and thus participating in promoting sustainable development. Industrial SMEs are of special interest as they can be considered to be responsible for a major part of pollution (European Commission 2004). The scope of the dissertation is limited both in theoretical and empirical dimensions. The theoretical scope is limited to managerial aspects and decision-making concerning the adoption of eco-efficiency. The empirical data in the multiple case study is limited to small and medium sized furniture industry in Brazil. In the survey study the empirical data is limited to industrial SMEs in Finland.

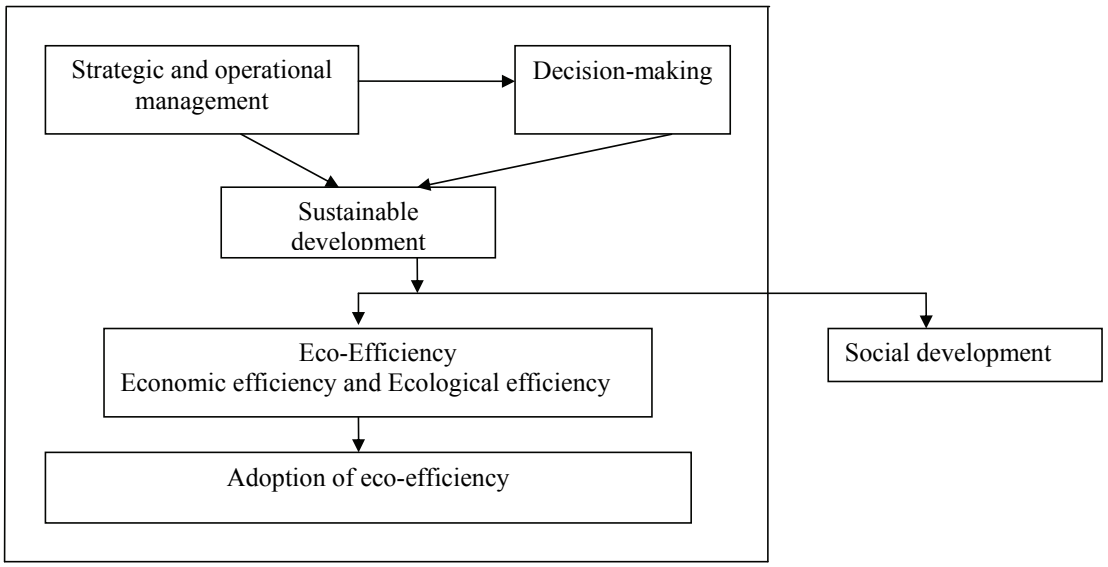


Figure 3 Framework of the study (Social development is not included in the scope of this study)

In the literature study, considerations for adopting eco-efficiency as well as a framework for promoting adoption of eco-efficiency is reviewed. It is not meant to be a full study on all issues affecting adoption of managerial methods. It is more a cursory examination of findings influencing practical decision-making in SMEs.

1.6 Research Methodology and Methods

The research methodology chosen is action research, and the research methods are a multiple case study, a survey and a case study. The basis for qualitative research is the description of real life, with an idea that reality is diversified. In qualitative research the objective is examined as entirely as possible. The aim is rather to find or unveil facts, than to verify already existing thesis. Humans are preferred as instruments in data collection.

According to Hirsijärvi et al. (1997) the researcher should rely more on own observations and discussions with the examined persons, than on information gathered with measuring means.

Aaltola et al. (1999) define action research as a process, which aims at changing and improving cases. Development of action can be considered as an ongoing process, which does not end at a certain better action. A process understood in a new way is central. They enclose interaction between real-life action and theoretical research as a research strategy in action research. They also point out that there is not only one absolutely wrong or right way in action research. Action research is under continuing change, and thus difficult to describe. It is important that the researcher recognizes his own approach and related angle of view. According to Heikkinen et al. (1999) action research has a strong connection with real life. They see that action research is not only everyday action, but it adds new understanding to it. Research material can be gathered by questionnaires, interviews and observations.

The data is collected from following sources.

1. A multiple case study, conducted in 2005 in Brazil, concerns eco-efficiency in industrial SMEs. Questionnaires and interviews were used to gather the material. The multiple case study material included fifteen questionnaires and fifteen interviews.
2. A multiple case study, conducted in Finland in 2006. The same questionnaire as in Brazil was used to examine the difference between Brazil and Finland in the acceptance of methods in industrial small and medium sized enterprises. In this study no questionnaires were returned.
3. A survey, concerning material flow management, was conducted in 2007 in Finland. The questionnaire was sent to one hundred and sixty-seven (167) companies, and eight (8) questionnaires were returned.
4. A case study concerning the applicability and acceptance of the developed frameworks in industrial small and medium sized enterprises was conducted as an interview in eight (8) enterprises in 2008 in Finland.

The data from the multiple case studies, the survey and the case study are analyzed and summarized.

1.7 Structure of the Dissertation

The structure of the study is shown in the Framework of the study (Figure 3). This dissertation includes six chapters. The first chapter consists of the background of the research area. It concerns sustainable development and eco-efficiency in small and medium-sized enterprises at industrial sectors. In addition, the first chapter comprises the definition of the research problem and the research questions, the determination of the scope and limitations of the research and the research methodology. It also describes the structure of the dissertation. The second chapter includes the theoretical literature review of sustainable development, strategic and operational management, decision-making, adoption of managerial methods, eco-efficiency, methods for implementing and evaluating eco-efficiency and material flow management. Next, the research methodology, methods, and the research design of this dissertation are presented. Thereafter, the dissertation describes the empirical results illustrating the complexity of adopting eco-efficiency. This section also highlights specific methods for measuring eco-efficiency in alignment with longer-term corporate goals for environmental and economic performance. The results are summarized and discussed.

Finally common frameworks to help in adopting sustainability and eco-efficiency in strategic and operational management are developed. Frameworks for recognizing a suitable method for adopting as well as for evaluating eco-efficiency are developed. The aim of these frameworks is to help enterprises to manage the adoption of eco-efficiency and to demonstrate and communicate eco-efficient improvements both internally and externally.

The applicability of created frameworks is studied among eight (8) enterprises. The contribution to existing knowledge is evaluated. The final section summarizes the findings and raises issues for future considerations.

2 LITERATURE REVIEW

2.1 Theoretical background

This chapter includes an overview of existing literature on sustainable development and eco-efficiency and their connection to industrial activity. The framework of strategic and operational management and decision-making, as well as adoption of managerial methods or tools such as eco-efficiency, is also scrutinized. In the second section, different managerial methods for eco-efficiency are discussed. Driving forces for eco-efficiency are considered in the third section, and a conclusion of the theoretical background is drawn in the final section.

2.1.1 Sustainable Development

The Industrial Revolution, which set the basis for how business and industrialised society operate, appeared when the world population was much lower and natural resources more abundant. The linear use pattern – *mine-use-dispose* – of resources has led to pollution, resource depletion, exploitation and other sustainability problems on a staggering scale. Sustainable development, or sustainability, has been under discussion already from the latter half of the past century, and there has been a vast diversity in defining sustainability during the latter half of the past century (Mebratu 1998, Edwards 2000). Some authors claim that the definition of sustainability will remain fuzzy, elusive, contestable, and ideologically controversial for some time (Galdwin et al. 1995).

Environmentalists and government officials started using the terms sustainability and sustainable development when discussing environmental policy already in the late 1980s

(Morris 2002). Various explanations can be essentially sorted into three classes of views. The first one is the intergenerational equity view, which focuses on the fairly developed well-being of human society, not only within but between generations. The representatives of this view include the widely cited notion from the World Commission on Environment and Development (WCED 1987) and the U.S. President's Council on Sustainability Development (PCSD 1994). The other two views are the 'critical limits' view and the 'competing objectives' view (Farrell 1998). The critical limits view gives emphasis to the limits on the planet's carrying capacity, within which the quality of human life can be improved. This view was adopted by the World Conservation Union, United Nations Environmental Programme, and Worldwide Fund for Nature (WCU/UNEP/WWFN) in 1991.

The competing limits view depicts sustainability as a normative term, which implies that multiple environmental, economic, and social objectives have to be met simultaneously. According to Elkington (1997) the Triple Bottom Line Theory describes a good elaboration of these competing goals under the umbrella of sustainability. It collects the whole set of different values, issues and processes that companies must take into account in order to minimize any harm resulting from their activities. This set can be used to create economic, ecological and social value. The company's purpose and the needs of all the company's stakeholders such as shareholders, customers, employees, business partners, governments, local communities and the public have to be considered clearly. Important elements in attempts to achieve sustainability have been especially governmental regulation, increasing consumer awareness, implementation of end-of-pipe technologies in industry and the development of 'green' products (Dobers et al. 2000).

Sustainable development has emerged during the 1990s as a compelling concept in the discourse on environmental issues. The Rio Declaration on Environment and Development, "The Earth Summit", (United Nations 1992) raised sustainable development as a worldwide phenomenon and to the concern of all nations. The Earth Summit catalyzed the creation of Agenda 21, new international treaties on climate change, biological diversity,

desertification, and high seas fishing. After the Earth Summit cities and towns worldwide have developed sustainability plans by using Agenda 21 as a sustainability blueprint. The need for sustainable development results from the global ecological and social conflicts rising from the current economic system and its underlying value structures (Zabel 2005). Welford (2002) describes that the economy should be considered to be a part of the eco-system when aiming to sustainable development.

Sustainable development is a concept aiming to ecological, economical and social goals in order to ensure human survival and a good, free and meaningful life also for future generations (WCED 1987, Welford 2000). Sustainable development consists of social, economic, and environmental dimensions (Linnanen et al. 1997, Welford 2000, Vanhala et al. 2002). These three dimensions of sustainable development should be seen important and integral parts of a large whole. They should not be treated as three separate concepts to be managed; they should be considered together (Welford 2000).

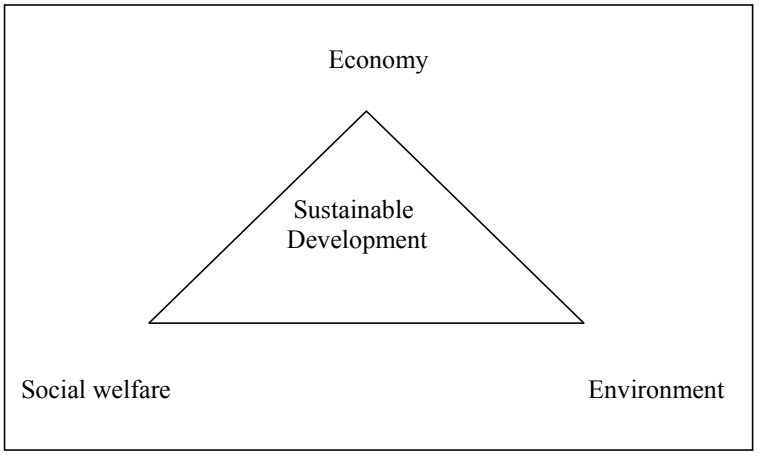


Figure 4 The three dimensions of sustainable development

The responsibility for sustainable development is universal and it concerns all groups from consumers to communities and states globally (United Nations 1992, Meadows et al. 1993, Elliot et al. 2004). The European Commission declares that all players must become active

in promoting sustainable development. The Commission stresses that Member States, regions, businesses and individual citizens all have their share of the responsibility (Commission of The European Communities 2005). Porter (1991 b) also presents that a appropriate legal pressure encourages competitiveness by adding benefiting environmental solutions at a company level.

To promote sustainable consumption and production patterns The European Commission has set operational objectives and targets in its Renewed EU Sustainable Development Strategy (Counsel of the European Union 2006). The key objectives in environmental protection are to take into account the limits of the natural resources and ensure protection and improvement of the quality of the environment. It also urges to prevent environmental pollution and to promote sustainable consumption and production to break the link between economic growth and environmental degradation.

Use of natural resources	**State of environment**	**State of Sustainability**
More than nature's capacity	Environmental degradation	Unsustainable
According to nature's capacity	Environmental equilibrium	Steady-state situation
Less than nature's capacity	Environmental renewal	Sustainable development

Table 1 Use of natural resources and sustainability

EU also involves business and social partners to foster cooperation and common responsibilities to achieve sustainable consumption and production.

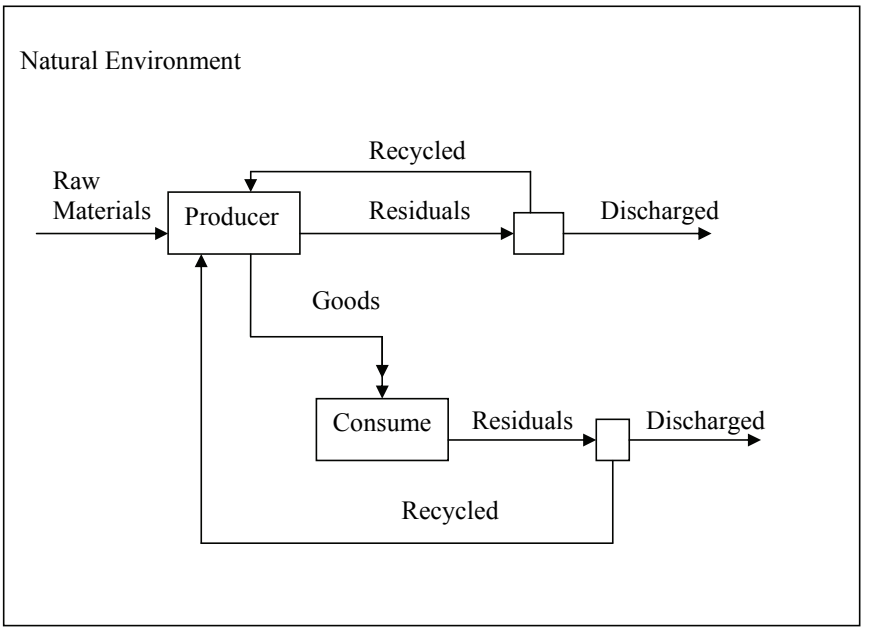


Figure 5 Environmental concerns of Economical actions (Field 1997)

The Rio Declaration on Environment and Development – Agenda 21 program (United Nations 1992) stresses the global responsibility of the market forces. In a WBCSD report, Holiday and Pepper define sustainable development as follows: *"Sustainable development is about ensuring a better quality of life for everyone, now and for generations to come. Thus it combines ecological, social and economic concerns and offers business opportunities for companies that can improve the lives of the world's people"* (Holiday and Pepper 2001, p.54). They stress a holistic approach to markets and sustainability by introducing seven keys for progress within the market system which is presented in Table 2.

Sustainability through the market	Seven value propositions
1. Innovative	Novel technical and social resources-new ways to improve lives while boosting business
2. Practice eco-efficiency	Economic benefit and environmental performance
3. Move from stakeholder dialogues to partnerships for progress	Shared understanding, aligned action and social inclusion
4. Provide and inform consumer choice	A different kind of demand by enhancing appreciation for values that support sustainability
5. Improve market framework conditions	A stable, corruption free socio-economic framework that facilitates positive change
6. Establish the worth of Earth	Environmental conversation and promotion of resource efficiency
7. Make the market work for everyone	Economic benefit and social cohesion

Table 2 A holistic approach to sustainable development (presented by Holiday and Pepper 2001)

Porter and Payne also point out that the business world has to recognize and acknowledge the sustainable development issues, and they should educate others about it (Porter et al.1995, Payne et al. 2001). Sustainable development is, nevertheless, not clearly recognized among industry. Springett (2003) presents that managers have a very sketchy understanding of sustainable development. They do know something about environmental management but they lack a holistic and deeper understanding of it.

2.1.2 Eco-Efficiency

Global concern about the environment has resulted in the spread of eco-efficiency.
The impact of human activities has extended locally, continentally and globally, since the middle of the 18th century (Alhonsou et al. 2001). Increasingly environmental consequences

are thought to be caused by human beings (Haila et al. 1992, Berninger et al. 1996, Alhonsou et al. 2001). Eco-efficiency plays a major role in sustainable development. The basic contribution to sustainable development is presented to be eco-efficiency (Holliday et al. 2002). They describe eco-efficiency as a management strategy that combines environmental and economic performance. It enables more efficient production processes and the production of better products and services. At the same time it decreases resource use, waste and pollution along the entire value chain.

Eco-efficiency creates more value with less impact by de-linking goods and services from the use of nature and it can open up significant business opportunities. Eco-efficiency means producing goods and services with less energy and fewer raw materials, which results in less waste, less pollution and less cost (Rissa 2001, Holliday et al. 2002, UNCTAD 2003).

The seven elements for companies to improve their eco-efficiency, described by WBCSD (in the introduction), can be connected to three broad objectives (Holliday et al. 2002):

- Reducing the consumption of resources, including minimizing the use of energy, materials, water and land, enhancing recyclables and product durability and closing material loops
- Reducing the impact on nature, including minimizing air emissions, water discharges, waste disposal, and the dispersion of toxic substances as well as fostering the sustainable use of renewable resources
- Increasing product or service value, which means providing more benefits to customers through improving the functionality and flexibility of products as well as providing additional services (such as maintenance, upgrading, and exchange services)

Companies can have four opportunities for achieving eco-efficiency (Holliday et al. 2002). Firstly, the move to selling services rather than selling products. In this way, companies can save in material costs, reduce pollution and avoid risks. Secondly, companies can re-

engineer their processes to reduce consumption of resources, reduce pollution, and avoid risks while simultaneously saving costs. Process changes can also be related to delivery or to supplier operations, as well as to distribution, customer use, or disposal (Lehni 2000). Closed-loop manufacturing and more efficient production processes can cut companies´ material use by more than 90 percent in the long run (Holliday et al. 2002). Closed-loop manufacturing means recycling materials and resources back into the production process, without any emissions of toxic substances. Thirdly, companies can co-operate with other companies to find creative ways to revalorize their by-products, which is a possibility for selling their waste products to companies that can use it as feedstock. This is in line with eco-efficiency, as it allows the creation of more value with fewer resources and less waste.

The fourth opportunity is to redesign their products. Products designed according to ecological design rules can often be cheaper to produce and use. Products can be smaller and simpler, they can include a smaller variety of materials, and they can be easier to disassemble for recycling. Because such products can provide a higher value for their users, while the negative influence on the environment is minimized, they can be considered as eco-efficient products. Environmental impacts can lead to greater financial consequences, because of increased promotion of environmental awareness by international governments and other bodies as well as voluntary acceptance of the need to address environmental issues to maintain corporate legitimacy (Burritt 2004).

It is claimed that eco-efficiency has widely become accepted as a key strategic theme for global business towards sustainable development (Ehrenfeld 2005). EU also stresses the importance to promote innovative, competitive and eco-efficient economy (Counsel of the European Union 2006). Most definitions of eco-efficiency stress that economy and ecology do not exclude each other but, on the contrary, that a combination represents a benefit for the enterprises and the society. The goal of eco-efficiency is to create value for the society and the company. Ecological and economic sustainable development is an ideal aim, but a demanding one. Achieving the ideal situation is probably impossible, but it is definitely a field of growing global interest (Markkanen 2004, Da Silva et al. 2004).

Welford (1997) points out that eco-efficiency is a valuable part of corporate strategies. Eco-efficiency is usually calculated as the economic value added by a company in relation to its aggregated ecological impact (Schaltegger et al. 1998). This idea was popularized by the WBCSD as the ´business link to sustainable development´ (Schmidheiny 1992, DeSimone et al. 1997). A measure of eco-efficiency can be calculated as "*the value of goods and services produced to the environmental inputs used compared to the damage associated with the production"* (Markandya et al. 2001 p.66). Several factors affect companies' willingness to increase the eco-efficiency of their products and processes. Cramer (1999) argues that the chief among these are corporate leadership, external stakeholder pressure, how much room the company has to manoeuvre and the potential for competitive advantage

2.1.3 Strategic and Operational Management

Philip Selznick (1957) has pointed out to the utopian tendencies of many ideas about leadership and strategy. He claims that the idea to formulate overall generalised purposes rests on utopian wishful thinking, which will be often corrected by more realistic but uncontrolled criteria. Selznick hopes that strategists will maintain a balance between utopianism and opportunism. Three sources of success are identified in the early literature on strategic management. They are: the goal should be clearly described, there should be willingness to analyze both the external and the internal environment, and there should be utopian and realistic kind of leadership.

Common to most strategic management approaches is the assumption that success has to be defined in financial terms. Non-financial success is a contradiction in terms. It is assumed that *"firm success is manifested in attaining a competitive position or a series of competitive positions that lead to superior and sustainable financial performance"* (Rumelt et al. 1994, p.425).

René ten Bos (2000 p. 33-34) argues that *"behaviour which does not tribute to the firm's financial performance does not constitute an object of study for strategic management". Why a particular firm chooses to use the fruits of its competitive position in order to meet non-financial ends, is a separate question".*

"Stubbart (1985) has been one source of inspiration for post-economic strategic studies. Concluding that the state of the art is far behind the state of the world, he urges nothing less than a revolution in the field, something which he justifies by pointing out that traditional strategic management has failed to work and should become an intelligent management theory". Such an intelligent theory could be more restrained because the objective of it is not to predict and control but to facilitate more attention to actual strategic processes in organisations. The point is that the focus is on the strategy maker (and not on normative models) and this makes it more consistent with contemporary research models instead of urging the practitioner to follow impossible methods" (René ten Bos 2000 p. 50)

Strategic management is a key activity for organisations´ ability to sustain competitive advantages in the long run. It is crucial for enterprises to optimise their strategies in order to build unique competencies. In the 1990s there has been a prominent change in corporate strategy toward environmental problems; the emergence of sustainability as corporate strategy. Corporate environmental concerns resulted first in pollution control and pollution prevention-strategies in compliance with government mandates to reduce environmentally harmful outputs. The second stage resulted in Environmental Management Systems, Life-Cycle Assessment, Industrial Ecology, Design for Environment and other strategies, intended for prioritizing changes to the product systems with respect to environmental concern. The ongoing stage is sustainable development, which proactively attempts to go beyond resource conservation to assure the wellness of future generations. Porter has also discussed the competitive strategy position of corporate environmental strategy in different countries (Porter 1991a, Porter 1996).

Porter et al. (1995) argue that corporate responsibility can lead to more efficient use of resources, better reputation, improvements in investors´ trust, and new market opportunities. *"An organisation's competitiveness is directly and indirectly affected by growing environmental pressure from its different stakeholders"* (Kumpulainen et al. 2008 p.477)

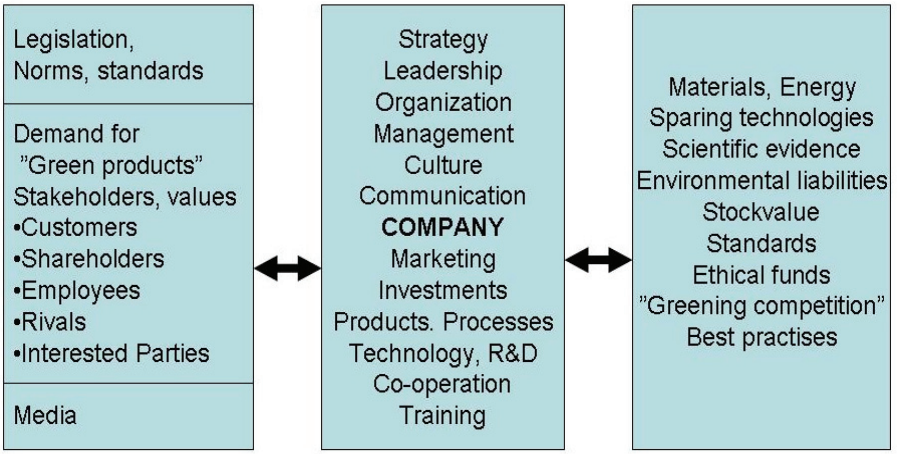


Table 3 Actors and issues influencing the "Green challenge" of companies (modified from Peattie et al. 1997)

The most important departure of the sustainability concept from orthodox management theory is said to be in its realisation that economic sustainability alone is not a sufficient condition for the overall sustainability of a corporation. The efficient use of natural resources has become widely accepted as an important criterion for corporate sustainability (Schaltegger et al. 1998). At present most managers have accepted corporate sustainability as a precondition for doing business.

Hart (1995) has developed a theory of competitive advantage and it is based on the firm's relationship to the natural environment. It includes three different strategies, and they are pollution prevention, product stewardship and sustainable development. Propositions are

developed for each strategy which is concerned with key resource requirements and their contributions to contain competitive advantage. According to Hart (1995 p.989) *"one of the most important drivers of new resources and capability development for firms will be the constraints and challenges posed by the natural (biophysical) environment"*.

Combined interest in competitiveness and ecological responsibility often leads to innovations that would not be realised otherwise. This kind of innovations can result in more ecologically benign products or processes which can have positive effects in efficiency or marketing, or products or processes that can be superior in other ways (Bansal et al. 2000). According to Bansal et al. (2000) competitiveness is the potential of ecological responsiveness to improve profitability in long-term. According to the respondents in their study, ecological responses improved competitiveness. These responses included energy and waste management, source reductions resulting in a higher output for the same inputs, eco-labelling and green marketing, and the development of so called eco-products.

A growing segment of consumers want ecologically friendly products, packaging and management practises (Shrivastava 1995, Bansal et al. 2000). Environics International Ltd, a research group that tracks consumers' environmental views, found that 25 percent of consumers worldwide can be considered "green" in actions as well as attitudes (Flisi 2001). Environmental actions are considered to have great positive influence on the product image (Ytterhus 1997). The reputation advantage is claimed to be enhanced by environmental performance (Kemp 1993). On the contrary, bad environmental reputation can have a negative effect on the company's sales (Bansal et al. 2000).

There are at least four reasons why industry can gain from adopting a strong environmental stance. These are efficiency (material, energy, labour, and capital), image (causing better market share and employees), market opportunity (end-of-pipe and source reduction equipment) and compliance (avoiding non-compliance costs). (Turner et al. 1993).

Porter´s (1985) generic competitive strategy model suggests three alternatives which are cost leadership, differentiation and focus. Competitive strategy model can be considered for big markets as well as for Niche markets.

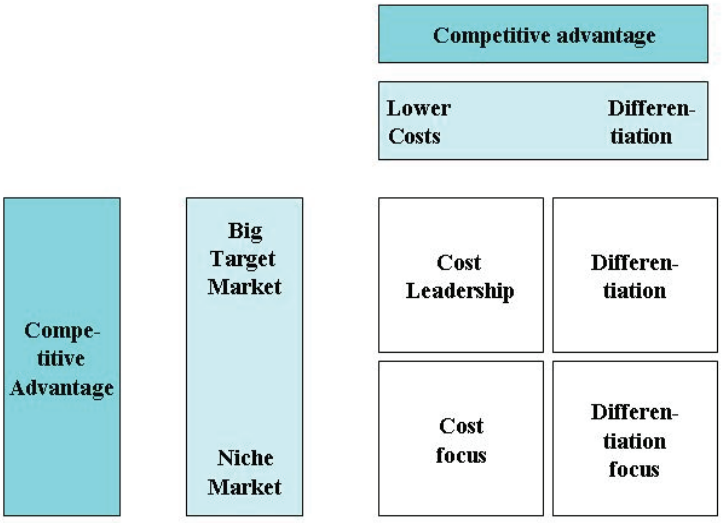


Figure 6 Porter strategy matrix (Porter 1985)

According to Porter (1985) there are two major ways how a firm can gain a cost advantage. These are control of cost drivers and configuring the value chain. Porter describes that once the company has identified the value chain and diagnosed the cost drivers of activities which have significant value, cost advantage will grow out of controlling those drivers better than the competitors.

Peattie (1995) applied these Porter's ideas to environmental issues as follows:

- Cost leadership: Environmental considerations can give possibilities for cost leadership. Increasing costs of poor environmental performance will increase the potential of greening / environmental efforts which will mean lower cost strategies

in the future. There exist increasingly more opportunities to reduce costs by reducing resource inputs, which in turn lead to cost leadership

- Differentiation: Environmental thinking has been increasing. Mass-market products, which are differentiated on the basis of superior eco-performance, can have a miraculous effect on company strategy.
- Focus: A focus strategy involves targeting a product, which is differentiated or low in cost, to a particular segment of the market. This has lead to a situation where green products have gained mass-market acceptance.

The following figure represents the generic strategies for green competitive advantage. If the market scope is narrow green cost focus can decrease costs and differentiation can lead to green nichemanship. When the market scope is broad, green cost leadership will lower costs and differentiation will lead to eco-excellence.

