Interactions between economic and environmental performance in companies

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Content

Abstract

Ever since environmental issues came on the agendas in the 1960ies the interaction between economy and environment has been of interest. In the beginning it was often stated that environmental measures should be “within reason” with respect to their economic and technical feasibility. Later the polluter pays principle was established. During the following years the knowledge of the interaction increased and several concepts and tools came into use such as Environmental Management Accounting (EMA), Life Cycle Costing (LCC), Life Cycle Assessment (LCA) and Eco-efficiency. Several studies showed that there may also be benefits from environmental management in companies, especially for some types of firms. Decreased risks, decreased material costs, increased innovation and productivity are examples

on such benefits. Although there is still an uncertain relation between specific environmental issues and costs or benefits to a company, there is much to be learnt from history on how social costs of environmental issues are internalised in the economy of companies.

1 Introduction

Environmental issues have been on the agenda in companies since the 1960ies. A growing industry and increased demands on living standard triggered many conflicts due to local impacts. Regulatory systems developed in most countries and companies were forced to install cleaning equipment or undertake other technical measures to decrease emissions. These "end-of-pipe" solutions meant costs to companies. The PPP principle (Polluter Pays Principle) was established as a guide for the level of cleaning ambition. The risk of unforeseen costs from environmental accidents or disposed toxics led investors to request environmental reporting in companies. During the late 1980ies an increasing interest was paid to products. Besides cost, some companies experienced benefits in market shares from increased environmental performance of their products. Other benefits were also detected as a result of environmental programmes, like personnel engagement and innovation. As the picture became more and more complex with many different types of impacts, measures and industrial processes involved, system analytical tools were developed to give an overview of the situation and guide decisions. Such tools were LCA (Life Cycle Assessment) and LCC (Life Cycle Costing), RA (Risk Assessment) and CBA (Cost-Benefit Analysis).

This report has been written as an attempt to synthesise the state of art in present knowledge on the linkage between the economy of companies and their environmental impact. A basic question for many companies is which type of environmental work that is economically efficient and which is not. This question is also of interest for authorities, which have the role of designing an efficient regulatory framework.

2 Defining economic performance

There are several types of economic efficiency:

- Pareto efficiency
- Kaldor-Hicks efficiency
- X-efficiency
- Allocative efficiency

"Pareto efficiency, or Pareto optimality, is a central concept in game theory with broad applications in economics, engineering and the social sciences. A change that can make at least one individual better off, without making any other individual worse off is called a Pareto improvement: an allocation of resources is Pareto efficient when no further Pareto improvements can be made" (myWiseOwl, 2005).

"Kaldor-Hicks efficiency is a type of economic efficiency that occurs only if the economic value of social resources is maximized. A Kaldor-Hicks improvement is any alternative that increases the economic value of social resources.

The idea is related to Pareto efficiency. Under Pareto efficiency, an outcome is more efficient if at least one person is made better off and nobody is made worse off. Under Kaldor-Hicks efficiency, a more efficient outcome can leave some people worse off. Here, an outcome is more efficient if those that are made better off could *in theory* compensate those that are made worse off and lead to a Pareto optimal outcome.

The key difference is the question of compensation. Kaldor-Hicks does not require compensation, and thus does not necessarily make each party better off. Pareto efficiency does require making each party better off (or at least no worse off)." (myWiseOwl, 2005)

"In economics, **x-efficiency** is the effectiveness with which a given set of inputs are used to produce outputs. If a firm is producing the maximum output it can given the resources it employs, such as men and machinery, and the best technology available, it is said to be x-efficient. x-inefficiency occurs when x-efficiency is not achieved. In a market with perfect competition, there will in general be no x-inefficiency because if any firm is less efficient than the others it will not make sufficient profits to stay in business in the long term. However, with other market forms such as monopoly it may be possible for x-inefficiency to persist, because the lack of competition makes it possible to use inefficient production techniques and still stay in business."(myWiseOwl, 2005)

"Allocative efficiency is the market condition whereby resources are allocated in a way that maximises the net benefit attained through their use." (myWiseOwl, 2005)

The two first types of efficiency is on the society level, x-efficiency relates to company management and Allocative efficiency could relate to companies or to society. In a similar way as for LCA, we notice differences due to choice of system boundaries and trade-off methods. When looking at a single decision in a company involving allocation of money for environmental reasons, the allocation efficiency is of main interest. In companies, the main interest is maximizing the net benefit, i.e. the profit. Although there are social responsibilities in companies, in this study, they are treated of as means to stay in business and achieve a good profit, rather than as a separate goal. Thus to be allocative efficient within a company, an investment in environmental performance has to be evaluated in economic terms and compete with other economic investments. From the society's point of view, there is a need to design regulations so that environmental investments that are beneficial for both the society and company are favoured.

3 Defining environmental performance

Economy has a common measure in the monetary unit. Still there is many ways of defining economic efficiency depending on choice of system boundaries and trade-off methods. For environmental issues there is no common unit. There may be several types of impacts on the environment from human activities, like impacts on biodiversity, aesthetics, human health and natural resources. To decrease the impacts on biodiversity, one may have to use more natural resources. In this case there is a trade-off necessary between different types of impacts.

Any choice depends on three aspects (Munthe 1997):

- What is included for consideration
- How are trade-offs made
- How is uncertainty addressed

When looking at different overviews of environmental impacts it is clear that there are differences in what people include in the environmental issue. One line that divides is abiotic resources. Some people do not consider metal ores or impacts on man made materials to be an environmental issue; they think it belongs to the economical sphere. Others include abiotic resources in environmental issues. Another line that divides is the time of concern. The significance of the depletion of abiotic resources or impacts from global warming is heavily

dependent of the time aspect. A third line that divides is the area considered. Many local governments have a mandate for safeguarding the local environment and seem to pay little or no attention to global issues. The philosopher Peter Singer (Singer 1975) has coined the term "moral circle" for what encompasses our moral objects.

Trade-offs is made in two principally different ways. One is weighting everything in the same dimension, like in economics. The other is to set targets to various environmental qualities and weigh different impacts according to their induced change in distance to the targets. These differences reflect different ethics, the first being of a more pragmatic type than the other and similar to economic efficiency as defined by Kaldor-Hicks. The distance to target approach is of a Pareto type and comparable to our legal performance criteria for being good citizens: follow the laws. In practice we mix these types of trade-offs and one may describe the different trade-off options as "number of unique qualities" considered.

The third aspect is uncertainty. The precautionary principle is often accepted, but it may be interpreted in many ways. The uncertainty aspect is linked to the two preceding aspects in that many impacts are uncertain with respect to occurrence and significance. Should an impact be included, when there is just a hypothetical concern, and observed change, or do we need consensus by a governmental organisation? Is uncertainty addressed as an "either we include it or not" or in a statistical way with an estimation of the uncertainty and its consequences on the outcome of a study?

Steen (2006) has illustrated these different ways of defining environmental performance by a three dimensional picture (fig 1).

