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PRESENT USE AND NEED FOR ENVIRONMENTAL ANALYSES AT ERICSSON CORPORATE AND SITE LEVELS[1]

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Ericsson, a major international telecommunications company, has environmental effects through its activities and products. It is desirable that the company lowers its environmental impact and delivers solutions that reduce resource consumption and detrimental emissions. This paper examines the environmental work at the corporate level and the site level, as well as the information needed to perform environmental management, according to regulatory, company environmental policy and sustainability demands. Additionally, some environmental systems analysis tools are discussed. From the discussions, it is concluded that:

- *Ericsson is well advanced concerning regulatory societal and environmental policy demands.*
- *The information requirements for sustainability are not completely met. Probably this can be improved through a combination of LCA and MFA.*
- *The system boundaries and environmental aspects may be as important as the analysis methodology chosen.*
- *A higher degree of the environmental performance information should be incorporated in the corporate management system.*

[1] En något utökad version av detta kapitel har tidigare publicerats som en separat rapport: Cerin, P. & Ramírez, J.I. (1999) *Present use and need for environmental analyses at Ericsson corporate and site levels*, Institutionsrapport TRITA-KET-IM 1999:24 (Stockholm: Kungl. Tekniska Högskolan, Industriellt miljöskydd/Industriell ekonomi och organisation).

INTRODUCTION

Aim

The aim of the study reported in this chapter is to increase the understanding of how different models and methods for environmental system analysis may be used, for extracting and handling the information, which is required for various purposes, and for different levels, at the telecommunication and data communication company Ericsson.

Method

The method used in this study is first to analyze Ericsson's present environmental work, both at the corporate level and at a specific site level, namely the Kumla plant, which assembles cellular mobile telephones. Both these organizations as well as their activities are described. Secondly, the environmental information needed by Ericsson according to regulatory, company environmental policy and sustainable development demands are discussed. In a third step, some tools for environmental systems analysis are presented and their applicability within Ericsson is discussed.

The environmental analysis tools discussed are CBA (Cost-Benefit Analysis), EIA (Environmental Impact Assessment), MFA (Material Flow Analysis), MIPS (Material Intensity Per unit Service), and LCA (Life-Cycle Analysis). Other tools, e.g. DEC[2] (Ranganathan, 1999) and CAESAR[3] (Caduff, 1997) are not presented due to only being different presentation techniques. More methodologies for management are not taken up.

How to read this chapter

The disposition of this chapter follows very much the method used in the study:

Section 2 presents the current corporate organization of Ericsson and current environmental work at corporate level is briefly presented. Section 3 presents the current environmental work and the environmental management system (EMS) implementation project organization at a specific site level (Kumla plant). Section 4 comprises a discussion of the environmental information needed by Ericsson according to regulatory, company policy and sustainable development demands. Section 5 illustrates a brief description of some tools for environmental systems analysis, and their applicability within Ericsson. Finally, section 6 displays the results comprised of syntheses and the thereof drawn conclusion.

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[2] Dow Eco Compass

[3] CAuse Effect Sensitive and Aspect Related

ERICSSON CORPORATION

Corporate organization

Ericsson is a major supplier of telecommunications systems as well as related terminals. The services, which Ericsson produces, are telecom and Internet-based datacom for wired and mobile communications over public and private networks. Ericsson has more than 100 000 employees in 140 countries of which 23 000 (in 23 countries) are dedicated to research and product development consuming more than 20 per cent of the company's sales. At present, Ericsson's product portfolio is renewed every two years. A visualization of Ericsson's organization is presented below (Figure 3.1).

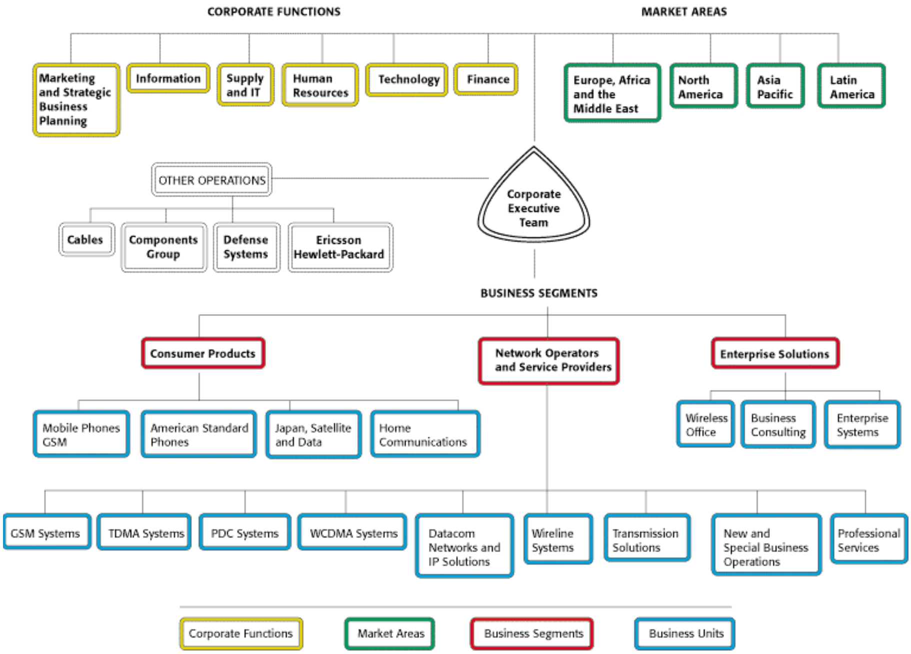

Figure 3.1 Ericsson's organizational chart

During 1998-1999 the whole company has been reorganized,[4] in order to strengthen the corporate management and customer focus. A corporate executive team (CET) has been created, which includes three managers from business segments[5] and four managers responsible for the geographical market areas,[6] as well as managers for each of the following six corporate functions:

- Finance
- Technology
- Supply & IT
- Marketing
- Human Resources
- Corporate Communications

There is also a Vice President in the team. The people within this CET are the only ones, which report directly to the corporate executive officer (CEO). This team is intended to strengthen the co-ordination of Ericsson's corporate functions.

The reorganization that started 1998 has not yet been fully implemented. Instead during the mid 1999 the responsible CEO was released of his duties, because the executive board felt the reorganization of the company was going to slowly and leading to an exponential rise in administration costs due to the rapidly growing complexity of the organization. Today, it is hard to tell whether or not this will lead to new significant changes of the company, however the people within the CET[7] are said to remain the same.

Corporate environmental organization

Some of Ericsson's stakeholders, i.e. Telia, BT and DoCoMo, require the company to communicate its environmental performance and to deliver solutions that help to reduce global resource consumption and emissions detrimental to nature.

The business areas of Ericsson, specifically telecom and datacom, have little

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[4] The new CEO since the spring of 1998, introduced this reorganization of Ericsson in order to create a more customer oriented company focusing customer needs, present as well as future ones.

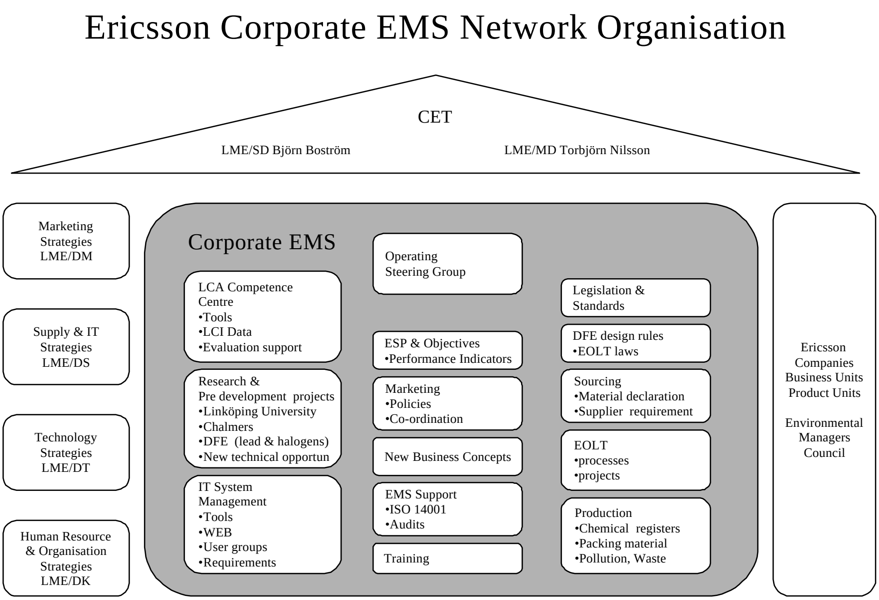
[5] The three business segments are Network Operators, Consumer Products and Enterprise Solutions.