Market Scope	Low cost	Differentiation
Broad	Green cost leadership	Eco-excellence
Narrow	Green cost focus	Green nichemanship

Figure 7 Generic strategies for green competitive advantage (Peattie 1995)

According to Porter et al. (1995b) the level of resource productivity, environmental improvement and competitiveness come together. Resource productivity opens a new way of looking at the full systems costs and the value associated with any product. Resource inefficiency most often exists in form of incomplete material use and poor process control, which result in unnecessary waste, defects and stored material. According to Day (1998) process efficiency has clear short-term benefits on the company, especially in the form of

waste reduction. By reducing costs, process efficiency gains in that companies can lower their immediate impact on the environment and establish a cost advantage.

2.1.4 Decision-Making

Decision-making can be described in many ways, and it is not in the scope of this study to present a definition of decision-making. However, the following will give a brief overview of this field.

First of all, theories of decision-making can be divided into normative and descriptive theories. The normative approach is usually employed by the rational tradition of management sciences. This approach usually implies that objective decision models are developed and used to select the most rational and optimal solution. The descriptive approach is usually employed by organisation theorists. This approach implies the study on how people make decisions in practise, for example, whether or not they use the recommendations of the objective models. The rational tradition thought in management sciences is led by the assumption that decision-making among managers is rational or quasi-rational. Rationality is described as the relationship between given ends and the means chosen to achieve these ends. The view is that managers choose the best alternative, based on the evaluation of several alternatives at hand. Rational decision-making is described to assume knowledge of all alternatives, knowledge of consequences, consistent preference ordering and a decision rule, selection criteria (March 1988). The decision process is often described as a sequence of activities. The Handbook of Systems Analysis describes the process as being (Findeisen et al. 1985):

1. Define the problem
2. Establish a goal
3. Search for alternative ways for fulfilling the goal
4. Assess alternatives by analyzing their consequences
5. Choose the alternative that leads to the best goal fulfilment

6. Follow up the consequences of action

Rational models for decision-making have been criticised from a descriptive perspective. March and Simon (1958) discussed the limits of human information processing and its relationship to simplifications in the decision process. Simplifications imply that not many decision alternatives, and very often only one, are included in the process. They also describe that simple rather than complex evaluation criteria are applied. This kind of thinking questions the existence of sequential decision process, as well as the concept of performance maximisation. Concerning the differentiation between strategic and operative decisions, March and Simon made the distinction between standard operating procedures and decisions that are unique and most probably creative in character (March et al. 1958).

There is a growing awareness among management researchers that rational models may not reflect the actual structure of decision making in organisations. As organisations are more knowledge-intensive (Nonaka et al. 1995), they have a flatter hierarchy and they are more boundary-less (Hirchhorn et al. 1992), important decisions can be taken and performed on all levels of the organisation. It has become difficult to distinguish strategic decisions from operative decisions, as all decision-making probably has characteristics typical to strategic as well as operative decision making. Some researchers describe that decision-making is the key to understanding an organisation's management processes.

Management is argued to be equivalent to decision-making (Pugh et al. 1996). According to this perspective, an organisation is a collective choice making unit, following a bounded rationality, which means utility maximising within limits set by imperfect human cognition and information processing. Czarniawska-Joerges (1992) describes that decisions are not necessarily rational; it is very likely that they do not exist or that they are something else, such as a way of legitimising actions already done.

Strategic and external factors may also influence decision making. According to Child (1972) strategic choice perspective suggests that managers make strategic choices. They

make choices regarding goals, procedures, technologies and domains of the company. According to this perspective, top managers select and interpret their business environment, respond to the elements that are fixed and attempt to shape the remaining elements to their advantage.

External control perspective describes that decision in business companies are largely determined by characteristics of the external environment. It is claimed that the more stable the organisation's environment is, the more bureaucratic is the organisation´s structure and the more turbulent the environment is the more organic is the organisation´s structure (Lawrence et al. 1969). It is also suggested that organisations are coupled to other parts in other companies and thus shape an organisational field. Organisations become more alike as professional practice. Governments and other institutions require that managers adapt to standard practice. Legitimate actions are those that form the common view; they do not have to be effective (DiMaggio et al. 1983, Czarniawska-Joerges 1992).

Major decisions in organisations are about business effectiveness, and that involves both creativity and efficiency, which also means doing the right things and not only doing things right (Drucker 1963). Creativity is needed to find opportunities that provide businesses with significant results, and efficiency of operations is needed to secure competitiveness. The most important factor when making environmental decisions is the balance between decisions concerning companies´ environmental impacts and economic benefits. The benefits can be increasing profitability, cost savings, improved public image, increased competitiveness, and the long-term survival of the company. Other important arguments when making environmental decisions are legal requirements, working conditions, and avoidance of conflicts with the local community (Kahelin 1991, Ketola 1991, Bichta 2003).

There is no doubt that sustainable development would require remarkable changes in individual human behaviour, especially in the industrialized countries (Welford 2000, Zabel 2005). In SMEs decision-making is often limited to only one or a few persons. This indicates that individual attitudes, responsibility and behaviour towards the environment

have influence on decision-making. Costarelli et al. (2004) explain that the more ambivalent the attitudes toward the environment are, the lower the strength of environmentally friendly behavioural intention is. Several researchers have found that assessing general environmental values can also be useful in predicting general environmental behaviour (Stern et al. 1993, Kaiser et al. 1999, Olli et al. 2001, Barr et al. 2005). Values are viewed as a dimension of moral scope (Stern et al. 1993). It is also described that basic values, such as clean environment, are more permanent than attitudes, which are often very superficial (Allardt 1983, Suhonen 1994, Rauwald et al. 2002).

General environmental values are positively related to personal norm, and personal norm further correlates significantly with responsible environmental behaviour (Corraliza 2000, Nordlund et al. 2002). General environmental knowledge is probably important, but alone it is not enough to inspire environmentally responsible behaviour. Both motivation and knowledge of what needs to be done are necessary (Zimmermann 1996, Kilbourne et al. 2005). The influence of emotions in strategy work is also important. Studies of decision-making in neurological patients, who can no longer process emotional information normally, suggest that people make judgments by evaluating consequences and their probability of occurring, and also at a gut-feel or emotional level (Bechara 2004). Owner and manager personality is claimed to be directly related to smaller firm behaviour, through focus of control effects (Hansemark 1998).

2.1.5 Adoption of managerial methods

There are various explanations in the innovation diffusion literature which explain why companies adopt certain managerial technologies and not others. Innovation theories can be applied to the spread of ideas, methodologies and concepts (Rogers et al. 1971). Innovation theories can be classified in two main categories. They are called the efficient choice explanation and the institutional explanation. The efficient choice explanations basically assume that the company and the innovations it adopts are tools for the production of goods

or services to the society (Abrahamson 1991). The new managerial technology will have to be more efficient than the technology it replaces, as well as to provide the company with some measurable advantages.

The institutional explanation for adoption or rejection of innovations is based on institutional theory (Abrahamson 1991, Abrahamson 1996). Institutional theory points out that organisational choice is not always purely efficient and based on efficiency or effectiveness criteria (DiMaggio et al. 1983). Organisations tend to imitate each other or other institutions in the society.

Strategy tools, such as Balanced Scorecard, SWOT (Strengths, Weaknesses, Opportunities, and Threats) Analysis, Total Quality Management, Scenario Analysis etc. are developed to support organisations for maintaining and creating strategic advantages. Strategy tools are described to have specific advantages and features which work best in favourable contexts and in knowledgeable hands (Brown et al. 2004). Traditionally, organisation and management theory takes a neo-institutional view of strategy tools. The neo-institutional view described in many management studies has been criticized of showing managers as naïve and unrefined followers of fashion (Benders et al. 2001).

Tool adoption can be seen as a macro-level phenomenon and use of a strategy-tool is seen as management fads and fashions that cannot be explained by rational behaviour in organisations (Abrahamson 1996). A managerial fad is when organisations imitate other similar organisations, such as a company following the example of another company recognized as having a leading management practise. A managerial fashion is when organisations outside the group of companies influence the adoption. These can be consultancies, academia or companies in other industries.

Some recent literature has pointed out the importance of treating organisations as active agents (Benders and van Veen 2001). On the other hand, strategic management literature, often pointed more for readers who are practitioners, consultants or tool developers,

describes an array of strategy tools and suggests that closer attention should be paid to the selection of tools (Dyson et al. 1998). These two streams of literature take different approaches to the questions of organisational agency, rationality of tool choices, and expertise of the users, which makes it challenging to generate a profound understanding of practical tool adoption. Strategy tools are a part of business school education, management consulting, popular management literature, and management scholars promote them (Sahlin-Andersson et al. 2002). It is not clear when to use what tools in practise (Sahlin-Andersson et al. 2002). Tools are often said to be adopted in organisations because of the institutional forces that rise from the specific environment in which that organisation is situated (Abrahamson 1996).

Individual choices of which strategy tools to employ are often guided by institutional pressures (Abrahamson 1996). Decisions about strategy tool use are based on power discourses, underpinned by specific political and technical rationales and affected by economic, political, historical, and cultural aspects. The set of strategy tools actually employed in an organisation is not a consequence of careful planning, but the result of answering diverse needs and pressures at multiple levels. The set of tools that is appropriate for an organisation is dependent on that organisation's individual need. Strategy tools are an intrinsic part of the modern strategy work and a well-balanced set of strategy tools has the capability to support strategic success.

It is also suggested that relationships between the user, the tool, and the context bring an incoherent and often contradictory plurality to strategy-tool use, which makes the choice of a suitable strategy tool challenging. Overall, in a dynamic social setting with changing markets and different demands on tools, it is quite clear that no single strategy tool inadequate. The task of finding just one most-suitable strategy tool is therefore not appropriate. Rather the task is to compile a set of tools that jointly cater to different contextual needs and demands and support different forms of strategy work. Collecting a set of strategy tools, rather than just concentrating on individual tools, increases freedom of choice. It also increases the possibilities for discovering and supporting organization's

strategic advantages. The set of tools selected, should work together by complementing each other, supporting different viewpoints and facilitating work on issues that require special attention.

It is not always clear when to use what tools in practise (Sahlin-Andersson et al. 2002). It is said that a company can significantly increase its chances for successful adoption of the eco-efficiency approach if it cooperates with other partners (Cramer 1999)

2.1.6 Conclusions

Sustainable development is a worldwide phenomenon, which is supported by NGOs, governments and the business world. Eco-efficiency is in the centre of this phenomenon, and it has developed into an extensively recognized method for integrating ecological and economic considerations into core business processes. The ecological dimension of sustainable development has become an important part of the global business environment, and thus the natural environment is a strengthening theme in strategic management. It is argued (Ketola 1998) that linking strategic environmental visioning and planning is essential for the long-term survival of companies. Eco-efficiency has widely become accepted as a key strategic theme for global business towards sustainable development (Ehrenfeld 2005).

Eco-efficiency and resource productivity provide the necessary, practical link between environmental performance, sustainability and business value. Financially speaking, eco-efficiency and resource productivity can be considered drivers of market value similar to the elements associated with other business drivers such as tax and cost minimization, profitable growth, and working and fixed capital efficiencies.

Strategic management is a key activity for organisations´ ability to sustain competitive advantages in the long run. Common to most strategic management approaches is the

assumption that success has to be defined in financial terms. In 1990s there has been a prominent change in corporate strategy toward environmental problems: the emergence of sustainability as corporate strategy. Porter et al. (1995) argue that corporate responsibility can lead to more efficient use of resources, better reputation, improvements in investors´ trust, and new market opportunities. The most important departure of the sustainability concept from orthodox management theory is said to be in its realisation that economic sustainability alone is not a sufficient condition for the overall sustainability of a corporation (Galdwin et al. 1995a). One widely accepted criterion for corporate sustainability is the efficient use of natural resources. At present most managers have accepted corporate sustainability as a precondition for doing business.

Management is argued to be equivalent to decision-making (Pugh et al. 1996). Major decisions in organisations are about business effectiveness and that involves both creativity and efficiency, which also means doing the right things and not only doing things right (Drucker 1963). Creativity is needed to find opportunities that provide businesses with significant results, and efficiency of operations is needed to secure competitiveness. The most important factor when making environmental decisions is the balance between decisions concerning companies´ environmental impacts and economic benefits. It has become difficult to distinguish strategic decisions from operative decisions, as all decision-making probably has characteristics typical to strategic as well as operative decision making. There is no doubt that sustainable development would require remarkable changes in individual human behaviour, especially in the industrialized countries (Welford 2000, Zabel 2005). In SMEs decision-making is often limited to only one or a few persons. This indicates that individual attitudes, responsibility and behaviour towards the environment have influence on decision-making.

There are various explanations in the innovation diffusion literature which explain why companies adopt certain managerial technologies (managerial methods, strategy tools) and not others. Strategy tools are developed to support organisations for maintaining and creating strategic advantages.

Strategy tools have specific advantages and features which work best in favourable contexts and in knowledgeable hands Decisions about strategy tool use are based on power discourses, underpinned by specific political and technical rationales and affected by economic, political, historical, and cultural aspects. The set of strategy tools actually employed in an organization is not a consequence of careful planning, but the result of answering diverse needs and pressures at multiple levels. The set of tools that is appropriate for an organization is dependent on that organization's individual need. Strategy tools are an intrinsic part of modern strategy work and a well-balanced set of strategy tools has the capability to support strategic success.

The relationships between the user, the tool, and the context bring difficulties to strategy-tool use and this can make the choice of a suitable strategy tool challenging. It is not clear when to use what tools in practise.

2.2 Managerial methods for Eco-Efficiency

Eco-efficiency can be considered to be a strategy tool, managerial technology, a managerial method or tool, as well as methods and techniques for Quality Management, Balanced Scorecard, and Total Quality Management etc. Strategy tool is described as a generic name for any method, technique, model, tool, framework, methodology or approach used to facilitate strategy work. Strategy tools are often based on academic research and they are introduced into practice by business schools, consultants, business articles and strategy literature (Sahlin-Andersson et al. 2002). The idea behind strategy and managerial tools is to transform "best practises" or theoretical know-how into steps that are integral to the tool. Ideally, use of the tool then releases knowledge in a practical and contextual form that supports more effective strategies and facilitates strategizing. Eco-efficiency combines knowledge, methodology and practice and uses these for linking environmental management and economic results. Tushman and Anderson (1986, p. 440, as cited by

Abrahamson 1991, p.588) define managerial technologies as *"those tools, devices and knowledge that mediate between inputs and outputs"*.

2.2.1 Methods for incorporating Eco-Efficiency

This part of the study was done as a literature study on seventeen common methods for incorporating eco-efficiency and comparing these methods to each other.

Eco-Efficiency (EE)

The concept of eco-efficiency was first introduced in 1992 by the Business Council for Sustainable Development (WBCSD) in its landmark report Changing Course. Eco-efficiency was further defined at the first Antwerp Workshop on Eco-efficiency held in November 1993 as follows: *"Eco-efficiency is reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the earth's estimated carrying capacity"* (UNEP 1998, p.3.).

Eco-efficiency is mainly a management philosophy which focuses on business opportunities and allows companies to become more environmentally responsible and more profitable. It is a combination of economical and ecological efficiency, and is basically about doing more with less. It means producing more goods and services with less energy and natural resources. Eco-efficient business gets more value out of the raw materials as well as producing less waste and less pollution. It fosters innovation and therefore growth and competitiveness (UNEP 1998).

Business Council for Sustainable Development (WBCSD) has identified seven success factors for eco- efficiency:

1. Reduce the material intensity of goods and services (provide the same good and service with less material),

2. Reduce the energy intensity of goods and services (related to point one because generation of energy is related to the use of material),
3. Eliminate or reduce toxic dispersion (dispersion of toxic materials),
4. Enhance material recyclables (when using material make it as to enhance recycle, closing material cycles, closing loops),
5. Maximize sustainable use of renewable resources (do it in line with the capacity of natural recourses),
6. Extend product durability and
7. Increase the service intensity of goods and services.

These elements clearly cope and help further the successful United Nations cleaner production initiatives towards sustainable production and consumption patterns. Eco-efficiency starts from issues of economic efficiency which have positive environmental benefits, while cleaner production starts from issues of environmental efficiency which have positive economic benefits. Eco-efficiency highlights also welfare as a part of sustainable development.

Eco-efficiency is the more efficient use of materials and energy in order to reduce economic costs and environmental impacts. This is widely considered a pragmatic approach, particularly among business, but it has been noted that improved unit efficiency does not necessarily lead to lower consumption levels. Economic output may rise with constant or reduced resource inputs. Two of the most familiar methods for achieving improved eco-efficiency are environmental management systems and cleaner production.

Compared to sustainable development, eco-efficiency (as well as the other concepts mentioned in this study) is not sufficient by itself, because it integrates only two of sustainability's three elements, economy and ecology, while leaving the third, social progress, outside its embrace. Nevertheless, eco-efficiency is a more understandable and useful starting point towards sustainability, especially for SMEs, than sustainability.

Biomimicry

Nature has for over thousands of years developed systems which create materials at room temperature, from non-toxic materials and with low energy use. Today's methods are "heat, beat, and treat" using high temperatures, high energy, and often toxic materials. Biomimicry is a new way of linking the human-made world to the natural world. This philosophical shift returns to the pre-scientific revolution notion that all things are intimately connected. The intension of Biomimics is to use nature as a model, a standard of measure, and as a mentor (Reed 2003). Benyus was the first person to propose that learning from nature could be a perfect tool for eco-design. Benyus (1997) describes biomimicry (from bios, meaning life, and mimesis, meaning to imitate) to be a new way to study nature's best ideas and then imitate these designs and processes to solve human problems

Benyus (1997) has presented nine principles for biomimicry which are as follows:

1. Nature runs on sunlight
2. Nature uses only the energy it needs
3. Nature fits form to function
4. Nature recycles everything
5. Nature rewards cooperation
6. Nature banks on diversity
7. Nature demands local expertise
8. Nature curbs excesses from within
9. Nature taps the power of limits

Biomimicry (also called Bionics in Europe) gets ideas from nature for the way we can make or do things. Biomimicry is inspiration using the principles which nature has demonstrated to be successful design strategies. Biomimicry can operate on any scale, from super-adhesive tape that imitates a gecko's skin to a high-rise building that imitates a termite mound for passive air conditioning. The humans have been getting ideas from other animals and plants as long as we have been around.

Benyus (1997) describes that Biomimicry can be achieved on different levels such as form or function, process level, system level and design level. Forms and functions are the most common. Biomimetic processes are harder to achieve, but tend to have bigger benefits. There are cases where the actual manufacturing of a product is done as nature would do it. Biomimetic systems are closed-loop life cycles, where outputs and by-products become inputs for something else. This may be where nature has the most to teach us. Everything alive is part of multiple complex systems such as predator/prey, waste/fertilizer, parasite/host etc. Only a few of these have similar solutions in modern industry. Benyus argues that the kind of biomimicry which is used most frequently at present is actually the fourth level, the design level. She describes that the design level includes genetic algorithms, iterative design (which means making multiple prototypes, user-testing them in order to find the favorites, then mixing and matching elements to create other prototypes which are in turn user-tested). When using Biomimicry in design it can produce things that are biomimetic on the form/function, process, and system levels, but it can also produce things that nature has never developed (such as an oddly shaped satellite antenna).

Not everything involving biology is biomimetic. "Bio-utilization" is using parts of organisms as raw materials. It can be for example a house made of wood, or a cancer drug made from horseshoe crab blood. Modeling from nature is the domestication of organisms – for example herding sheep and using algae to make hydrogen for fuel cells. These strategies can also be used for green design.

Biomimicry is a method for looking at natural systems to solve problems such as keeping cool in the heat, recycling toxic waste or self-cleaning and biomimicry does not involve taking from nature, but instead mimicking the way how the problem has been solved over millennia. (Vartan 2006, Benyus 2002). “Biomimetics” is described as products or processes that copy natural designs. They are by nature usually non-polluting and they use minimal energy (Vartan 2006). Biomimicry suggests that business is one of nature’s systems and it operates according to the same ecological principles. It uses nature as a model to design systems, technologies, and materials. Biomimics is already, learning how to grow food,

harness energy, weave fibers, compute, find cures, and run a business. Nature can manufacture in water, without toxins, use abundant raw materials and it uses very little energy. Nature can bank on the diversity of poly-cultures rather than the vulnerability of monocultures. Nature does not compute using symbols, it computes using shape. (Ackerman 2000, Autumn.et al.2002).

Biomimicry is a new way of viewing and valuing nature. It introduces what we can not extract from the natural world, but on what we can learn from it. One major application of biomimetics is the field of biomaterials, which involves mimicking or synthesizing natural materials, and applying this to practical design. A major advance of biomaterials is that they are normally biodegradable. In addition, the extreme temperatures and hazardous chemicals which are used in production are usually unnecessary with natural alternatives (Kennedy 2007).

Another application of biomimetics is the field of robotics. Animal models are being used as the inspiration for many different types of robots. Researchers study the mechanics of animals, and then apply these observations to robot design. The goal is to develop a new class of biologically inspired robots with greater performance in unstructured environments (Clark et al. 2001). Today, many companies are using this emerging science to design their products.

Benyus describes ten strategies of a mature ecosystem (Benyus, 1997, pp. 253-254):

1. Use waste as a resource.
2. Diversify and cooperate to fully use the habitat.
3. Gather and use energy efficiently.
4. Optimize rather than maximize.
5. Use materials sparingly.
6. Do not foul their nests.
7. Do not draw down resources.
8. Remain in balance with the biosphere.

9. Run on information.
10. Shop locally.

The philosophy that has evolved in the developed world regarding nature is two-pronged: what can we extract from nature and how can we control nature? Biomimicry, on the other hand, looks to nature as a guide. Biomimics do not focus on controlling nature, rather they want to imitate nature and even learn how to duplicate the materials and processes of nature. Businesses and industry are starting to implement examples provided by nature (Reed 2003). The challenge of the method is described by Reed (2003) in the following way: Select a product that has multiple parts. Start with an item that has just a few parts and later work on a complex product. Create a new design that considers the pre-life, useful life, and the end-life of your selected product. When creating your new design, assemble a portfolio that contains the following sections:

1. A clear definition of the problem.
2. Brainstorming and research notes.
3. Sketches of several possible solutions.
4. Criteria and constraints of each idea.

Rationale of why you chose one design over the others. Think of this section as a list of items you could use in a marketing campaign for your product.
When working on the design portfolio, the following essential questions should be addressed (Reed 2003):

1. Does the design use recycled materials?
2. Does the design use a minimal number of parts and materials?
3. Is this product easily assembled?
4. Can my design be quickly disassembled for upgrading, repair, or recycling?

Cleaner Production (CP)

The definition of Cleaner Production that has been adopted by UNEP is as follows: Cleaner Production is the continuous application of an integrated preventive environmental strategy

to processes, products, and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner Production can be applied to the processes used in any industry, to products themselves and to various services provided in society. Cleaner Production is a strategy to continuously improve products, services and processes to reduce pollution and waste at the source, which can also result in financial benefits. Cleaner Production is the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks for humans and the environment. It is about making more efficient use of the materials and energy we employ when we conduct our business, while minimizing the generation of wastes and emissions, but at the same time increasing business profitability and creating a more sustainable community. (UNEP 1998, UNEP 2004)

Cleaner production is a strategy to prevent emissions at the source and to initiate a continuous preventive improvement of environmental performance of organizations. In terms of Cleaner production the focus of management should be on prevention rather than on cure in avoiding environmental problems. The inclusion of commitment to prevention in the environmental policy is one prerequisite of the standard ISO 14001. But how can a formalized environmental management system help to start a process of continuous improvement and voluntary self regulation? We conclude from our experience that Cleaner production and ISO 14001 go well together and support each other in helping an organization to really decrease its environmental effect. Analysing environmental management systems introduced on the basis of Cleaner production projects demonstrates, that Cleaner production supplies management and employees with systematic tools to decrease the environmental impact. At the same time it is possible to save costs from use of materials and energy and motivate the organization as well create awareness throughout the enterprise (Fresner 1998).

Cleaner Production applies to:

- Production processes: For production processes, Cleaner Production results from one measure or from a combination of measures conserving raw materials and

energy, eliminating toxic and dangerous raw materials and reducing the quantity and toxicity of all emissions and wastes. It also prevents and controls spills during production processes.

- Products: For products Cleaner Production reduces negative environmental, health and safety impacts along the entire life cycle of a product from raw materials extraction to its ultimate disposal.
- Services: For services Cleaner Production implies incorporating environmental concern into designing and delivering services.

The intension of this approach is similar to that of Green Productivity. Cleaner Production requires changes in attitudes, responsible environmental management, creating conductive national policy environments and evaluating technological options (UNEP 1998, UNEP 2004). Other preventive approaches, such as eco-efficiency and pollution prevention, serve similar goals. Cleaner Production deals primarily with preventing waste production, not waste treatment. Unnecessary waste can be reduced both by implementing cleaner production processes and through an improved utilisation of production inputs. As a result, negative environmental impacts are reduced and competitiveness of the company is increased through a reduction in production costs. This leads to a win-win situation, both the environment and business win.

There are seven steps to develop a Cleaner Production program. Before going through these steps the most critical factor is the commitment of the top management.

1. The top management selects an engineer or manager (CP Champion),
2. CP Champion will put together a CP Team,
3. The CP Team will review past and present environmental and economic activities and contracts of the organization and identify opportunities where improvements can be done,
4. CP Team will concentrate on the most promising opportunities and research the ways that would help reducing costs or improving environmental performance of the organization,

5. CP Team will make the CP plans, which include recommended changes to achieve goals,
6. CP team keeps track of improvements and barriers monthly, and
7. Steps 4, 5 and 6 are repeated until most of the Cleaner Production opportunities are explored and changes implemented.

The development of a Cleaner Production program can be done in different ways. In addition to the method mentioned above, there is another way developed by United Nations Environment Programme (UNEP 1998). Figure 8 below demonstrates the phases.

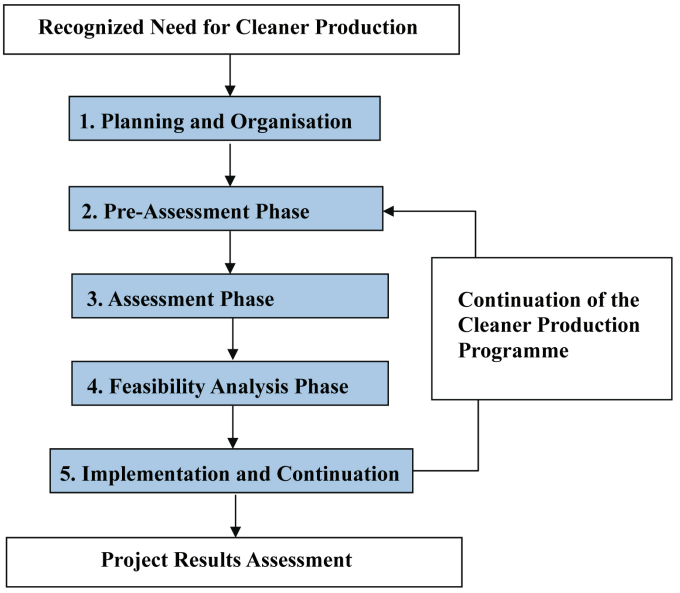


Figure 8 Five phases of Cleaner Production assessment (UNEP 1998)

Cleaner Production improvements can reduce or even eliminate the need for end-of-pipe investments and can therefore provide both financial and economic benefits. With no capital investment roughly 20-30 percent reduction in pollution can often be achieved. In addition to economical and environmental benefits, Cleaner Production saves employees from undue injuries, raises employee morale and business's profile amongst its

competitors. Cleaner Production requires an attitude change and responsible environmental management. Cleaner Production needs also creating of conductive national policy environments and evaluating of technology options. For successful implementation of Cleaner Production, not only internal co-operation among managerial, technical, and operating staffs of industrial enterprises is needed, but also external support and incentives of finance, policy and the marketplace.

Design for Environment (DfE)

Design for Environment is a design process in which environmental attributes are treated as a design objective to reduce the environmental impact and improve the performance of the product. These efforts are made to ensure effective use of natural resources throughout the entire life cycle of the product. When effectively applied, this process will lower production and operational costs. Design for Environment is referred to Eco-Design (Lewis et al. 2001, Sroufe et al. 2000).