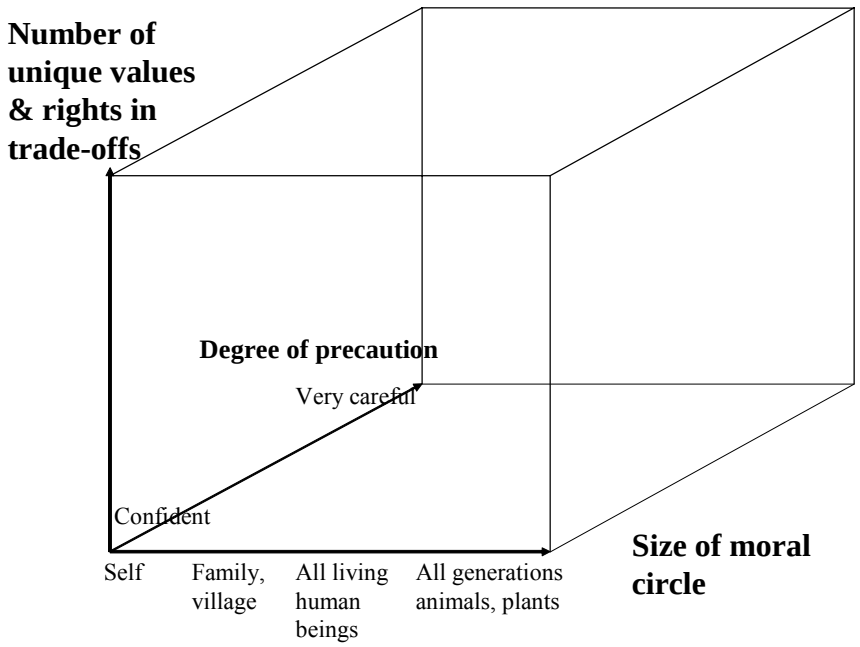
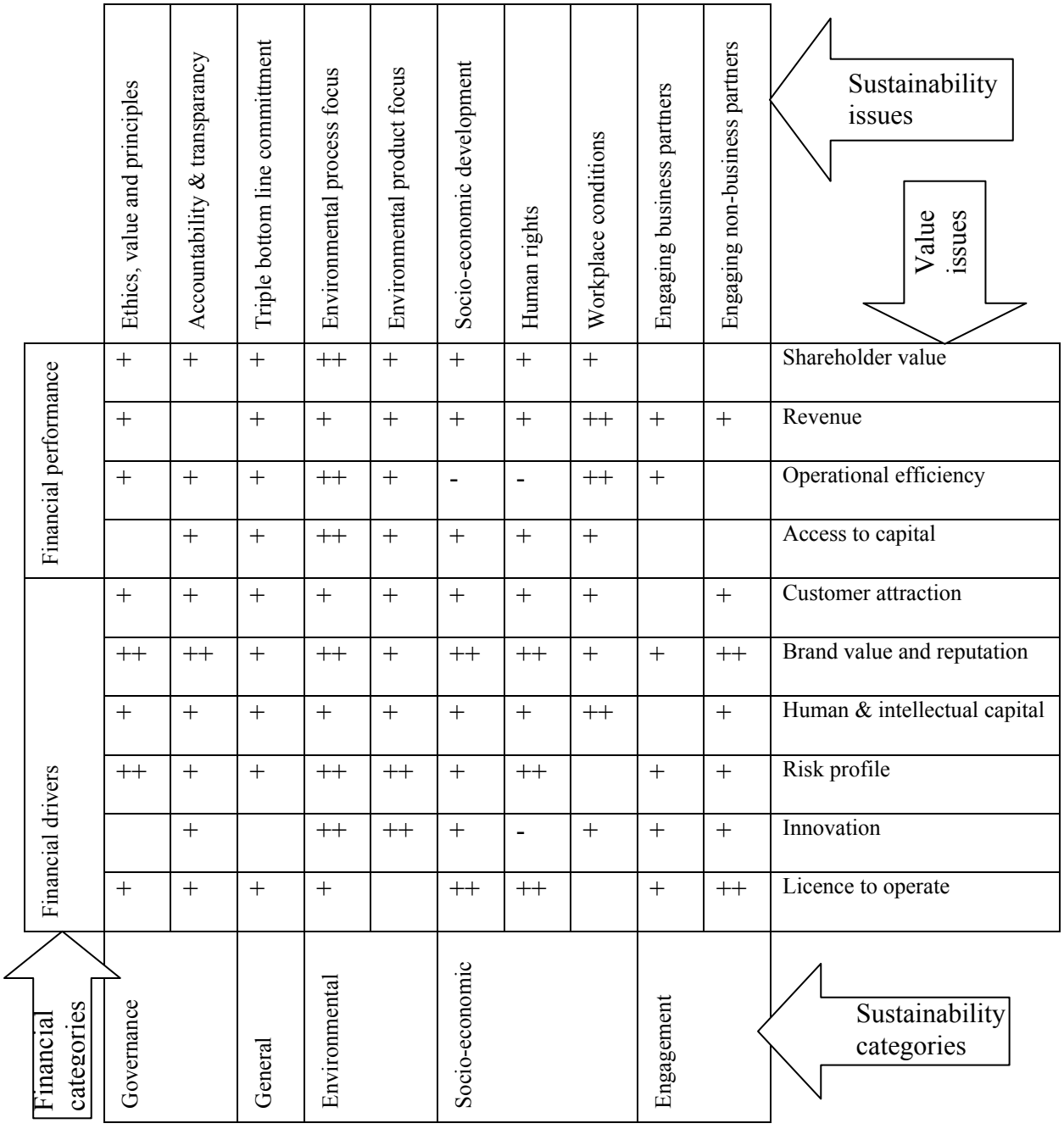


Figure 1 Different views on environmental performance.

The costs and benefits related to environment – or broader: sustainability - for companies are likely to be significantly different depending on how environment is defined.

4 Review of current literature

World Business Council for Sustainable Development (WBCSD) har investigated the business case for sustainable development (Heemskerk, 2002). In figure 2 they summarize their results.



	Ethics, value and principles	Accountability & transparancy	Triple bottom line committment	Environmental process focus	Environmental product focus	Socio-economic development	Human rights	Workplace conditions	Engaging business partners	Engaging non-business partners	
Financial performance	+	+	+	++	+	+	+	+			Shareholder value
	+		+	+	+	+	+	++	+	+	Revenue
	+	+	+	++	+	-	-	++	+		Operational efficiency
		+	+	++	+	+	+	+			Access to capital
Financial drivers	+	+	+	+	+	+	+	+		+	Customer attraction
	++	++	+	++	+	++	++	+	+	++	Brand value and reputation
	+	+	+	+	+	+	+	++		+	Human & intellectual capital
	++	+	+	++	++	+	++		+	+	Risk profile
		+		++	++	+	-	+	+	+	Innovation
	+	+	+	+		++	++		+	++	Licence to operate

Figure 2 Type of evidence available for various relations between sustainability and value creation. (Heemskerk et al. 2002)
"-" implies a negative impact, no sign means no impact, "+" means weak moderate positive impact and "++" indicates a strong positive impact.

Very few attempts have been made to quantitatively estimate what this means. The most comprehensive study that has been found is made by Willard (2002). He has looked at seven types of benefits of a triple bottom line for a hypothetical company, SD inc. (Table 1) and found the added benefits to increase the profit the order of 38%.

Table 1 Increase of profit in a fictive company due to applied sustainable development.

item	% increase of profit
Annual savings on recruiting costs	0.03
Annual savings from higher retention rates	1.3
Annual benefits on increased productivity	25.2
Annual benefits in manufacturing costs	5.5
Savings in commercial site operating cost	0.9
Inceased revenue, and resulting profit	5.0
Expense reduction from reduced risks	0.6
Total	38.4

Willards structuring of issues is different from WBCSD´s but it contains almost the same elements (Table 2).