[6] The four corporate offices will be established in Europe, Africa & the Middle East, North America and Asia & Oceania.

[7] Except for the new CEO, Kurt Hellström, and the person replacing his old position as manager of the Asia & Ociania Market Area, also represented in the CET.

environmental impact in relation to their revenues and total stock value. Ericsson has e.g. the second lowest tons of CO_2/sales, which estimate carbon-dioxide emission (representing global warming potential) relative to current operations, among those companies on the Stockholm Stock Exchange with working external environmental information system (FinansTidningen, 1998). Therefore, the attention from environmentalists has been of minor degree. However, the community of IT and telecom foresee a gigantic explosion of their products and services in the future where they will be used by a vast number of people in the world. Therefore it will probably lie in these companies' own interest to show that an excessive use of their services will lead to sustainable development, by reducing the use of services that cause larger environmental damages.

At this moment, a new environmental organization is gradually becoming discernible. Characterizing for this organization is its network structure. The corporate environmental organization is named "Ericsson Corporate Environmental Management Network Organization" (Figure 3.2). The actual composition of the members of Ericsson's environmental organization, as well as its structure, has been determined mostly by the original workplace of these members, which is within all Ericsson levels, i.e. the corporate level, marketing unit-, business unit- or product unit levels. Therefore it is hard to grasp a clear



picture of the interactions between the different parts.

Figure 3.2 Ericsson's corporate environmental management organization.

(Note: for a complete list of acronyms, see glossary in Appendix 3.1.)

As the title of the corporate environmental organization proclaims it is not a hierarchy organization. Perhaps a suitable description would be organization by available skills.

At present, the core of the environmental management network can be considered included within the Ericsson strategic planning organization (ESP), which prepares the basis of decisions made in the CET.

Moreover, the operating steering group (OSG) plays an important role within the corporate environmental organization, since the OSG draws environmental objectives and coordinates the environmental work. This group will consist of ten people; i.e. the Environmental Officer, Mats-Olov Hedblom and the Environmental Coordinator Lars Göran Bernau, plus the major Environmental Managers within Ericsson. These two organizations, ESP and OSG, constitute a part of the corporate EMS body within the corporate environmental organization, (see below). The corporate EMS body incorporates other functions as well e.g. Life Cycle Assessment Competence Centre (likely to), Marketing, EMS Support, Training, DFE design rules and End of Life Treatment among others.

The organizations surrounding the corporate EMS are four of the six corporate functions, namely the functions of:

- Technology
- Marketing
- Supply & IT
- Human Resources

There is also an environmental managers council (EMC) surrounding the corporate EMS. The EMC consist of approximately 150 people, managers from different Ericsson companies, business- and product units as well as the area responsible experts within the corporate EMS.

On top of this, we have the CET mentioned earlier. Within that team there will be two persons responsible for environmental issues and they are the managers of the corporate functions of Marketing as well as Supply & IT. These two persons are reporting directly to the CEO. These managers of the CET, on the other hand, receive their information from the OSG, essential within the corporate EMS. The corporate environmental officer will report to the Marketing officer, while the environmental coordinator will report to the Supply & IT manager. Hereby, these two corporate functions are the cornerstones of the corporate EMS.

Corporate environmental vision and policy

Ericsson corporate environmental vision

The message brought by Ericsson's environmental vision is that the company can increase its earnings and at the same time lead to increased sustainability, due to Ericsson's skills and business areas, e.g. information technology.

Although, this vision might lead the company into a false sense of rest, considering that there seems to be no actual need for reducing its own impacts, and might also make the company unable to see the absolute effects of the IT products sold by Ericsson.

> "We have the environmental and technological skills to fully take advantage of our business opportunities as the leading company in a world where IT products promote and act as means for an ecologically sustainable global development."

Ericsson corporate environmental policy

The main message delivered by the environmental policy is that Ericsson's products have not only low environmental burdens, but they also enable great potentials for lowering the environmental impacts in society, depending on how the products are used by the customers.

This policy intends to highlight the company potentials and obligations in cutting back environmental impact, in a sustainable manner, by using a holistic view and environmental concerns.

The policy is to be modified this fall of 1999.

> "**Ericsson shall** contribute to sustainable development of the world society by developing, producing and offering products and services with low environmental load that also **provide customers with possibilities to lower their environmental impact**." (The bold font is our own highlighting to show the sections we find most important.)

Present corporate environmental work

Ericsson's current corporate environmental work is summarized below, following, in broad outline, the ISO 14000 structure.

From an operative point of view Ericsson has dedicated a substantial effort to implement environmental management systems (EMS), according to the ISO 14001 standard, at sites with a significant environmental impact. These implementations were based on the existing quality assurance systems, which follow the ISO 9000 standard. Among the important links between the environmental and quality systems, there are two concepts applied at Ericsson: Time-to-Market (TTM) and Time-to-Customer (TTC), as a measure of a product total quality.

Large amount of environmental information is gathered by various evaluations, but it does rarely affect the day to day operations. The use of analyzing tools has to be incorporated into the ongoing activities. To do so, all stages of the ISO 14001 (ISO, 1996) five-step Policy-Plan-Do-Check-Act-, and the ISO/FDIS 14031 (ISO, 1998) four-step Plan-Do-Check-Act processes, have to be utilized. Today the stages performed at corporate level are 1 and 2 (to some extent) respectively 1, 2 (to some extent), 3 and 4.

Environmental management systems – EMS (ISO 14001-series / EMAS)

Today, a number of Ericsson manufacturing and office sites are certified in accordance to the international environmental management system standard ISO 14001. A general Ericsson strategy established that all entities with significant environmental loads[8] should get an EMS certification.

Due to the independent status of the companies within Ericsson, coordination of the EMS implementation at the different sites has been rather reduced. Twenty-two out of 35 manufacturing sites have certified EMS, while 12 plants are working on achieving EMS certifications. Another challenge is the today constantly changing world of tele- and datacom, which requires its companies to steady reorganization to keep up with the rapid branch pace. Therefore, Ericsson is aiming at a common corporate environmental management system, or umbrella certification, in the future, covering the activities taken place at offices, but not all operations in manufacturing plants.

Environmental auditing – EA (ISO 14010-series)

Environmental audits are carried out by third parties certifying various Ericsson sites. These certificates are usually only covering a specific site, but arising now are corporate umbrella certificates as achieved by the Swedish company SKF. The competing communication solutions-provider Motorola is working on an enterprise EMS registration.

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[8] The strategy as well as the corporate environmental policy does however not state what is a significant environmental load. It is not specified if the certification should be applied on entities with direct impacts only or also to entities with indirect ones as well.

Environmental labels and declarations – EL (ISO 14020-series)

In the ISO 14020-series three types of labels are considered: Type I labels, which are awarded by third-parties (e.g. EU Eco-label); Type II labels, are single attribute (e.g. energy use) and self-declared statements; Type III labels are based on standardized LCA practice. At present, Ericsson is aiming at Type III labels.

Type III Environmental Impact Indicators are consistent with the Environmental Condition Indicators, ECI, specified under the EPE below.

Environmental performance evaluation – EPE (ISO 14030-series)

Ericsson has been performing research studies, investigating the value of their products when those exit the phase of use, 10 to 20 years from now.

When conducting LCAs and End of Life (EOL) studies Ericsson is dividing the Environmental Burdens (EB) into Environmental Impact Categories (EIC). The formula below visualizes the burdens per impact category (ICI, 1997):

$$EB = (W_a * PF_a) + (W_b * PF_b) + (W_c * PF_c) + ... + (W_n * PF_n)$$

where *EB* denotes the Environmental Burden of each environmental impact category, *W* denotes the weight in tons for each substance emission, and *PF* denotes the specific potency factor based on the known or estimated environmental risk posed by an individual substance to the specific category under consideration.

Life cycle assessment – LCA (ISO 14040-series)

The Ericsson corporate environmental management assigns life cycle assessments an important role in Ericsson's environmental work. A lot of effort is made to perform these studies in order to find out the environmental load contributions from Ericsson's products or more accurate, functions of products and services. Studies are made on; switching centers, radio base stations, cables and populated printed circuit boards, etcetera. Today, Ericsson has a desire to evaluate the whole company's contributions to a societal context, i.e. not only to show the environmental loads from their product, but to include the dynamic effects that Ericsson's products will have on the behavior on the public and thereby on the environment.