The Design for Environment approach is adopted to ensure that environmental problems are minimized, and that environmental factors in general provide a source of innovation. The life cycle approach also helps to guard against problems addressed in one stage negatively affecting the environmental performance at another stage. The insight that reuse and recycling create good economical and ecological opportunities make Design for Environment a sound business proposition at a practical level. Design for Environment provides a powerful tool for designing sustainable products. Product planning and design phase are such stages where waste avoidance, source reduction, water conservation and energy efficiency can be implemented into products, services and buildings. (Lennox et al. 1995, Sroufe et al. 2000, Lewis et al. 2001).

The vision of Design for Environment should specify at least six environmental characteristics as follows:

- Minimize Environmental impact.
- Be safe of their intended use.

- Optimize consumption of energy and materials.
- Meet or exceed all applicable legal requirements.
- Be reusable and/or recyclable.
- Ultimately be disposed of in an environmentally safe and responsible manner.

The vision also specifies the desired business effects of decisions regarding the environmental characteristics of the product. Environmentally responsible products will provide a competitive advantage and business success by:

- Contributing to revenues profits and growth.
- Minimizing delays in market introduction.
- Avoiding mistakes that harm sales.
- Eliminating barriers that prevent world-wide acceptance.

This vision can help business on succeeding in the market place, by meeting the market's environmental requirements. Achieving this vision will not be easy, but the absence of a clear vision will almost guarantee a future of ineffective reaction. (Paton 1995)

Eco-Design (ED)

Eco-design is a systematic application of environmental life cycle considerations at the product design stage. Eco-design aims to avoid or minimize the environmental impact of the product throughout its life cycle. It consists of the whole chain from materials extraction, through production processes, packaging and transport, product use phase, and finally to end-of-life disposal.

Other terms referring to the same approach are design for environment, life cycle design and environmentally conscious design and manufacturing. Cleaner production can be regarded as a predecessor of eco-design. The eco-design stage is a crucial step for improving the environmental performance of a product. Ecological design is using nature and technology together. Ecology is the basis for design. Strategies as conservation, regeneration and stewardship can be applied at all levels of scale to produce revolutionary

forms of buildings, landscapes, communities, cities and applied technologies. Eco-design is a part of eco-efficiency.

Guide lines for Eco-design:

- The idea is to design the whole product life cycle, not only a “green” product
- Energy consumption during the whole life cycle should be considered
- Increasing the product lifetime
- Designing of service, not only a product
- Use of recycled materials
- Recyclables

The results of eco-design are limited, because it is a design specific activity that focuses on the redesign or optimization of existing products. The changes to the product tend to be incremental and they result only in a percentile reduction of the overall environmental impact of the products (Hoed 1997, Wimmer et al. 2001).

Eco-Innovation (EI)

The idea of eco-innovation is fairly recent. The first appearance of the concept of eco-innovation in the literature is in a book (Driving Eco-Innovation: A Breakthrough Discipline for Innovation and Sustainability) by Fussler et al. (1996). In a subsequent article, Peter James defines eco-innovation as new products and processes which provide customer and business value while significantly decrease environmental impacts at the same time (Planet Eco Innovation).

A common position is that this definition should be complemented, eco-innovations should also bring greater social and cultural acceptance. This 'social pillar' that should be added to the EI definition is necessary because it defines learning and thus the effectiveness of eco-innovations and of policies that promote them (Planet Eco Innovation).

Eco-innovation is innovation for sustainable development. Eco-innovations can be defined as different products, processes or organizational innovations that add market value and

increase environmental and social acceptance. Eco-innovations are building blocks for sustainable development. Eco-innovations may also be seen as tools for enhancing the social, economic and environmental acceptance of development. Eco-innovation refers to all kinds of innovations that are of use to the environment: techniques, processes and business related innovations, in short; innovative pro-environment activity (Komission tiedonanto) (in Finnish).

Eco-innovations may be:

1. Products or services,
2. Processes that reduce environmental load,
3. Organizational and business models or
4. Marketing and design sketches

These kinds of innovations have lower environmental impacts compared to those alternatives that are mainly being used nowadays. These kinds of innovations have been helpful in finding solutions for different kinds of environmental problems, either directly or indirectly (Halonen et.al. 2007):

Eco-Innovation aims to develop new products and processes which provide customer and business value but significantly decrease environmental impact. Eco-innovation considers environmental aspects of the product at early stages of the new product development process. The five basic rules for eco-intelligent products are the following (the same as in MIPS thinking):

1. Maximize the number of service units obtainable from products during their entire useful life.
2. Minimize the life-long material input into processes, products, and services
3. Minimize the life-long energy inputs into processes, products, and services
4. Minimize the land use (surface coverage) per unit service from cradle to grave.
5. Minimize the dispersion of toxics.

Eco-intelligent products are nontoxic utensils, objects, foodstuffs, machines, vehicles, buildings, and infrastructures etc. that produce a maximum number of high quality service units at competitive prices with a minimum of natural materials and land use. Eco-intelligent Processes can be described as technical procedures that function at competitive prices by utilizing eco-intelligent products and equipment and a minimum input of natural resources with the smallest possible output of waste and toxic substances. Eco-intelligent Production is an organizational, managerial and technical process for producing goods and services at competitive prices that utilize eco-intelligent products and equipment and a minimum input of natural resources with the smallest possible output of waste and toxic substances. Eco-intelligent consumption can be described as utilization of eco-intelligent products and services.

The following principles are presented as trends in understanding ways in which sustainable development can be reached within the context of eco-innovation.

1. Focusing on prevention: There is a crucial shift from “end of pipe” thinking to focusing on prevention of pollution. The idea of prevention shifts public policy towards demand management, creating incentives for increased efficiency, regulation targets for pollution and reference use, and applying eco-design to products and systems. The requirement of prevention can be considered as the central constraint shaping eco-innovation.

2. Preserving and restoring “natural capital”: Industrial development has now reached the point where the depletion of natural resources is threatening future prosperity.

3. Thinking in terms of life cycles: The goal is to minimize impacts, and to do that over the entire life cycle of products and services - from the point of reference extraction, through manufacture, transport, distribution, consumption and disposal or reuse at the end of life. The implications of this perspective include: the designing of new “industrial ecologies” - in particular, co-locating industries

which use each other's "waste" as inputs to "close system cycles". They include the development of the principles of eco-design, or life cycle design, (for example, optimizing reuse of components), of eco-indicators which track the inputs and outputs of products through their lifetime, and of eco-labels which declare these inputs. They include new frameworks for "product policy", including legislative frameworks which require producers to take responsibility for the final disposal of their products at the end of their life.

4. Increasing eco-efficiency (by "factor X"): Eco-efficiency refers to doing more with less. The aim is to reduce the material, energy and pollution intensity of goods and services. Approaches to this include innovating to increase material recyclables and component reuse, extend product durability, maximize use of renewable references, and reduce the overall requirement for material inputs.

5. Decarbonizing and dematerializing the economy: Central to the problem of global warming is the massive production of carbon dioxide from processes of production and consumption. The principles of eco-innovation urge us to turn our attention sharply to prevention. This requires us to substantially reduce the carbon intensity within the economy. Emissions could be reduced through more efficient use of energy and increasing the share of lower carbon-emitting fossil fuels, advanced fossil fuel technologies and renewable energy technologies. Decarbonizing the economy relies on a shift to renewable energy references and the reduction of energy intensity of production and consumption. Achieving either of these demands sustains innovation. Decarbonization represents just one driver for eco-innovation. Beyond that is dematerialization - the potential, greatly enhanced by the role of information technology, to decrease the intensity of reference flows through the economy. Eco-innovation supports dematerialization through an increasing number of approaches - "light-weighting" of products, "e-materialization" where information flow is substituted for hard products (for example, on-line delivery of entertainment), "long-life" increases in durability of

products, and “service substitution” where products are displaced by services, for example, washing machines being replaced by washing services.

6. Eco-innovation by design: Innovation will not produce these results without being shaped to meet the goals of sustainability. And this requires not just conscious design of each product to meet these goals, but comprehensive design strategies which encompass the systems in which products are used and consumed, and services created and delivered. There is a well known set of eco-design (or “life cycle design”) rules and methods which, when appropriately applied, can reduce the whole-of-life environmental impacts of products by somewhere in the order of 50–75 percent, within current market conditions. There continues to be experimentation and investment in “eco-product” development by business.

The above is a set of principles. The ambitious objective of reaching a state of sustainable development is presented to require determined and vigorous innovation along all these dimensions (Falk et al. 2006). According to the definition for eco-efficiency from Falk et al. (2006) and the World Business Council for Sustainable Development, eco-innovation does fulfill the principles of eco-efficiency quite profoundly, because one of the six strategic principles for eco-innovation includes the goal of increasing eco-efficiency. Besides that, the principles of eco-innovation include ideas of eco-efficiency, such as reducing material and energy intensity and increasing material recyclables.

Eco-innovation supports dematerialization through an increasing number of approaches - “light-weighting” of products, “e-materialization” where information flow is substituted for hard products (for example, on-line delivery of entertainment), “long-life” increases in durability of products, and “service substitution” where products are displaced by services, for example, washing machines being replaced by washing services.

Eco-innovation can be applied to the entire life cycle of products and services - from reference extraction to manufacture, transport, distribution, consumption and disposal or

reuse. Through eco-innovation entire processes or parts of them can be designed or improved to be more ecological. Eco-innovation is applied when designing some ecological product or redesigning some product to be less environment consuming. Eco-innovation is at its best when planning and developing services or improving products and services or entire production processes, because then it's possible to create optimally environmentally friendly products and services, in comparison to only designing or redesigning parts of the processes.

At present, much emphasis is placed on the environmental and economic pillars of eco-innovations. Eco-innovations social pillar (e.g., social acceptance, ownership, and learning) represents a major bottleneck to sustainable development. Indeed, many potential eco-innovations, albeit technically feasible, are not yet implemented because of social, institutional, and cognitive barriers (Planet Eco Innovation). This emphasis on the social pillar of eco-innovation reflects the concern that the barriers to many eco-innovations, and thus to sustainable development, are more on social acceptance than on the economic and environmental ones (Planet Eco Innovation).

Eco-Controlling

Eco-controlling is mentioned to be based on the basic process of financial controlling (Horvarth 1994). Eco-Controlling images a strategic approach to environmental issues and suggests systematic management procedures for different steps from strategy formulation to data management, decision support, control, implementation and communication (Schaltegger and Sturm 1998). The concept is specifically developed to link environmental strategy with financial and strategic targets of top management. The system thus focuses on the improvement of eco-efficiency. Eco-controlling is rapidly growing into a core management tool, passing through stages of development similar to financial controlling. The method covers the planning, control and supervision of the company's production processes.

The eco-controlling concept can be divided into five modules (Schaltegger and Sturm 1998):

1. Objectives and targets: The formulation of environmental objectives and targets is based on the commitment to comply with all relevant environmental regulations, and to continuously improve environmental performance. Environmental performance is linked mainly to environmental impacts caused either by risks, or by continuous interventions in the natural environment. The analysis of the expected exposure of a company to different environment problems and the weight given to these aspects by various stakeholders enables management to prioritise on environmental issues with high priority for the company. To complete objectives and targets of an eco-controlling system, an environmental target system has to be approved by top management.

2. Data management: The recording of environmental data and environmentally induced financial information is necessary as a basis for effective decision-making. For every environmental target the company needs to collect the necessary data. The main focus in data management is an environmental inventory of inputs and outputs. This procedure follows the methodology of management accounting, but all the figures are measured in either kilograms or mega joules. In an analogy to cost centres and cost carriers, environmental impact added centres and environmental impact added carriers are identified. These enable the users of eco-controlling to analyse where a pollutant is emitted and by which products. Economically, it does not make sense to aim at a full inventory of all mass and energy flows – apart from the fact that this target can hardly be achieved. The process of data collection will usually be spread over several years, becoming more in-depth each year until the marginal benefit of more detailed information matches the marginal costs of collection. The main question is: do the allocation methods reflect the different environmental effects of the materials used or the pollutants emitted?

3. Performance evaluation: The reason for collecting data about corporate environmental impacts as well as environmentally induced financial impacts is to calculate eco-efficiency, and to measure how well the operations of the firm contribute to, or detract from, sustainable development. In the performance evaluation a system is necessary to assess, aggregate and present recorded data to support decision-making. Decisions for setting environmental priorities within a company rely on impact assessment approaches. The most widely used approach to assess environmental impacts is the two-step approach of classification and characterisation which are based on natural sciences. To reach a clear conclusion about corporate environmental performance, it is necessary to make a qualitative assessment of the importance of the various indicators. For every environmental objective with high priority, an environmental performance figure should be calculated. As a result, the organisation has a set of key figures that measure environmental performance based on the environmental effect register. These figures are then compared to the objectives and targets.

4. Value based environmental programs: Eco-controlling addresses different levels of the organisation and combines the very different tasks of shop floor environmental data collection and strategic environmental management. The costs and benefits of programs can be quantified by analysing the economic effect of management decisions regarding environmental issues on value drivers in terms of decreasing or increasing shareholder value. The analysis of the costs and benefits of implementing programs is based on quantitative estimates of the effect of these value drivers.

5. Communication: Internal and external communication is an integrated part of eco-controlling. Internally, communication addresses issues such as the role of the environmental strategy for the success of the company, or progress towards the targets documented. The increasing importance of external communication of environmental issues can be seen by the rapidly growing number of so called

"environmental reports". The content of a report should reflect the specific situation of the firm as well as the information needs of the stakeholders addressed.

Eco-controlling does have an effect on the producing process, but it does not interfere with the life cycle of the whole product. So it surely makes a difference, from the environmental point of view, but still keeps in mind that the main purpose of the company is to make a profit with its product - no matter what the product is. Eco-controlling is rapidly growing into a core management tool, passing through stages of development similar to financial controlling. The method covers the planning, control and supervision of the company's production processes. Eco-controlling puts the focus of environmental management on the particular processes of a given company. It does not attempt to include environmental impact over the life cycle of a company's products.

Environmental Management Systems (EMS) and ISO 14001

The Environmental Management System, ISO 14001, was first published in 1996 (the latest version in 2004). It has rapidly become the most important environmental standard in the world. Thousands of organisations use it and environmentalists support it. Governments also actively encourage its use. ISO 14001 applies to all types of organisations. It does not matter what size they are or what they do. ISO 14001 is an internationally accepted standard that defines the requirements for establishing, implementing and operating an Environmental Management System (EMS).

ISO 14001 consists of 17 requirements that should appear in the Environmental Management System, and the organization has to achieve them for getting the recognition. These requirements can be included in the following main headings:

- Environmental policy
- Planning (risk assessment, operational control, objectives, targets and management programmes).
- Implementation and operation (roles, responsibilities and authorities of staff, structure of EMS and environmental procedures, the process for dealing with

emergency situations, training, internal and external communication as well as the EMS documentation).

- Checking and corrective action
- Management review

ISO 14001 enables a company to identify and manage its environmental impacts and to integrate environmental management into their daily operations, long-term planning and it provides greater certainty of organisational/ management commitment. An Environmental Management System is intended to provide a framework for improving environmental performance. EMS is a management approach which enables an organization to identify, monitor and control its environmental aspects. EMS is a part of an overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy. EMS consists of the continuous improvement cycle of 'plan, act, check and review', and as such is an effective environmental management tool. It is probably the best-known form of environmental assurance.

The main benefits of EMS are the internal operational efficiencies gained through the use of a management system by an organization, rather than supply chain or marketing advantages. Main aspects are on the environmental aspects / impacts and how to avoid them, not eco-efficiency.

ISO 14001 is concerned with environmental management - what the organization does to minimize its harmful effects on the environment. Just as ISO 19001 does not signify product quality, ISO 14001 does not signify a "green" or "environmentally friendly" product. The focus of ISO 14001 is on the process, not performance, at least not directly. It specifies how organizations manage processes influencing quality and environment. The strengths of EMS lay in the management system approach that provides an excellent tool for coordinating activities and staff, and achieving cost savings. All companies can use ISO

14001 for developing their own environmental management plan. (International Standard ISO/FDIS 14001:2004)

Green Productivity (GP)

Green Productivity was launched in 1994 in line with the 1992 Earth Summit recommendations describing that both economic development and environmental protection would be key strategies for sustainable development. Green productivity is a term used by the Asian Productivity Organization (APO) to address the challenge of achieving sustainable production. Asian Productivity Organization defines Green Productivity as a strategy aiming at enhancing productivity and environmental performance of overall socio-economic development. GP is described to be an application of suitable techniques, technologies and management systems to produce environmentally fair goods and services (Asian Productivity Organisation 2002). Just like Cleaner Production, Green Productivity is a strategy for enhancing productivity and environmental performance for overall socio-economic development. It is the application of appropriate techniques, technologies and management systems to produce environmentally compatible goods and services. Green Productivity not only gives great emphasis to waste prevention, but also to energy conservation and pollution control. In addition, there has to be a participative approach by the business in concern and, therefore, training of employees is also given top priority in Green Productivity. Green Productivity aims to ensure environmental protection while making business profitable. The concept of Green Productivity shows that for any development strategy to be sustainable it needs to have a focus on quality, profitability and environment. This is called the triple focus of Green Productivity.

Green Productivity recognizes that all waste and pollution generated are resources the company has bought but cannot sell. When business produces waste, it represents a failure to convert resources into saleable products. From this perspective, pollution and waste are the inverse of corporate productivity; they are what a company produces when it is not productive. Green Productivity seeks to eliminate waste and pollution. It also sets out to

promote innovations that create new valuable products and processes. Thus Green Productivity tries to help a company to increase productivity.

Distinguishing characteristics of Green Productivity are the following:

- Environmental compliance: pollution prevention, source reduction, end-of-pipe controls
- Integrated people based approach: production-environment integration , team work, safe and healthy working conditions, information-driven improvement, information measurement, reporting disclosure
- Productivity improvement: continuous improvement cycle

Yueh Kwong (2004) has described guiding principles for Green Productivity, and they are as follows:

Environmental Management Principles:

- Accountability
- Polluter Pays Principle
- Precautionary Principle
- Principle of Inter-generational and Intra-generational Equity

Productivity Principles:

- Profitability
- Competitive Advantage
- People Centred Orientation
- Socio-economic Benefits
- Multi-stakeholder participation

Main features for Green Productivity are good material productivity; good energy efficiency, waste and pollution have minimal impacts, good product safety during use, long life cycle of the product, reuse possibility of the product and good recycling possibilities. Green productivity is an integrated productivity system. It proposes ecological efficiency as

the best way to obtain the best productivity system. Green Productivity comprises with the sustainable development goal. Although this idea requires relevant changes in the behaviour and operation of the industry, it defines a good method to work from now to the future. A main deficiency of the method is that it is a complicated strategy that involves lots of time and resources. Real profitability can be achieved in the long run. Green productivity thinking is growing in Europe and Japan

Industrial Ecology (IE)

Industrial Ecology, also called Industrial Metabolism (IM), focuses on the potential of industry in reducing environmental burdens throughout the product life cycle. It examines local, regional, and global materials and energy use and flows in products, processes, industrial sectors and economies. Industrial ecology is described to be interested in government programs and policies that facilitate environmental practices relevant to industrial ecology (Ehrenfeld 2007).

Industrial Ecology and Industrial Metabolism are concepts for patterns of industrial production and are closely related to the Cleaner Production concept. Industrial Ecology and Industrial Metabolism focus on industrial systems and economic activities, and their connections to fundamental natural systems. Basically, they aim to imitate the material recycling aspect of an ecosystem - material flow management is the crucial aspect of these approaches. Industrial Ecology uses the metaphor of metabolism to analyze production and consumption by industry, government, organizations and consumers, and the interactions between them. Industrial Ecology focuses on tracking energy and material flows in all industrial systems, including the site, region, and national and global economy. (Van Berkel et al. 1997).

The main difference between Industrial Ecology and eco-efficiency is that the focus of Industrial Ecology is on minimizing waste from production, and the main focus of eco-efficiency is on minimizing resource and material use in production.

Integrated Product Policy (IPP)

Integrated Product Policy (IPP) might be better termed 'environmental product policy'. It is an attempt by the European Commission (Commission of the European Communities 2003) to create conditions in which environment-friendly products, or those with a reduced impact on the environment can be made. The Integrated Product Policy approach is based on the idea that there can be a new dynamic in which producers find incentives to include environmental aspects in their strategic thinking as well as in their product design. All products cause environmental degradation in some way, whether from their manufacturing, use or disposal stage. The goal of Integrated Product Policy is to minimise these by looking at all phases of a products' life-cycle and taking action where it is most effective. Integrated product policy includes all environmental aspects from design and production to use and disposal as described in LCA. (Commission of the European Communities 2001).

Main features for Integrated Product Policy are the following:

1. Takes into account all environmental impacts of the product and services throughout the whole life cycle (life cycle based)
2. Impacts in water, air and soil are looked at simultaneously as well as their interactions
3. Environmental impacts beside economical and social impacts (cost effectiveness, carefulness)
4. All actors in the product chain have their own responsibilities in minimizing the environmental impacts (shared responsibility, polluter pays)
5. Need for co-operation between different actors including customers (customer orientated, legislation demands)
6. Continuous improvement

Lean Manufacturing or Lean Production

Lean Manufacturing, also called Lean production, is a way of producing products where all unnecessary actions are eliminated. The basic idea is to focus in actions in production

which bring value to the customer. All actions that don't fulfil this idea are considered as waste. The goal of lean manufacturing is to get the right amount of right products into the right place in the right time. At the same time, all that is unnecessary is reduced, and the company is flexible and open to changes. It is important to focus only in activities that produce value to the customer. This is a way to significantly reduce expenses and time. This method was originally developed by Toyota Motor Company when they were trying to intensify their production process.

Lean Manufacturing is more a philosophy of continually reducing waste in all areas and in all forms. Lean Manufacturing (also known as the Toyota Production System) is, in its most basic form, the systematic elimination of waste - overproduction, waiting, transportation, inventory, motion, over-processing, defective units - and the implementation of the concepts of continuous flow and customer pull. Five areas drive Lean Manufacturing (Cost, Quality, Delivery, Safety and Morale). (Spann et al. 1999, Toyota Production System)

The basic elements are waste elimination, continuous one piece workflow, and customer pull. When these elements are focused in the areas of cost, quality and delivery, this forms the basis for a lean production system. Employee empowerment and promoting a way of thinking oriented at improving processes, imitation of customer relationships, fast product development and manufacturing, and collaboration with suppliers are the key strategies of leading lean companies. Non-value added activities or waste are eliminated through continuous improvement efforts. Focus on continuous improvement of processes - rather than results - of the entire value chain. The lean manufacturing is a mindset, a concept, way of thinking - not techniques; culture - not the latest management tool. Continuous product flow is achieved through physical rearrangement, system structure and control mechanisms.

Every system contains waste, i.e. something that does not provide value to your customer. Whether you are producing a product, processing a material, or providing a service, there are elements which are considered 'waste'. The techniques for analyzing systems, identifying and reducing waste and focusing on the customer are applicable in any system, and in any industry. Just as mass production is recognized as the production system of the 20th century, lean production is viewed as the production system of the 21st century.

Pollution Prevention (PP, P2)

Pollution Prevention is defined as the use of processes, practices, materials, products or energy to avoid or minimize the creation of pollutants and waste, and reduce overall risk to human health and the environment. P2 seeks to eliminate the causes of pollution rather than to treat the waste generated. It involves continuous improvement through design, technical, operational and behavioral changes. Pollution Prevention encourages changes that are likely to lead to lower production costs, increased efficiencies and more effective protection of the environment. Pollution prevention shifts the emphasis from controlling pollution once it has been created to preventing its creation in the first place. It includes waste minimization, recycling, energy recovery and zero-emission processes. In addition, Pollution Prevention encompasses waste treatment and remediation measures. (U.S. Environmental Protection Agency).

The terms Cleaner Production and Pollution Prevention are often used interchangeably. The distinction between the two tends to be geographic: the term pollution prevention tends to be used in North America, while Cleaner Production is used in other parts of the world. Both, Cleaner Production and pollution prevention focus on a strategy of continuously reducing pollution and environmental impact through source reduction which is eliminating waste within the process rather than at the end-of-pipe. Waste treatment does not fall under the definition of Cleaner Production or Pollution Prevention because it does not prevent the creation of waste.

Environment Canada defines Pollution Prevention as the use of processes, practices, materials, products or energy that avoids or minimizes the creation of pollutants and waste, and reduces the overall risk to human health or the environment. The US Environment Protection Agency (EPA) defines Pollution Prevention as source reduction - preventing or reducing waste where it originates, at the source - includes practices that conserve natural resources by reducing or eliminating pollutants through increased efficiency in the use of raw materials, energy, water and land. Under the Pollution Prevention Act of 1990, pollution prevention is the national environmental policy of the United States. (Garner et al. 2005).

Product Oriented Environmental Management (POEM)

The objective of POEM (Product Oriented Environmental Management) is to establish a systematic drive for continuous improvement of the life cycle environmental performance of products by integrating environmental aspects in strategic management decisions. POEM can be seen as an elaboration of EMS (Environmental Management System) that focuses especially on product development and product design / redesign. (de Bakker et al. 2002)

Responsible Care (RC)

Responsible Care is a global initiative launched in Canada in 1985 by the chemical industry to promote continuous improvements in health, safety and environmental protection. The program is largely based on the principles of quality- and environmental management systems and standards. Responsible Care focuses more on health and safety aspects and straight environmental aspects, not so directly on eco-efficiency. Eco-efficiency can be considered as the next step for a Responsible Care program. (American Chemistry Council 2008)

Waste Minimization (WM)

Waste Minimization is the strategic reduction of waste at source, through improved manufacturing methodologies, more careful work procedures and improved product specifications. It is capable of generating massive savings.

The concept of waste minimization was introduced by the U.S. Environmental Protection Agency (EPA) in 1988. In this concept, waste prevention approach and its techniques are defined as on-site reduction. Source reduction of waste by changing input raw materials, technology changes, good operating practices and product changes. Off-site recycling by direct reuse after reclamation is also considered to be a waste minimization technique, but it has a distinctly lower priority compared to on-site prevention or minimization of waste.

Currently, waste minimization and pollution prevention terms are often used interchangeably. Pollution prevention means avoiding waste in the first place by reducing it at the source. Waste minimization can be considered as a broader term which includes recycling and other ways to reduce waste which must be treated or disposed of. (Crittender et al. 1995)

Zero Waste

Zero Waste is a 'whole system' approach to resource management that maximizes recycling, minimizes waste, reduces consumption and ensures that products are made to be reused, repaired or recycled back into nature or the marketplace. The result is that manufacturers have to redesign products to reduce materials consumption and facilitate reuse, recovery and recycling. Zero Waste represents a new planning approach for the 21st Century. Zero Waste defines the discipline required to create a more sustainable interaction with our natural world, including the principles of conserving resources, minimizing pollution, maximizing employment opportunities, and providing the greatest degree of local economic self-reliance. Zero Waste is said to confront the whole idea of endless consumption without needing to say so (Hollender 2000). Zero Waste is a design principle. When planning for waste elimination, the objective of 100 percent elimination is not the point. The best option is to start planning for the elimination of waste rather than managing waste (Murray 2002). This quote summarizes the model shift from 20th Century Waste Management to 21st Century Resource Management (Connett et al. 2000).

2.2.2 Methods for Evaluating Eco-Efficiency

There are many reasons for companies to evaluate the eco-efficiency of their processes, whether due to environmental legislation, pressure from clients and partners, decrease of natural resources, or the willingness to act in a responsible way in business. By combining and taking into account environmental and financial information, companies may improve several business processes: decision-making, tracking and documenting performance and progress, identifying and prioritising possibilities for improvement, product development, recognising cost savings and other benefits related to eco-efficiency reports carried out for stakeholders (UNCTAD 2001, Muller et al. 2001, The National Roundtable on The Environment and Ecology 2001, Verfaillie et al. 2000).

Even though eco-efficiency analysis seems to be an important means of finding environmental improvements, it does not exist as an agreed-upon method with appropriate tools (Huppes et al. 2005). Brattebø (2005) describes that analysis of eco-efficiency should be designed in such a way that it includes the choices of impact categories and indicators, and that the analysis should be understod meaningful, easy to work with and appropriate to the user and decision-maker.