Table 2 Comparing environmental cost and benefit issues raised by WBCSD (Heemskerk et al. 2002) and Willard (2002).

Value issues according to WBCSD	Types of benefits according to Willard
Shareholder value	
Revenue	Increased revenue/market share
Operational efficiency	Increasing employee productivity
Operational efficiency	Reduced expenses in manufacturing
Operational efficiency	Reduced expenses at commercial sites
Access to capital	Easier financing
Customer attraction	Increased revenue/market share
Brand value and reputation	Increased revenue/market share
Human & intellectual capital	Easier hiring of the best talent
Human & intellectual capital	Higher retention of top talent
Risk profile	Reduced risk,
Innovation	Increasing employee productivity
Licence to operate	

It is evident that the benefits of environmental performance are guided by how it is perceived by different stakeholders. A strict correlation to performance regarding its many aspects is difficult to deduct. However, one may expect that as environmental economics advance, more shades than good and poor and more dimensions will develop. Environmental product declarations (EPDs) may promote such a development. In EPDs quantitative LCA results are given for a number of environmental issues. EPDs are primarily aimed for business-to-business-relations, but may also be used for public procurement. Being highly exposed public information it may strongly influence stakeholder views on a company's environmental performance.

Stoeckl (2004) finds that different types of firms may benefit differently from environmental self-regulation. She mentions some key characteristics firms that may benefit most. They are:

- Large firms, which are likely to have comparatively low investments in relation to their turnover.
- 'Dirty firms', which can easily pick 'the low hanging fruits'.
- Firms which are capable of differentiating products on environmental grounds.
- Firms operating in regions of relatively high socio-economic status, or in environmentally 'sensitive' areas, or dealing with environmentally 'sensitive' products.
- Firms selling product to relative affluent consumers.
- Firms operating in highly competitive markets that have access to cost reducing environmental programs or firms operating in very concentrated markets that have access to environmental programs that raise short-run costs and long run benefits.
- Firms that are members of industry-wide associations

4.1 Shareholder value

According to WBCSD's value matrix (figure 2) there is a weak moderate positive relation between most sustainability issues and shareholder value and strong relation to an environmental process focus.

If Willard's estimate on the full effect of a triple bottom line, 38% increase of profits, were correct, the shareholder value would be on the same level. But investors today probably pay more attention to the risk factors for which Willard estimated the benefits to be in the orders of a few percent. Figures of this magnitude may be found in literature reviewed by Stoeckl (2004).

When USEPA published their Toxic Release Inventory, June 19, 1989 it led to a significant decrease in the stock prices of the company group involved. The first day after the companies' names were made public, the stock prices of publicly traded firms fell with 0.284% as an average (Konar and Cohen 1997). The authors refer to "the efficient market hypothesis" that "predicts that in a well-functioning capital market, security prices provide the best available unbiased estimates of the value of a company's assets".

Stock market based measures is one of two main classes of measures of financial performance, the other being accounting based measures (Konar and Cohen 1997). Stock market based measures are forward looking while accounting generally reflects historic performance.

Considering the complexity and poor knowledge about the relation between emissions, cost and benefits for a company, it is unlikely that the market actors 1989 fully understood the impact on the concerned companies' financial performance. One may also question whether the results obtained are applicable outside US, in countries with another legal tradition.

4.2 Revenue

Willard assumes a 5% increase of revenues due to increased prices and market share. This is mainly caused by the financial drivers "Customer attraction" and "Brand value".

Stoeckl (2004) says: "Consumers caring about the environment is a necessary – but not sufficient – condition for firm-level environmental programmes to raise demands. Not only

must consumers care about the environment (condition a), but they must have access to good quality information about the environmental performance of different firms (condition b), and they must act upon that information (condition c).” These conditions are different for different countries and company types.

An extreme impact on sales was experienced by Shell when they decided to dump the Brent Spar oil-drilling platform in the North Sea. The sales dropped more than 30% in some countries (Jensen 2002).

Stoeckl concludes that demand side effects are likely to be largest when:

- firms are able to differentiate its products on environmental grounds
- consumers care about the environment
- consumers have access to information on environmental performance
- consumers are wealthy and effluent and
- firms are large

4.3 Risks

There are many examples of companies that have had to face large, unexpected cost due to environmental and social impacts. Some of these risks may be internalised through insurances, but insurance companies only offer insurances, when the risk can be predicted and when there is a business case for them. Risks may be seen as extreme outcome of other costs and categorized as market risks, balanced sheet risks, operating risks, capital cost risks and sustainability risks. The risk concept could be very useful for internalising externalities that may cause future, real cost to the company. The internalised cost would be calculated from the formula:

$$\sum_{ij} p_{ij} \cdot c_{ij} \cdot d_j \text{ , where}$$

p is the probability of an event i on the j:th year, c is the cost of the event i on the j:th year and d is the discounting factor for the j:th year to present time. Such events could be new taxes, new prevention costs, liabilities, loss of market shares etc. In the report “Late lesson from early warnings” the European environmental agency have investigated a number of environmental problems from its early discovery to control measures were taken. This report and the process of demanding control measures from companies are described in chapter 10.

4.4 Operational efficiency

If revenues represent the income side, operational efficiency represents costs to do what is necessary for the incomes.

Willard (2002) discuss several links between sustainability issues and operational efficiency including

- Increasing employee productivity (mainly through commitment)
- Reduced expenses in manufacturing
- Reduced expenses at commercial sites

The increase in employee productivity is partly on the individual plane and partly due to teamwork and improved working conditions. Reduced expenses in manufacturing may be due to energy savings or less material waste. Stoeckl (2004) reviews several examples on energy savings, but of course energy savings are easier to make when there has been little concern about this before.

Reduced expenses on commercial sites include building maintenance, temperature control, ventilation, etc. Energy efficiency is important here as well as for manufacturing. Other issues has to do with employee consumables, waste handling, water conservation, landscaping costs, office space and business travel (Willard 2002).

4.5 Innovation

New demands in society create new business opportunities, and phase out old ones. Innovation is a necessary for the adaptation, either to increase benefits or decrease costs.

4.6 Access to capital

Standard&Poor (2004) use environmental criteria in rating loans with properties as security or for real estate transactions. These criteria are based on the standard ASTM E 1527-94, with some additional requirements. Their investigations include historical uses of properties in the surrounding area, hydrogeology (well records), storage tanks, PCB items, regulatory records, environmental databases of off-site conditions, wetlands, lead-based paint, lead in drinking water, asbestos, radon, ozone-depleting substances and compliance assessment. Environmental insurances may be used for risk management, especially in property transfer contexts.