However, the current development process of some products, such as mobile phones, does not consider the LCA methodology.

The LCA methodology has also been applied to specific case studies, such as a study comparing the environmental loads of the mobile networks of Stockholm and Sacramento, California. This study was carried out jointly by Ericsson, Telia and AT&T. The method used in this study is Life Cycle Stressor Effects Assessment, LCSEA. The LCSEA considers not only the potential effects as an ordinary LCA, but also where the emissions take place (local effects).

Work place analysis – WPA

Another tool used at Ericsson is the Eco-Workplace Analysis, which is basically an LCA applied to the activities of the employees. The activities comprise building operations, IT equipment and paper consumption, commute and business travel. The impact categories included in such analyses include resource consumption (e.g. water, metals, minerals, electric energy etc), as well as emissions/wastes (e.g. greenhouse gases, acid rain gases, hazardous waste etc). An example of the results of such an analysis is presented in Figure 3.3.

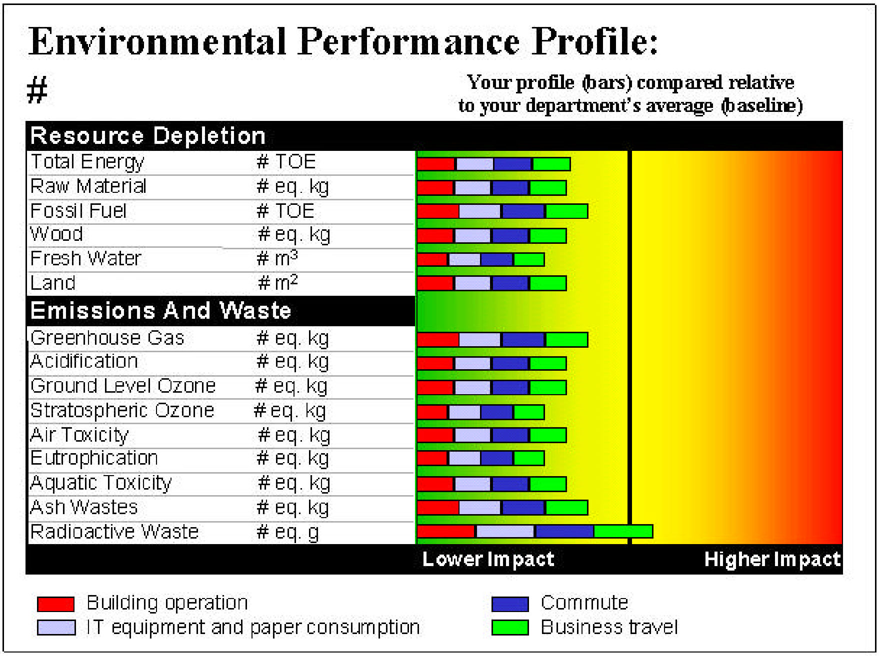

Figure 3.3 Environmental performance profile used in work place analysis.

These results may then be aggregated to department, company and up to corporate levels or aggregated to a district level, compare inventory scope to ordinary MFAs, or the aggregation can be used in very broad LCAs where e.g. the contributions from the product supporting functions in all life-cycle phases.

SITE LEVEL – KUMLA PLANT

Environmental policy at Kumla

The environmental policy at Kumla states that the environmental work at the plant has to be at world level, since Kumla is world leading regarding mobile phones manufacturing. Ericsson corporate environmental policy is also valid at Kumla. This implies "according to the Kumla Environmental policy" that:

- Environmental matters will be given priority at all management levels
- We (at Kumla) strive in our daily work to continually reduce use of natural resources
- We (at Kumla) prevent contamination
- All of us take part by being given possibility and responsibility to identify and influence the environmental aspects which are connected with Kumla's business idea
- Our environmental work is characterized by continuos improvement of environmental aspects, as well as work procedures which integrate with other improvement work, through goal setting and follow-up
- We (at Kumla) have sufficient knowledge and instruction in order to active cooperate to the accomplishment of Kumla's environmental goals
- We (Kumla) support the reduction of environmental loads through the application of an integral view by the total process of development (TTM), and manufacturing & distribution (TTC) process of mobile telephones
- We (Kumla) communicate with clients, neighbors, authorities, suppliers and other stakeholders in environmental questions
- We (at Kumla) use the best technology from the environmental point of view in the development of new production and distribution methods

EMS implementation project organization at the Kumla plant

The factor, which triggered the implement of an environmental management system (EMS) at the Kumla plant was Ericsson's corporate strategy affirming all the activities and product units within the company, which have an environmental effect,[9] to be certified according to ISO 14000 by year 2000 at the latest.[10]

The implementation process was started during spring 1997. It was then decided

[9] As stated earlier the corporate environmental policy does not state what is a significant environmental aspect. It is not specified if the certification should be applied on only entities with direct impacts or also to entities with indirect ones as well.

[10] Today, this corporate goal has been changed to that all the activities and product units within the company, which have an environmental effect, to be **certifiable** according to ISO 14000 by year 2000 at the latest

to procure the support of the administration consultant Arthur D. Little (ADL), which had carried out other assignments at Kumla, and had experience of implementing an EMS at other companies. ADL suggested carrying out the work in two phases:

- Phase 1: ”Analysing and Evaluating the Current Situation”
- Phase 2: “Implementation”

The milestones of Phase 1 were:

1. To establish the most relevant environmental aspects at Kumla
2. To carry out a “Gap Analysis”, in order to establish the existing baseline and what was missing to attain a working environmental management at Kumla

Another important principle of ADL’s approach was that environmental aspects receive enhanced support if some “business value” can be associated to them. This principle was considered very beneficial at Kumla and resulted in the implementation of an EMS having received a greater support from the plant’s direction. In comparison, at the Linköping plant, where a traditional approach was applied, the introduction of an EMS has gone at a slower pace.

A 3-step process was used to establish the relevant aspects (Figure 3.4).

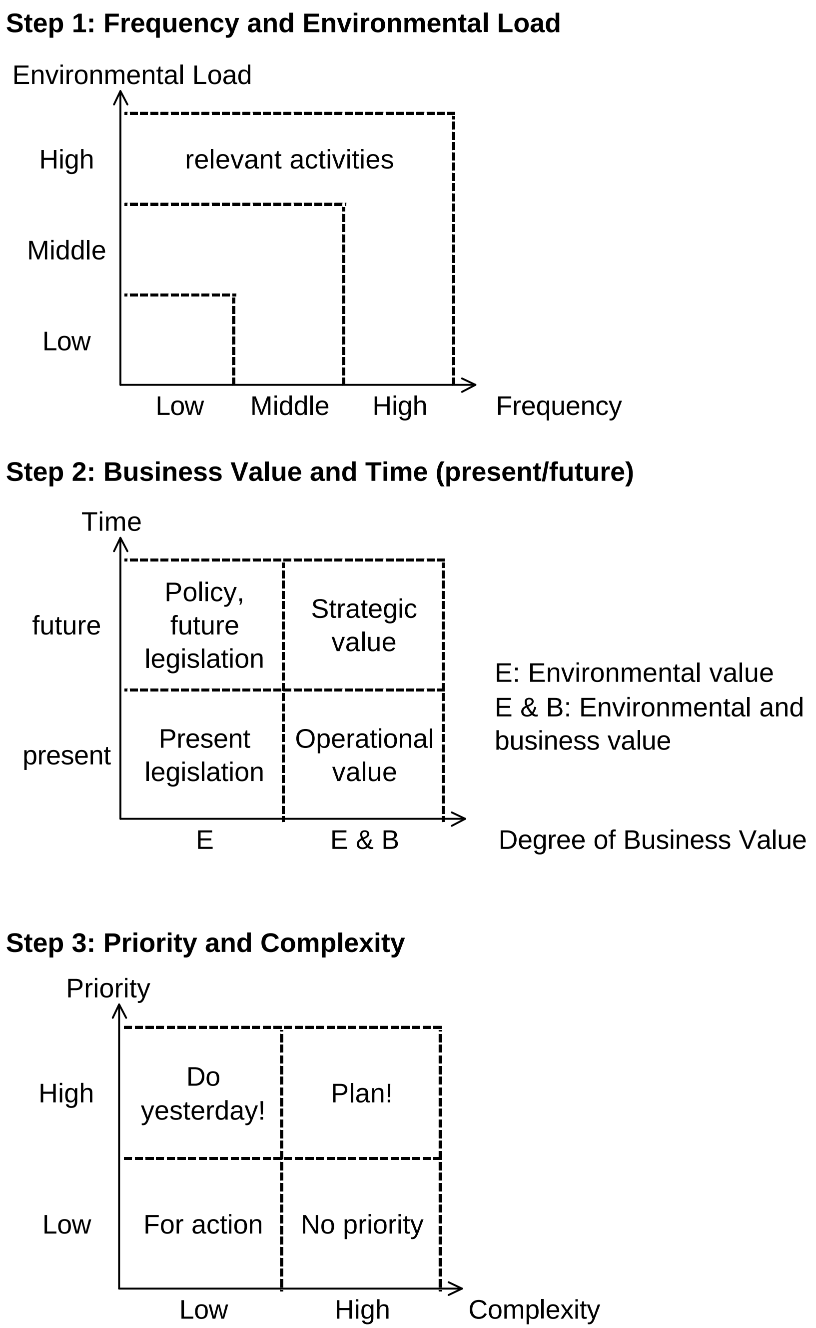

Figure 3.4 A 3-step process used at Kumla Plant to establish relevant environmental aspects