The selection of the financial indicators used for analysing and reporting is a relatively clear and transparent procedure in companies from industrialised countries, but defining appropriate indicators to describe ecological effectiveness is a challenging task. The essential problem with eco-efficiency indicators is the lack of fixed rules or standards for identification, measurement, evaluation and acceptance of environmental information. In comparable industrial sectors, the environmental metrics and indicators vary from company to company, whereas across industrial fields, similar environmental indicators are not at all defined. Problems appear also in linking environmental information with economic considerations (UNCTAD 2001). The result can lead to a situation in which indicators can be incorrectly selected, misused, or misinterpreted, and in which the outcome generates misleading conclusions. If large companies have not succeeded in defining valuable metrics

and indicators and to select high-quality tools for evaluating eco-efficiency, the variety of different methods, tools and related definitions for implementing and evaluating eco-efficiency is as confusing for SMEs.

Strategic Management and Methods for Evaluating Eco-Efficiency

According to Porter (1991), strategy is conducting a company into line with its business environment in order to achieve and maintain a dynamic balance. An enterprise leadership strategy will be a key tool for considering relations between an organisation and the environment. A sustainability-promoting enterprise has to strike a balance between environmental excellence and business competitiveness. Ecological issues have become an increasingly important part of the global business environment.

In companies, significant elements of a comprehensive strategic management model are according to David (1999) external analysis, internal assessment, strategic direction and plans, the implementation process of these plans and the performance evaluation of actions. The external environment includes social, technological, economic, environmental, and political trends and developments. Economic issues have been essential questions in strategic management for decades. From a management perspective, environmental issues should be developed as strategic factors instead of considering them as operational cost issues or regulatory requirements (Winsemius et al. 2002; Burritt et al. 2002). Strategic planning defines the objectives and assesses the internal and external situation of the company in order to formulate and implement strategy, and to evaluate progress for environmental improvements and adjustments. It is suggested that eco-efficiency measures can give valuable information to politicians and managers to aid their decision making (Kuosmanen 2005).

The capacity to manage improvements performed by a company depends on establishing valid methods to measure performance. Most measurements of environmental performance are based on the requirements of official reports on environmental loads. When companies started to develop environmental goals that move beyond compliance, new methods for

measuring and tracking improvement were required (National Research Council Staff 1999).

Huppes et al. (2005) point out that for the economic part of eco-efficiency there are three approaches, which are based on life cycle costing. They are market-cost-related values, as in management accounting and budget cost accounting, cost-benefit analysis, and a steady-state type of cost. There is less consensuses on what constitutes relevant environmental impacts and which models are adequate for the empirical environmental analysis, as well as on how different types of environmental effects should be combined into a single indicator when evaluating and scoring the ecological part of eco-efficiency (Huppes et al. 2005).

In order to effectively manage the ecological and environmental issues of a company, with their related costs and benefits, an organisation needs systematic practices (methods) for data collection, analysis, use of information and reporting. Some of these methods are discussed below.

Environmental Management Accounting (EMA)

EMA (environmental Management accounting) is a widely discussed method for evaluating the environmental loads and costs caused by a company's processes. Environmental Management Accounting can be presented as a combined approach providing the transition of data from financial accounting and cost accounting to increase material efficiency, reduce environmental impact and risk and reduce costs of environmental protection (Jasch 2001). The basic purpose of EMA is to account the financial impacts of environmentally-related activities such as environmental protection activities and investments. EMA primarily involves finding and tracing environmental costs (e.g. site-specific clean-up costs), but also allocation of costs to products and services, investment appraisal, and life cycle costing (Schaltegger et al. 1996). EMA takes its data from both financial accounting and cost accounting. EMA is considered instrumental in increasing materials efficiency, in reducing environmental impact and risk, as well as in reducing the costs of environmental protection. Both financial and physical data are used in EMA. (Bennet 2002).

EMA can be used for identification, collection, analysis, and use of two types of information for internal decision-making. These types are physical information about the use, flow and end-state of energy, water and materials, and financial information about environment-related costs, benefits and savings (Jasch 2001). A key benefit of good EMA data is the opportunity to identify and reduce environmental costs (Burritt et al. 2002, UNDSD 2001). The main problem with EMA is the lack of a standard definition of environmental costs (Jasch 2001, United Nations 2001). A major limitation of EMA, especially for SMEs, is that even though it provides valuable information, it is costly and time consuming because it requires collection of process and emissions data from a wide range of stages and thus is impractical to use on a regular basis.

Data Envelopment Analysis (DEA)

DEA provides a nonparametric efficiency analysis or activity analysis for estimating production frontiers and evaluating relative efficiency of decision-making units (DMU). DEA assumes the performance of the DMUs by using the concepts of efficiency, or productivity, which is measured as the ratio of total outputs to total inputs. Also, the efficiencies estimated are relative to the best performing DMU or DMUs. In the DEA context different units that can be compared to each other can be companies, branches or processes, because they can identify and vary their inputs and outputs. The advantages of DEA are its immediate applicability to multiple-input multiple-output technologies, and the minimal assumptions about the production technology. DEA can handle inputs and outputs without knowing the price or the weights, and it produces one single measure for each DMU which can be compared to other DMUs (Blumenberg 2004). A major limitation of the method can be its requirements for extensive data and that DEA only calculates relative efficiency measures (Kuosmanen et al. 2005).

Eco-Compass

The Eco-Compass (Fussler et al. 1996) is argued to be one of the best streamlined Eco-innovation tools. The Eco-compass was designed to condense environmental data into a

simple model, which would assist in the integration of environmental issues within the business decision process. Eco-Compass is a comparative tool to evaluate existing products or to compare a current product with new development options, and it identifies opportunities to eco-efficient innovations (Fussler et al. 1996). With Eco-Compass it is possible to compare a new product to an existing practice by measuring the following aspects: the quantity of materials wasted in their manufacture; their risk to health and environment; energy use throughout their life; their revalorisation potential by recycling, incineration for energy, or reuse; their natural resource conservation; and length of their useful life. It gives information to enable decision-makers to optimise products and services towards a sustainable satisfaction of demand.

The Eco-Compass has six "axes" that represent significant environmental issues: mass intensity, human health and environmental risk, energy intensity, reuse revalorisation of waste, resource conservation and extending service and function. The Eco-compass is a comparative spider diagram, which evaluates new options or designs against the original design or 'base case'. Each of the axes records a score from 0-5 for the new product. The base case always scores 2 in each dimension and the new option can score from 0 (environmental impact doubled) to 5 (environmental impact reduced by at least factor 4).
When scores are plotted for all six dimensions, it takes a new shape, making it easy to compare its environmental performance with that of a baseline (Fussler et al.1996). The Eco-Compass consists of a set of indicators that drive and measure economic, social and environmental performance (Raising the Bar 2004).

The Eco-Compass developed by Dow Europe (Fussler 1996) is a tool for assessing the environmental impact of a product. The assessment is made by constructing a series of concentric hexagons, with each corner representing a different environmental dimension. These are (moving clockwise from the top of the diagram)

- Service extension (for example making products last longer)
- Revalorization (re-manufacturing, reuse and recycling possibilities)
- Resource conservation (renew ability of materials used)

- Energy (consumed per unit of production)
- Material intensity (weight of resources used per unit of production)
- Health and environment (risks to people and ecosystems)

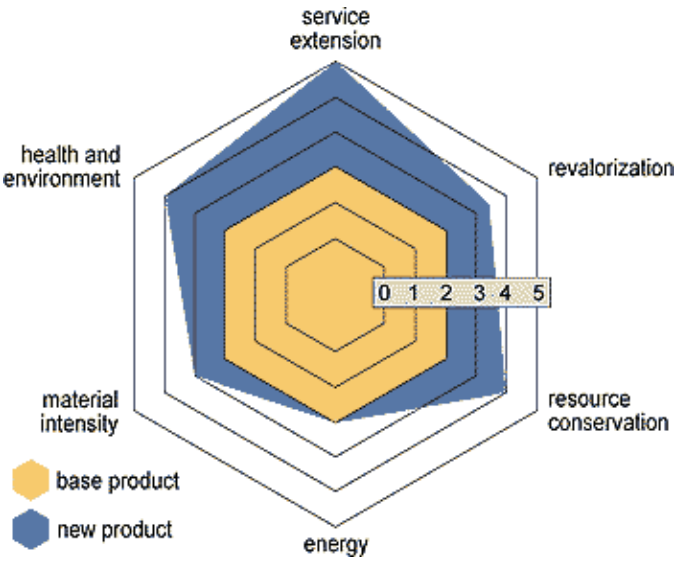


Figure 9 Eco-compass (Fussler 1996)

Eco-Efficiency Analysis (EEA)

EEA is a method that builds upon LCA (Life Cycle Analysis, described on page 82). In contrast to LCA, EEA examines and identifies not only the environmental dimension, but also involves life cycle costing, thus exploring the economic dimension. With this integrated approach and a clear portfolio presentation of findings, EEA is a suitable tool with which to evaluate the advantages and drawbacks of various products or options for action, both from an environmental perspective and with regard to total cost. This permits both economics and ecology to be included in the equation when products and processes are being developed and optimised. The entire life cycle of a product is evaluated, from extraction of raw materials, through production, to recovery. In EEA all relevant costs and environmental impacts can be calculated. EEA serves well as a basis for decisions

regarding new investments, or for optimizing product development processes. EEA is a systematic methodology for incorporating a broad range of environmental impacts and costs into processes and products regarding decisions, and the method is capable of handling a large number of environmental impact categories over the entire product life cycle, which can be seen as advantages of EEA (Shonnard et al. 2003). The advantages and disadvantages of EEA are mainly the same as with LCA.

Environmental Performance Evaluation (EPE)

EPE describes a formal process for measuring, analyzing, reporting and communicating an organisation's environmental performance in relation to the criteria set by the company's management. The process intends to collect information and to measure how effectively an organisation manages its environmental impact on an ongoing basis. It is primarily a procedural tool giving guidance on what to do, but not how to do it. EPE is considered to be the same as ISO 14031.

The Global Reporting Initiative (GRI)

GRI is a voluntary, multi-stakeholder approach to develop a corporate reporting system based on sustainability. It is suitable for measuring the performance of a separate facility or groups of facilities to be used for reporting and external communication. GRI can serve as a database for eco-efficiency calculations. (Sustainability Reporting Guidelines).

ISO 14031

ISO 14031 is an International standard on Environmental Performance. It describes a process for counting environmental performance and gives guidance on the design and use of environmental performance evaluation (EPE) within an organisation. ISO 14031 is recommended to be used as the primary approach for selecting specific environmental influence indicators in a sector or a company. It can be used as a screening stage for LCA. It is a procedural tool and can be used to aid decision-making (International Organization for Standardization 1997).

Life Cycle Assessment (LCA)

LCA is a method for evaluating effects that a product has on the environment over the entire period of its life, from raw material acquisition through to production, use and disposal. Thus the method also covers increasing resource-use efficiency and decreasing liabilities. It is a method for assessing the environmental aspects and potential impacts with product and service systems (International Organization for Standardization 1997). LCA can be used to support strategic and operational decision-making as well as awareness rising (internal learning purposes), but it can also serve as a tool for communication (Baumann 1998). It may also be used prospectively when developing new products or processes, and retrospectively, when improving processes or products. It may also be used for purchasing decisions. Life cycle approaches provide valuable information, but they are costly and time consuming, because they require collection of process and emissions data from all life cycle stages, and are thus impractical to use on a regular basis (Steen 2005). For indicators based on LCA it is not typically possible to allow comparisons over time, as the data is case-specific and usually collected only once.

It is also difficult for companies to understand what the results mean for their finances (UNCTAD 2001). Fussler et al. claim that LCA is an important tool for collecting and analysing data, but the final assessment is so complex that it is difficult to base decisions on this method only (Fussler et al. 1996). The benefits of LCA, compared to other environmental management tools can be described as follows: significant impacts in the life cycle become obvious, and trade-offs between improvements at one life cycle stage and increased impacts at another life cycle stage are revealed (Brady 2005). An LCA offers a good view of the used materials and processes (Steen 2005).

Methods for Evaluating Material Use

The following methods, developed by Whuppertal Institute, are based on the idea that the more material is used, the more ecological effects are caused; they can be considered as simplified estimates of ecological impact (Rissa 2001). Material and energy flows are

viewed as being fundamental to environmental problems and that they also underline economical success (Bailey et al. 2001). Dogru et al. (1998) also noted the benefits of focused attention to material and energy flow. These methods focus on material flows of products and services and are discussed separately below.

Material Intensity Analysis (MAIA)

MAIA is used to quantify the life cycle wide requirement of primary materials for raw materials, products and services. Analogous to the quantification of the cumulative energy requirements, MAIA provides information on basic environmental pressures associated with the magnitude of resource extraction and subsequent material flows, which generate waste or emission (Rissa 2001). It has been conceived of as a screening step for LCA. It has also been used to apply the concept of dematerialisation in practice and to contribute to the implementation of eco-efficiency (factor 4 to 10). MAIA quantifies the material intensity of products and services and demonstrates options for material and energy savings in industry in order to increase resource productivity and supports sustainable product design (Schmidt-Bleek et al. 1998).

Material Input per Unit of Service (MIPS)

MIPS is defined as tones of materials that must be moved on a 'cradle-to-grave' basis (in other words the material flows) for any given service or product, is an interlinking indicator based on MAIA. The methods of MIPS and related Factor 4 or Factor 10 mean an increase of resource efficiency while reducing the total use of natural resources. The idea is to de-couple economic growth and the use of natural resources. With MIPS it is possible to examine the sustainability of production by breaking products into services that they provide and examining the amount of materials needed in order to provide that unit of service (Ritthoff et al. 2003, Spangenberg 1999).

MIPS consist of two components, the Material Input (MI) and the Service unit (S). The material input includes all materials primarily taken from or moved through nature, which are required on a system-wide basis, i.e. for production, demand and disposal processes.

The determined material inputs are subdivided into five input categories; the unit of measurement is the mass in kilograms or tonnes. The five input categories in MIPS calculations are abiotic (non-renewable) raw materials, biotic (renewable) raw materials, soil transport, water and air (Schmidt-Bleek et al. 1998). MIPS can be used for communication and to support decision-making, because it gives consolidated information on complex life cycle wide environmental impacts (Busch et al. 2006); it can also be used as a simplified LCA and a screening method for LCA (Rissa 2001). The use of one unit (kilogram) for mass and energy, so that it can be used to monitor progress in dematerialisation, and that the symbol MI of an ecological rucksack is easy to understand, can be seen as advantages (Rissa 2001).

Wastes arising are only considered in terms of the material input, which can be seen as a weakness. MIPS does not consider the difference between different kinds of material streams and their possible toxicity, which can be considered a weakness (Rissa 2001). The basic calculation is clear and easy, but it is difficult to define or quantify the service part of a product (Moffatt et al. 2001, Ritthoff et al. 2003)

Ecological Rucksack

The material input factor MI in MIPS, without the weight of the product, is the total weight of material flow carried by an item of consumption in the course of its life cycle. It results from recording and accounting all materials found behind a final product or service. Hidden material flows should also be included. MI is defined as the sum of all materials that are necessary for production, use, recycling and disposal (Spangenberg et al., 1999). The concept of ecological rucksack deals with displaced environmental impacts but has a more technical focus. It focuses on reducing material intensity and increasing resource efficiency. It can be used for decision making when comparing different product possibilities. The benefit of ecological rucksack is that calculations are comparatively easy to carry out, and it makes hidden material flows visible (Rissa 2001). The main use is in product design and comparing different product possibilities (Schmidt-Bleek et al. 1998).

Most of the concepts for evaluating eco-efficiency are based more or less on life cycle thinking, or the aforementioned WBCSD framework (Verfaillie et al. 2000). Despite this, there are basic differences in their focus and in which indicators they include or propose.

The UNCTAD conceptual paper (UNCTAD 2001) recommends that all enterprises report their eco-efficiency at least with respect to the following environmental elements: energy use, water use, global warming contribution, contribution to ozone depletion, and waste. The WBCSD has outlined the following core elements to implement eco-efficiency: reduction of material and energy intensity, reduced dispersion of toxic substances, enhanced recyclables, maximised use of renewable, extended product life and increased service life (Verfaillie et al. 2000), which indicates that these issues should all be included in the evaluation of eco-efficiency. Chemical and biological oxygen demand (COD, BOD) as well as priority heavy metals (PHM) are also often mentioned as environmentally significant factors.

2.2.3 Material Flow Management (MFM)

Resource consumption generates a major part of environmental loads and thus also contributes heavily to global ecological problems. In most western industrialised countries absolute material flows and material flows per capita are increasing. The goal of sustainability stresses the necessity of an absolute reduction of material flows. Thus the task would be to find a path of economic development without increasing material flows in absolute terms (Hammer et al. 2003). Experiences in recent years have shown that increasing material efficiency can result in remarkable cost reductions and improve the competitiveness of enterprises. MFM offers enterprises a great potential for achieving new economic competitive advantage.

In manufacturing companies approximately 60 percent of costs are related to materials, whereas only 25 percent of costs are related to personnel (Bundesumweltministerium

2001). The eco-efficient optimisation of material flows aims at reducing costs while simultaneously achieving long-term sustainability with the help of ecological and social aspects. MFM combines the quantification of material and energy flows in physical quantities (mass or volume) with their environmental impacts and relevance (Wagner et al. 2006). Weizsäcker et al. (2004) argue that creating as much prosperity as possible with a given amount of resources is one of the most important prerequisites for a sustainable economy. Clearest cost saving potentials of eco-efficiency practises can be obtained when focusing on the internal material and energy flows. According to the management consulting company Arthur D. Little, increasing material efficiency can cut costs by 20 percent in almost every case (Fisher et al. 2004). Effective accounting systems are needed to illustrate and define these saving potentials. Co-operation between stakeholders is also essential for efficient MFM (Wagner et al. 2006). Stakeholders of all supply chain parts – from raw material delivery to end-of-life handling – should be considered. This can lead to wider use of eco-efficiency strategies in individual enterprises and supply chains.

Historically Material Flow Management (MFM) is a young method that can be understood as an implementation-orientated advancement of the methodology of Material Flow Analysis (MFA). MFM was established as a policy tool after the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro 1992. MFM is the systematic analysis, assessment and optimisation of material and energy flows in a system, in most cases a production system. By detecting possibilities for optimisation and by closing the material loops, significant cost savings can be achieved and, at the same time, the environmental impact caused by the operations of the company can be reduced (Wagner et al. 2006).

The term Material Flow Management covers a wide spectrum of methods and approaches in the literature. In general, material flow management means the analysis and specific optimisation of material and energy flows that arise during manufacturing of products and provision of services. Material flow management is defined as *"Management of material flows by the involved stakeholders refers to the objective-oriented responsible, integrated*

and efficient controlling of material systems, with the objectives arising from both the economic and ecological sector and with the inclusion of social aspects" (Wagner et al. 2006, p.8). Thus material flows, including energy flows, have an essential role in eco-efficiency and sustainable development ideology. Material flow management can be differentiated into internal and external material flow management. Internal material flows refer to movements of substances and materials within a company, and external material flows describe the path of a material along the value-added chain.

The implementation of MFM offers enterprises a high potential for realizing new economic competitive advantage. The eco-efficient optimisation of material flows aims at reducing costs while simultaneously achieving long-term sustainability with the help of ecological and social aspects. Knowledge of existing methods and the latest trends is a key prerequisite for successfully implementing, refining and disseminating of MFM approaches (Wagner et al. 2006). Intelligent handling of materials, energy flows and substances that are produced intentionally or unintentionally in companies, becomes increasingly important due to rising production costs and the damage they may cause to the environment. An examination of company practice demonstrates that eco-efficiency is relevant for decision-making, if specific optimisation projects can show clear cost saving potentials. The most practical approach lies in focusing on the internal material and energy flows. The efficient use of resources can become a determining factor in the competitiveness of the company (Busch et al. 2006).

There are some difficulties with using the full potential of material flow management, being as follows (Wagner et al. 2006): Efficient material flow management requires co-operation on the part of all stakeholders, including other companies. The interaction between several organisations requires management and cross value-added chain management for optimising the benefits for all parties involved. Examining physical material flows alone is not sufficient for reaching an efficient co-operation between several stakeholders. Both, the organisational structure and information flows, have to be taken into account.

2.3 Driving forces for Eco-efficiency

Eco-efficiency is promoted by several different institutions. These institutions include worldwide organizations as United Nations and European Union, governments, companies as well as individuals. Sustainable Development public sector, supply chains and eco-efficiency itself have a major role in driving eco-efficiency.

2.3.1 Sustainable Development

Nature has been an important resource for humans through the history of mankind. It has been exploited more and more intensively since the industrial revolution in order to create economic wealth and human progress. Even though the development has been revolutionary, nature is an increasingly limited resource. The earth sets the ultimate limits to natural systems, and because nature has its limits, the material bases of economics are also limited. Essentially, the natural systems do not need human systems, but human systems are dependent on natural systems. This means that the goals of sustainable development cannot be possible without considerations of the limits of the environment and natural resources. The nature provides humans with services that cannot be substituted, at least not completely, by human actions. These are for example life supporting systems (air, water) and inputs for production and goods (minerals, forests).

Many environmental problems have risen to public concern after the Second World War (Crocker 1999). Climate change above all has become one of the greatest environmental challenges facing the world today. Rising global temperatures will bring changes in weather patterns, rising sea levels and increased frequency and intensity of extreme weather events. UK Environment Secretary Hilary Benn described the Bali Roadmap, decided at the United Nation Climate Change Conference in Bali, to be the most significant agreement to

protect the world and its inhabitants. UNEP (2007) has stated that growing global concern about environmental problems especially pollution, biodiversity loss, poverty, health, working circumstances, safety and inequity, have promoted sustainability approaches for industry. Sustainability, corporate social responsibility and related trends have become a part of business practises for an increasing number of companies worldwide. Understanding how to integrate these concepts into business planning can be an important part of business in order to be successful.

2.3.2 Public sector

The public sector addresses growing concern about the accelerating deterioration of the human environment and the natural resources, and the consequences of that deterioration for economic and social development. The Rio Declaration on Environment and Development (United Nations 1992) as well as Agenda 21 has laid the basis for the public sector around the world to take action for the environment. The action plan encourages adoption and reporting of best environmental practices (United Nations 1992). *The European Commission explicitly recognizes the need for sustainable management and protection of our environment and concludes that environmental protection is a "key duty" that we have for future generations"* (Dimas 2005, p.1).

2.3.3 Supply chains

All business relies on their supply base and customers to survive. Many small and medium size companies act increasingly more as subcontractors for bigger companies, which mean that they are essential parts of a supply chain. The supply chain consists of the interactions between a business and its customers and suppliers. As defined by the Supply Chain Council, a supply chain encompasses every effort involved in producing and delivering a final product from a supplier's supplier to a customer's customer. According to The Global

Supply Chain Council, supply chain management *"is the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers"* (Cooper et al. 1997, p.113).

When addressing supply chain activities and processes, a product life cycle perspective is necessary for considering all of its parts, especially suppliers, manufacturers, distributors, and customers. Effective management of information, materials, products, and money to all its parts in the supply chain demands activities such as forecasting, new product realisation, order and entry as well as processing. The term supply chain management has been used to explain material planning and control, flows of information and logistics activities, not only in an organisation, but also between companies involved in the supply chain (Cooper et al. 1997, Fisher 1997). Effective supply chain management is dependent on many internal and external environmental variables of an organisation. Uncertainty in demand, technology and supply is a fundamental issue to be managed (Van Hoek 1998, Chen et al. 2004).

Understanding changing customer needs, and designing supply chains to deliver products and services can help organisations to outperform their competition (Carson et al. 1998, Sinha et al. 1998, Tan et al. 1999). The role of top management in understanding the complexity and need to support changes in the existing supply chain is said to be a critical requirement (Monaszka et al. 1993, Krause 1999). In this time of outsourcing and preparing organisations for the increasing competitive markets, supply chain coordination is suggested to be a critical capability to organisations (Lee 2002). Managing supply chain integration through shared vision can result in better payoffs.

There is a clear shift in organisations moving from push to pull supply chain, an increasing level of outsourcing and a high level of information technology exploitation in supply chain integration. The success of supply chain initiatives is argued to be largely dependent on linking the supply chain strategies with the business strategies and promoting a supply chain understanding among the members of the whole value chain (Sahay et al. 2003).

The globalisation of consumption patterns, sourcing and outsourcing arouses more complex supply chains. This can also be influenced by the increasing visibility and scrutiny of 24-hour news and the Internet, which can cause unsustainable practise in some supply chains. New Zealand Business Council for Sustainable Development, NZBCSD, (2003) has defined that sustainable supply chain is management of raw materials and services from suppliers to manufacturer and through service providers to customers and back.

There are many initiatives by private and public organisations who are conducting codes of conduct for themselves and their suppliers. The code of conduct (ethical guidelines) is a document that presents a number of social and environmental standards and principles. Companies themselves and their suppliers or contractors are expected to observe these codes of conduct. Therefore companies have realised that these standards have no actual effect, unless the company's business partners are evaluated and required to follow these codes. Organisations need to come to terms with the social and environmental impacts, as well as the cost structure of their supply chains, and to find ways to manage them.

One way how companies can differentiate themselves, reduce costs, and improve service is to consider the social, environmental and economic factors related to their supply chains. The greatest benefits can be achieved by extending the focus as far as possible upstream towards the raw materials, downstream towards the consumer, and then back again as the product and wastes are recycled.

2.3.4 Eco-Efficiency

It is widely agreed that environmental management systems (EMS) have failed to broaden the scope of corporate environmental management. The reason for this is that they do not systematically address environmental concerns outside the factory gate. Transport and logistics, energy supply, sourcing of raw materials and other inputs, product design and end-of-life considerations are outside the factory gate (Jäger et al. 1998, Steger 2000,

Hamschmidt 2002, Kuisma et al. 2001, Ankele et al. 2002). There are also some indications that EMS has increased continuous environmental improvement (Jäger et al. 1998, Steger 2000). Ammenberg et al. (2002) found that implementation of EMSs resulted usually in significant environmental improvements within two years.

Referred to environmental management systems, eco-efficiency (according to its definition) widens the scope outside the factory gate, and by this way it can give more opportunities for companies. There are many examples of remarkable economic success stories resulting from adoption of eco-efficiency and environmental considerations into company practices. BASF, DuPont, 3M, Ciba-Geigy and Xerox can be regarded as good examples. Most important drivers for environmental considerations and work in SMEs are: commitment of management, consumer demands, reduced resource demand, competition, legislation, demands for subcontractors and future legislation (NUTEK 2001, Hillary 1999). Hillary also notes that communication channels, skills, knowledge and attitudes are improved in SMEs which adopt environmental management systems (Hillary 1999).

Citizens and consumers demand more environmental goods, they insist environmental policy, and green products from companies. As technological development and economic growth go hand in hand, it becomes easier and possible to adopt eco-efficient solutions into production and consumption (Kutznets 1955). It seems obvious that consumer pressure towards sustainable and environmental behaviour of companies will increase.

An exploratory study by Rusinko (2007) suggests that environmentally sustainable manufacturing practices can increase competitive outcomes. In particular, different types of environmentally sustainable manufacturing practices (e.g., pollution prevention, product stewardship) can influence competitive outcomes (manufacturing cost, product quality). Efficiency improvements mean that more output can be extracted from less input, which normally means less environmental pressure. However, it is argued that efficiency improvements can possibly cause a rebound effect or Jevons paradox (Binswanger 2001),

which means an increase in total resource use, because inputs become cheaper and more attractive in relative terms.

2.4 Conclusions

Sustainable development has emerged during the 1990s as a compelling concept in the discourse on environmental issues. “The Earth Summit” (United Nations 1992) raised sustainable development to be a worldwide phenomenon and to the concern of all nations. Growing global concerns about climate change, environmental problems such as pollution, biodiversity loss, and about social problems related to poverty, health, working circumstances, safety and inequity, have also promoted sustainability approaches for industry (UNEP 2007). It seems obvious that consumer pressure towards sustainable and environmental behaviour of companies will increase.

Sustainability, corporate social responsibility and related trends have become a part of business agenda for an increasing number of companies worldwide. The earth sets the ultimate limits to natural systems, and because nature has its limits, the material bases of economics are also limited. This means that the goals of sustainable development cannot be possible without considerations of the limits of the environment and natural resources. Understanding how to integrate these concepts into business planning can be an important part of business to be successful.

“The European Commission explicitly recognizes the need for sustainable management and protection of our environment and concludes that environmental protection is a "key duty" that we have for future generations” (Dimas 2005, p.1). Porter and Payne also point out that business has to recognize and acknowledge sustainable development issues as well as to educate others about it (Porter 1996, Payne et al. 2001). Sustainable development is, nevertheless, not clearly recognized among industry. Springett (2003) presents that managers have a very sketchy understanding of sustainable development. They know

something about environmental management but they lack a holistic and deeper understanding of it.