Dow Jones sustainability index is a well known rating system for companies. It may have some impact on the access to capital, but the index is more a sustainability management rating than a sustainability rating. Besides it uses non transparent weighting factors for aggregating different index types (table 3)

Table 3 Corporate Sustainability Assessment Criteria considered for Dow Jones Sustainability index

Dimension	Criteria	Weighting (%)
Economic	Codes of Conduct / Compliance / Corruption&Bribery	5.5
	Corporate Governance	6.0
	Risk & Crisis Management	6.0
	Industry Specific Criteria	Depends on Industry
Environment	Environmental Performance (Eco-Efficiency)	7.0
	Environmental Reporting*	3.0
	Industry Specific Criteria	Depends on Industry
Social	Corporate Citizenship/ Philanthropy	3.5
	Labor Practice Indicators	5.0
	Human Capital Development	5.5
	Social Reporting*	3.0
	Talent Attraction & Retention	5.5
	Industry Specific Criteria	Depends on Industry

5 Environmental Management Accounting

Environmental Management Accounting (EMA) combines physical and financial data in a company for the purpose of bringing environmental management and economic accounting together. Management is thereby given the connection between environment and economy. The physical data is on material and energy input, material flows, products waste and emissions. The financial data shows expenditures, costs, earnings and savings related to company activities with potential environmental aspects or impacts. Environmental expenditure is the sum of the following costs: waste and emission treatment, prevention and environmental management, material purchase value of non-product output and processing costs of non-product output.

By working with EMA there is a possibility to make more well-founded decisions, in popular terms "most environment for the money". The result of implemented EMA is increased material efficiency, reduced environmental impact and risk, and reduced costs for environmental protection.

5.1 Brief history

- In the early 1990s, US EPA was the first national government organization in the world to establish a formal programme to promote the use of EMA. At the same time the United Nations also presented a first framework, with a focus on how environmental economy could be reported in the companies' financial reporting.
- In 2002 the United Nations Division on Sustainable Development (UNDSD) published the document *Environmental Management Accounting: Policies and Linkages*, written by a commissioned expert group.
- The International Federation of Accountants (IFAC) commissioned a guidance document that was published in 2005 (IFAC, 2005). One of the goals with the document is to reduce some of the international confusion by providing a general framework and set of definitions.

5.2 Comparison LCA and EMA

EMA was implemented at a paper mill of the Swedish company SCA for comparisons of environmental costs already for the years of 1998/1999. It was part of a research project of United Nations Commission on Sustainable Development (UNCSD), with the aim to demonstrate tangible financial benefits which can be gained by good environmental performance.

Within the hygiene business division of SCA life cycle assessment (LCA) has been used regularly in product development since more than 10 years (ref). The division's LCA practitioners were commissioned by SCA to do a comparison between EMA and LCA. The purpose was to see if the two tools harmonized in where to put focus on the environmental work.

When comparing the two sets of results, there is of course the main difference of the scope for the two tools. EMA is investigating flows "gate-to-gate" and LCA follows the flows from "cradle-to-gate".

This difference is probably the reason for lack of correspondence between high costs according to EMA and high values in the impact categories of the LCA. In the EMA accounting there highest costs are within "Material purchase value of non-product output" with raw material cost, cost of operating materials and energy. Only the energy costs (i.e. costs for effiency losses) corresponded to high contribution in the LCA from steam production at the mill.

The loss of raw materials where caused by purchased waste paper, where a proportion is lost in the de-inking process. In an LCA a product manufactured from waste paper usually have a lower environmental impact than products manufactured from virgin fibre.
The third high cost in the EMA system was for paper chemicals, but in an LCA the chemicals have a rather low impact.

Conclusions from this project seems to be that although the environmental costs are well identified, it is not that simple that these costs should be controled in order to have a lower environmental impact, i.e. loss of waste paper.

5.3 Danish pilot project

In 2003 the Danish Environmental Protection Agency (Miljöstyrelsen) started a project in which nine different Danish companies tried the implementation of EMA. Two basic foundings came out of the project:
At the start of the work with EMA in a company, it is very important that a cross-functional group is appointed with participation from both environmental and economic groups within the company.
The second important finding of this project is the consideration of which costs are relevant to follow.

The following perspectives were to be taken into consideration for finding out which costs are relevant to follow in the set-up of EMA

- Economical perspective
- Customer perspective
- Perspective of internal processes
- Learning and development perspective
- Stakeholder perspective

Perspective	
1. Economical perspective	Which costs and incomes are there in relation to the different environmental aspect? What can be earned/saved? How important is the environmental costs for the total economical development of the company? Is environmental economy relevant for our investors?
2. Customer perspective	Are the environmental aspects on interest for the customers? Is it relevant for the company's image? Is it possible to use concretely in the marketing? If the customers now how much of the product's price is caused by environmental concern, will it have any impact of the sale.
3. Perspective of internal processes	Which relation is it between the environmental aspects and all internal processes, e.g. production, logistics, waste management. Could there be changes or improved efficiency? What's the value of the changed processes?
4. Learning and development perspective	Is there any connection to need for training/development of employees. Connection to employee satisfaction?
5. Stakeholder perspective	Are there external stakeholders, i.e. authorities, neighbours, etc. that have an interest in the actual environmental problems?

5.4 Cost categories of EMA

EMA focus on costs internal to the company and places particular emphasis on accounting for environmental costs. It encompasses not only environmental and other cost information, but also explicit information on physical flows and fates of materials and energy.
The following cost-categories are defined to be environment related:

- Materials cost of product output
- Material costs of non-product outputs
- Waste and emissions control costs
- Prevention and other environmental management costs
- Research and development costs
- Less tangible costs (e.g. future regulations, company image)

The following cost-categories are defined to be environment related:

1. Materials cost of product outputs	Includes purchase costs of natural resources such as water and other materials that are converted into product, by-products and packaging
2. Materials costs of non-product outputs	Includes the purchase costs (and sometimes) processing costs of energy, water and other materials that become Non-Product Output (NPO) (waste and emissions
3. Waste and emissions control costs	Includes costs for: handling, treatment and disposal of waste and emissions; remediation and compensation costs related to environmental damage; and any control-related regulatory compliance costs
4. Prevention and other environmental management costs	Includes the costs of preventive management activities such as cleaner production projects. Also includes costs for other environmental management activities such as environmental planning and systems, environmental measurement, environmental communication and any other relevant activities
5. Research and development costs	Includes the costs for R&D projects related to environmental issues
6. Less tangible costs	Includes both internal and external costs related to less tangible issues. Examples include liability, future regulations, productivity, company image, stakeholder relations and externalitities

5.5 More information on EMA

Miljöekonomistyring i danske virksomheder, arbejdsrapport fra Miljöstyrelsen Nr 11 2004

EMA-guide, Miljöstyrelsen, http://www.mst.dk/ Industri/ Milj%c3%b8%c3%b8konomistyring/ EMA-guide/

International Guidance Document: Environmental Management Accounting, International Federation of Accountants, 2005

Environmental Management Accounting, international website hosted by EMARIC: www.emawebsite.org

6 Life Cycle Costing

To consider more than the purchasing cost when buying merchandise is rather logical and life cycle costs are probably been considered more or less as long as there has been business. In the 1970s LCC was legally mandated for weapon systems procurement by the US-government and for the building programs at public institutions in several US-states (Sherif, Kolarik 1981)

LCC studies typically have other system boundaries than LCA. They also differ as they include a temporal aspect. Future cost during the life cycle is discounted and presented as cost for a reference year, normally the year of the study.