As a result of this analysis a number of aspects as well as degree of influence were pointed out. These conclusions are shown below:

Aspect	Influence		Possibility	Existing	Existing	Effects
	Kumla [1)]	Lund [1)]	to reduce costs	legislation	Corporate goals	on vicinity
Energy use	high				yes	
Resource use	high		high	yes	yes	
Water use	high					
Emissions to air	high			yes	yes	
Noise	high			yes	yes	yes
Emissions to soil and water	high					
Waste management	high		high	yes		
Hazardous waste	high			yes	yes	
Production method	moderate	high			yes	
Product planning	moderate	high			yes	
Supplier selection	moderate	high				
Accident prevention	high			yes		
Emergency readiness	high			yes		

[1)] Design is carried out at Lund while production is carried out at Kumla

Phase 2, i.e. the practical implementation, was started at the beginning of 1998. A project group defined policy and objectives; afterwards this was made extensive to all of the employees working at Kumla, mainly through course activities. The Kumla plant obtained the ISO 14001 certification by turn of the year 1998-99.

Some specific practices developed as a consequence of Phase 2 were:

a) The preparation of guidelines for machine procurement, and
b) The analysis of transport form used by the employees

The guidelines for machine procurement requires that the machine supplier has to specify following data:

- Energy consumption (kW/h)
- Waste produced (kg/h, specification)

- Emission to air during normal operation (kg/h, specification)

- Chemicals consumption during normal operation (kg/h, specification)

In the transport form analysis, a poll was made among the employees in order to survey the proportion who traveled by car (alone or in group), bus, bicycle or walking, and the proportion who would be willing to change to a transport form with less environmental load.

Regarding organization, the roles of environment contact person and environment group have been created in order to coordinate environmental management work. According to Kumla's organization, each unit chief is responsible for all the activities within the unit; function of the environment contact person is to support the unit chief concerning environmental matters. The function of the environment group is to assist with specific competence in the areas of environmental legislation, management and general knowledge.

Today, the environmental management system in Kumla is an integrated part of the quality management system, ISO 9001. For example, the ”General Requirements of Machine Procurement” has several requirements where environment is one among others.

INFORMATION NEEDED ACCORDING TO…

…Regulatory societal demands

The society imposes demands upon Ericsson through legislation. These demands can be:

a) Restriction on emissions
b) Reduction of waste generated
c) Restriction in the use of hazardous substances
d) Requirement regarding facilities to manage and deposit wastes
e) Requirements to carry out remediation of contaminated soil or water, under the responsibility of the plant site
f) Documentation of emissions and waste
g) Documentation of use of energy and other resources, such as water
h) Study the environmental impacts of a new plant or a significant change of an existing plant (EIA), in order to apply measures in order to reduce the negative effects and continue to comply with regulations after the construction or modification of the plant
i) Requirements to take back the packages or products after use (producer responsibility)

At present, the legislation is mainly oriented at restraining the emissions of the manufacturing activities at site level. The company's environmental loads are viewed as being those directly originating from within the judicial entities. The limits usually cover the following emissions:

- Liquid waste emissions
- Gaseous emissions
- Solid waste emissions
- Noise

The limits imposed vary depending on the country where the plant is located, and even within a country there can be different limits, based e.g. on the sensitivity of the recipients. Implementation differences are significant between countries and even within them, depending on regional labor market conditions and strength of regional authority.

It is usually required that data of emissions, waste generation, energy and resource use be presented in an annual environmental report. Therefore, the information needed according to the regulatory societal demands for a corporation is mainly given by those measurements of the yearly environmental report at site levels. Eventually, a simple MFA of the plant processes can be useful in order to reduce the waste generated or the use of energy and resources.

The upcoming producer responsibility requirement,[11] on the other hand, imposes much higher demands, restricted not only to site level, but also along the whole product chain, design – manufacturing – selling – retrieval, in order to enable a low cost system to take back the used packages or products.

…Environmental policy demands

As mentioned earlier, the core of Ericsson's Environmental Policy is to "contribute to sustainable development[12] of the world society by developing, producing and offering products and services with low environmental load that also provide customers with possibilities to lower their environmental impact". This imposes the following requirements regarding indicators or aggregate

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[11] Producer responsibility legislation for electronic equipment is already implemented in some countries, i.e. Switzerland and the Netherlands and will become judicial enactment in Sweden 2001 and in the EU 2005.

[12] However, there is no explanation to what Ericsson means by the expression ”sustainable development”. Are they referring to an expression used by the World Commission on Environment and Development (i.e. the ”Brundtland Commission”, presented further down) or are they only regarding sustainable development as an ecological phenomenon? Perhaps as something else?

information:

a) The environmental load from all life cycle stages of Ericsson's products.
b) Potential products and services, which can be substituted by Ericsson's products, and their environmental load, e.g. teleconferences instead of airplane trips.
c) Possible new application of Ericsson's products which may reduce the energy and material throughput, e.g. distance control of heating and illumination system, or an information system which enables streamlined physical transports.
d) The very crucial point is whether the more efficient services described in b) and c) will lead to a sustainable development where lesser resources are used or if it only will act as means for ordinary economic growth releasing resources for other use.

In order to make an estimation of the environmental load of a product it is necessary to have information of the material and energy and energy flows required by the manufacture, use and disposal/recycling of the product. It is not sufficient with this data, however, since some evaluation of the environmental effects of these flows has to be made in order to obtain an environmental load.

As it is today, the scope of many Ericsson EMS projects are related to specific sites with considerable effects on the environment as advocated in Ericsson's corporate environmental strategy. However, as declared by the EMS project group in Kumla, earlier, the production site does not have control over all environmental aspects caused by the plant activities. Hence, the EMS should also cover the decision-making activities, and not only the locally controlled activities, which have an environmental impact. The EMS and the linked scope of environmental analyses should expand from being based on mere TTC[13] approach to a more extensive TTM[14] decision chain, following the product-group in the company rather than one single organizational unit, which usually is not as persistent over time. In this case, an EMS e.g. certain covering cellular phones, including the design facilities in Lund and the production plants, two in Sweden and one in England, would replace the Kumla EMS. Heribert *et al*. (1993) describes somewhat similar thoughts how to integrate and coordinate the environmental work, based on the cradle to grave use of life-cycle methodology.

Evidently, there is a high degree of uncertainty when acquiring this data,

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[13] Time-to-Customer (TTC), as a measure of a product total quality including the time from the start of manufacturing to customer.
[14] Time-to-Market (TTM) as a measure of a product total quality including the time from the start of designing over the market phase.

especially concerning the activities outside the control of the company.

…Sustainable development demands

According to ”Bruntland Commission’s” report *Our Common Future* (WCED, 1987), sustainable development is understood as ”development …that meets the needs of the present without compromising the ability of future generation to meet their own needs”. This can be interpreted in several ways, Harremoës (1996) gives the following version of sustainability with a resource component and a pollution component:

“Society should use its resources such that the society can continue its mode of operation without exhausting its resources.”

Not only environmental concerns lie in the concept sustainable development, but also creating social equity. This equity is an intra-generational such, but also an inter-generational that means that will shall provide the future generations the possibility to live with the same standard as we are (Turner *et al.*, 1994; Bergström *et al*., 1998). These political concepts are very broad, and need to be broken down into apprehensible goals to see whether the two equities, environmental and social, enable each other or acts as counterparts.

In order to attain some indicator that resources are used in a sustainable manner, information is needed about the fluxes of substances and energy in society, together with knowledge about their scarcity, as well as environmental effects. Moreover, some dynamic tool to forecast these fluxes given alternative solutions are needed, in order to make comparisons between these alternatives.