All business relies on their supply base and customers to survive. Many small and medium size companies act increasingly more as subcontractors for bigger companies, which mean that they are essential parts of a supply chains. A sustainable supply chain is defined as being management of raw materials and services from suppliers to manufacturer and through service providers to customers and back (NZBCSD 2003).

There are many initiatives by private and public organisations who are conducting codes of conduct for themselves and their suppliers. Companies can differentiate themselves, reduce costs, and improve service by considering the social, environmental and economic factors relating to their supply chains. The best benefits can be achieved by extending the focus as far as possible upstream towards the raw materials, downstream towards the user and then back again so that the product and wastes can be recycled.

The basic contribution to sustainable development is described to be eco-efficiency. Eco-efficiency is described to be a management strategy that combines environmental and economic performance. It enables more efficient production processes as well as the production of better products and services. At the same time it can reduce resource use, waste and pollution along the entire value chain. (Holliday et al. 2002).

Eco-efficiency creates more value with less impact by de-linking goods and services from the use of nature and it can open up significant business opportunities. Eco-efficiency means producing goods and services with less energy and fewer raw materials, which results in less waste, less pollution and less cost (Rissa 2001, Holliday et al. 2002, UNCTAD 2003).

Referred to environmental management systems, eco-efficiency widens the scope outside the factory gate, and thus it can give more opportunities for companies. Remarkable

economic success can be gained from adoption of eco-efficiency and environmental considerations into company practices (BASF, DuPont, 3M, Ciba-Geigy, Xerox etc.). Most important drivers for environmental considerations and work in SMEs are: commitment of management, consumer demands, reduced resource demand, competition, legislation, demands for subcontractors and increasing legislation (NUTEK 2001, Hillary 1999). Because technological development and economic growth go hand in hand, it becomes possible to adopt eco-efficient solutions into production and consumption (Kutznets 1955).

Eco-efficiency has widely become accepted as a key strategic theme for global business towards sustainable development (Ehrenfeld 2005). There are several methods for incorporating eco-efficiency considerations into business processes.

Material Flow Management becomes central, because material flows, energy flows included, have an essential role in eco-efficiency and sustainable development ideology. Clearest cost saving potentials of eco-efficiency practises can be gained when focusing on the internal material and energy flows (Fisher et al. 2004).

The literature review combines sustainable development, eco-efficiency, strategic and operational management, decision making and adoption of managerial methods together. It also shows that the methods mentioned differ from each other.

Eco-efficiency and described methods can be considered to be strategy tools. Most of the methods mentioned in this work consider management of material flows central for eco-efficiency. The idea behind strategy and managerial tools is to transform “best practises” or theoretical know-how into steps that are integral to the tool. Ideally, use of the tool then releases knowledge in a practical and contextual form that supports more effective strategies and facilitates strategizing. Eco-efficiency combines knowledge, methodology and practice and implies these for linking environmental management and economic results.

Common to most strategic management approaches is the assumption that success has to be defined in financial terms. Strategy tools are an intrinsic part of the modern strategy work, and a well-balanced set of strategy tools has the capability to support strategic success. It is also suggested (Abrahamson 1996) that relationships between the user, the tool, and the context bring difficulties to strategy-tool use and this can make the choice of a suitable strategy tool challenging.

The set of tools selected should work together. They should complement each other, support different viewpoints and facilitat work on issues that require special attention. It is not always clear when to use what tools in practise (Sahlin-Andersson et al. 2002).

This leads to the conclusion that the raised research questions could bring new theoretical knowledge to adoption of eco-efficiency into strategic and operational management of industrial SMEs.

3 RESEARCH METHODOLOGY AND METHODS

The research methodology is action research, and the present study includes a literature review, a multiple-case study, a survey and a case study. The choice of the methodology is based on the following facts:

- The researcher's empirical experience and understanding on the researched issue
- The pressure for small and medium-sized companies to adopt sustainability and eco-efficiency considerations into their practises
- The need of the researcher to develop his knowledge and expertise in order to contribute to the development of a commonly agreed framework and guidelines for helping companies in adopting eco-efficiency

Development questions associated to growth and strategy models of companies concern strategic innovations and business models of companies as well as development of guiding models and operation modes (Baden-Fuller et al. 1996, Markides 1997, McGrath et al. 2000). In this area the strategic questions and how the sharpening of strategy is seen are central. Strategy is not seen as a process guided from top to down, but rather as performed on all levels of the organisation.

3.1 Methodological Choices

Ontology is the branch of philosophy that deals with theories about the structure and behaviour of the world that humans perceive. Oncologists seek to articulate the fundamental types of phenomena that exist in the world, and the relationships that can arise among these different types of phenomena. Ontology can be proposed at various levels of abstraction. At the most general level, ontology articulates the fundamental constructs we need to be able to describe any phenomenon in the world. At any transmit level ontology shows the constructs which are needed to describe particular types of phenomena that

happen in some domain, for example architecture, nursing, and carpentry. At lower levels, ontology shows the constructs which are needed to describe specific worlds. (Green 2005).

The approach of this study is based on realistic ontology. According to Burrell et al. (1979) realistic ontology assumes an understandable and coherent reality to exist. This reality is regardless of an observer and his conceptions of it. The researcher and the researched object are supposed to be independent entities, the researcher obtaining information from the latter, and this makes this study epistemologically an objectivist one. According to Guba et al. (1994), a pure objectivist would say that the researcher does not affect the studied object, in this case an organisation, and, other way around, that the researcher is not affected by the research object. Even though this present study can be classified as an objectivist inquiry, the case organisations may affect the researcher's interpretation, and, other way around, the research intervention possibly have some effect on the case organisations. This way the researcher acknowledges the effects of the cases on him and the effects of him on the cases constituting possible sources of bias (Patton 1990).

The epistemological approach is said to be close to critical realism which assumes real reality but only imperfectly understood (Guba et al. 1994). You can either remain faithful to traditional theory and argue that decisions exist before action, or you can leave traditional theory and argue that decisions do not exist before action. Bos (2000) claims that only if you are willing to make this kind of a straightforward choice, you do not have to struggle with ontology. Mintzberg et al. (1998) notices the same problem with the ideas about strategy which oscillates between a rather straightforward realistic ontology and the belief that you should get off from any ontological claim whatsoever. In the first discourse, the existence of strategy and decision-making is doubted or even totally denied. In the second discourse, strategy and decision-making are assumed to exist in real organisations. According to Bos (2000) when synthesizing all what he has said Mintzberg comes up to a strange proposition, decisions sometimes do exist and sometimes they do not exist.

Chia (1996) has argued that we can learn much from a perspective that decision and action are considered equal meaning that an action is a decision, a decision is an action, and one is not caused by the other. Both action and decision focus our attention on parts of reality. By means of our actions and decisions we cut a part out of reality, and then think this part constitutes the real reality, which is only to say that we make it more important than anything else. Thus, decision and action may be ontological gestures we make in order to create certain realities at the expense of other realities, or of people who believe in them. A strategic decision is thus a way to create realities and to exclude other realities. Whatever we may think of this insight, it nicely applies not only to the way in which strategic decision-makers in organisations create their own realities, but also to the way in which those who have created their own object of study.

The chosen research methodology is action research, and the research methods are a multiple case study, a survey and a case study. Kemmis et al. (1988, p.5) define action research as follows: "*Action research is a form of collective, reflective inquiry that participants in social situations undertake to improve:*

(1) The rationality and justice of their own social or educational practices;

(2) The participants´ understanding of these practices and the situations in which they carry out these practices.

Groups of participants can be teachers, students, parents, workplace colleagues, social activists or any other community member – that is any group with a shared concern and the motivation and will to address their shared concern. The approach is action research only when it is collaborative and achieved through the critically examined action of individual group members."

The definition of action research consists of three parts (Zuber-Skerrit 2001) and they can be described as:

1. Action research is about people reflecting upon and improving their own practise;
2. By tightly interlinking their reflection and action; and

3. Making their experiences public to other people concerned by and interested in the respective practise.

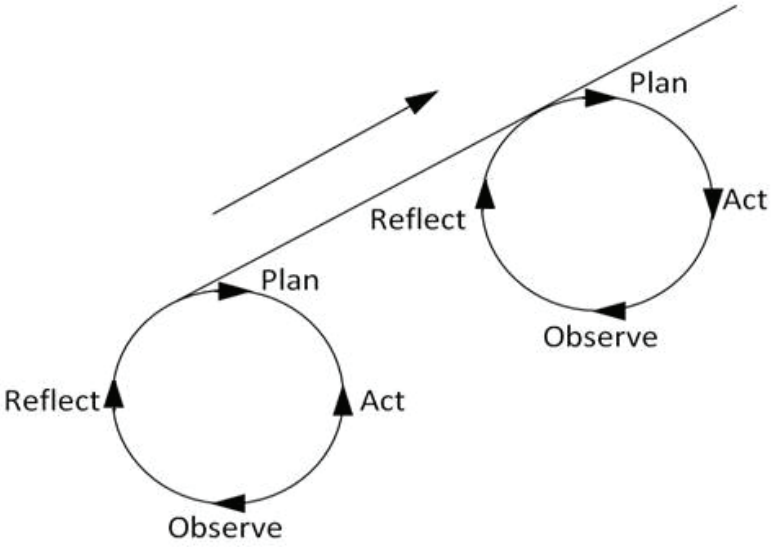


Figure 10 The spiral of action research cycle (Zuber-Skerrit 2001)

Action research aims to develop practical situations and competencies of the participants without essentially telling objectives to be achieved (McNiff 2000). Action research generates practical theory. It is done by people who want to improve their understanding of their practise in order to improve their dealings with others in social situations. Action queries begin by asking questions like how do I improve my work (Whithead 1989). The intension is in the first place to understand the work more completely by studying it and raising awareness, and then by imagining ways in which it can be improved. The research process involves gathering data which generate evidence to show that claims to improved practice are real, and subjecting the evidence to the critical examination of others for their validation that the practice has improved. Personal action research which asks, “How do I improve my work?” is without exception participative, as one researcher looks to another for validation of claims that the work has improved. Winter (1989) points out that action

researchers need to develop their understanding rather than aim to change a particular situation.

McNiff (2000, 206) describes that it is not always important, or even possible, to show how you have influenced a situation but it is important to show how you have developed your own understanding of the situation by engaging with the problematic. You can also show how your improved understanding could now be put to use in this current situation or another.

McNiff (2000) notes also that when people become critically aware of their own personal and social development, they can bring that awareness to the business which threatens human and ecological environments. The research element of action research demands people to observe and monitor their actions and reflect on them. Monitoring and reflecting on practice generates theory. Because the theory is the property of an individual practitioner it constitutes a personal theory of practice. When practitioners consider the knowledge base of their work, and how they have come to that knowledge, they are generating their own epistemology of practice. Doing action research begins with asking, how do I improve my work. Although it is an individual intention, it is always undertaken with others who might be influenced by the research. Action research is always a collaborative effort in that researchers will call on others in the same work grouping to support their claims to new knowledge (or not, as the case may be).

McNiff (2000) presents following important questions when planning action research:

1. What is my research interest?
2. Why am I interested?
3. What kind of evidence will I gather to show why I am interested?
4. What will I do about it?
5. What kind of evidence will I gather to show that what I am doing is having an influence?
6. How will I explain that influence?

7. How will I ensure that any judgements I might make are reasonably fair and accurate?
8. What will I do then?

Answers to the questions above for planning this research are presented below:

1. What is my research interest? In literature and the academic world, eco-efficiency has become a well known phenomenon when considering environmental and economic issues in industry. According to many articles and descriptions, eco-efficiency is a key approach towards sustainable development and securing the sustainable development of companies. There are several methods for implementing and evaluating eco-efficiency. The research interest is whether eco-efficiency can be a key method for strategic management in industrial SMEs.

2. Why am I interested? When working as a teacher, consultant, and a project manager with environmental management topics the researcher had noticed that eco-efficiency is far from well-known among small and medium size enterprises and the public, especially outside the academic and consultative world. Several methods for adopting and implementing eco-efficiency have been developed, mostly by academics and consultants, but there is a lack of guidance for strategic differentiating of the methods and choosing a right or suitable method for a particular situation.

3. What kind of evidence will I gather to show why I am interested? First of all, theoretical knowledge about the adoption and applicability of eco-efficiency methods for strategic management is needed. Secondly, the acknowledgment and the use as well as use intensity of eco-efficiency methods in practise have to be studied. Information about the motivation for adopting or neglecting eco-efficiency methods is also needed.

4. What will I do about it? McNiff (2000) describes that monitoring and reflecting on practice generates a theory. Because a theory is the property of an individual practitioner it constitutes a personal theory of practice. When practitioners consider the knowledge base of their work, and how they came to that knowledge, they are generating their own epistemology of practice. Doing action research begins with asking, how do I improve my work? Although it is an individual undertaking, it is always undertaken in company with others who might be influenced by the research. Action research is always a collaborative effort in that researchers will call on others in the same work grouping to support their claims to new knowledge. This leads to a literature review and discussions with fellow researchers as well as to constitute a field study among companies.

5. What kind of evidence will I gather to show that what I am doing is having an influence? As McNiff (2000) describes it is not always important, or even possible, to show how you have influenced a situation but it is important to show how you have developed your own understanding of the situation by engaging with the problematic. You can also show how your improved understanding can now be put to use, in this current situation or another. The literature review and multiple case study evidence will result in the creation of the frameworks for choosing suitable methods for adopting eco-efficiency practices. The frameworks can then be put to use. Winter (1989) points out that those action researchers need to develop their understanding rather than aim to change a particular situation.

6. How will I explain that influence? The research process involves gathering data which gives evidence to show that claims to improved practice are real and exposing the evidence to critical evaluation of others for their validation that the practice improved. Personal action research which asks, how do I improve my work, is surely participative, as one researcher looks to another for validation of claims that the work has improved. Generated frameworks are presented for validation.

7. How will I ensure that any judgements I make are reasonably fair and accurate? Judgments, which the researcher has made, are presented for external evaluators and for academic audience for criticism.

8. What will I do then? The next step is to present the developed frameworks to companies so that they can judge the applicability of these frameworks for improving their work on eco-efficiency.

Yin (2003) defines a case study as an empirical examination that investigates a existing phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident. Case studies need not always include direct, detailed observations to be a source of evidence. According to Yin (2003) case studies typically use multiple sources of data. Qualitative methods are recommended for descriptive research in order to understand phenomena (Ellram 1996).

A multiple case design was chosen for the present study. The reason for choosing multi case design was the possibility for literal and theoretical replication, and that the analytical conclusions directly arising from multiple cases will be more powerful than those coming from a single case alone. Evidence from multiple cases is often considered more gripping and the overall study is therefore regarded as being more robust (Herriott et al. 1983). Secondly, the contexts from several cases are likely to differ to some extent. If under these varied circumstances the researcher can still arrive at common conclusions from the cases, they will have expanded the external generalizability of the researchers findings, again compared to those from a single case alone (Yin 2003).

A research design is essential for every type of empirical research. The design is a logical series that connects the empirical data to a study's initial research questions and, finally, to its conclusions (Yin 2003). Yin presents that five components of a research design are especially important:

1. A study's questions: the basic question of this present study is how and why SMEs include (or neglect) eco-efficiency considerations into their company strategies and operations. It can be approached in the first stage with the following questions: do SMEs adopt methods and models for implementing eco-efficiency and for evaluating eco-efficiency in practise and which factors enable or disable the adoption of them.
2. Its propositions, if any: environmental considerations have become an important part of the success of companies beside economic questions. Environmental and economic considerations are combined in the eco-efficiency methodology. Eco-efficiency can derive mutual benefits to companies. These issues are described in the introduction and literature review when answering the research question: can eco-efficiency be considered as a key element in business strategies for SMEs?
3. Its units of analysis: units of the study are small and medium size industrial enterprises. In SMEs the decision-making is concentrated to only one or a few persons, which in this case means that the managers of the companies can be considered as representatives for the units of analysis.
4. The logic linking of the data to the propositions: literal replication was used on cases 1-12. Three additional cases, 13-15 (big companies), where used for making theoretical replication. The data received from the case study gives valuable information for designing a framework for differentiating methods of eco-efficiency and guiding in use of these methods in strategic and operational management. Data from the survey gives information for linking the research question, can material flow management be a link to eco-efficiency, to the proposition concerning the use of material flow management as a first step towards eco-efficiency.
5. The criteria for interpreting the findings: criteria for interpreting the data were discussed with the external reviewer (fellow researcher). Findings of the research where evaluated by an external reviewer and posed for public criticism in three scientific congresses. The developed frameworks were presented to eight (8) companies for evaluation of their applicability.

3.2 Quality of research designs

As a research design should represent a logical set of statements, the quality of any given design can be assessed by certain logical tests (Yin 2003). Four tests have been commonly used to establish the quality of any empirical research (Yin 2003, Kidder et al. 1986). The four tests are: Construct validity, internal validity (for explanatory or causal studies, not for descriptive or exploratory studies), external validity and reliability.

1. Construct validity

   Construct validity points to establishing correct operational measures for the constructs which are studied. In case studies construct validity can be improved by using multiple sources of evidence and establishing a chain of evidence.Key informants should review the draft case report (Yin 2003).

2. Internal validity

   This present study is an exploratory study and thus internal validity is not required.

3. External validity

   External validity points out to establishing a domain to which a study's findings can be generalised (Yin 2003). In the present study multiple case study design was used to increase external validity. Analytical conclusions directly arising from multiple cases are more powerful than those coming from a single case alone. Secondly, the contexts from several cases are likely to differ to some extent. If under these varied circumstances the researcher can still arrive at common conclusions from the cases, they will have expanded the external generalizability of the researchers findings compared to those from a single case alone (Yin 2003).

4. Reliability

Reliability refers to demonstrating that the operations of the study can be repeated with the same results. A good instruction for doing a case study is to do the research so that an auditor can repeat the procedures and arrive at the same results (Yin 2003). The reliability of a research study is based on the transferability of the results and on the internal coherence.

3.3 Data Collection

Data collecting methods for the present study are qualitative. Qualitative methods are proposed for descriptive research aiming to understand phenomena (Ellram, 1996).

The researcher participated as a European environmental expert at a Brazilian development project coordinated by UCS, Universidade de Caxias do Sul. The aim of the project was to study the critical points of processes in furniture industry in order to find possibilities for improvements. It included economical-, quality- as well as environmental points of view. Some of the enterprises volunteered as pilot companies for the planned improvements.

The group of companies studied consisted of three big companies (over 250 employees), three medium sized (50-250 employees) and nine small companies (3-25 employees). The industry branch was furniture industry. The size of the company, processes, machinery, use of material (including energy and water), residues and waste, use of environmental management or eco-efficiency methods and use of methods for evaluating eco-efficiency and eco-efficiency indicators used were recorded.

A multiple case study approach was utilised in this present study for studying industrial SMEs and the use of eco-efficiency methods. The multiple case study approach follows guidelines proposed by Yin (2003) and Eisenhardt (1989) which promote consistency in observation, results and data gathered across case organisations. During the first six month period, a questionnaire and interviews were used to reveal the use of eco-efficiency

methods and the motivation for adopting or neglecting those methods. The questionnaire, adapted and modified from the questionnaire used in an environmental management project of Universidade de Caxias do Sul (Schneider et al. 2006), and used in the present research is presented in appendix A. The questionnaire was sent before the interviews, during which time respondents could elaborate on their answers, and motivations. The interviews, among the fifteen companies who answered, ranged beyond this debate into a range of factors and events emerging during implementation and other issues that the respondents found to be important to raise. Open-ended interviews with the managers or management representatives in the companies were conducted, using the questionnaire results as a starting point. The findings from interviews were reported only as a summary and discussed with the interpreter and an external reviewer. The case companies were chosen among furniture industry in South Brazil. The same questionnaire was sent to eight (8) Finnish furniture companies in 2006.

The following step was to conduct a survey, where material flow management issues in industrial small and medium size companies were studied. The aim was to get an answer to the following research question: Can material flow management be a link to eco-efficiency? A survey was used for data collection in Finland. A questionnaire was developed from the former questionnaire used in Brazil. It was sent by email to one hundred and sixty seven (167) randomly selected industrial SMEs in Finland. The questionnaire was attached with an introducing letter. The mailing was repeated after two weeks to those companies who did not respond to the first mailing. The questionnaire was evaluated by two fellow researchers and two company managers before it was emailed.

Finally a case study approach was utilised in this present study for studying the applicability and acceptability of the developed frameworks. An informative letter with four (4) guiding questions was sent by email to eight (8) companies in Finland. Managers of the companies were interviewed within a week after sending the email.

3.3.1 Multiple case study

The selection of an appropriate case population is claimed to be important, because it controls irrelevant variations and helps to define the limits for generalizing the findings (Eisenhardt 1989). The case population was selected from small and medium size enterprises in furniture industry.

Use of methods for implementing eco-efficiency

The main data sources of this study are a questionnaire and interviews. Questionnaires were sent to fifty-four (54) companies in Brazil and eight (8) companies in Finland. A total of fifteen (15) answered questionnaires were returned (28 percent) in Brazil. In Finland no questionaires were returned and no answers were received. The questionnaire is presented in Appendix 1.

A total of fifteen (15) interviews were conducted between March 2005 and May 2005 in Brazil. The interviews lasted between 45 to 90 minutes and were conducted in person. Persons interviewed were managers in the companies and in two cases they where quality managers. The questionnaire (shown in Appendix 1) formed the basis for interviews.

Use of methods for evaluating eco-efficiency

The same data resources, as described above, were used to explore the use of methods for evaluating eco-efficiency. Use of indicators for eco-efficiency where also investigated.

3.3.2 Survey

Material flow management in SMEs

A questionnaire survey among Finnish industrial SMEs focused on material flow management issues was used to investigate the existing practises of material flow management. The survey was performed in 2006. The companies where randomly selected

among industrial SMEs in Finland. The questionnaire, with an introducing letter (Survey questionnaire, shown in Appendix 2), was sent by email to one hundred and sixty seven (167) companies around Finland. Nine (9) companies answered the questionnaire. Additional two (2) companies answered, that they are very small and they do not have this kind of efforts.

3.3.3 Case study

Applicability of the developed frameworks

An interview among Finnish industrial SMEs was conducted in order to evaluate the applicability of the developed frameworks. The interviews were performed in autumn in 2008. The companies were selected from different branches in order to review the applicability more widely. An introduction letter with four (4) guiding questions (Appendix 3) was sent one week before the interview to eight (8) small and medium sized companies in Southern Finland.

3.4 Data Analysis

3.4.1 Qualitative Analysis

The goal of the multiple-case study was to reaveal the use of different methods for implementing eco-efficiency and the methods for evaluating eco-efficiency. The questionnaire was enclosed with an informative letter describing the background for the study and the confidentiality of answers was assured. Questionnaires were analysed according to what extent the different methods were used and known. Interviews were used to deepen the understanding about the reasons for adopting or neglecting the methods described. Interviews were guided by open-ended questions based on the questionnaire, which the companies had already filled in. During the interview, a description of the study was presented and the confidentiality of responses was assured.

3.4.2 Statistical Analyses

The aim of the survey was to study current practises of material flow management in industrial SMEs. A questionnaire with closed-end questions was used. The reason for using closed-end questions was due to the planned use of binomial test for analysis. The survey was performed in January to May 2007. The companies were randomly selected, but in such a way that they represented a broad spectrum of industrial small and medium size enterprises. Only nine (9) companies returned the questionnaire and thus a statistical analysis was not justified. A summary of the results is presented.

All research and writing in Brazil and Finland was conducted by the writer. In Brazil fellow researchers participated in the research only as interpreters during interviews.

4 RESULTS OF RESEARCH

The theoretical knowledge concerning the adoption and applicability of eco-efficiency for strategic and operational management was gathered in the literature review. The literature review gives the answer to the research question Q1: can eco-efficiency be considered as a key element in business strategies for SMEs. The results are presented in section 4.1.

Data from the multiple case study concerning recognition and use of eco-efficiency methods will give the answer to research question Q2: do SMEs use these methods and models in practise. In order to answer this research question a multiple case study, using a questionnaire and interviews was conducted. Based on the results from the multiple case studies it could be noticed that the research question Q3 (Which factors enable or disable the applicability of methods for eco-efficiency) is relevant from a practical point of view and that there is a need for a general and more comprehensive understanding of it from the literature. It was found that knowledge about eco-efficiency was sparse and the use of eco-efficiency methods was rare. Therefore the following areas of literature were examined in order to extract the necessary information for understanding the neglecting of eco-efficiency. These literature areas were: decision-making and adoption of managerial methods.

The results from the multiple case study questionnaires and the literature research generated an interview among the managers who had answered the questionnaire in the multiple case study. The interviews could give a deeper answer to the third research question Q3: Which factors enable or disable the applicability of methods for eco-efficiency. Discussions and co-operation with collaborating researchers was fruitful when designing the questionnaire for the multiple case study as well as when realising the interviews. The answers of the interviews and the literature review on decision-making and adoption theories indicated that material flow management could be a practical approach towards eco-efficiency.

The results from the multiple case study and the survey are presented in three sections. The use of methods for implementing eco-efficiency is presented in section 4.2. Motivations for adopting or neglecting eco-efficiency methods at studied companies are also presented. The use of methods for evaluating eco-efficiency and the use of eco-efficiency indicators are presented in section 4.3. The use of material flow management practices in nine (9) companies is presented in section 4.4. Results from the multiple case study and the survey generated the development of frameworks which could be used to help in adopting eco-efficiency. These frameworks are presented in section 5. The applicability of the developed frameworks is also presented in section 5.

4.1 Eco-Efficiency as a key element in Business Strategies

In many cases eco-efficiency is connected to business strategy but the connection is not clear, especially for small and medium size enterprises. The role of eco-efficiency in business strategy was studied by a literature review.

Research question Q1: Can Eco-Efficiency be considered as a key element in business strategies for SMEs.

Sustainable development is a worldwide phenomenon, which is supported by NGOs (Non Governmental Organizations), governments and the business world. Eco-efficiency is in the centre of this phenomenon, and it has developed into an extensively recognized method for integrating ecological and economic considerations into core business processes. The ecological dimension of sustainable development has become an important part of the global business environment, and thus the natural environment is a strengthening theme in strategic management. It is argued (Ketola 1998) that for assuring long-term survival of the company, linking of strategic environmental visioning and planning is essential.

Eco-efficiency and resource productivity provide the necessary, practical link between environmental performance, sustainability and business value. Financially speaking, eco-efficiency and resource productivity can be considered drivers of market value similar to the elements associated with other business drivers such as tax and cost minimization, profitable growth.

Strategic management is a key activity for organisations´ ability to sustain competitive advantages in the long run. Common to most strategic management approaches is the assumption that success has to be defined in financial terms. In 1990s there has been a prominent change in corporate strategy toward environmental problems: the emergence of sustainability as corporate strategy. Porter et al. (1995) argue that corporate responsibility can lead to more efficient use of resources, better reputation, improvements in investors´ trust, and new market opportunities. The most important difference of the sustainability concept from orthodox management theory is said to be in its realisation that economic sustainability alone is not a sufficient condition for the overall sustainability of a company (Galdwin et al. 1995a). The most broadly accepted criterion for the companies' sustainability consists of efficient use of natural capital. Corporate sustainability is at present accepted as a precondition for doing business (Hedstöm et al. 1998, Holiday 2001).

Management is argued to be equivalent to decision-making (Pugh et al. 1996). Major decisions in organisations are about business effectiveness and that involves both creativity and efficiency, which also means doing the right things and not only doing things right (Drucker 1963). The most important factor when making environmental decisions is the balance between decisions concerning companies´ environmental impacts and economic benefits. It has become difficult to distinguish strategic decisions from operative decisions, as all decision-making probably has characteristics typical to strategic as well as operative decision making. There is scarcely no doubt that sustainable development requires remarkable changes in individual human behaviour, especially in industrialized countries (Wellford 2000, Zabel 2005). In SMEs decision-making is often limited to only one or a

few persons. This indicates that individual attitudes, responsibility and behaviour towards the environment have influence on decision-making.