SETAC hosted a working group on LCC (SETAC 2006). The group who examined LCC from an environmental perspective identifies three types of LCC:

- Conventional LCC
- Environmental LCC
- Societal LCC

"Conventional LCC has never been explicitly developed into a broad and generally applicable methodology. Instead it has been developed – based on the principal life cycle view – in the context of application specific procedures in certain sectors. Taken as a whole, the work done so far can be seen as a general methodology with examples of application in specific settings." (Rebitzer 2004)

Environmental LCC does not imply that environmental costs have to be calculated, only that the approaches (including system boundaries) of environmental LCA and conventional LCC are compatible.

Societal LCC can be seen as a combination between LCC and CBA. It includes monetized externalities of social and environmental kinds.

An LCC tool is available at dantes.info.

LCC is an important input for assessing ecoefficiency.

7 Eco-efficiency

The term eco-efficiency was introduced by WBCSD 1991 for the RIO conference. The definition of eco-efficiency that today is most widely spread and which is gaining acceptance was coined by WBCSD (Jollands and Patterson, 2004):

> "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"

This definition emphasizes the qualitative aspect of eco-efficiency. It is similar to the definition of Pareto-efficiency in that it suggests that there is a state of efficiency, which can be achieved. Below this view will be challenged.

Eco-efficiency represents the relation between economic and environmental performance. To have a measure that increase with decreasing environmental impacts or increased economic performance it was suggested by WBCSD that it should be represented by economic performance per environmental performance. There is however other ways of getting an increased eco-efficiency with decreasing environmental impact – as will be shown below. The

concept of eco-efficiency is intentionally not well defined and several suggestions on measures for eco-efficiency have been given (Huppes and Ishikawa, 2005).

Within the project reported here, (Interaction between economic and environmental issues in companies) we have defined a new measure for eco-efficiency. It is based on an engineering tradition, where the efficiency of an activity is useful output divided by input. We have chosen to compare input value with output value of a business activity, including external environmental value changes – all expressed in monetary terms.

The main reason for using these types of measures was an experience from studying the communication of environmental performance of products. These Studies showed that very few did understand the measures presented. Less GWP was clearly better than more GWP but how big was the problem caused by a single product?

We therefore asked ourselves: what could be understood? What could inform about the significance of an increased or decreased environmental performance? A measure would be more understandable, the more comparable it was to everyday measures we use. So if the eco-efficiency would be 100% when the value created in a business had no impact on the environment, it would be comparable to what we mean by a fully efficient process without any losses. If the eco-efficiency was 0% it would create no net value. The value losses due to environmental damage would be equal to the added value of the business activity. The algorithm below create such a measure:

$$\text{Ecoefficiency} = (V_{int}-C_{ed})/V_{int}$$

Here V_{int} is the business internal value and C_{ed} the environmental damage costs.

V_{int} may be different for different business stakeholders. For the capital suppliers and producers V_{int} is their respective profits, for the user V_{int} may be estimated from the LCC of the product.

C_{ed} was estimated by the EPS 2000d method (Steen 1999).

It C_{ed} is larger than V_{int} , the value of eco-efficiency becomes negative and if C_{ed} is less than zero, i.e. there are net positive environmental impacts, the value of eco-efficiency becomes more than 100%. It is very unusual that this happens.

To investigate how this type of eco-efficiency measure would function in practice two case studies were made. One case study concerned a chemical plant, seeking guidance for installing increased incineration capacity for COD in waste water. The other case was an electric motor with and without a frequency converter.

The first case study showed that the present water treatment by incineration already had a negative eco-efficiency (-90%) and that increased incineration of COD and consequent decrease of COD emission to water further decreased the eco-efficiency (-198%) (Skantze, 2005). This was because the use and combustion of fossil fuels caused a larger damage cost than was decreased through the reduction of COD. The lesson learnt from the case study was that the eco-efficiency measure we used gave a very clear signal and pointed at a trade-off between local and global impacts, which may not have been considered when the choice of waste water treatment method was made in the first place.

The second case study (Lyrstedt, 2005) showed approximately the same eco-efficiency for the electric motor with and without frequency converter (81 and 82% respectively) despite that the frequency converter saved a lot of energy. In the study we used the life cycle cost as an estimation of V_{int} . The lesson learnt from this case study was that the system boundary was too narrow to give guidance for the choice between alternative motor concepts. As the main costs and environmental damages were caused by electricity production, the eco-efficiency we saw was that of electricity production, regardless of how much that was used. If we had increased the system boundaries to the whole plant where the motor was used, there would have been a more clear improvement in terms of eco-efficiency. The case demonstrated that efficiency and effect is not necessarily the same thing.

The effect is an efficiency times a volume. If there is a dependency between changes in the efficiency and volume, interpretation of eco-efficiency changes become particularly tricky. For instance, if the eco-efficiency of a product related business is increased by lowering the life cycle impact from the product or raising its price, the sales volume may decrease in favour of a competing product, which has a larger impact on the environment.

But normally, an increase in eco-efficiency is likely to result in an improved environment. If there is a budget restriction, which is true for most economic systems, there is a limited amount of money to spend each year. If the environmental impact per spent monetary unit decreases (= increased eco-efficiency) the total impact will decrease. If a person buys an expensive car, using more gasoline than the average, it may still be eco-efficient and give a net positive effect on the environment. This is because the buyer had less other money to spend on other goods or services impacting the environment. Of course in the specific case, it depends on the alternatives, but as an average in society, the alternative is the average impact per spent monetary unit. This means that a good strategy would be to purchase goods and services that have an eco-efficiency above average.

To get a better overview over how this type of eco-efficiency measure would vary, we used EPD data (EPD = environmental product declaration) and some data published elsewhere to evaluate the eco-efficiency from a broad set of product life cycles (Lyrstedt et.al 2006). The results, which are shown in table 4 is to be seen as examples, and not as representative for the respective product groups. The table shows that there is enough resolution in the material to differentiate between alternatives and that the magnitude of the efficiency is reasonable.

When discussing the results from the case studies with different groups, one reaction was that it is unreasonable that the eco-efficiency increases when the price of a product is increased. It is the same product and if it's environmental performance is good, the increased price will decrease the sales volume – perhaps at the benefit of the competitors worse alternative - and this will not be "eco-efficient".

To this one can say two things:

1. Eco-efficiency is a term related to business. Even if it is the same product, it is another business, when the price is raised.
2. Efficiency and effect might not be the same. When selecting eco-efficiency as an indicator for environmental management, a check has to be made to ensure that there are no such negative correlations. Normally there is not.

Table 4 Examples of ecoefficiency measures for various product sales

Product group	Eco-efficiency (%)		
Machinery and equipment		*Pulp and Paper products*	
Sink Mixer	37	Particle board	87
Submersible Pumps 1,3-32 kW	74-81	Incontinence product	29-45
Electric Motor 1278 kW	81		
White Goods		*Furniture, Curtain rails (no material recycling)*	
Washing machine	84	Nickel plated Steel	96
Fridge	68	Solid Birch	98
Freezer	70	Powder coated Steel	83
		Anodised Aluminium	79
Electricity, Gas and Heat		Stainless Steel	7
Nuclear Power	97		
Hydro Power	99	*Food and Beverage*	
Wind Power	93	Pork	86
District Heating, (Gothenburg)	45	Beef	76
		Chicken	81
Other non Metallic Mineral product		Milk	85
Cement	11	Potato	96
		Drinking Water (Gothenburg)	94
Radio, Television &			
Communication equipment			
LCD TV	90		
Fax machine	96		
Photocopier	97		

8 Stakeholder perspectives in ABB

The society and stakeholder demands on corporate handling of social and environmental issues have increased substantially during the last decade. As a response to this demand, the industrial sector has spent large amount of resources in developing and implementing management systems and tools for sustainability issues, such as environmental management systems (EMS), occupational health and safety management systems (OHSMS), life cycle assessments (LCA), environmental product declarations (EPD) and sustainability reports (SR). An important question to consider is consequently how companies as well as their stakeholders perceive the economic, environmental and social benefits from using these systems and tools in companies.