It should be noted here, that a material resource and its scarcity are relative concepts, since the fact that a certain substance is considered scarce at one point in time, depends, among other factors, of the use given that substance. This use can be modified by e.g. substitution or development of new technologies. Based on this, some authors have pointed out that the limiting factor is human resources (e.g. Simon, 1996). However, the need for information about fluxes would still be valid, since it would point out which uses of material resources must be modified at a given time.

The information needed by Ericsson according to sustainable development demands would in consequence be:

a) Information of the fluxes of the substances and energy used in Ericsson's products and services, including the whole life cycle: production → use → disposal/recycling.
b) Information on the present scarcity of the resources used.
c) Information about the environmental effects of the substances and energy used.
d) Information regarding the changes in human behavior when new technologies and their potential services are introduced.

It would be very beneficial for sustainable development to apply the concept proposed at the company's policy; namely that Ericsson's products can be used to reduce its customer's total environmental load. Information would then be needed about the customer's present environmental load, and how this load can be modified through the use of the company's product.

Some of this information is similar to that required according to environmental policy demands. The difference would be that in the case of sustainable development demands, the information would have to cover all of Ericsson's activities, and not only concentrated to Ericsson's products and their use. In other words, the company has to live sustainable itself, not only relying in its products' good performance, and make sure its customers uses Ericsson's technology in an environmentally efficient manner. An approach to EMS and environmental analyses, which includes the company TTM activities as described earlier, is recommended, as well as the requirements stated in ISO 14001.[15] However, it is not enough to examine one's own contribution and one's customers' in order to receive information for sustainable development decisions. As the corporate policy also points out, the company has to involve suppliers in Ericsson's EMS and studies. Thus, the scope of the environmental work should cover all life-cycle phases of the actual company, up-stream as well as down-stream (Heribert *et al.*, 1993; Borgström & Ekroth, 1997) to enable actions towards eco-sustainable development. Empowering such development, the study has to be made broad, incorporating the behavior of people dealing with the product group (Figure 3.5).

Ericsson's environmental policy is consistent with sustainable development to some extent. As mentioned before, Ericsson's policy has as objective "to

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[15] In ISO 14001, Clause 4.3.1 (ISO, 1996) it is stated that: "*The organization shall* establish and maintain (a) procedure(s) to *identify the environmental aspects of its activities, products or services* that it can control and over which it can be expected to have an influence, in order *to determine those which have or can have significant impacts on the environment*. The organization shall ensure that the aspects related to *these significant impacts are considered in setting its environmental objectives*. The organization shall keep this information up-to-date." (Parts in *italics* are the authors' own considerations of importance in this matter of scope.)

contribute to sustainable development of the world...”. However when translating this statement in operative goals, sustainability becomes diffuse, concentrating instead in complying with an environmental certification or achieving business values such as cost reduction by effective use of resources.

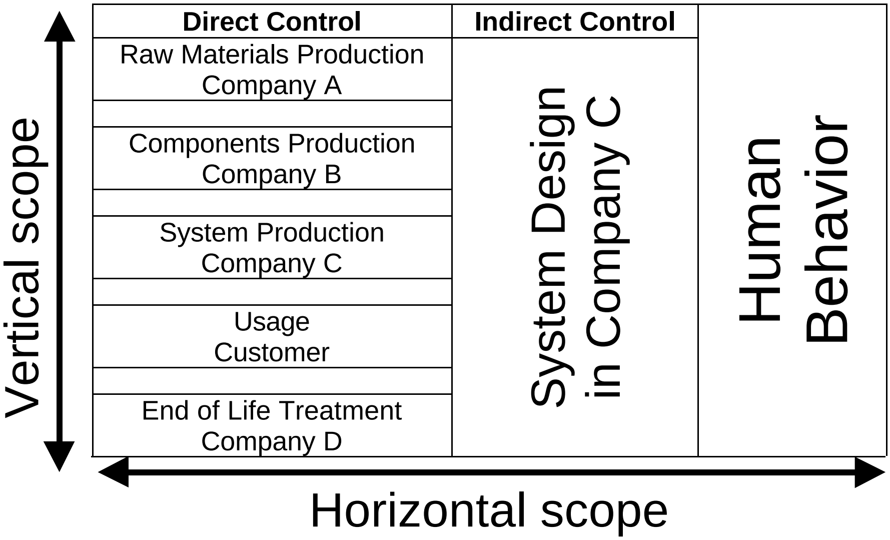

Figure 3.5 Relationship between different environmental scope of analysis methods.

ENVIRONMENTAL ANALYSES METHODS

Material flow analysis – MFA

Description

Material Flow Analysis (MFA) is a tool for analyzing regional metabolisms, which gives an opportunity to understand how the society physically interacts with the environment (Burström, 1998). The use of MFA may encompass more than flow analyses of materials, i.e. energies. This methodology, MFA, is in other words designed to quantify the physical metabolism of complex biological and cultural systems, the biogeogenic and the anthropogenic. Often the system borders in these studies are regional, consistent with societal borders e.g. municipal, provincial and national or unrestrained by judicial borders following the ecosystems in nature e.g. catchment areas or islands. The methodology of MFA in brief:

- Goal & Scope
- Quantifying fluxes and reservoirs
- Interpretation

Process, goods and materials may define the anthropogenic systems. Indicator materials can identify the metabolic process of systems (Baccini & Brunner, 1991). The choice of material flux systems to describe the anthroposphere is based on four essential activities, namely:

- To nourish
- To clean
- To reside and work
- To transport and communicate

To us it seems like MFA is a more or less similar to the Life Cycle Inventory (LCI) [16] phase in the LCA methodology. Both tools set a goal and scope in the beginning of a study, which sets functional units, system boundaries, data requirements, assumptions and limitations. The MFA, as well as the LCI, do quantify material and energy flow within and crossing the system borders, defined in the goal and scope. What can be discussed in an MFA and LCI study is the goal and scope choices made, but no major valuation is incorporated when classifying, characterizing and weighting data, as done in Life Cycle Impact Assessments, LCIAs. The relation between these different terms is illustrated in Figure 3.6.

One great difference although, is the utilization, the scope, of the methods. MFA, is as described above, a tool for analyzing regional metabolisms, while LCI is a tool for analysis of material and energy flows during products or services life cycles, incorporating perhaps several regions into its study. These differences are connected to the goal and scope chosen, given that municipalities or regional authorities usually use MFAs while LCA is more often employed by the industry.

Another difference is that the standardization of the LCA/LCI methodology has come much further than the MFA methodology, which makes it more difficult to compare the results of separate MFA studies. Likewise, the availability of standardized database structure is much greater for the LCA/LCI methodology.

[16] The corporate world usually uses LCI, Life Cycle Inventory, as the provider for LCA, Life Cycle Assessment. The life-cycle inventory is a list of material and energy flows (Linnanen *et al*, 1996). In this study, we consider LCI as being a stricter category of MFA, Material Flow Analysis (energy flows included), due to the existing set of LCA guidelines by ISO 14040-series, which often is used as a role by enterprises.

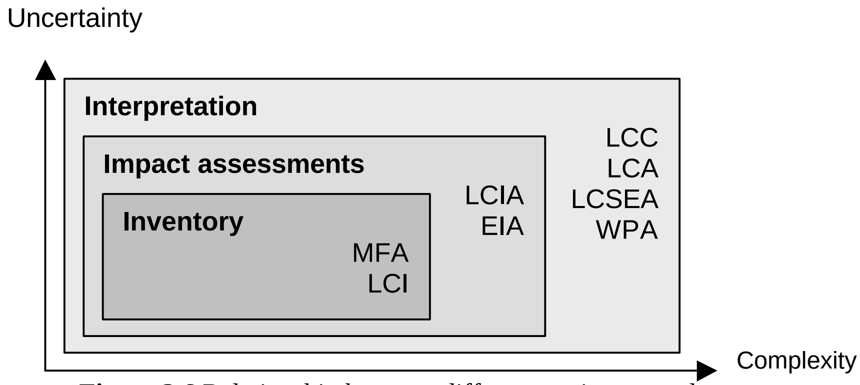

Figure 3.6 Relationship between different environmental a
methods (complexity vs. uncertainty scales)

There is, although benefits from reviewing MFA studies to learn more about how the material and energy fluxes work in a societal context. MFAs will be really useful in future if they adhere to the ISO standards for LCA. The MFA and LCI data will then be in the same format and can be exchanged back and forth, however, that is not the situation today.