There are various explanations in the innovation diffusion literature which explain why companies adopt certain managerial technologies (managerial methods, strategy tools) and not others. Strategy tools are developed to support organisations for maintaining and creating strategic advantages. Strategy tools are described to have specific advantages and contours which work best in factual connection and in knowledgeable hands (Brown et al. 2004). It is claimed that tools are often adopted in organisations depending on the institutional forces that rise from the specific environment in which that organisation is situated (Abrahamson 1996). The set of strategy tools actually employed in an organisation is not a consequence of careful planning, but the result of answering diverse needs and pressures at multiple levels. The set of tools that is appropriate for an organisation is said to be dependent on that organisation's special needs. Strategy tools are an inherent part of the modern strategy work, and a well-balanced set of strategy tools has the capability to support strategic success. It is also suggested that relationships between the user, the tool, and the context bring difficulties to strategy-tool use and this can make the choice of a suitable strategy tool challenging (Abrahamson 1996). It is not clear when to use what tools in practise (Sahlin-Andersson et al. 2002).

According to the literature review, it seems obvious, that eco-efficiency fulfils the criteria for being a key element in business strategies.

4.2 Use of methods for implementing Eco-Efficiency in SMEs

The respondents were top managers of the companies, except in two cases, where the respondents were quality managers. Over half, 67 percent, of the fifteen (15) companies had participated in the UCS (Universidade de Caxias do Sul) project concerning process

efficiency. The data from the interviews served as background information for the researcher in order to help in designing the frameworks.

Research question Q2: Do SMEs use Eco-Efficiency methods in practise.

Two large companies and one small company had incorporated eco-efficiency (or related) systems (Waste Minimisation, Cleaner Production, Pollution Prevention and Green Productivity) and eight companies (30 percent) knew of at least one method. Sustainable development, as well as eco-efficiency, is usually not known in SMEs. They did not know the definition for sustainable development nor eco-efficiency, but in discussions they understood something about these issues. As a summary, Eco-efficiency is not usually known at enterprises nor do they know different methods for incorporating eco-efficiency (except for the biggest ones).

Research question Q3: Which factors enable or disable the adoption of Eco-Efficiency methods.

The development and use of eco-efficiency methods has a lot of limitations and challenges in companies. Understanding the terminology is difficult and the needs and benefits of incorporating eco-efficiency are not clear to most companies who don't have trained personnel. For companies, especially for small and medium size enterprises, it is not easy to modify existing information systems and management practices to incorporate these considerations.

It is also difficult to find the connection between environmental parameters and value parameters which have functional value, for example for decision-making. The three key areas within the furniture sector where greatest ecological and economical efficiency can be achieved are use of raw materials (mainly wood), energy use and VOCs (volatile organic compounds) used for coating.

Motivations for adopting or neglecting eco-efficiency are rather similar to those for adopting environmental management systems. The difference is in the respect that eco-efficiency and related methods are more unknown than environmental management systems. Main drivers for eco-efficiency considerations are legislation, stakeholders and market and customer demands. University and consultant co-operation has a positive influence on these considerations, especially when financial support is available. Main barriers identified are lack of human and financial resources, lack of time, and lack of knowledge and information, which seem to have an influence on motivation. Environmental work is in most cases considered as cost demanding.

Very encouraging is, however, that some enterprises have implemented improvements, which can be considered as eco-efficiency improvements, in their processes. The main driver for these improvements has almost without exception been purely economical. Examples of eco-efficiency related improvements observed during company visits were: changing painting nozzles to smaller ones using less paint is due to saving in paint costs, using smaller pieces of wood board by attaching them together with finger joints or with glue saves money in terms of "new" wood board and saving in waste costs. Additional examples are re-use of plastic foam pieces by making new plastic foam out of it, wood chips and saw dust can be used as energy resource for heating (for example at a near-by brick factory), paint filters made from paper can be used instead of water screens (filters can be disposed more ecologically than polluted water) in painting cabins. These kinds of improvements improve economical efficiency, but at the same time they are also ecologically efficient improvements because they save resources.

	Company **Small and Medium Size Companies**	Workers	Expertise	Use of methods	Know EE	**Ind.used** Quant./$ Products	**Ind.used** Environm.
1	AMB M´0veis e Decoracoes Ltda	3	Q		3	no	EAMW
2	DS Móveis e Decoracoes	6			1	Quant./$	EAMW
3	Formaden Móveis	9	Q,HS		1	no	EAMW
4	Madenobre-Indústria e Comércio de Madeiras Ltda	10	Q		3	no	EAMW
5	Majestic Indústria e Comércio de Estofados Ltda	12	Q,E,HS		6	no	EAMW
6	Mobi Móveis Laqueados	3	Q,E	1		no	EAMW
7	Móveis Biondo	3	Q,HS		1	no	EAMW
8	Móveis Cosilar	25	Q,E,HS			no	EAW
9	Móveis Dalla Costa Ltda	96	Q,E,HS			no	E,Wwood
10	Móveis Tremarin Ltda	50	Q			no	no
11	SCA Industria de Móveis Ltda	195	Q,E,HS		2	no	E
12	Tocchi Móveis	10	Q,HS			no	EAMW
	Big Companies						
13	Móveis Carraro S/A	816	Q,E,HS	4	3	no	no
14	Treboll Móveis Ltda	360	Q,E,HS	1	10	no	no
15	Chies. Chies e Cia Ltda	260	HS		8	Quant./$	EAMW
	Expertise: Q=Quality, E=Environmental,HS=Health&Safety	Env. Indicators: E=Energy,A=Water,M=Material,W=Waste EE=Eco-Efficiency					

Table 4 Summary of the multiple-case study questionnaires

As a conclusion of the use of methods for implementing eco-efficiency the following can be noticed. Environmental issues do not seem to be of high priority in decision making in SMEs. One major reason is that they are still mostly considered to be cost resulting issues. Main reasons for uptake of environmental and ecological issues into decision-making and practise at SMEs are authorities, legislation and client demands. On the other hand, many companies have already focused and put effort on avoiding extra costs such as waste costs, optimising material and water use, and improving energy use to increase their profit. In most cases companies do not regard these improvements as ecological effectiveness: they are implemented for their economic benefits.

The strategic basis of Cleaner Production (CP) and Pollution Prevention (PP, P2), as well as Eco-efficiency and most concepts lay on Life Cycle Assessment / Life Cycle Analysis

(LCA). LCA consists the whole life cycle from natural resources extraction to production to use to ultimate disposal. The information from LCA is used to design products and services in order to reduce the impacts, and to increase the sustainability of the products and services and the entire life cycle chain of production. This is also called Design for Environment or Green Design. For SMEs, Design for Environment usually appears to be too time-consuming and too expensive to implement.

4.3 Use of methods for evaluating Eco-Efficiency in SMEs

The second part of the multiple case study was conducted as a part of a project where environmental management systems in the furniture industry in the Serra Gaucha region of South Brazil were studied in 2004-2005 (Schneider et al. 2006). The main areas of concern in environmental impacts of the furniture industry are energy use, water use, wood related waste (dust, sawdust, woodchips and -pieces), plastics, painting residues (liquid waste, paints, lack, cans, solvents) and glue residues.

None of the case companies used any of the described methods for evaluating eco-efficiency. Despite this, 44 percent of the case companies used one or more of the indicators asked. Only one of the three large companies used all indicators mentioned, even though they did not have any eco-efficiency or environmental management system, while the other two large companies, having implemented an eco-efficiency system, did not carry out any measures on a regular basis. All three large companies mentioned had an environmental or quality manager. In the medium sized companies (50-195 employees), only energy use was measured by two of them on a regular basis. Among the small companies, nine (43 percent) measured energy use, water use, material use and waste amounts, and one company additionally used economical indicators. The main waste components measured were wood residues (woodchips and -pieces, sawdust) due to delivery to a brick plant situated in the area. Energy and water use were measured due to

their high volume and economic value. The use of different indicators is illustrated in Figure 11.

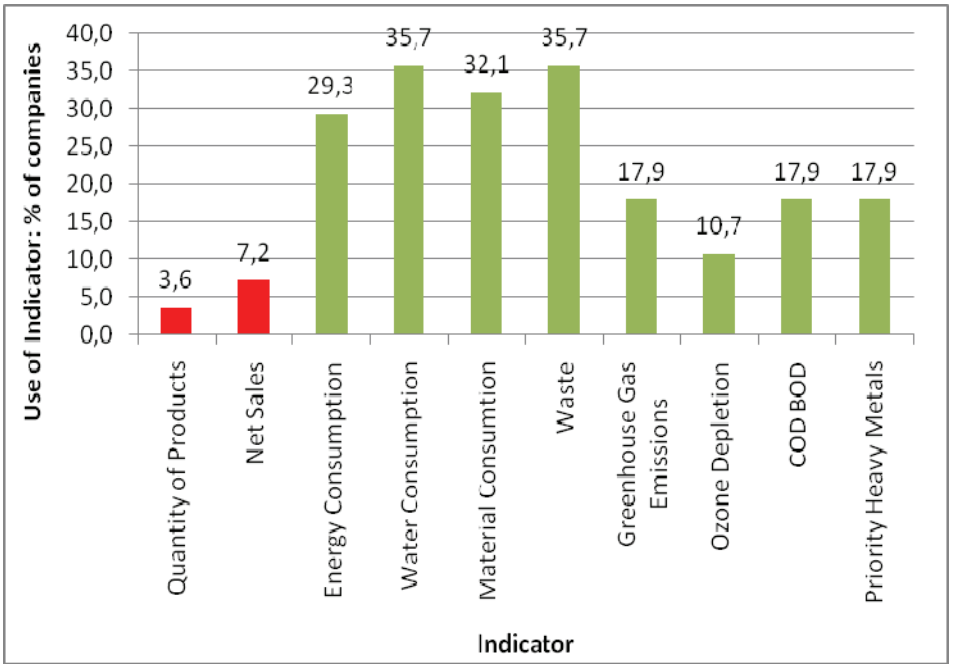


Figure 11 Use of indicators in SMEs

The conclusions concerning the use of methods for evaluating eco-efficiency can be summarized as follows: The studied companies did not use the described methods to evaluate eco-efficiency: they did not even recognise them. Despite this, about 80 percent of the companies did use some environmental indicators even though they did not use economical indicators (only two companies did use). An interesting point is that there does not seem to be a relationship between whether the company has an environmental management or eco-efficiency system or not, and the use of indicators.

4.4 Material Flow Management in SMEs

This section describes the practices of material flow management in eight companies in Finland and it gives an answer to the fourth research question:

Research question Q4. Can material flow management be a link to eco-efficiency?

According to the findings of the multiple case study it seems that material flow management can be considered as a link to eco-efficiency.

Results from the multiple case study and the interviews showed that companies had done material improvements which were connected to material handling and material flows. This notice raised the question if material flow management could be a first step towards eco-efficiency.

Current situation and practices of material flow management (MFM) and accounting in eight Finnish companies was studied with the survey. The survey concentrated on implementing, refining and disseminating MFM approaches and accounting issues in SMEs. Difficulties and possibilities for using or avoiding relevant methods were also discussed.

The companies that were studied were three metal companies, two technology companies, two furniture / wood companies, and one chemical company. All the companies were SMEs. The information related to the survey was gathered by questionnaires.

Results of the survey were analyzed in respect to the seven WBCSD recommendations for success factors for eco-efficiency. The factors' linkages to MFM were taken into account. Measuring and evaluation practices were also considered. The following issues were considered in more detail:

- Material reduction efforts

- Energy saving efforts
- Eliminating or reducing toxic dispersion efforts
- Enhancing material recycling efforts
- Accounting and evaluation

Material Reduction

The majority of the companies (88 %) had already made material reduction improvements related to material flows. The main motivation for realised improvements was financial benefits. Material prices had increased often more than the company had accounted, and all the costs could not be set on the prices of the products. Companies had also discovered that material which is left over can be used in other products.

Energy Saving

Most of the companies had made improvements in saving energy (75 %) and half of the companies (50 %) had improved their energy efficiency. These efforts were done mainly because of financial reasons as a result of increasing energy costs and decreasing profit margins.

Toxic and Hazardous Substances

Improvements in the elimination and reduction of hazardous substances in companies (73 % and 71 %)) were mostly done due to environmental legislation. The companies' image (and building of it) may also have had an influence on these improvements.

Material Recycling

Material recycling was considered in half of the companies. Main recycling activities were concentrated on recovering the surplus materials and packaging issues.

Accounting and Evaluation

Both eco-efficiency and MFM point out the need for accounting and evaluation practises. Most of the companies do evaluate or count material flows to some extent, but only one

company had implemented the ISO 14031 standard and one uses environmental cost and profit calculations.

The accomplished improvements in the studied companies are presented in the following table (Table 5). All companies did not answer all questions and thus the total number of answers for all questions is not always eight in table 5.

Accomplished improvements	Practise / do not practise	Practise %
Material use has been improved	7/1	88
Surplus material is collected	8/0	100
Separate collection	5/0	100
Energy saving actions implemented	6/2	75
Improvements in production processes	5/3	63
End of life exterminating improvements	3/5	38
Disassemble of materials improved	4/4	50
Recyclables of materials improved	4/4	50
Energy efficiency improvements	4/4	50
Guidance for end of life phase	3/5	38
Hazardous substances replaced with less hazardous	6/2	75
Use of hazardous substances decreased	5/2	71
Use of water decreased	3/5	38
Water purification	2/6	25
Waste assorted	8/0	100
Waste minimization	5/3	63
Minimization of packaging material	4/4	50
Use of incoming packaging	5/3	63
Use of recyclable packaging materials	4/3	57

Table 5 Material flow management practises in SMEs

Conclusions of material flow management can be summarized as follows:
A considerable part of ecological problems and environmental risk potential are caused by resource consumption and handling of material flows. Eco-efficiency and sustainable development issues are, however, not commonly recognized by small and medium-sized enterprises (SMEs). Material flow management (MFM) is relatively unknown as a method

though more than a few companies have improved their processes and operations in respect to material flows. The main reason for this has been financial benefits.

The eco-efficient optimisations of material flows aim at reducing costs, which means that quantitative and financial accountings should also be considered. Several companies have evaluated and even calculated material flows, although they do not use any identified method or tool for accounting. Despite of this, SMEs are not aware of the many economic benefits that can be achieved with efficient MFM. Understanding these benefits could make MFM and eco-efficiency also more acceptable and widely used. The main reasons for neglecting eco-efficiency or MFM issues are the following: Lack of time, lack of personnel to adopt methods in question, and methods are considered to be too complicated and exhaustive.

4.5 Conclusions

As there are numerous alternatives for organizing production processes, it is very difficult, almost impossible, for SMEs to comprehensively assess the environmental impacts of their production, and at the same time know all the economic implications which a change in their processes or inputs might have. Moreover, most SMEs are not always even aware of alternative production processes and accessible technologies, which could help them to meet the double target of producing in an economically viable and environmentally sound way.

The development and use of eco-efficiency methods has a lot of limitations and challenges in companies. Understanding the terminology is difficult and the needs and benefits of incorporating eco-efficiency are not clear to most companies who don't have trained personnel. For companies, especially for small and medium size enterprises, it is not easy to modify existing information systems and management practices to incorporate these considerations. Most often the management does not have enough knowledge about eco-

efficiency and how to combine these considerations into different processes and practises in the company.

Concerning strategy work and use of eco-efficiency methods, the multiple-case study and the survey clearly show that eco-efficiency and related methods are far from known among industrial SMEs. Some companies have made material efficiency related improvements, but they are initiated mostly for economical reasons.

5 DEVELOPMENT OF FRAMEWORKS

Frameworks to help in the adoption of eco-efficiency in strategic and operational management and frameworks for deciding suitable methods for implementing and evaluating eco-efficiency in industrial SMEs are presented in this chapter.

Concerning strategy work and use of eco-efficiency methods, the multiple-case study and the survey clearly show that eco-efficiency and related methods are far from known among industrial SMEs. Some companies have made material efficiency related improvements, but they are initiated mostly for economical reasons. This action research suggests the following novel frameworks, which can be used in industrial companies when adopting eco-efficiency methods and practices.

5.1 Sustainability, Eco-Efficiency and Business Strategy in SMEs

The first framework, Framework of sustainability and business strategy for SMEs (figure 12), connects sustainability strategy to other business strategies. Michael Porter (1991) argues, that environmental issues and strategic management are clearly connected to each other. According to him the act of bringing a company into line with its business environment to maintain a dynamic balance is a strategic issue. The ecological dimension of sustainable development has become an important part of the global business environment, and thus the natural environment is a strengthening theme in strategic management.

Sustainability strategy has become as important as other more traditional strategies, such as marketing strategy, production and technology strategy, personnel strategy and financial

strategy. Sustainability and eco-efficiency considerations are connected to all other strategies in the business strategy as described in figure 12.

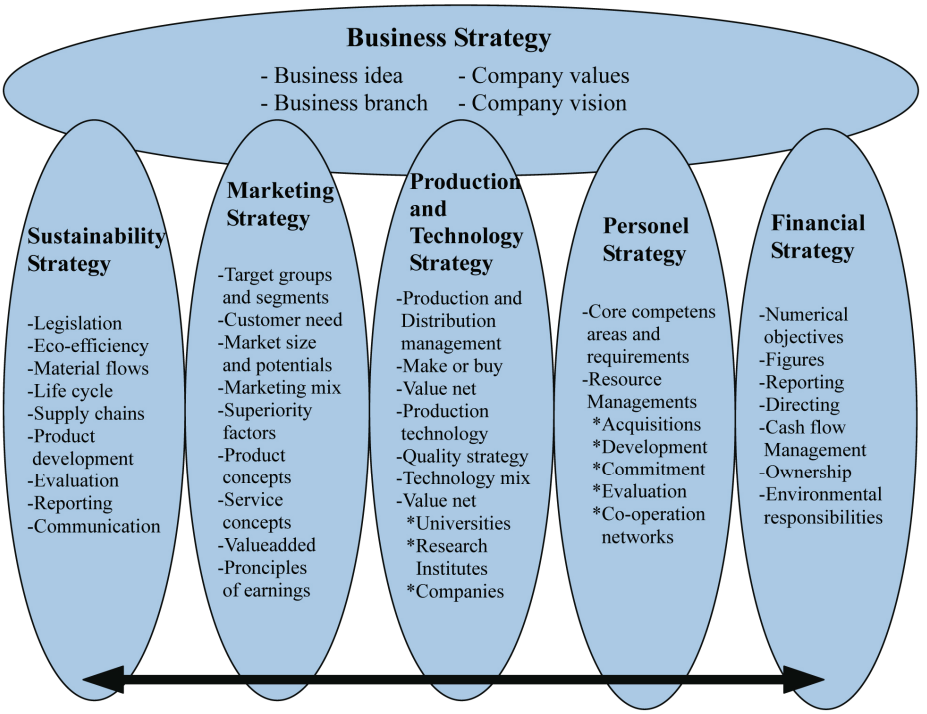
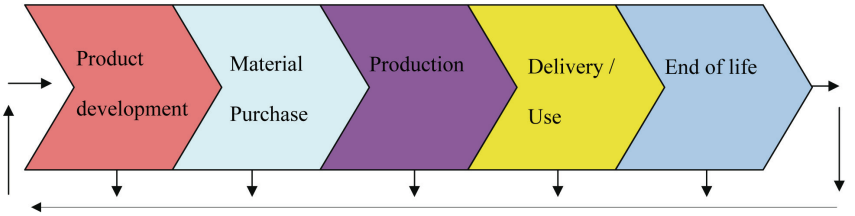


Figure 12 Framework (1) of sustainability and business strategy for SMEs

Sustainability and ecological improvements can be benefited in marketing strategy. Many international programs, such as ETAP (Environmental Technology Action Plan) in EU, point out the need for sustainability considerations, e.g. best available techniques (BAT) in production and technology strategy. EU also involves business and social partners to foster cooperation and common responsibilities to achieve sustainable consumption and production. The need for sustainability and eco-efficiency expertise and knowledge is an issue of personnel strategy, and sustainability issues can have an important influence on the financial strategy. Sustainability considerations in business strategy are difficult issues for SMEs, but they should be taken into account, especially when SMEs are parts of supply chains.

5.2 Eco-Efficiency in different process strategies

Decision-making involves the analysis of different alternatives and their consequences, and the subsequent commitment to action, usually in connection with a commitment with resources (Janssen 1992, Kirkwood 1997). The second framework illustrates necessary considerations for different process strategies in the life cycle of production, from raw material extraction to production, use, and end of life of products.



BAT

Recycling

Functionality

User phase, durability, energy use

Packaking

Logistics

Use of toxic material

Save rare materials

Material intensity

Environmental impact

Legislation

Design

Storage

Primary or secondary material

Origin of material
-extraction
-distance
-labour
-energy source
etc.

Transportation

Storage

Availability
-replacement possibility

Energy supply
-solar, water, coil, wind, oil...

Material use, by-products, waste, faults, other use

Material recovery

Process efficiency

Competence

Production efficiency

Process control

BAT

Logistics, form of transportation

Packaking

Delivery distance

Information logistics

Logistics co-operation (combined logistics)

Use and maintenance instructions

Use of energy

Ecological effects

Health and safety issues

Reuse possibilities

Recycling possibilities

Instructions for consumers

Disassembling

Material recovery

Parts recovery

Energy use

Waste management considerations: incineration, landfill

Take-back

Figure 13 Framework (2) of Eco-Efficiency considerations in different process stages in SMEs

5.3 Methods for implementing Eco-Efficiency

As there are numerous alternatives for organizing production processes, it is very difficult, almost impossible, for SMEs to comprehensively assess the environmental impacts of their production, and at the same time know all the economic implications which a change in their processes or inputs might have. Moreover, most SMEs are not always even aware of alternative production processes and accessible technologies, which could help them to meet the double target of producing in an economically viable and environmentally sound way.

In order to support SMEs in their efforts to meet international standards and improve their production processes, eco-efficiency methods and evaluation tools should assist in the development and optimisation of production processes, while considering commercial and environmental aspects at the same time. The objective of these tools should be on identifying production processes yielding the best environmental performance at the lowest possible cost. In this respect eco-efficiency methods and eco-efficiency analysis are strategic instruments, which can assist SMEs in their selection of the most cost-effective and environmentally sound production processes. A unifying concept, guiding both public and private decision makers, could foster sustainability more strongly.

Abrahamson (1996) suggested that relationships between the user, the tool, and the context bring difficulties to strategy-tool use and this can make the choice of a suitable strategy tool challenging. Overall, in a dynamic social setting with changing markets and with different demands on tools, it is quite clear that no single strategy tool is adequate for every purpose. The task of finding just one, most suitable strategy tool, is therefore not appropriate. Rather the task is to compile a set of tools that jointly cater to different contextual needs and demands, and to support different forms of strategy work. Collecting a set of strategy tools, rather than just concentrating on individual tools, increases the freedom of choice. The set of tools selected should work together by complementing each other, supporting different viewpoints and facilitating work on issues that require special attention. Sahlin-Andersson

et al. (2002) point out that it is not always clear when to use what tools in practise. The following framework, presents possibilities for choosing a suitable method.

ECO-EFFICIENCY CONCEPT	STAGE Raw material	Pro-duction	Trans-port	Waste	Energy	Use	Eco-nomy	Society	Inno-vation	Ser-vice	Design focus
Biomimicry	(x)	x		(x)	x				x		x
CP	x	x	x	(x)	x		x		x		(x)
DfE	x	x	x	x	x		x	x	x	x	x
Eco-Controlling	(x)	(x)	(x)	(x)	(x)		x				
Eco-Design	x	x	x	x	x		(x)	(x)	x	x	x (*)
ECO-EFF.	x	x	x	x	x	x	x	(x)	x	x	(x)
Eco-Innovation	x	x	x	x	x	x	(x)	(x)	x	x	x
EMAS	(x)	(x)	(x)	(x)	(x)						
GP		x	(x)	(x)	x	(x)	x	x	x		
IE	x	x	x	x	x		(x)	x			
IPP	x	x	x	x	x	(x)	x	x	(x)	x	(x)
ISO 14001	(x)	(x)	(x)	(x)	(x)						
Lean Manufact.		x	x	x	x	x	(x)			(x)	
POEM	(x)	(x)	(x)	(x)	(x)						x
PP	x	x	x	(x)	x		x		x		(x)
RC	(x)	x	(x)	(x)	(x)		x	(x)			
WM	x	x	x	x	x	x	x		x		(x)
Zero Waste	x	x			x	x		(x)	x		(x)
	x= included		(x) = indirectly included				* = for existing products				

Table 6 Framework (3) for Eco-Efficiency methods and different aspects of evaluation

For companies there can be four opportunities for achieving eco-efficiency (Holliday et al. 2002).

1. The move to selling services rather than selling products (concentrating on the user phase). In this way companies can save in material costs, reduce pollution and avoid risks.
2. Companies can re-engineer their processes to reduce consumption of resources, reduce pollution, and avoid risks while simultaneously saving costs (production phase). Process changes can also be related to delivery or to supplier operations as well as to distribution, customer use, or disposal (Lehni 2000).
3. Companies can co-operate with other companies to find creative ways to revalorize their by-products, which is a possibility for selling their waste products to

companies that can use them as feedstock (relates to the purchase phase). This is in line with eco-efficiency as it allows the creation of more value with fewer resources and less waste.

4. Redesign their products (product development phase). Products designed to ecological design rules can often be cheaper to produce and use.

When considering the use of eco-efficiency methods in different stages of the whole process, they can be recommended as in the following framework. The framework of methods for different process strategies for SMEs is based on above mentioned remarks and can help companies in finding the most suitable method for their needs.

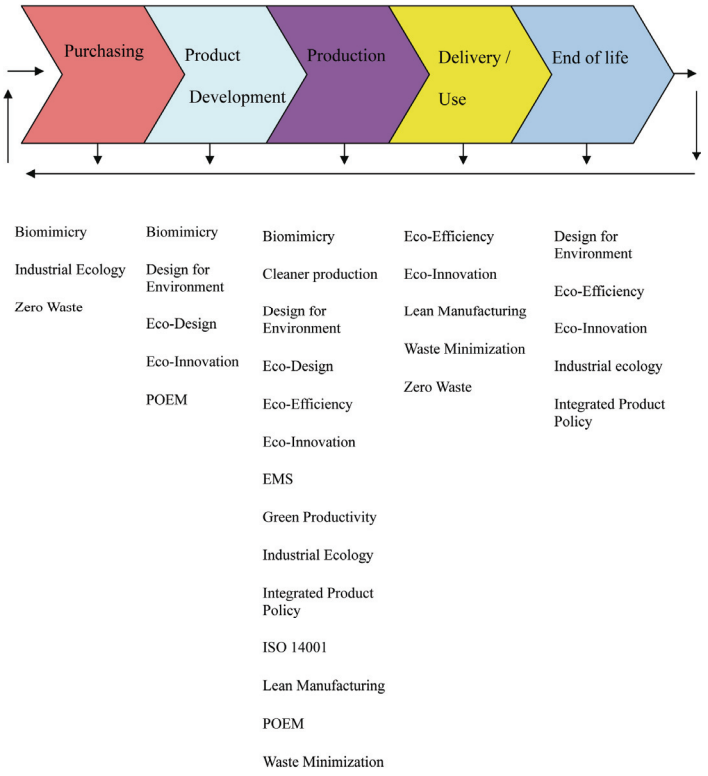


Figure 14 Framework (4) of Eco-Efficiency methods for different process stages in SMEs

The development and use of eco-efficiency methods has a lot of limitations and challenges in companies. Understanding the terminology is difficult and the needs and benefits of incorporating eco-efficiency are not clear to most companies who don't have trained personnel. For companies, especially for small and medium size enterprises, it is not easy to modify existing information systems and management practices to incorporate these considerations.

5.4 Methods for evaluating Eco-Efficiency

SMEs increasingly acknowledge the importance of environmental issues. The furniture industry in Brazil is striving to reach US and European markets, and realises the need for environmental issues to be considered thanks to increasing material, energy and waste costs, the need for compliance with environmental legislation, and permit conditions. Despite these needs, SMEs seem to lack the management capability and sufficient personnel experienced in environmental issues, which prevents the uptake of environmental management and eco-efficiency systems. SMEs found it unpractical and meaningless to evaluate or measure greenhouse gas emissions, ozone depleting substances, and priority heavy metals, especially because legislation already limits the use of substances causing these impacts. There did not seem to be a relationship between whether the company had an environmental management system or eco-efficiency system or not, and the use of indicators.