The aim for a study made by Swanström and Cerin (2006) was to analyze how some key stakeholder groups perceive the economic, environmental and social outcomes from using systems and tools for managing aspects of sustainability in companies. The study was conducted as a questionnaire study embracing actors in industry with ABB as the focal company, the financial sector and academia. In total 105 responses of 155 questionnaires were received which gives us the overall response rate 67,7 percent for the entire study. The answers from the respondents were divided into eight fairly distinguished groups. The three groups in industry were; *ABB Country Sustainability Controllers* (29), *ABB Group Account Managers* (19), i.e. sales managers for ABB key customers and *ABB Customers* (9). The three groups in the financial sector were; *Finance Banks* (10), i.e. SRI Analysts and Environmental Managers at banks, fund and insurance companies, *Finance SRI Advisors* (8), i.e. SRI advisors in SRI advisor firms and *Finance Portfolio Managers-&-Analysts* (7). Finally, the two groups from academia were*: Academia Environmental Management* (13), i.e. researchers working with environmental management and tools for environmental analysis and *Academia Accounting-&-Investment (*10), i.e. researchers working with environmental and social performance related to environmental accounting, sustainability reporting and sustainable investments.

All stakeholder groups, except for the Academia Accounting-&-Investment group, perceive that the use of systems and tools for managing sustainability issues result in higher environmental and social performance for the company and its products. It is, however, according to a majority of all respondent groups not likely that the economic performance of the company automatically improves by taking these actions.

The study shows that ABB has quite successfully reached out to the financial actors included in the study permeating ABB's sustainability objectives, actions and results. The Finance SRI Advisor firm respondent group, which is the most critical group to many issues within corporate extended responsibility and how to handle those, is also the respondent group that shows the strongest support to the normative statement that *"ABB is a proactive company in the sustainability area."* Since a large number of the SRI advisors are quite concerned with real performance of environmental and social aspects this requires not only communication skills from ABB, but also actual progress and sound management strategies. The only respondent group showing even stronger support for ABB's proactiveness in the sustainability area is, perhaps not surprising, ABB's own Country Sustainability Controllers.
The findings of the study show that it is vital for ABB and for manufacturing industry in general to implement a product focus when addressing the environmental aspects of the organisation. Environmental performances of ABB's products and services are what the customers request since it affects their own operations. This product focus is also the focus for the financial analysts and they see a need for linking the dependence on environmental aspects to the generation of ABB's revenues, which for active products of ABB go via its services and the economic solutions offered customers. Indications are provided from the larger firm of the respondent group Finance SRI Advisors that they do not care much for initiatives like carbon neutral companies and plants (unless driven by marginal cost cuts), which currently is well perceived among industrial actors – firms and perhaps especially consultants – and NGO's. The negative stand simply arises because these increased costs within the company will oftentimes not come anywhere near to generate the business needed to cover them and the major environmental gains lies in product improvements. But, in the view of Finance SRI Advisors, for social issues working conditions upstream in the value chain and coherent HR standards within the corporation globally are vital in the evaluation.

All respondent groups in industry and the financial sector – perceive that companies provide their business stakeholders with requested information and do not see the systems and tools for analysis and communication as being too resource consuming. The academic groups developing new systems and tools for handling sustainability issues was not the most critical group on the efficiency of these tools but saw the greatest need of all respondent groups for improving the very same efficiency – an indication of the respondents speaking for their own benefits.

Contrary to the view of the ABB Country Sustainability Controllers, the ABB Group Account Managers do not see management programs as important driving force for working with sustainability issues which clearly displays the essential *cultural belongings* of these two professional groups within the company. The Group Account Mangers do, however, regard management programs, especially environmental management systems, as being the most important tool to have implemented from a customer perspective which fits well with the *power interest* of these managers. These systems are consequently seen by ABB Group Account Mangers as important from a customer perspective, but the Group Account Managers do according to the responses not see these systems as a significant force for them to work with sustainability issues. Thus, to what degree are these managers involved in the actual improvement processes? The *information asymmetries* make it difficult and resource demanding for procurement staff to retrieve a holistic picture of the environmental performance inside the supplier and its services, making them satisfied by checking aspects i.e. the existence of EMSs. The main driving force for ABB Country Sustainability Controllers can be seen as internal – legal and governmental requirements and management programs – while ABB Group Account Managers perceive customers as the most important driver.

Another finding is that the ABB Country Sustainability Controllers see management commitment as the biggest obstacle for working with sustainability issues, while most ABB Group Account Managers does not see this commitment as insufficient. One out of five of the ABB Group Account Managers do not see a problem at all for integration of sustainability issues in the daily activities. The identification of management commitment as the largest obstacle for working with environmental issues has, moreover, increased since a LCA study carried out on ABB 1999.

The main result from the longitudinal study – comparing the current results with the result from the study on the LCA tool conducted in 2001 based on data from 1999 – is that environmental/sustainability managers feel that the driving forces for working with environmental/sustainability issues have shifted from management programs towards legislation and awareness in society. Environmental and sustainability managers currently sees management commitment as an increased main obstacle for working with environmental and sustainability issues compared to the previous study. LCA data is demanded by customers to the same extent as for six years ago and it there is a small increase in using LCAs in marketing while LCA is seen by both line managers and sustainability managers as providing less competitive advantage than before.

The voluntary initiatives taken by industry and other actors in society on environmental and social aspects are expected by some Academia Accounting-&-Investment respondents to become transformed into mandatory demands and regulations ahead. Some respondents from the academic groups stressed the fact that the expeditious economic development of the enormous late-coming economies puts new requirements on the environmental and social

aspects of company services. Resource scarcity is going to be a rapidly increasing actuality that needs to be addressed as well as the social and environmental demands on services sold to the new arising markets.

Additional it is important to note that, in general, it is very difficult and resource consuming (high transaction costs) for company stakeholders to retrieve a good picture from the outside-in regarding the internal management of environmental and social issues and the resulting outcome in environmental, social and economic performances.

The responses from Finance SRI Advisors indicate a need for comparable and reliable indicators that show how companies' environmental and social performances affect their economic performances and describe the strategic management thereof – e.g. how dependent is company revenues on carbon emissions and child labour and what strategies are taken to address the associated business risks.

To deal with how environmental and social aspects influence company revenues and future market shares should, hence, be the core of corporate strategies, management and product assessments of sustainability issues.

9 Activities in Akzo Nobel

Akzo Nobel is paying an increased interest in eco-efficiency, has made several case studies and aim at using eco-efficiency in evaluating investment options.

One of the case studies was about control of COD emissions to water and is published as a CPM report (Skantze, 2005)

10 Interventions from society

To act on environmental deterioration has mainly been a governmental responsibility. Companies have learnt to adjust to various kinds of regulations – often meaning costs – to safeguard the environment. These costs typically come as a consequence of an impact being discovered and well known. Governments have formulated various policy principles to guide regulations. Such policy principles are the PPP or "Polluter Pays Principle" meaning that the polluter shall pay the cost of environmental damage in one way or the other. During the last decade the PPP acronym has been partly replaced by IPP, Integrating Product Policy and its "get the prices right" principle. In this there is an ambition to integrate external costs in the price of a product.