Applicability

By comparing the MFA tool with the environmental information needed, it can be seen that a MFA could supply a significant amount of this information, especially according to the sustainable development demands. However, the information supplied by a MFA would have to be complemented with another tool that can aggregate the information providing the specific environmental pressures of the substances and energy fluxes.

Regarding Ericsson, an aspect that can restrict the applicability of MFA, both at site and corporate level, are the resources that can be dedicated to gathering the information required by an MFA. In other words, the company management as well as the employees can consider that it is too cumbersome and costly to gather all this information, in relation to the benefits, and the available resources (time, qualified personnel, etc.). Therefore, it could be interesting to analyze which information is already easily available, from e.g. environmental reports, existing LCA/LCI studies etc.

Ecological rucksack, Material Intensity Per unit Service – MIPS

Description

MIPS, Material Intensity Per unit Service, is a tool for initial estimation and comparison of environmental impacts of infrastructures, goods, and services. The method is applicable as a way of conducting LCAs, or even MFAs, simplifying them by ease up the initial work-heavy inventory phase. According to its proposers, assessments for goods and infrastructures could thus be greatly simplified, cost effective and internationally harmonized with less resistance than until now has been the case (Schmidt-Bleek, *et al*., 1997: 1ff). The parents of this MIPS method is the Factor 10 Club, working for a urgent dematerialization of economies by de-linking economic growth from material intensity by a factor of 10.

The method, MIPS, is one-dimensional, taking only weight of man moved materials, from the biosphere (biogeogenic system) to the technosphere (anthropogenic system). These materials are e.g. plowed soil, overburdens, minerals, water, fish and plants et cetera. It does however, not take into account the distance the materials have been moved and it does not measure nor assess the eco-toxicity associated with this processes and materials. The MIPS is composed of five different ecological rucksacks:

- Abiotic materials
- Biotic materials
- Soils
- Water
- Air

Schmidt-Bleek *et al*. (1997) further states, the calculations use Material Intensity, MI, which composes all natural resources necessarily to manufacture,[17] use and dispose a product. To make it possible to elucidate the ecological rucksacks for products, a number of base materials are given their MIs. For example a more rare mineral only available in lower concentrations has a higher MI; i.e. copper (500) while iron (7). We can hereby determine the rucksack of an ordinary 22 kg PC to (14 000 kg) for production and the normal usage rucksack is close to (7 000 kg). The producing of a 0.5 kg heavy populated circuit board for a switching center needs approximately 800kg of moved materials (Cerin, 1998).

[17] Including, overburdens and disposals from mines et cetera (Kågeson, 1998).

The formula below visualizes the MIPS expression (ICI, 1997):

$$\sum (M_i * MIM_i) = MI = MIPS * S$$

where *M* denotes materials involved, *MIM* denotes material intensity of materials (rucksack), *MI* denotes the total material input, *MIPS* denotes the material inputs per service unit, and *S* denotes the service unit.

Applicability

On a general perspective, there are some critics of the MIPS methodology, e.g. Kågeson (1998) criticizes that this methodology, in order to achieve a single dimensional assessment (tons) leaves out important environmental aspects, such as eco-toxicity. Moreover, Kågeson criticizes the Factor 10 approach, on which the MIPS methodology is based. For instance, MIPS and Factor 10 intend to achieve an absolute reduction in tons, unlike the Factor 4 (Weizsäcker *et al.*, 1997), which sees a relative reduction measured in material and flow intensity per GNP (see Figure 3.7, below).

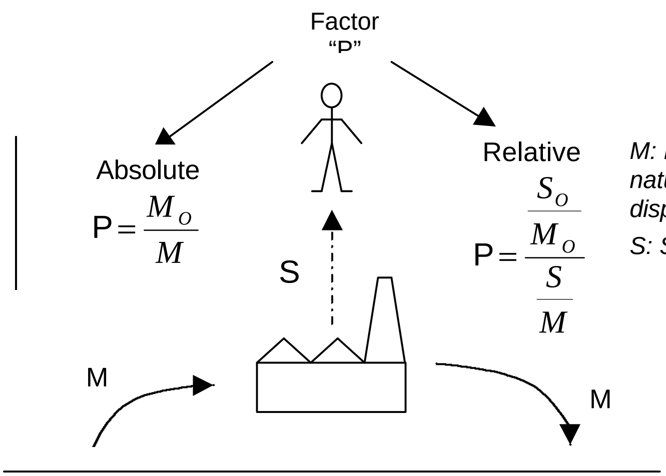

Figure 3.7 Absolute and relative factor comparisons. Picture from Holmberg (1998).

Dematerialization can be measured by using MIPS, but it does not really take a stand on the flow quality, recycled or dissipated, and it does not at all consider transmaterialization, toxicity and scarcity (Holmberg, 1998). With MIPS it seems like local effects constitute negligible effects on global sustainability.

The MIPS methodology is in many cases not sufficient for legislative purposes, i.e. evaluating resulting scarcity and pollution from corporate operations, due to the one-dimensional inventory and accounting. Kågeson (1998) has also shown that the correspondence between the use of non-renewable materials and the resulting future scarcity and air, water and soil pollution are weak. The exception is global air pollution i.e. ozone depletion and carbon oxide emissions.

Ericsson could use MIPS as a work and time effective front-end design tool,[18] but it has not the accuracy for being a back-end design tool, giving valuable information to future design projects. MIPS could neither give results that would pass an environmental auditing nor environmental labeling.

Cost-benefit analysis – CBA

Description

Actually all decisions are made on the bases of gains and losses, and cost–benefit analysis (CBA) is one method to sum up the net gains often compared with a status quo alternative among others for ranking.

If we incorporate time into a CBA formula, the net present value (NPV) should then preferable be positive (Turner, Pearce & Bateman, 1994) as shown below:

$$\sum_t \frac{B_t - C_t}{(1+r)^t} > 0$$

B	Benefit in year t	*r*	discount rate
C	Cost in year t	*t*	year t

When taking environmental concerns into account one way is to measure the gains and losses in wellbeing. One way of doing this is to see what people are willing to pay (WTP) to receive an environmental asset e.g. a living lake. WTP can also be expressed in terms of willingness to avoid something or willingness to accept (WTA) a loss in welfare, e.g. polluted air for a certain compensation. There is also a price for peoples willingness to restore (WTR) an environmental asset.

In order for CBA to work as an instrument steering towards ecological efficiency, environmental items has to be incorporated into the benefits and costs. This can be achieved either by a regulatory command-and-control (CAC) approach or/and by the often more efficient, in the long run, economic incentive

[18] Front-end design is product and service evaluations that can be influencing the actual studied case. The reason why is, it often uses a method which needs little information to be carried out and gives fast answer return.

(EI), approach. A life cycle cost study is one model for internalizing the cost from e.g. customers as well as from the producer responsibility.

Applicability

Criticism has been raised that it is hard to find the real willingness-to-pay (WTP), because result tends to be depending on researches and/or analysts subjective values. The different alternatives of WTP, i.e. WTA and WTR often present great diversity in people's preferences even though they study the same environmental asset.

Moreover, the problem of interest is not easy to deal with, because some emissions do not result in environmental effects until long after occurring while the interest makes a future cost less significant. Discounting therefore "discriminates" the future, shifting costs for environmental burdens to future generations. An example from Turner *et al*. illustrates the dilemma by taking the cost from a leaking nuclear waste repository equal to £1000 million in 100 years' time. If the discount rate is 8 per cent then the present value (of the damage from leaked material 100 years from now) will only be £ 450 000.

Concerning Ericsson, at site level, it could be said that cost-benefit is implicitly applied when seeking "business value" in order to establish relevant environmental aspects. That way, some aspects that are related to sustainability are pointed out, such as reduction of energy and material use. Otherwise, it is difficult to see in which other way this methodology can provide a measure of improved sustainability.

I/O-analysis (input–output), may be used as a CBA tool for determining environmental costs and reductions thereof, and thereby environmental savings. At Sulzer Technology Corporation they used an I/O balance sheet in financial terms on material and energy flows in a plant location to track major areas of savings (Schröder & Winter, 1998). Richardsson (1999), senior consultant at Pricewaterhouse Coopers, also calls attention to the need for I/O balance sheets in order to measure a corporation's environmental performance. Appendix 3.2 shows how such an I/O environmental performance scorecard might look like.