In this study, several methods for evaluating eco-efficiency and included indicators are compared. This work aims to find a framework for identifying correspondence and variation between selected methods and indicators used for evaluating eco-efficiency. Eleven (11) commonly described methods are compared. The focus of the study is on the applicability of these methods and tools for SMEs. Methods compared:

DEA (Data Envelopment Analysis)
Eco-Compass

Ecological rucksack (backpack)
Eco-efficiency Analysis (EEA)
Environmental management Accounting (EMA
EPE (Environmental Performance Evaluation)
GRI (Global Reporting Initiative)
ISO 14031
LCA (Life Cycle Analysis)
MAIA (Material Intensity Analysis)
MIPS (Material Input Per Service Unit)

There are various approaches for categorizing methods and tools for evaluating eco-efficiency aspects and performance. They can be described in relation to different characteristics, stressing, for example contextual, methodological and generic issues (Baumann et al. 1999, Wrisberg et al. 2000). Important characteristics for these methods and indicators, especially for SMEs, should be that they are easy to understand, use and interpret. They should have a clear connection to daily operations.

In this work, the focus is on the following aspects:
1. Procedural or analytical aspects (Table 7)
Procedural tools focus on the procedures and stages of using a tool. Analytical tools centre on technical aspects. The use of specified indicators is considered here as a technical aspect.

Methods for evaluating eco-efficiency		
Method	Procedural	Analytical
DEA		x
Eco-Compass	x	x
EEA	x	x
Ecological rucksack		x
EPE/EPA	x	(x)
GRI		x
ISO 14031	x	(x)
LCA	x	(x)
MAIA		x
MIPS		x
(x) Guidance		

Table 7 Framework (5), Procedural or analytical aspect

The advantages of DEA are its immediate applicability to multiple-input multiple-output technologies, and the minimal assumptions about the production technology. It can handle inputs and outputs without knowing the price or the weights, and it produces one single measure for each DMU which can be compared to other DMUs (Blumenberg 2004). The main limitation of the method can be its requirements for extensive data and that DEA only calculates relative efficiency measures (Kuosmanen et al. 2005). This method can be considered as an analytical method.

The Eco-Compass (Fussler et al. 1996) is argued to be one of the best streamlined Eco-innovation tools. The benefits of Eco-Compass appear especially in combining environmental data into a simple model, which would assist in the integration of environmental issues within the business decision process. Eco-Compass is mentioned to be a comparative tool for evaluating existing products or for comparing a current product with new development options, and it is possible to identify opportunities to eco-efficient

innovations (Fussler et al. 1996). It gives a concrete set of indicators that drive and measure economic, social and environmental performance (Raising the Bar 2004). Eco-Compass can be used as a procedural as well as an analytical method.

Eco Efficiency Analysis (EEA) serves well as a basis for decisions regarding new investments, or for optimizing product development processes. EEA is a systematic methodology for incorporating a broad range of environmental impacts and costs into processes and products regarding decisions, and the method is capable of handling a large number of environmental impact categories over the entire product life cycle, which can be seen as advantages of EEA (Shonnard et al. 2003). The advantages and disadvantages of EEA are mainly the same as with LCA. EEA can be used as a procedural as well as an analytical method.

The Ecological Rucksack method focuses on reducing material intensity and increasing resource efficiency. It can be used for decision making when comparing different product possibilities. The benefit of ecological rucksack is that calculations are comparatively easy to carry out, and it makes hidden material flows visible (Rissa 2001). The main use is in product design and comparing different product possibilities (Schmidt-Bleek et al. 1998). Ecological Rucksack can be considered more as an analytical method.

ISO 14031 describes a process for counting environmental performance and gives guidance on the design and use of environmental performance evaluation (EPE) within an organisation. ISO 14031 is recommended to be used as the primary approach for selecting specific environmental influence indicators in a sector or a company. It can be used as a screening stage for Life Cycle Assessment (LCA). It is a procedural tool (ISO 1997) and can be used to aid decision-making.

Life Cycle Assessment (LCA) can be used to support strategic and operational decision-making and awareness rising (internal learning purposes), but it can also serve as a tool for communication (Baumann 1998). Life cycle approaches provide valuable information, but

they are costly and time consuming, because they require collection of process and emissions data from all life cycle stages, and are thus impractical to use on a regular basis (Steen 2005). For indicators based on LCA it is not typically possible to allow comparisons over time, as the data is case-specific and usually collected only once. It is also difficult for companies to understand what the results mean for their finances (UNCTAD 2001). Fussler et al. (2006) claim that LCA is an important tool for collecting and analysing data, but the final assessment is so complex that it is difficult to base decisions on this method only. The benefits of LCA, compared to other environmental management tools are as follows: significant impacts in the life cycle become obvious, and trade-offs between improvements at one life cycle stage and increased impacts at another life cycle stage are exposed (Brady 2005). An LCA offers a good view of the used materials and processes (Steen 2005). LCA is more a procedural method but serves also as an analytical method.

MAIA quantifies the material intensity of products and services and demonstrates options for material and energy savings in industry in order to increase resource productivity and supports sustainable product design (Schmidt-Bleek et al. 1998). It has been conceived of as a screening step for LCA. It has also been used to apply the concept of dematerialisation in practice and to contribute to the implementation of eco-efficiency (factor 4 to 10). MAIA is considered as an analytical method.

Material Intensity per Product Service (MIPS) can be used also for communication and to support decision-making. It gives combined information on complex life cycle wide environmental impacts (Busch et al. 2006); it can also be used as a simplified LCA and a screening method for LCA (Rissa 2001). The use of one unit for mass and energy (kg), so that it can be used to monitor progress in dematerialisation, and that the symbol MI of an ecological rucksack is easy to understand, can be seen as advantages (Rissa 2001). MIPS does not consider the difference between different kinds of material streams and their possible toxicity, which is a weakness (Rissa 2001). The basic calculation is clear and easy, but it is difficult to define or quantify the service part of a product (Moffatt et al. 2001, Ritthoff et al. 2003). MIPS is mainly an analytical method.

Most of the concepts for evaluating eco-efficiency are based more or less on life cycle thinking. In respect of how easy it is to understand, use and interpret these methods, MIPS and Eco-Compass can be appropriate for SMEs. These methods also have a clear connection to daily operations.

2. Indicator aspect (Table 8)

Various indicators are used to evaluate ecological and economic aspects. The selection of indicators used in this comparison is based on WBSCD and UNCTAD proposals for generic indicators in evaluating eco-efficiency (Verfaillie et al. 2000; UNCTAD 2001) added with chemical and biological oxygen demand (COD, BOD) and priority heavy metals (PHM). Indicator aspects of different methods for evaluating eco-efficiency are presented in the following framework.

Methods for evaluating eco-efficiency GHG= Green House Gases, ODS= Ozone Depleting Substances, COD= Chemical Oxygen Demand, BOD= Biological Oxygen Demand											
Indicator	Sales	Net	Energy	Water	Material	Material	Waste	GHG	ODS	COD	PHM
	Product	sales			Extract	Use				BOD	
Method											
DEA			x	x	x	x					
Eco-Compass			x	x	x	x					
EEA	x	x	x	x	x	x	x	x	x	x	x
Ecological rucksack			x	x	x	x	(x)				
EPE/EPA	(x)	(x)	x	x	x	x	x	x	x	x	x
GRI	x	x	x	x	x	x	x	x	x	x	x
ISO 14031	(x)	(x)	x	x	x	x	x	x	x	x	x
LCA			x	x	x	x	x	x	x	x	x
MAIA			x	x	x	x	(x)				
MIPS			x	x	x	x	(x)				

Table 8 Framework (6), Indicator aspect of methods for evaluating Eco-Efficiency

Most of the methods described above are appropriate for evaluating ecological aspects of companies' operations and comparing dissimilar options or possibilities. WBCSD recommends sales of products and net sales as indicators for eco-efficiency, but only EEA, which is mainly a procedural method, and GRI, mainly a method for reporting to external interest groups, include them. In other methods, economic issues are evaluated in relative terms when comparing possible improvements or savings between alternative choices. For SMEs, MIPS and Eco-Compass could be recommended, even though they do not include all indicators. As mentioned in the conclusion, SMEs do not find it reasonable to evaluate or calculate GHG, ODS, COD, BOD and PHM.

Most companies did not have qualified personnel in these issues, and so the understanding of needs and benefits which can be achieved by using eco-efficiency methods and indicators, is not clear or known. Lack of consensus on methods and indicators to be used systematically worldwide may also have an influence on the recognition and uptake of them in companies. It is especially unclear for companies as to which method would be the most suitable one in their company and field of business. Companies find it also difficult, or even impossible, to measure or value an innovation that emerges from eco-efficiency considerations or reputation benefits.

The development of methods and indicators for evaluating eco-efficiency still faces a challenge to make them attractive and applicable for SMEs. To enhance the use of eco-efficiency evaluating issues, only a few indicators should be selected at the beginning to test the availability and use of data, and understanding the philosophy behind evaluating eco-efficiency. Thus, the first step to make eco-efficiency issues more understandable and important to companies could be to start with a few environmental indicators at materials and energy flow level, and an economic indicator such as quantity of products provided to customers. These indicators are usually sufficient to identify existing optimisations and cost-saving potential. They are commonly accepted, clear, and straightforward indicators and they do not demand expertise to use them. The second step would be the uptake of an

evaluating method. MIPS and Ecological rucksack could be advisable methods for evaluating eco-efficiency, because they are relatively easy to carry out and understand.

One of the main objectives of increasing the uptake and use of eco-efficiency and related evaluation methods is to make them more widely known by authorities, public organisations and training institutes.

A considerable part of ecological problems and environmental risk potential are caused by resource consumption and handling of material flows. Many companies already improve their material flows, but they do not recognize these efforts as eco-efficiency improvements. Material flow management and related accounting systems are a potential possibility for SMEs and their supply chains to start working on their eco-efficiency and sustainability considerations. Possibilities for enhancing the implementation of MFM or eco-efficiency issues are either to make the evaluation and accounting methods easier to implement or to get help from eco-efficiency experts or consultants. The key question for using external help within SMEs is costs, and thus the use of experts or consultants needs also financial support.

Nevertheless, MFM and related accounting systems are a potential possibility for SMEs and their supply chains to start working on their eco-efficiency and sustainability considerations. Companies do already have parts of these methods in practise.

5.5 Applicability of the developed frameworks

In this section the acceptance and applicability of the developed frameworks is discussed and it gives the answer to the fifth research question:

Research question Q5. Can the developed frameworks help enterprises in adopting eco-efficiency in their strategic and operational management?

According to the answers of studied companies it seems that frameworks 1, 2, 3 and 6 are at least useful. Frameworks 4 and 5 were considered not so useful.

In the case study the acceptance and applicability of the developed frameworks was evaluated. The interviewed companies were from different branches. The companies that were studied were two metal companies, one chemical company, one print house, one furniture company, one logistics company, one cable company and one textile company. All the companies were SMEs. The information related to the case study was gathered by interviewing managers of seven (7) companies and a production manager of one (1) company. A pre-questionnaire (Appendix 3) was sent one week before the interviews to the managers of the companies. Time used for interviews was approximately two hours at the company sites.

Interviewed companies:

Arwina is specialized in purifying used industrial solvents for over thirty years. The purified solvents are recycled back to use. The company is situated in Southwest Finland and it employs eleven people. The company has implemented the Quality system ISO-9001 and the Environmental management system ISO-14001, but they are not sertificated. Managing Director Marjatta Wiitanen was interviewed on 11.12.2008 at 10.00 am.

Globe Hope Ltd. was founded in 2003 and it has currently nine employees. It is an innovative Finnish design company with the idea to design and produce quality and ecologically aware fashion for people who value sustainable development. Globe Hope clothing has been given a new life from already existing products and materials such as old hospital textiles, army wear, work-wear, and vintage materials. By re-cutting, re-sewing, dying and printing, Globe Hope clothes are re-awoken pieces of history that serve a forward-looking and fresh contemporary youth. Managing Director Seija Lukkala was interviewed on 11.12.2008 at 2.00 pm.

Hakaniemen Metalli Oy and its subsidiary High Metal Production Oy manufacture innovative stainless sheet metal structures by utilizing laser technology for cutting and welding. They have a certified Green Card Quality Management System. The companies design, manufacture and deliver module sheet metal structures, appliances and systems to customers operating in domestic and export markets. The company has thirty employees. Managing Director Matti Nurminen was interviewed on 26.8.2008 at 12.00 am.

Jaakko Pohjola Oy is a family owned company concentrated on transport services for over forty years. The company offers transport services for construction equipment and for contract transport in Finland. They have an Environmental management system ISO-14001. The company is situated in Pirkanmaa and they have thirty-five employees. Managing Director Virpi Pohjola was interviewed on 24.10.2008 at 12.00 am.

Kirjapaino Markprint Oy is a print house established in the year 1985. The company uses newest technology for producing high quality print works. The company employs twenty-eight people in Lahti. They have the right to use the environmental label, Ympäristömerkki, since 1993. Production Manager Arto Näveri was interviewed on 3.10.2008 at 12.00 am.

Osateos Oy mechanizes and assembles cast iron structures for end customers and their supply chain. The company is situated in Vantaa and it empoyes thirty-two people. They have a certified Green Card Quality Management System. Managing Director Kimmo Lappalainen was interviewed on 26.8.2008 at 9.00 am.

Reka Cables Ltd. produces installation, control, instrumentation and power cables for the needs of industry, construction and electricity supply. Their cable production commenced in Hyvinkää in 1961. Reka Cables is a Finnish industrial company that operates internationally. In Finland the company employs two-hundred and sixty people. The company has certified Quality system ISO-9001 and Environmental management system

ISO-14001 systems. The company has plants in Finland and Russia, and its key market areas are the Nordic and Baltic countries and Russia. Reka Cables is part of Neomarkka Group. Production Manager Tuula Råman was interviewed on 22.8.2008 at 2.00 pm.

Stala Oy is a Finnish company established in 1972. It manufactures stainless steel sink units and sink bowls for domestic kitchens, as well as waste sorting systems. The number of employees is seventy-five. The company has trade abroad. The production site is in Lahti. The company has a Quality system ISO-9001 and an Environmental management system ISO-14001. Managing Director Tuija Rajamäki was interviewed on 24.10.2008 at 2.30 pm.

The interviewees evaluated the frameworks as presented in the following table. The evaluations are not in the order in which the companies are presented.

	Frame 1	Frame 2	Frame 3	Frame 4	Frame 5	Frame 6
Company						
C1	2	3	2	1	2	2
C2	2,5	3	2	1	1	1,5
C3	3	3	2	1	2	2
C4	2	3	1,5	1	1,5	2
C5	2	3	3	2	2	2
C6	1	1	1	1	1	1
C7	2	2	3	2	2	3
C8	3	3	2	1,5	1,5	2
	2,2	2,6	2,1	1,3	1,6	1,9
3=Very useful 2=Useful 1=Not so useful 0=Not useful						

Table 9 Applicability of the developed frameworks

The interviewees were asked to give each framework a score from zero (0) to three (3) where zero was considered as not useful and three was considered as very useful.

Framework 1 was well accepted and considered to be useful (2.2) for connecting sustainability and eco-efficiency issues to strategic and operational management. The

interviewees (6 of 8) thought that this framework could be used in strategic planning when considering sustainability and environmental issues. The interviews resulted in the following remarks concerning strategic management:

1. Strategic importance of environmental issues is increasing, especially when supportive connections to other operations of the company can be seen.
2. Ecological issues are connected to strategic management, but the value added has to be seen.
3. Strategy starts from customer level, and as customers are increasingly more interested in environmental and sustainability issues, they become also strategic questions for the company.
4. Quality management systems are considered as strategic methods and thus environmental management systems can also be considered as strategic methods.
5. Positive effects on the image of the company can be seen as strategic aspects.
6. Most important strategic issues are economical issues, if environmental improvements have a positive economical effect; it is easier to consider them as strategic issues.

Framework 2 was also well accepted and considered to be very useful (2,6) for connecting sustainability and eco-efficiency issues to strategic and operational management. Interviewees (7 of 8) thought that this framework could be used in operational planning.

Frameworks 3, 5 and 6 were considered to be useful when the company has made a decision to adopt eco-efficiency methods into their practices. Framework 4 was considered less useful. Following remarks were pointed out:

1. Most important strategic issues are economical issues, if environmental improvements have a positive economical effect; it is easier to consider them as strategic issues.
2. Environmental issues rise from cost-benefit considerations.

3. The company does not have any environmental management system, but the frameworks support eco-efficient thinking.
4. Frame 1 connects sustainability (ecological) ideas very well to other strategies, it is very useful.
5. Frame 1 is good. It is important to recognize sustainability strategy as an own strategy, not only recognizing parts of it in other strategies.
6. Frame 1 is a good starting point for considering ecological and sustainability issues of the company. It connects these issues to other, more familiar issues.
7. Frame 2 connects strategic thinking very well to operative thinking, which is much easier to understand in industrial companies.
8. Frame 2 works well as a check list in decision-making.
9. Frame 3 can be very useful when the company has already decided to use some method for implementing eco-efficiency and ecological issues into their processes.
10. Frame 3 is useful when considering which method to choose.
11. Frame 5 is not so useful.
12. Frame 6 can be useful when the company has decided to use a method for evaluating eco-efficiency.

The case study gives evidence and shows that the developed frameworks can be for help in decision-making when considering eco-efficiency issues. Framework 1 was considered useful and the reason was that the connection to other business strategies was easy to recognise. Framework 2 was considered very useful and the reason was that it shows concretely how eco-efficiency considerations can be connected to the different processes of the company. Framework 3 was also considered useful because the differences between the methods for implementing eco-efficiency can be clearly recognised. Framework 6 was considered useful because the differences between the methods for evaluating eco-efficiency can be clearly recognised. Frameworks 4 and 5 where considered not so useful as the other frameworks.

6 DISCUSSION

In this chapter the findings as well as reliability and validity of the present study are discussed. Theoretical contributions and implications for practitioners are identified.

6.1 Discussion of the research results

The aim of this thesis was to study adoption of eco-efficiency in industrial small and medium sized enterprises (SMEs). The objective was to contribute to the development of commonly agreed frameworks and guidelines for helping SMEs to adopt sustainability and eco-efficiency practises. An important issue to consider is the need for a commonly accepted framework. There are a great number of different methods for adopting eco-efficiency and sustainability issues but are they suitable for all needs and situations? Should a synthesis or guidelines be worked out on existing methods? The frameworks should be applicable to all kinds of enterprises and thus also to companies lacking resources for comprehensive adoption of these issues. Emphasis is therefore especially on the need of SMEs.

Sustainable development is a worldwide phenomenon, which is supported by NGOs, governments and the business world. Eco-efficiency is in the centre of this phenomenon, and it has developed into an extensively recognized method for integrating ecological and economic considerations into business strategy and core business processes. Eco-efficiency has widely become accepted as a key strategic theme for global business towards sustainable development (Ehrenfeld 2005). Researchers and consultants are well acquainted with sustainable development and eco-efficiency, but as Springett (2003) argues sustainable development is not clearly recognized among the industry. Springett (2003) presents that managers have a very sketchy understanding of sustainable development. They know

something about environmental management, but they lack a holistic and deeper understanding of it.

It is often suggested that organisations have or should have an overarching strategy, but in practise only few organisations do have. They can have some kind of intentions which are generally played out on a personal level. An overall strategy is absent or exists only on paper. It is mostly thought that leadership is, or should be, somewhere in organisations, but very often it is merely an ever-changing set of relationships that are barely comprehensible. The situation is the same when combining eco-efficiency to strategy. Sustainability strategy has become as important as other more traditional strategies, such as marketing strategy, production and technology strategy, personnel strategy and financial strategy. Sustainability and eco-efficiency considerations are connected to all other strategies in the business strategy as described in figure 12.

The need for sustainability and eco-efficiency expertise and knowledge is an issue of personnel strategy, and sustainability issues can have an important influence on the financial strategy. Sustainability considerations in business strategy are difficult issues for SMEs, but they should be taken into account, especially when SMEs are parts of supply chains.

Decision-making involves the analysis of different alternatives and their consequences, and the subsequent commitment to action, usually in connection with a commitment with resources (Janssen 1992, Kirkwood 1997). The second framework (Figure 13) illustrates necessary considerations for different process strategies in the life cycle of production, from raw material extraction to production, use, and end of life of products.

The set of tools selected should work together by complementing each other, supporting different viewpoints and facilitating work on issues that require special attention. Sahlin-Andersson et al. (2002) point out that it is not clear when to use what tools in practise.

Possibilities for choosing a suitable tool or method are presented in frameworks 3 to 6 (Figure 13, Table 6, 7 and 8).

Data from the multiple case study (recognition and use of eco-efficiency methods) will give the answer to the second research question Q2: do SMEs use these methods and models in practise. In order to answer this research question a multiple case study, using a questionnaire and interviews was conducted. Based on the results from the multiple case studies it could be noticed that the third research question, Q3, is relevant from a practical point of view and that there is a need for a general and more comprehensive understanding of it from the literature. It was found that knowledge about eco-efficiency was sparse and the use of eco-efficiency methods was rare. Therefore the following areas of literature were examined in order to extract the necessary information for understanding the neglecting of eco-efficiency. These literature areas were: decision-making and adoption of managerial methods.

This led to an interview among the managers who had answered the questionnaire in the multiple case studies. The interviews could give the answer to the third research question Q3: Which factors enable or disable the applicability of methods for eco-efficiency. Discussions and co-operation with collaborating researchers was fruitful when designing the questionnaire for the multiple case studies as well as when realising the interviews. Answers from the interviews and the literature review on decision-making and adoption theories indicated that material flow management could be a practical approach towards eco-efficiency.

As there are numerous alternatives for organizing production processes, it is very difficult, almost impossible, for SMEs to comprehensively assess the environmental impacts of their production, and at the same time know all the economic implications which a change in their processes or inputs might have. Moreover, most SMEs are not always even aware of alternative production processes and accessible technologies, which could help them to

meet the double target of producing in an economically viable and environmentally sound way.

The development and use of eco-efficiency methods has a lot of limitations and challenges in companies. Understanding the terminology is difficult and the needs and benefits of incorporating eco-efficiency are not clear to most companies who don't have trained personnel. For companies, especially for small and medium size enterprises, it is not easy to modify existing information systems and management practices to incorporate these considerations. Most often the management does not have enough knowledge about eco-efficiency and how to combine these considerations into different processes and practises in the company.

Concerning strategy work and use of eco-efficiency methods, the multiple case study and the survey clearly show that eco-efficiency and related methods are far from known among industrial SMEs. Some companies have made material efficiency related improvements, but they are initiated mostly for economical reasons.

A considerable part of ecological problems and environmental risk potential are caused by resource consumption and handling of material flows. Eco-efficiency and sustainable development issues are, however, not commonly recognized by small and medium-sized enterprises (SMEs). Material flow management (MFM) is relatively unknown as a method though over fifty percent of companies have improved their processes and operations in respect to material flows. The main reason for this has been financial benefits.

The eco-efficient optimisations of material flows aim at reducing costs, which means that quantitative and financial accountings should also be considered. Several companies have evaluated and even calculated material flows, although they do not use any identified method or tool for accounting. Despite of this, SMEs are not aware of the many economic benefits that can be achieved with efficient MFM. Understanding these benefits could make MFM and eco-efficiency also more acceptable and widely used. The main reasons for

neglecting eco-efficiency or MFM issues are the following: Lack of time, lack of personnel to adopt methods in question, and methods are considered to be too complicated and exhaustive.

Results from the multiple case study and the survey lead to the development of frameworks which can be used to help in adopting eco-efficiency. These frameworks are presented in section 5. The case study interviews show that the developed frameworks can be for help in decision-making when considering eco-efficiency issues. The applicability of the developed frameworks is presented in section 5.

6.2 Reliability and validity of the study

Validity and reliability generally describe the quality of the research. As a research design is supposed to represent a logical set of statements, the quality of any given design can be judged according to certain logical tests (Yin 2003). Four tests have been commonly used to establish the quality of any empirical research, case study included (Yin 2003, Kidder and Judd 1986). The four tests are: Construct validity, Internal validity (for explanatory or causal studies, not for descriptive or exploratory studies), External validity and Reliability. These tests are described in section 3.2.2 (Quality of research designs).

1. Construct validity

In this study multiple-case design informants were used, and the questionnaires as well as the case study reports were reviewed by the interpreter (fellow researcher). An external reviewer was used to verify the logic of arguments, i.e., the chain of evidence. The external reviewer checked the multiple-case study write ups, analyses, and results. A case study design with interviews was used to evaluate the acceptability and applicability of the developed frameworks.

2. Internal validity

This is an exploratory study and thus internal validity is not required.

3. External validity

In the multiple-case study the focus was on furniture industry in Brazil and the findings can be generalised to that domain. In the survey the focus was on industrial small and medium size enterprises in Finland and the findings can be generalised to that domain in theory. In practise the generalisation can be criticised because of the low answering rate (5,4 percent). This can lead to an over optimistic evaluation of the situation in practise.

In the case sudy the focus was on industrial SMEs from different branches. The findings can be generalised to that domain in theory. Eight companies were interviewed and critics can be raised on the amount of companies. The findings comply with theoretical considerations and thus they can be generalised.

4. Reliability

In the multiple-case study the procedures were carried out with the presence of an interpreter (fellow researcher) who could do the same operations and would arrive at the same results.

In the survey study the response and answering rate for the questionnaire was very low (5,4 percent). There might be different explanations for such a low response, but the most obvious reason can be drawn from the multiple-case study results showing limited interest and acknowledgement about environment related issues. This can lead to modest interest in answering such questionnaires. Other possible explanations can be as follows: the subject is unknown to most of the companies, or the companies have not made improvements in these subjects, leading to such a low response.

In the case study the interviews can be repeated by another researcher with the same evaluation results.

7 CONCLUSIONS

There is a wide range of different methods for adopting eco-efficiency, as well as for evaluating eco-efficiency. Eco-efficiency, as a term, has been relatively unknown among industrial small and medium sized enterprises and common frameworks to differentiate these methods have so far been modest. The research questions set in the beginning are as follows:

Q1. Can eco-efficiency be considered as a key element in business strategies for SMEs?

Q2. Do SMEs use eco-efficiency methods and models in practise?

Q3. Which factors enable or disable the adoption of methods for eco-efficiency?

Q4. Can material flow management be a link to eco-efficiency?

Q5. Can the developed frameworks help enterprises in adopting eco-efficiency in their strategic and operational management?

This study gives answers to all these questions. Conclusions of the study are summarised in the following:

Sustainable development is a worldwide phenomenon which is supported by NGOs, governments and business world. It consists of social, economic, and environmental dimensions (Linnanen et al. 1997, Wellford 2000, Vanhala et al. 2002). Eco-efficiency is in the centre of this phenomenon, and it has been argued that it is an extensively recognized method for integrating ecological and economic considerations into core business processes. According to the research results of this study eco-efficiency cannot be considered as a recognized method, at least not among small and medium sized enterprises. The ecological dimension of sustainable development has become an important part of the global business environment, and thus the natural environment is a strengthening theme in strategic management. Sustainable development is, nevertheless, not clearly recognized among the industry and managers have a very sketchy understanding of sustainable development; they know some aspects of environmental management but lack a holistic and deeper understanding.

Eco-efficiency has a major role in sustainable development. Holliday et al. (2002) argue that the basic contribution to sustainable development is eco-efficiency. They describe eco-efficiency as a management strategy that combines environmental and economic performance. There is a clear connection between environmental issues and strategic management. Michael Porter (1991a) describes that strategy is the act of bringing a company into line with its business environment to maintain a dynamic balance. Ehrenfeld (2005) describes that eco-efficiency has become widely accepted as a key strategic theme for global business towards sustainable development. In practise the situation is often quite different; especially in industrial SMEs eco-efficiency it is mostly unknown.

Strategic management is a key activity for organisations´ ability to sustain competitive advantages in the long run. In 1990s there has been a prominent change in corporate strategy toward environmental problems; the emergence of sustainability as corporate strategy. Green et al. (2003) argue that an organisation's competitiveness is directly and indirectly affected by growing environmental pressure from its different stakeholders. The most broadly accepted criterion for corporate sustainability constitutes a firm's efficient use of natural capital. Corporate responsibility can lead to more efficient use of resources, better reputation, improvements in investors´ trust, and new market opportunities. At present most managers have accepted corporate sustainability as a precondition for doing business.

As an answer to the first question Q1, can eco-efficiency be considered as a key element in business strategies for SMEs (small and medium sized enterprises), the literature review clearly shows that it really is. Nevertheless the research results show that industrial SMEs do not recognize and acknowledge eco-efficiency and ecological issues as preconditions and as a strategic issue fin doing business.