For a company today it is of interest to know if there will be any new interventions from society and thus extra future costs of its present emissions and use of natural resources. There is of course no precise answer to such a question but, but there is a lot to learn from history. The EEA report "Late lessons from early warnings" (EEA, 2001) gives 14 examples on environmental issues and how they developed from they were first discovered or suspected until measures were taken and they meant tangible costs to companies and other parts of society. The negative effect of asbestos for example was discovered in UK as early as 1898, but it took 100 years before it was banned there. The CFC ban came quicker, but there still will be many skin cancers that could be avoided. But as the report states:

“However, being wise before it is too late is not easy, especially when the environmental or health impacts may be far into the future and the real, or perceived, costs of averting them are large and immediate.”

There have also been many false alarms, but not surprisingly the editors had difficulties to find sufficient documentation on these.

“Regulatory appraisal and control of technologies and economic development involves balancing the costs of being too restrictive on innovation with the hazards and costs of being too permissive, in situations of scientific uncertainty and ignorance.”

The case studies indicate the following aspects to be considered when estimating future tangible cost increases to a company from a particular environmental issue:

1. Maturity of the issue in the country where the company is located
2. What the abatement cost is compared to damage cost
3. How much of the cost that can be covered by the customers
4. Number of actors involved

10.1 Maturity of issue

The EAA report concludes in twelve lessons learnt from their case studies. These lessons may be used to check how far the society has proceeded with the issue. When looking at each aspect one may compare with issues already regulated. The lessons learnt are summarised in table 5. It may be difficult for an ordinary official in a company to make a judgement of the maturity, but for an environmental expert it should be possible.

10.2 Abatement cost compared to damage cost

Governments have since long used the BAT principle as a guide when enforcing restrictions to emissions. The BAT principle requests the use of Best Available Technology within reason. “Within reason” means that the cost for the technology must be reasonable with respect to the environmental damage. Sometimes this can be checked using cost-benefit analysis with a monetary assessment of costs and damages, but in other cases the damages may be violation of human rights or other unique values. In those cases damage cost is not useful for assessing what is reasonable. For instance, protecting some red-listed bird may be used as a reason for extensive abatement measures.

Table 5 Maturity of environmental issue

Lesson learnt	**Check the following**
1. Acknowledge and respond to ignorance, as well as uncertainty and risk, in technology appraisal and public policymaking.	Are these aspects mentioned in media and policy documents?
2. Provide adequate long-term environmental and health monitoring and research into early warnings.	Are such programs running or have been running?
3. Identify and work to reduce 'blind spots' and gaps in scientific knowledge.	Is there a discussion of blind spots and gaps aspects in R&D documentation
4. Identify and reduce interdisciplinary obstacles to learning.	Is there an interdisciplinary agenda?
5. Ensure that real world conditions are adequately accounted for in regulatory appraisal.	Is there an impact assessment of planned regulations?
6. Systematically scrutinise the claimed justifications and benefits alongside the potential risks.	Are there critical reviews?
7. Evaluate a range of alternative options for meeting needs alongside the option under appraisal, and promote more robust, diverse and adaptable technologies so as to minimise the costs of surprises and maximise the benefits of innovation.	Are there discussions of alternative options for meeting the needs?
8. Ensure use of 'lay' and local knowledge, as well as relevant specialist expertise in the appraisal.	Are there laymen and local knowledge involved?
9. Take full account of the assumptions and values of different social groups.	Are values of different social groups accounted for?
10. Maintain the regulatory independence of interested parties while retaining an inclusive approach to information and opinion gathering.	Are interested parties involved in a dialogue?
11. Identify and reduce institutional obstacles to learning and action.	Have institutional obstacles to learning and action been identified?
12. Avoid 'paralysis by analysis' by acting to reduce potential harm when there are reasonable grounds for concern.	Are there at least some actions taken on reasonable grounds?

10.3 How much of the cost that can be covered by the customers

If there is an increased willingness-to-pay for green products or all competitors get the same cost is increases and the price elasticity is favourable, the increased cost may be passed on to the customer. It is worth noting that the Taiwan authorities were instructed by Taiwan EPA to promote green products in public purchasing up to an extra cost of 10% (Taiwan, 1999). The extra costs accepted from a green bidder is dependent on the social and environmental benefits of the green product compared to the lowest priced non-green product. Here we have an example of directly internalised externalities.

10.4 Number of actors involved

One of the fastest regulatory processes was that of replacing freons. As the manufacturers were few, substitutes could be found and introduced in a relatively short time period. The opposite would be when decreasing CO_2 emissions. The actors involved are extremely numerous and this is likely to delay the process.

11 Discussion and Outlook

Considering the historical experience on how environmental cost are internalised in companies, it is tempting to use that knowledge to forecast future cost to companies from

today's environmental issues. Are there any early warnings today that companies can prepare themselves for?

Using the cost estimates made in the EPS system allowed us to forecast increased costs from measures against global warming from greenhouse gases already in the early 1990ies. The environmental issue of global warming from greenhouse gases may be considered as mature according to table 6. The abatement costs are large, but lower than damage costs (Stern 2006). As measures to be taken have to be global, it is likely that most of the costs can be transferred to the customers. Today, there are only a few measures taken, and consequently it is reasonable to expect a substantial cost increase within a near future. The many actors involved may however slow down the internalisation rate.

Table 6 Maturity of greenhouse gas issue

Lesson learnt	**Check the following**	**Status**
1. Acknowledge and respond to ignorance, as well as uncertainty and risk, in technology appraisal and public policymaking.	Are these aspects mentioned in media and policy documents?	Frequent mentioning
2. Provide adequate long-term environmental and health monitoring and research into early warnings.	Are such programs running or have been running?	National and international programs exist
3. Identify and work to reduce 'blind spots' and gaps in scientific knowledge.	Is there a discussion of blind spots and gaps aspects in R&D documentation	Yes, e.g. comparing impact forecasts from increased temperature with El Niño consequences
4. Identify and reduce interdisciplinary obstacles to learning.	Is there an interdisciplinary agenda?	Yes, IPCC
5. Ensure that real world conditions are adequately accounted for in regulatory appraisal.	Is there an impact assessment of planned regulations?	Yes, e.g in Kyoto preparations
6. Systematically scrutinise the claimed justifications and benefits alongside the potential risks.	Are there critical reviews?	IPCC
7. Evaluate a range of alternative options for meeting needs alongside the option under appraisal, and promote more robust, diverse and adaptable technologies so as to minimise the costs of surprises and maximise the benefits of innovation.	Are there discussions of alternative options for meeting the needs?	IPPC mitigation reports
8. Ensure use of 'lay' and local knowledge, as well as relevant specialist expertise in the appraisal.	Are there laymen and local knowledge involved?	Yes, e.g. Agenda 21 activies
9. Take full account of the assumptions and values of different social groups.	Are values of different social groups accounted for?	To some degree, but not necessarily beneficial for the issue
10. Maintain the regulatory independence of interested parties while retaining an inclusive approach to information and opinion gathering.	Are interested parties involved in a dialogue?	Yes
11. Identify and reduce institutional obstacles to learning and action.	Have institutional obstacles to learning and action been identified?	Identified, yes, but marginally reduced.
12. Avoid 'paralysis by analysis' by acting to reduce potential harm when there are reasonable grounds for concern.	Are there at least some actions taken on reasonable grounds?	Yes, Kyoto agreement