Environmental impact assessment – EIA

Description

An Environmental Impact Assessment (EIA), according to OECD Development Assistance Committee (OECD, 1992), is a procedure used to examine the environmental consequences, both beneficial and adverse, of a proposed development project and to ensure that these consequences are taken into account in project design. The EIA evaluates the expected effects on human health, the natural environment and on property. The EIA should consider alternative project designs (including the ”no-action” alternative), as well as mitigation measures or environmental safeguards that should be incorporated into the project design to offset adverse impacts.

Applicability

In the case of Ericsson, an EIA is applicable when a new plant is built or a significant modification is made to an existing plant. Obviously, this occurs only occasionally. Therefore, we have not further commented this tool in this report; in order to concentrate on the methods we consider more suited to analyze Ericsson’s main activities, such as the production and marketing of telecom products and services.

Life-Cycle Assessment – LCA

Description

According to ISO 14040, a Life Cycle Assessment, LCA, studies the environmental aspects and potential impacts throughout a product’s life (i.e. cradle-to-grave) from raw material acquisition through production and use to disposal. The general categories of environmental impacts needing consideration include resource use, human health, and ecological consequences.

It is important to keep in mind that LCA does not address economic considerations or social effects. Additionally, like all other scientific models, LCA is a simplification of the physical system and cannot claim to provide an absolute and complete representation of every environmental interaction (SETAC, 1993).

The methodological framework of LCA includes definition of goal and scope, inventory analysis, impact assessments and interpretation of results as illustrated in the picture below (Figure 3.8).

Most important items of the LCA framework (ISO, 1997) categories are:

1. Goal and scope (functional units, system boundaries, data requirements, assumptions and limitations)
2. Inventory analysis, ISO 14041 (allocation procedures and calculation of energy flows)
3. Impact assessments, ISO 14042 (classification, such as resource depletion, human health and ecological effects; characterization; weighting)
4. Interpretation, ISO 14043 (identify significant environmental issues and evaluate them and draft conclusions and recommendations)

An example of the workflow from inventory data to impact assessment in the LCA methodology is presented in Appendix 3.3.

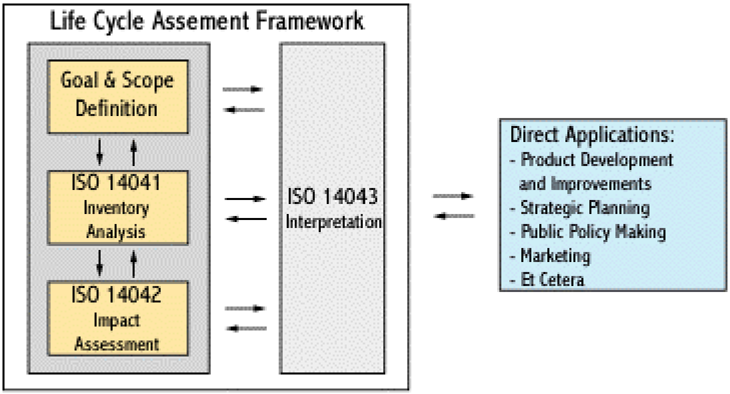

Figure 3.8 ISO 14040 – phases of the life-cycle assessment

Applicability

The inventory phase of LCA is very time consuming if everyone conducting an LCA should follow the chain back to the cradle. Besides the transparency and thereby the comparability, reliability and reusability would be of lower rank. In order to overcome these obstacles, an interaction between companies has to be obtained letting each player contribute with the LCI data of its expert area. To enable an interaction of LCI data between Swedish companies, the Centre for Environmental Assessment of Product and Material Systems at Chalmers University of Technology (CPM), has in corporation with Swedish companies developed a Swedish national LCI database: SPINE@CPM. This database is freely accessible for the CPM members financing the build-up of the database, often by own studies, which then are approved by CPM. The database structure is based on a system called SPINE, and the coming ISO 14048 standard for LCI-database format will be based on SPINE and the competing SPOLD structures. Ericsson and other participating companies can thereby ensure that what they produce will be consistent with the future standard on LCI format.

As indicated earlier in this chapter, Ericsson's corporate environmental management assigns LCA an important role in Ericsson's environmental work. However, LCA is not yet a tool used in all product development carried out by Ericsson.

At site level, such as the Kumla plant, it would be difficult to justify the introduction of LCA methodology, because of the fact that many of the factors taken in account in an LCA are not controlled by the plant, but by the Design Unit, based in Lund.

A recent application of the LCA methodology being utilized at a pilot scale at Ericsson is the "work place analysis" (WPA), which accounts the environmental impact of different activities of personnel, such as office space requirements, business travel and computer use.

SYNTHESIS AND CONCLUSIONS

Synthesis

As can be seen in sections 2 and 3, Ericsson is capable of handling regulatory societal demands and providing the information needed according to these demands, both at corporate and site level. Ericsson appears well prepared to meet the upcoming regulations, such as producer responsibility.

Concerning environmental policy demands, Ericsson is well advanced regarding the implementation of an environmental management system, according to the ISO 14001-standard, at the different production sites. A common corporate environmental management system, or umbrella certification, is planned on the near future. However, one of the principal objectives named in Ericsson's policy "to contribute to sustainable development of the world" has been considered only indirectly when establishing the operative procedures to attain the corporate environmental objectives. During the following years significant efforts will be allocated to improve Ericsson's environmental management systems.

Ericsson has not explicitly taken up, an approach regarding sustainable development demands, which would satisfy the information, required for decision making and management for a sustainable development. Nevertheless, Ericsson today performs WPA-evaluations of activities of the personnel, which might have environmental impacts.

Both the LCA and WPA methodologies are supported by MFA.

Conclusions

To achieve greater results in environmental performance, the indirect impacts from decision making in the design phase ought to be incorporated into the present EMS, covering activities with significant direct environmental impacts.

From the discussion on the different methodologies taken up in the fifth section, it can be concluded that probably a combination of methods will be needed in order to provide this information.

The LCA methodology is already applied within Ericsson, but it would have to be improved and consider a wider field of activities carried out by Ericsson, in order to be able to supply an adequate measure of progress toward sustainability within Ericsson. Therefore, the WPA could be introduced on a larger scale complemented with CBA giving incentives to both company and employees. Standardization and a clearer picture of the benefits is needed in order to overcome due concern for excessive cost and time required to implement such environmental systems analysis tools.

Ericsson has not explicitly taken up an approach, which would satisfy the information required for a sustainable development. Probably a combination of LCA (Life Cycle Assessment), e.g. applied to products and workplaces, supported by MFA (Material Flow Analysis) will be able to supply an adequate measure of progress toward sustainability within Ericsson.

However, perhaps most importantly, in order to receive maximum benefits, the environmental performance information gathered must to a much greater extent be incorporated into a corporate management system, which then will lead Ericsson to continuously check and act on the resulting conclusions of the analyses of gathered information.

ACKNOWLEDGEMENTS

We would like to thank our supervisors, Björn Frostell (Dept. of Industrial Ecology) and Staffan Laestadius (Dept. of Industrial Economics and Management) for sharing their insights and ideas, which we highly evaluate. We would also like to give our thanks to the manager of the Ph.D. course *Environmental Systems Analysis and Management 1999*, Fredrik Burström, who has been supporting this paper with his constructive commentaries.

At Ericsson there are several persons whose assistance we would like to express our gratitude to. From Bengt Baatz and Maria Vemdal we received generous and time-consuming help with the understanding of the environmental work at the Ericsson Kumla plant. Göran Mälhammar, Ericsson internal consultant in environmental matters, provided us with life-cycle consideration. The Ericsson corporate environmental manager, Mats-Olov Hedblom, communicated Ericsson's environmental visions.

Furthermore, we would like to emphasize that the access to Ericsson's Intranet has been very useful, enabling us to come across information regarding environmental work at both corporate and site levels.

Finally, we would also like to give thanks to David Bauner and Liselotte Roth, for their constructive comments on an earlier version of this chapter.

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[*)] Moreover, a considerable amount of information, has been gathered from Ericsson Environmental Intranet, at corporate as well as at various site levels.