Management is argued to be equivalent to decision-making (Pugh et al. 1996). The most important factor when making environmental decisions is the balance between decisions

concerning companies´ environmental impacts and economic benefits. It has become difficult to distinguish strategic decisions from operative decisions, as all decision-making probably has characteristics typical to strategic as well as operative decision-making. According to this study, economical factors are the dominating ones when making strategic and operational decisions. The research results show that decision making related to eco-efficiency consists mainly recognition of environmental legislation.

Decision-making is considered to involve the analysis of different alternatives and their consequences, but in SMEs the practice is far from that. Decision-making can be improved by frameworks, which will help in decision-making. In this study some frameworks, which can be used for help in decision-making have been presented (Figures 11-13 and Tables 7 and 8).

Concerning strategy work and use of eco-efficiency methods, the multiple case study and the survey clearly show that eco-efficiency and related methods are far from known among industrial SMEs. Some companies have made material efficiency related improvements, but they are initiated mostly for economical reasons.

Eco-efficiency can be considered to be a strategy tool, a managerial method or tool, as well as methods and techniques for Quality Management, Balanced Scorecard, and Total Quality Management etc. Strategy tools are developed to support organisations for maintaining and creating strategic advantages. Strategy tools are described to have specific advantages and features which work best in favourable contexts and in knowledgeable hands (Brown et al. 2004). Strategy tools are an intrinsic part of business school education, management consulting, popular management literature. Management scholars promote them, but it is not clear when to use what tools in practise (Sahlin-Andersson et al. 2002).

The set of tools that is appropriate for an organisation is dependent on that organisation's individual need. Strategy tools are an intrinsic part of the modern strategy work and a well-balanced set of strategy tools has the capability to support strategic success. It is also

suggested (Abrahamson 1996) that relationships between the user, the tool, and the context bring an incoherent and often contradictory plurality to strategy-tool use, which makes the choice of a suitable strategy tool challenging. It is not clear when to use what tools in practise (Sahlin-Andersson et al. 2002). The task of finding just one most-suitable strategy tool is therefore not appropriate. Rather the task is to compile a set of tools that jointly caters to different contextual needs and demands and supports different forms of strategy work. It also increases the possibilities for discovering and supporting organisation's strategic advantages. The set of tools selected should work together by complementing each other, supporting different viewpoints and facilitating work on issues that require special attention. The frameworks developed in this work can give clear guidance for choosing the right strategy-tools (methods) for each need. The results from the interviews concerning the applicability of the developed frameworks clearly show that they can be for help.

The adoption groups are usually classified as innovators, early adopters, early majority, late majority and laggards. Other groups, which are not usually considered, are companies which do not act in a responsible way and criminal actors. Especially, when considering ecological questions, these other groups are important to notice. There are signs of raising criminal activity concerning waste and hazardous waste handling.

There are several methods for incorporating eco-efficiency considerations in business processes because material flows, energy flows included, have an essential role in eco-efficiency and sustainable development ideology. Clearest cost saving potentials of eco-efficiency practises can according to Fisher et al. (2004) be obtained when focusing on the internal material and energy flows. In practise SMEs do material flow related improvements, but they do not realize them as eco-efficiency improvements.

All companies rely on their supply base and customers to survive. Many small and medium size companies act increasingly more as subcontractors for bigger companies, which mean that they are essential parts of a supply chain. There are many initiatives by private and public organisations who are conducting codes of conduct for themselves and their

suppliers. Companies can differentiate themselves, reduce costs, and improve service by considering the social, environmental and economic factors relating to their supply chains. New Zealand Business Council for Sustainable Development (NZBCSD) (2003) has defined that sustainable supply chain is management of raw materials and services from suppliers to manufacturer and through service providers to customers and back. The best benefits can be achieved by extending the focus as far as possible upstream towards the raw materials, downstream towards the user and then back again so that the product and wastes can be recycled.

An environmental management system can be a good starting point for eco-efficiency and sustainable development. For companies, which are not interested in environmental issues, a more relevant starting point could be material flow management issues, as the connection to economical benefits is more obvious and easier to understand.

Knowledge of eco-efficiency possibilities and adoption of eco-efficiency methods is important for SMEs, especially when they are subcontractors in supply chains. Eco-efficiency practices can give additional business opportunities, for example in recycling. Increasing waste handling costs, especially in handling of hazardous waste, have increased criminal activity. Understanding the possibilities raised by eco-efficiency practices can decrease use of criminal options.

In the near future companies are facing even more challenging demands. Availability of raw materials, energy, water and food is decreasing. Prices are increasing in such a rate, that it will hamper operation conditions. Consumers are getting more concerned about the world condition and are demanding more protective actions from governments and companies. This leads to the conclusion that one of the most important issues to develop is decoupling of production and consumption. The goal of sustainability stresses the necessity of an absolute reduction of material flows. Thus the task would be to find a path of economic development without increasing material flows in absolute terms (Hammer et al. 2003). Possibilities for doing this are still unclear and thus there is lots of work for

scientists and politicians to lead the way, for consultants to spread the ideas and for companies to adopt and implement the ideas. Consumers should also be educated about their role and possibilities.

This work provides new theoretical and practical insight in the dissemination aspects. It also possesses scientific value to existing theory for further dissemination of methods for eco-efficiency. This work connects material flow management as an integral part to eco-efficiency, both in theory and practise. As the object of the research the developed frameworks give new theoretical insight to connecting sustainability strategy to business strategy (Framework 1) and to the differences between the studied methods for implementing and for evaluating eco-efficiency. The work connects strategic management theory to sustainable development and eco-efficiency and this is illustrated in the first Framework.

The developed frameworks can be for major help in decision-making for SMEs**.** Even though response to the survey was limited, it clearly shows that material flow issues are more known and developed than eco-efficiency in SMEs. Generalization of the results must be considered with care because the return rate of the questionnaires was very low. The companies are more interested in economical improvements, which are also easier for them to understand. This leads to the conclusion that so far sustainable development and ecological considerations are not of major interest for them. One way to help SMEs in decision-making and their efforts in improving eco-efficiency could be a web-based portal where they can find descriptions, frameworks and training material concerning sustainable development and eco-efficiency. Material flow management issues and supply chain aspects should be included.

The main contribution of this thesis is on increased understanding of adoption of eco-efficiency into strategy work and adoption of suitable methods for eco-efficiency in industrial SMEs. It also increases understanding of material flow management as a link to

eco-efficiency and sustainable development. The developed frameworks can be for considerable help when adopting eco-efficiency in strategic and operational management.

The main outcomes of the research are summarised as follows:

- A recommendation for common frameworks for fitting sustainability and eco-efficiency considerations in business strategies. The developed frameworks will help enterprises to manage the adoption of eco-efficiency in their business strategy (Figure 12 and Figure 13).
- A recommendation for common frameworks to choose a suitable method for adopting as well as for evaluating eco-efficiency. The frameworks will help enterprises to manage the adoption of eco-efficiency and to demonstrate and communicate eco-efficient improvements both internally and externally (Figure 13, Tables 6, 7 and 8).
- Descriptions and recommendations for some common methods for adopting eco-efficiency.
- Descriptions and recommendations for some common methods for evaluating eco-efficiency.
- A description of use of material flow management as a link to eco-efficiency in SMEs.

Recommendations for further research

The importance of sustainability and eco-efficiency is increasing as worry about the global environmental situation is rising. Eco-efficiency is a promising possibility for companies to recognize the environment and at the same time increase their business possibilities. Companies have not so far noticed these possibilities. According to the results of this study following recommendations for further research can be suggested:

- Evaluation and reporting of material and energy efficiency in supply chains. Without correct evaluation and reporting it is not possible to reach right conclusions

of the current situation and thus find effective possibilities to improve material flows. So far it has been very rare to consider the whole supply chain.

- How can industrial companies be motified to participate in sustainability and eco-efficiency? Development of methods or tools for this purpose has not been enough. Knowledge of these methods is sparse. Legislation has not succeeded in increasing sustainability work in companies.
- How can the common acknowledgement of sustainability and eco-efficiency be increased? Can industry branches be the right channel for this or is it something else?

Small and medium size enterprises (SMEs) play an increasingly important role in economic growth, employment and local development. SMEs are a major source of technological innovation and new products which can have noticeable relevance in the ecological effects of products and production. SMEs also play an essential role as subcontractors in the downsizing, privatisation and restructuring of large companies. SMEs account for over 95 percent of enterprises and nearly 70 percent of employment in OECD economies. SMEs also generate a large share of new workplaces. As they have such a remarkable role it is of great importance to get SMEs to participate in promoting sustainable development and eco-efficiency. The results of this study can be for great help for companies towards eco-efficient practises.

"Nature does not reject the one who relies on it – Nature will take care of its own"
(modified from Heikkinen in 1890s)

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APPENDICES

Appendix 1 Case Study Questionnaire

Dear Managers
Is it possible to gain economical profit and efficiency with ecological efficiency?

We have lots of good examples from around the world and also from Brazil showing that economical and ecological efficiency (= eco-efficiency) go well hand in hand.

For example: *Ciba-Geigy responded to environmental standards by making process changes that saved 750 000 US$ per year and*

3M saved 120 000 US$ in capital investment and 15 000 US$ annually by replacing solvents with water-based solutions

I would ask for your valuable time for about one hour to answer the attached study questionnaire. The questionnaire is connected to an UCS project as well as my doctorate study. I work currently at UCS as a researcher in one of their projects.
The project deals with economical and environmental efficiency at small and medium size furniture industry. I will make a summery of the current eco-efficiency situation and possible improving possibilities according to your answers.

Benefits to the company:

- The company receives a summary of the current status of furniture industry in Brazil
- The company gets a good ”tool” to improve its knowledge about eco-efficiency:
  What kind of impacts, indicators and information could be used for making improvements?
- Gives possibilities to find a co-operation partner in Finland or Europe:
  New business possibilities, subcontracting, joint marketing, etc

I wish to receive the answered questionnaire rather in electric form by the end of May.
My contact details are below.

Thank you for your time and co-operation

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Cidade Universitária
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Email: ilpo.penttinen@turkuamk.fi

ANALYSIS OF ECO-EFFICIENCY IN WOOD INDUSTRY

I – COMPANY INFORMATION

Company:.....
.
Address:..... Postal code.....
City:.....
Telefone:..... Fax:.....Mobile:.....
E-mail:.....
Company established:.....

Contact
person:.....
Possition in the
company:.....

II – PRODUCTION

01- Main processes : ( ) Serial production ( ) By order ( ) Both
02-Use of raw materials (kg, tn, m3, m2) and valueshare of each (%):
04- Buying potential of the target customers:
(A=high and medium class, B=medium class, C= low class)
a. ( ) classe A.....% b. ( ) classe B .....% c. ( ) classe C.....%
05-Market area of products: a. ( ) National.....% b. ( ) International.....%
06-Export by country: (country, percentage % of export)
a) ....., ...% b) ....., ...%
c) ....., ...% d) ....., ...%
e) ....., ...% f) ....., ...%

III – STRUCTURE OF HUMAN RESOURSES

01-Employees (persons) a. Men..... b. Women.....
a) Management..... a. Men..... b. Women.....
b) Production..... a. Men..... b. Women.....
c) Projects / Enginering / Quality a. Men..... b. Women.....

EDUCATION OF EMPLOYE´S IN THE COMPANY

02- Educational background / Classification:
a) Iliterate b) High school graduation.....
c) Elementary school not completed..... d) University not completed.....
e) Elementary school completed..... f) University graduation.....
g) High school not completed..... h) Post graduation.....
03- Does the company have graduated technicians in production: a. ( ) yes b. ( ) no
04- Does the company have knowledge/expertise in following:
a. ( ) Quality management
b. ( ) Environmental management
c. ( ) Occupational health and safety management
04- Does the company have a product designer: a. ( ) yes b. ( ) no
If not, how are the products designed a. ( ) Outsourced
b. ( ) Experienced worker
c. ( ) Other .....
05- Are environmental issues included in planning / management a. ( ) yes b. ( ) no
09- Does your company have co-operation with educational / research institutes
a. ( ) yes b. ( ) no if yes wich c. ( ) private sector d. ( ) public
area e1. ( ) in research and development
e2. ( ) in training
e3. ( ) in consulting
e4. ( ) other.....

IV – MACHINERY AND EQUIPMENT

01- Level of automatization and quantity of machines used in production :
a. ( ) Manual..... b. ( ) Semiautomatic.....
c. ( ) Automatic / CNC.....
02- Maintenance of machinery: a. ( ) Corrective b. ( ) Preventive

V – ENVIRONMENTAL MANAGEMENT

01- Use of energy: .....Kwh/month
02- Use of water: .....m^3 /month a).....% Municipal
b).....% Ground water
c).....% Other.....
03- Does your company have separate waste collection: a. ( ) yes b. ( ) no

04- Does your company have / need an environmental license: a. ( ) yes b. ( ) no
For what kind of activity : a1. ( ) for running the process.....
a2. ( ) "waste" exploration .....
a3. ( ) "waste" extermination .....
a4. ( ) Other, what.....
05- Do you have co-operation with other companies a. ( ) yes b. ( ) no
If yes what kind of co-operatio a.1 ( ) Joint purchase
a.2 ( ) Joint transport
a.4 ( ) Purchasing of material in fixed size
a.3 ( ) "Waste" exchange
a.3 ( ) Other, what.....
06- Has your company thought of allternative / replacement rawmaterials (possible lack of materials in the future) a. ( ) yes b. ( ) no
07- Does your company have environmental / eco-efficiency systems:
a. ( ) yes b. ( ) no - if yes please answer Annex 1
In use for ( ) 0 – 5 years ( ) 5 - 10 years ( ) over 10 years
08- Does your company have Environmental impact / Eco-Efficiency evaluating or measuring systems
a. ( ) yes b. ( ) no - if yes please answer Annex 2
09-Does your company evaluate Eco-Efficiency / environmental progress with indicators
a. ( ) yes b. ( ) no - if yes please answer Annex 3

PROCESSES

5- Wastewater treatment plant:
a . ( ) Continuous b. ( ) Batch 5.3- Treatment flow.....
6- Steam boiler: a. ( ) yes b. ( ) no
c. Flow rate.....

RESIDUES

A) Class I:

B) Class II and III:

a. ( ) metal ..... (kg/mth) b. ( ) Textile..... (kg/mth)
c. ( ) Paper, cardboard..... ... (kg/mth) d. ( ) Organics..... (kg/mth)
e. ( ) Plastics.....(kg/mth) f. ( ) Foam .....(kg/mth)
g. ( ) Glass..... (kg/mth) h. ( ) Other.....(kg/mth)
Person responsible for information: .....

Annex 1. Environmental management / Eco-Efficiency program or system (mark x if your company has some of the following systems in use, v if you know it)

1. ( ) ISO 14001
2. ( ) EMAS
3. ( ) Cleaner Production
4. ( ) Pollution Prevention
5. ( ) Green Productivity
6. ( ) Waste Minimization
7. ( ) Industrial Ecology
8. ( ) Design for Environment
9. ( ) Lean Manufactoring (Toyota Production System)
10. ( ) Eco-design
11. ( ) Eco-Controlling
12. ( ) Eco-Innovation
13. ( ) Responsible Care
14. ( ) IPP (Integrated Pollution Policy)
15. ( ) Biomimicry
16. ( ) PCP planning and controlling the production

Annex. 2 Eco-Efficiency evaluating or measuring system/methods
Does your company use following indicators a. ( ) yes b. ( ) no
(mark x if your company has some of the following systems in use)

1. ( ) LCA (Life cycle analysis)
2. ( ) MIPS (Material input per service unit)
3. ( ) EPE / EPA (Environmental performance evaluation)
4. ( ) ISO 14031
5. ( ) MFA (material flow analysis)
6. ( ) CP Index (Clean Production Index)
7. ( ) MAIA (Material Intensity analysis)
8. ( ) Ecological Rugsack (backpack)
9. ( ) Ecological Footprint
10 ( ) Eco-Compass
11. ( ) GRI (Global Reporting Initiative)
12. ( ) Environmental costs / benefits calculations

Annex 3. Eco-Efficiency Indicators

Does your company measure / calculate following indicaters
(Fill in first yes / no and if yes, answer in more detail)

Product or service value

- **Quantity of product/service produced or sold a. ( ) yes b. ( ) no**
(tons, m3, pieces,…)
  - Products ……
  - Co-products …….
  - **Total amount of products ……..**
- **Net sales (USD / EUR) …….. a. ( ) yes b. ( ) no**
(whole sale minus bought products)

Environmental influence

- **Energy consumption (KWh) a. ( ) yes b. ( ) no**
  - Electricity ……...
  - District heat ……
  - Fossil Fuel (coil, oil) ……
  - Natural gas ……
  - Other fuel based (biomass, wood, waste fuel)……..
  - Non-fuel based (solar, wind) ……
  - **Total energy use ……**

- **Water consumption a. ( ) yes b. ( ) no**
Water intake (Cubic meters) Water discharged
  - Water bodies (lake, river)……. - Water bodies ……
  - Wells …….. - Ground water ……
  - Municipal supply …….. - Municipal system ……
  - Other …….. - Other ……
  - **Total water intake …… - Total water discharged ……**

- **Material consumption a. ( ) yes b. ( ) no**
Intake (tons,m3) Recycling and Reuse (tons,m3)
  - Raw materials …….. - Secondary materials ……..
  - Packaging material …….. - Used packages ……..
  - Office supplies …….. - “Waste” from others ……..
  - Indirect materials ……..
  - **Total material taken in …….. - Total material reused …….**

• **Waste (tons, m3) a. ( ) yes b. ( ) no: into**
- Landfill …….
- Air .....
- Water .....
- Soil .....
- Hazardous waste …….
- Incineration …….
- Recycling …….
    - Cans …….
    - Cardboard …….
    - Wood …….
    - Plastics …….
    - Sawing residues …….
    - Other …….

- Reuse …….
- On-site composting …….
- On-site energy generation …….
- **Total waste generation …….**

• **Greenhouse gas emissions a. ( ) yes b. ( ) no**

Metric tons (CO2 Equivalents) ……..
- CO2 (carbon dioxide)
- CH4 (methane)
- N2O (nitrous oxide)
- HFCs (hydrofluorocarbons)
- PFCs (perfluorocarbons)
- SF6 (sulphurhexafluorid)

• **Ozone depleting substance emissions a. ( ) yes b. ( ) no**

ODP tons (metric tons x ozone depleting potential)
- Chlorofluorocarbons
- Carbontetrachloride
- Methylchloroform
- Hydrobromofluorocarbons
- Methylbromide
- Bromochloromethane

COD/BOD …….. a. ( ) yes b. ( ) no
(Chemical / Biological Oxygen Demand)
Oxygen equivalent (mg / L), Oxygen amount (mg / L)
PHM (Priority Heavy Metals) …….. a. ( ) yes b. ( ) no
(tons)
- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury
- Zink

Appendix 2 Survey Questionnaire

Dear Managers
Is it possible to gain economical profit and efficiency with ecological efficiency?

We have lots of good examples from around the world and also from Finland showing that economical and ecological efficiency (= eco-efficiency) go well hand in hand.

For example: Ciba-Geigy responded to environmental standards by making process changes that saved 750 000 US$ per year and 3M saved 120 000 US$ in capital investment and 15 000 US$ annually by replacing solvents with water-based solutions

I would ask for your valuable time for about one hour to answer the attached study questionnaire. The questionnaire is connected to my doctorate study. I am doing my doctorate at Helsinki University of Technology.

This project deals with economical and environmental efficiency (eco-efficiency). Material flows have a central part in eco-efficiency considerations. This study concentrates on material flow management in industrial small and medium size enterprises (SMEs) and it is a part of the whole study concerning adoption of eco-efficiency in strategic and operational management of industrial SMEs.

Your answers will help in summarizing the current situation of eco-efficiency related material flow management practices in industrial SMEs and finding improvement possibilities. The objective is to develop frameworks to help adoption of eco-efficiency and material flow management issues into practices and thus help companies in their strive for economic and ecologic development.

Your answers will be confidential and they cannot be separated from the summary.

I wish to receive the answered questionnaire rather in electric form by the end of May.

Thank you for your time and co-operation

Ilpo Penttinen
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20700 Turku
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Fax: +350 10 5535 794
Email: ilpo.penttinen@turkuamk.

SURVEY QUESTIONNAIRE

I - Company Information

Company	
Branch of industry	
Adress	
Postal code	
City	
Telephone	
Fax	
Mobile	
E-mail	
Founded	

Contact Person	
Position	

Personnel and Turnover

			1 000 €	
Employees	<10		< 330	
	<50		330-1 700	
	50-100		1 700-3 400	
	100-500		3 400 -	

Expertise in the Company

Economic accounting	Yes		No	
Quality issues	Yes		No	
Environmental issues	Yes		No	
Product planning	Yes		No	
Safety and security issues	Yes		No	

II - Activities

Material

Mainly used materials

Metall	
Plastics	
Wood	
Electronics	
Biological material	

	Grosery				
	Chemicals				
	Hazardous materials				
	Other (What)				
Improvements in material use made		Yes		No	
Replacement materials are planned		Yes		No	
Recycled materials are used		Yes		No	
Surplus materials are collected		Yes		No	
Is surplus material used in own production		Yes		No	
	Surplus material is delivered to				
	Separate collection				
	Reuse				
	Incineration				
	Biological use				
	Hazardous waste collection				
	Landfill				
Energypotential audit is made		Yes		No	
Energy saving improvements are made		Yes		No	
In	Energy use	Yes		No	
	Heating	Yes		No	
	Lighting	Yes		No	
	Transport	Yes		No	

Production

Production processes have been improved	Yes		No

Product improvements

Lifetime is prolonged	Yes		No
Use of product widened	Yes		No
Discharge possibilities are improved	Yes		No
Separation of materials is improved (end of life)	Yes		No
Improvements in material recyckling are made	Yes		No
Energyefficiency improvements are made	Yes		No
Guidance in use is given	Yes		No
Guidance for reuse or discharge after use is given	Yes		No

Hazardous material

Hazardous materials are in use	Yes		No
Hazardous materials are displaced with less hazardous materials	Yes		No
Use of hazardous materials is minimized	Yes		No
Hazardous materials have been given upp	Yes		No
Hazardous materials are handled by the rules	Yes		No

Hazardous materials are stored by the rules	Yes		No

Water

Water is used in production	Yes		No
Water use has been improved (decreased)	Yes		No
Water is recycled	Yes		No
Water is purified after use	Yes		No

Waste

Waste is separated	Yes		No
Waste amounts have been decreased	Yes		No
Waste is used	Yes		No
For Energy use	Yes		No
Composting	Yes		No
Other, what?			

Packaging

Packaging materials are used	Yes		No
Single-use packaging is used	Yes		No
Reuse packaging is use	Yes		No
Packaging material use is decreased	Yes		No
Incoming packaging is used	Yes		No
Packaging materials are recyclable	Yes		No
Customers are advised in using packaging	Yes		No

Legislation

Legislation is known	Yes		No
Entering legislation is known	Yes		No
Company is prepared for entering legislation	Yes		No

Accounting and measurement

Following issues are monitored

If yes, mark M or R (M=quantitatively and R=in money)

Material use	Yes		No
Raw materials	Yes		No
Storage quantity	Yes		No
Material loss	Yes		No
Waste amounts	Yes		No
Energy use	Yes		No
Sales	Yes		No
Quantity of production	Yes		No
Environmental costs	Yes		No
Accidents	Yes		No
Sicknes days	Yes		No
Company has a method for evaluating environmental issues	Yes		No
Company has quantitative objectives	Yes		No
For Material use			
Energy use			
Water use			

	Waste amounts				
	Other, what				

Releases (does the company measure following releases)

Greenhouse gases (CO2 equivalents)	Yes		No	
Ozone destroying substances	Yes		No	
Chemical oxygen demand	Yes		No	
Biological oxygen demand	Yes		No	
Heavy metals	Yes		No	

Other

Environmental risks are evaluated	Yes		No	
Company is prepared for environmental accidents	Yes		No	
Environmental management system has been required or asked	Yes		No	
Company has an environmental management system	Yes		No	
Environmental training for personnell has been arranged	Yes		No	
training for use and handling of chemicals is arranged	Yes		No	
training for handling of hazardous waste is arranged	Yes		No	
other, what	Yes		No	
Company has chemical bookkeeping	Yes		No	
Company has waste bookkeeping	Yes		No	

Methods for implementing eco-efficiency

Are following methods in use or are they known in the company
(If the method is in use mark X, if the method is known mark V in the yes bok)

Environmental management or eco-efficiency methods

ISO 1400 (Ympäristönhallinta järjestelmä)	Yes		No	
EMAS (Ympäristön hallinta ja auditointi järjestelmä)	Yes		No	
Cleaner Production (Puhdas tuotanto)	Yes		No	
Pollution Prevention (Päästöjen ehkäisy)	Yes		No	
Green Productivity (Vihreä tuottavuus)	Yes		No	
Waste Minimization (Jätteiden minimoiminen)	Yes		No	
Industrial Ecology (Teollinen ekologia)	Yes		No	
Design for Environment (Ympäristön mukainen suunnittelu)	Yes		No	
Lean Manufactoring (Toyota Production System)	Yes		No	
Eco-design (eko-suunnittelu)	Yes		No	
Eco-Controlling (Eko-kontrolli)	Yes		No	
Eco-Innovation (Eko-innovaatio)	Yes		No	
Responsible Care (Vastuu Huomisesta ohjelma)	Yes		No	
IPP (Integrated Pollution Policy = Yhdistetty päästöpolitiikka)	Yes		No	
Biomimicry (Luonnon jäljittely)	Yes		No	
POEM (Tuotesuuntautunut ympäristön hallintajärjestelmä	Yes		No	
PCP (tuotannon suunnittelu ja kontrolli)	Yes		No	

Methods for evaluating or accounting eco-efficiency

LCA (Life cycle analysis eli elinkaariarviointi)	Yes		No	
MIPS (materiaali-intensiteetti palvelusuoritetta kohti)	Yes		No	
EPE / EPA (ympäristötehokkuuden arviointi)	Yes		No	
ISO 14031 (Ympäristön hallintajärjestelmä)	Yes		No	
MFA (materiaalivirtalaskelma)	Yes		No	
CP Index (Clean Production Index eli puhdas tuotanto indeksi)	Yes		No	
MAIA (Materiaaliintensiteetti analyysi)	Yes		No	
Ecological Rugsack (ekololginen selkäreppu)	Yes		No	
Ecological Footprint (ekologinen jalanjälki)	Yes		No	
Eco-Compass (ekokompassi)	Yes		No	
CRI (yhteiskuntavastuu raportti)	Yes		No	
TMR / TMF (Materiaalien kokonaiskäyttö)	Yes		No	
Ecoindicator 99	Yes		No	
Environmental management costs/benefits calculations	Yes		No	
Environmental Management Accounting (Ympäristölaskenta)	Yes		No	

Appendix 3 Introduction Letter, case study

TURUN AMMATTIKORKEAKOULU
TURKU UNIVERSITY OF APPLIED SCIENCES

Hyvät Yritysjohtajat

Teen väitöstyötäni Teknillisen Korkeakoulun Tuotantotalouden osastolla. Väitöstyöni liittyy ekotehokkuuteen ja sen liittämiseen pienten ja keskisuurten teollisuusyritysten strategiseeen johtamiseen.

Työni loppuunsaattamiseksi on oleellisen tärkeää, että saan yritysten mielipiteitä kehittämistäni malleista. Mielipiteenne ovat arvokkaita mallien kehittämisessä yrityksiä palveleviksi.

Haastattelua varten toivon teidän etukäteen pohtivan omaa / yrityksenne näkemystä ja kantaa seuraaviin asioihin:

1. Liittyvätkö ympäristöasiat yrityksen strategisiin päätöksiin?
2. Ovatko ympäristöasiat tärkeitä yrityksen menestymisen kannalta?
3. Onko yrityksessänne pohdittu ympäristöasioita?
4. Onko yrityksessänne tehty toimenpiteitä ympäristöasioiden huomioimiseksi?

Haastattelussa käymme läpi kehittämiäni malleja ja keskustelemme niiden käyttökelpoisuudesta ja hyödystä yrityksen menestymisen kannalta. Haastattelu kestänee 2-3 tuntia.

Saatte halutessanne kehittämäni mallit käyttöönne.

Olen hyvin kiitollinen ajastanne ja vaivannäöstänne:

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