Another issue that is highlighted by the EPS data is the depletion of abiotic resources, e.g. fossil fuels and ores. Checking versus table 3, we find that this issue is immature (Table 7). Cost-benefit studies are hampered by the fact that the value of abiotic resources to future generations is seldom discussed. The value is almost exclusively determined from present market values. Even so, recycling is beneficial in many cases. As abiotic resources are traded globally and no global treaties are within sight, it seems unlikely that costs may be passes on to the customers. Besides there are many actors involved. Therefore it seems likely that no substantial cost increases – except the market driven ones – will happen in the nearest future. This forecast is supported further from earlier failures of resource management of fish stocks. Still, a strategy reducing the consumption of scarce resources may be beneficial, but then for pure market reasons or for long term planning reason. Only if the production of oil and some metals peak within a couple of decades it seems likely that society will intervene.

Table 7 Maturity of abiotic resource issue

Lesson learnt	**Check the following**	**Status**
1. Acknowledge and respond to ignorance, as well as uncertainty and risk, in technology appraisal and public policymaking.	Are these aspects mentioned in media and policy documents?	Scarce mentioning, but EU has put the issue on the agenda
2. Provide adequate long-term environmental and health monitoring and research into early warnings.	Are such programs running or have been running?	No, only occasional studies
3. Identify and work to reduce 'blind spots' and gaps in scientific knowledge.	Is there a discussion of blind spots and gaps aspects in R&D documentation	Very little
4. Identify and reduce interdisciplinary obstacles to learning.	Is there an interdisciplinary agenda?	Only for oil. (Peak oil movement)
5. Ensure that real world conditions are adequately accounted for in regulatory appraisal.	Is there an impact assessment of planned regulations?	No
6. Systematically scrutinise the claimed justifications and benefits alongside the potential risks.	Are there critical reviews?	No
7. Evaluate a range of alternative options for meeting needs alongside the option under appraisal, and promote more robust, diverse and adaptable technologies so as to minimise the costs of surprises and maximise the benefits of innovation.	Are there discussions of alternative options for meeting the needs?	To some degree
8. Ensure use of 'lay' and local knowledge, as well as relevant specialist expertise in the appraisal.	Are there laymen and local knowledge involved?	To some degree in Agenda 21 activities. (Recycling)
9. Take full account of the assumptions and values of different social groups.	Are values of different social groups accounted for?	Very little
10. Maintain the regulatory independence of interested parties while retaining an inclusive approach to information and opinion gathering.	Are interested parties involved in a dialogue?	Yes, from a recycling of waste perspective, but not from a broad resource management perspective
11. Identify and reduce institutional obstacles to learning and action.	Have institutional obstacles to learning and action been identified?	No
12. Avoid 'paralysis by analysis' by acting to reduce potential harm when there are reasonable grounds for concern.	Are there at least some actions taken on reasonable grounds?	Yes, waste recycling

Emissions of particles and gases forming secondary particles in the atmosphere are also issues that may lead to regulations. It is however complicated issues and when tested on the

checklist in table 5 (see table 8), they are less mature than the greenhouse gas issue, at least with respect to atmospheric dimming. For ordinary respiratory health effects, the issue is more mature and there is likely to be extra costs, mostly related to vehicle emissions.

Table 8 Maturity of particle issue

Lesson learnt	**Check the following**	**Status**
1. Acknowledge and respond to ignorance, as well as uncertainty and risk, in technology appraisal and public policymaking.	Are these aspects mentioned in media and policy documents?	To some degree
2. Provide adequate long-term environmental and health monitoring and research into early warnings.	Are such programs running or have been running?	To some degree
3. Identify and work to reduce 'blind spots' and gaps in scientific knowledge.	Is there a discussion of blind spots and gaps aspects in R&D documentation	Very little
4. Identify and reduce interdisciplinary obstacles to learning.	Is there an interdisciplinary agenda?	Only for oil. (Peak oil movement)
5. Ensure that real world conditions are adequately accounted for in regulatory appraisal.	Is there an impact assessment of planned regulations?	No
6. Systematically scrutinise the claimed justifications and benefits alongside the potential risks.	Are there critical reviews?	No
7. Evaluate a range of alternative options for meeting needs alongside the option under appraisal, and promote more robust, diverse and adaptable technologies so as to minimise the costs of surprises and maximise the benefits of innovation.	Are there discussions of alternative options for meeting the needs?	To some degree
8. Ensure use of 'lay' and local knowledge, as well as relevant specialist expertise in the appraisal.	Are there laymen and local knowledge involved?	To some degree in Agenda 21 activities. (Recycling)
9. Take full account of the assumptions and values of different social groups.	Are values of different social groups accounted for?	Very little
10. Maintain the regulatory independence of interested parties while retaining an inclusive approach to information and opinion gathering.	Are interested parties involved in a dialogue?	Yes, from a recycling of waste perspective, but not from a broad resource management perspective
11. Identify and reduce institutional obstacles to learning and action.	Have institutional obstacles to learning and action been identified?	No
12. Avoid 'paralysis by analysis' by acting to reduce potential harm when there are reasonable grounds for concern.	Are there at least some actions taken on reasonable grounds?	Yes, waste recycling

Atmospheric dimming is a relatively new concern, but severe in that it balances global warming and probably is responsible for the African draught. Aircrafts, ground level traffic and forest fires contribute significantly to atmospheric dimming.

12 Conclusions and recommendations

For a company, it is of interest to know: which are the costs and benefits from the company's environmental protection activities, how do these costs and benefits develop within the relevant planning horizon, and which options are there to control them.

The direct costs and benefits was identified in chapter 4 above and most of them are in principle easy to estimate. In practice, there may be problems because the bookkeeping may not be organised to identify environmental costs and benefits. There is also an allocation problem in that many measures are taken for several reasons, environmental reasons being one of them. There are two types of allocation principles: average and marginal. For monitoring of economic performance, average allocation may be suitable, while for choices between alternatives the marginal approach may be the most suitable.

Benefits from increased market shares and increased performance by employees are extremely difficult to estimate, but the classification given by Natali Stoeckl and reported in chapter 4 above may be helpful. The estimations given by Willard may be used as a reference, but they are clearly allocated in a marginal type of way. Other types of stimulation of employee performance may have the same effect.

The development of costs and benefits in time depends on two mechanisms: the external development of environmental issues, as described in EEA's "Late lessons from early warnings" and the company's exposure to these issues. Looking at the "early warnings" of today we might expect raising cost and benefits related to greenhouse gases, particles and gases forming secondary particles (SO2, NOx, VOC). Increase cost for use of scarce metals due to interventions from the society seems less probable. However the cost is likely to increase anyway due to normal market mechanisms.

Keeping track of these substances with a life cycle perspective and evaluating the eco-efficiency of the parts of the supply chain will help in identifying and focussing on reducing future costs. If using the PPP principle, the damage cost of present emissions may be compared to abatement costs. If higher, a future cost may be expected covering the difference.

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