APPENDIX 3.1 GLOSSARY

Acronyms	Compound Terms
ADL	Arthur D. Little
CAC	Command And Control
CBA	Cost Benefit Analyses
CEO	Corporate Executive Officer
CET	Corporate Executive Team
CPM	Centre for Environmental Assessment of Product and Material Systems, Chalmers University of Technology
DFE	Design For Environment
DK	Directory of Human Resources and Organization
DM	Directory of Marketing
DS	Directory of Supply and Information Technology
DT	Directory of Technology
EA	Environmental Auditing
EB	Environmental Burden
EI	Economic Incentives
EIA	Environmental Impact Analyses
EIC	Environmental Impact Category
EL	Environmental Labels and Declarations
EMAS	Eco-Management and Audit Scheme
EMC	Environmental Managers Council
EMS	Environmental Management Systems
EOL	End of Life
EOLT	End of Life Treatment
EPE	Environmental Performance Evaluation
ESP	Ericsson Strategic Planning
FDIS	Final Draft International Standard
ICC	International Chamber of Commerce
ICI	Multinational British-based chemicals and materials company
ISO	International Standards Organization
IP	The Internet protocol defines how information travels between systems across the Internet.
I/O	In and Out accounting
IT	Information Technology
LCA	Life Cycle Assessments
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessments
LCC	Life Cycle Cost
LCSEA	Life Cycle Stressor Effect Assessment
LME	Lars Magnus Ericsson, (the founder of Ericsson) symbolizes Corporate Level
MD	Marketing Director, the Head of DM
MFA	Material Flow Analysis

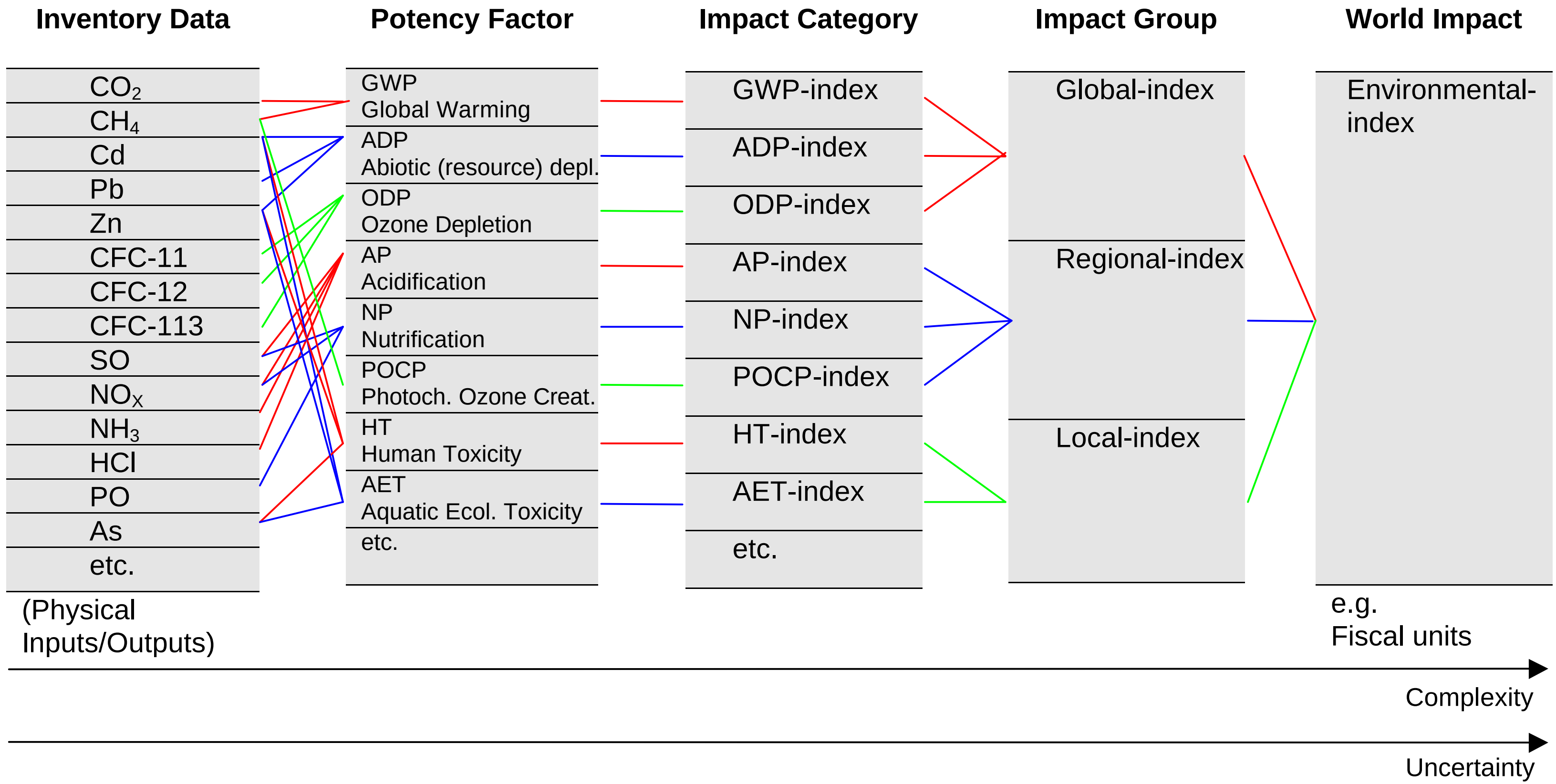
Acronyms	Compound Terms
MIPS	Material Intensity Per Unit Service, Ecological rucksack
NPV	Net Present Value
OSG	Operating Steering Group
PF	Specific Potency Factor
SD	Supply and IT Director, the Head of DS
SETAC	Society of Environmental Toxicology and Chemistry
SPINE	Large industries and research centers developed SPINE to help businesses provide customers with environmental declarations (ISO 14025). LCI-database, which will partly format the base for the coming ISO 14048 standard together with SPOLD
SPOLD	Society for the Promotion of Life-Cycle Development. LCI-database, which will partly format the base for the coming ISO 14048 standard together with SPINE
TTC	Time To Customer Time from received order to delivered product to customer
TTM	Time To Market Time from product idea to full scale production to market
W	Weight in tons
WPA	Work Place Analysis

APPENDIX 3.2 INPUT/OUTPUT BASED ENVIRONMENTAL PERFORMANCE SCORECARD

<table>
<tr><th rowspan="15">Environmental Performance I/O-Balanced Scorecard</th><th rowspan="3">Cate-gory</th><th colspan="2">Non-Financial</th><th colspan="6">Linked Financial Accounts</th></tr>
<tr><th rowspan="2">Last Year</th><th rowspan="2">This Year</th><th colspan="3">Last Year</th><th colspan="3">This Year</th></tr>
<tr><th>Abso-lute</th><th>Relative Total Fiscal I/O</th><th>Relative Sold Functions</th><th>Abso-lute</th><th>Relative Total Fiscal I/O</th><th>Relative Sold Functions</th></tr>
<tr><td rowspan="4">In-put</td><td colspan="2">Raw Material Consumption</td><td colspan="6">Procurement Costs of Raw Materials</td></tr>
<tr><td colspan="2">Water Consumption</td><td colspan="6">Costs of Water Consumption</td></tr>
<tr><td colspan="2">Energy Consumption</td><td colspan="6">Costs of Different types of Energy</td></tr>
<tr><td colspan="2">Use of Toxic or Dangerous Substances</td><td colspan="6">Procurement Costs of Toxic or Dangerous Substances</td></tr>
<tr><td rowspan="8">Out-put</td><td colspan="2">Solid Waste</td><td colspan="6">Waste Treatment Costs
Waste Disposal Costs
Waste Transport Costs</td></tr>
<tr><td colspan="2">Waste Water</td><td colspan="6">Operating Costs of Water Treatment Facilities</td></tr>
<tr><td colspan="2">Heavy Metals Emissions</td><td colspan="6">Costs of Heavy Metals Discharged with Waste Water</td></tr>
<tr><td colspan="2">Substances Causing Eutrophication</td><td colspan="6">Operating Costs of Specific Effluent Treatment</td></tr>
<tr><td colspan="2">CO_2 Emissions</td><td colspan="6">Amount Paid in CO_2 Emissions Related Taxes</td></tr>
<tr><td colspan="2">SO_2 Emissions</td><td colspan="6">Amount Paid in SO_2 Emissions Related Taxes</td></tr>
<tr><td colspan="2">NO_X Emissions</td><td colspan="6">Amount Paid in NO_X Emissions Related Taxes</td></tr>
<tr><td colspan="2">VOCs</td><td colspan="6">Costs of Discharged Products Containing VOCs</td></tr>
</table>

Based on: Rikhardsson (1999), Rauberger & Wagner (1999) and Schröder & Winter (1998).

APPENDIX 3.3 POSSIBLE LEVELS OF DATA AGGREGATION IN LCA



Atik & Schultz (1998), ICI (1991), van der Werf (1999) and Baumann & Tillman (1995) constitute the foundation to this diagram.